Appendix C
Design Criteria

APPENDIX C

Design Criteria

In conformance with requirements from the 1996 Corrective Action Consent Agreement (CACA) (California Department of Toxic Substances Control 1996) and the 2013 Remedial Action/Remedial Design (RD/RA) Consent Decree (U.S. Department of the Interior [DOI] 2013), this appendix describes the design criteria for the groundwater remedy at the Topock Compressor Station (TCS). The design criteria are the technical parameters upon which the design is based, and are based on the translation of the identified applicable or relevant and appropriate requirements (ARARs) and the Environmental Impact Report (EIR; California Department of Toxic Substances Control [DTSC] 2011) mitigation measures (where applicable) into site-specific engineering parameters.

The design criteria are grouped into engineering disciplines (Civil [Section C.2], Structural [Section C.3], Geotechnical [Section C.4], Mechanical [including electrical] [Section C.5], Electrical [Section C.6], Instrumentation and Control [Section C.7], and Architectural [Section C.8]). In addition, this appendix describes PG&E Personnel Requirements (Section C.9) and design criteria for Health and Safety (Section C.10) and Noise (Section C.11).

This appendix includes five Attachments that contain a large amount of data; these Attachments are presented in PDF format on the CD-ROM version of the Final Basis of Design (BOD) Report (enclosed within the report binders).

- Attachment A contains a detailed description of the in situ remediation design basis including carbon substrate selection and discussion of chemical reactions.
- Attachment B provides calculations in the following order:
  - Remedy-produced water pump calculations – recirculation; conditioned water transfer; filter feed
  - Remedy-produced water influent tank eductor sizing
  - Remedy-produced water caustic usage
  - Structural calculations related to the Remedy-produced Water Conditioning Building, conditioned water storage, freshwater storage, and Contingent Freshwater Pre-injection Treatment Building
  - Load calculations for the existing L-300 pipe
  - Hydraulic analysis of freshwater injection system (using EPANET software[1])
  - Hydraulic analysis of National Trails Highway In-situ Reactive Zone (NTH IRZ), Inner Recirculation Loop, and TCS Recirculation Loop wells
  - Structural design calculations for the MW-20 Bench and Moabi Regional Park long-term remedy support area structures, and remediation well vaults
  - Fire protection plan calculations for the MW-20 Bench Carbon Amendment Building, Operations Building, and Moabi Regional Park Workshop Building
  - Sand separator collection system
  - Soluble carbon substrate and emulsified vegetable oil dosing calculations
  - Moabi Regional Park Construction Headquarters (CHQ) lighting calculations
  - Moabi Regional Park CHQ yard piping head loss and tank sizing calculations
  - Structural design calculations for the Compressor Station Ponds
  - TEG load calculations for the Compressor Station Ponds

[1] Developed by the U.S. Environmental Protection Agency for hydraulic network modeling and drinking water quality analysis. For details, see http://www.epa.gov/nrmrl/wswrd/dw/epanet.html.

- Attachment C summarizes information on existing site geology and geotechnical data in support of the groundwater remedy design and to propose areas where supplemental geotechnical investigation is needed to verify design parameters.
- Attachment D includes a bulletin on remediation well design and field approach.
- Attachment E includes a summary of the hydraulic analysis of the firewater system.

C.1 Codes and Standards

The Groundwater Remedy Project is generally being designed in accordance with the applicable standards, codes, ordinances and regulations, including but not limited to:

- American Association of State Highway and Transportation Officials: http://www.transportation.org
- American Concrete Institute (ACI): https://www.concrete.org/
- American National Standards Institute (ANSI): http://ansi.org/
- American Petroleum Institute (API): http://www.api.org/
- American Railway Engineering and Maintenance of Way Association: https://www.arema.org/
- American Society for Testing and Materials (ASTM) International: http://www.astm.org/
- American Water Works Association Standard (AWWA): http://www.awwa.org/
- American Welding Society (AWS): http://www.aws.org/
- Asphalt Institute: http://www.asphaltinstitute.org/
- Arizona Department of Transportation Policy for Accommodating Utilities on Highway Rights of Way: http://azdot.gov/business/engineering-and-construction/utility-and-railroad-engineering/utility-coordination
- Burlington Northern Santa Fe Railway (BNSF) Utility Accommodation Policy: http://www.bnsf.com/communities/faqs/pdf/utility.pdf
- California Building Code (2013) as amended by San Bernardino County: http://www.ecodes.biz/ecodes_support/Free_Resources/2013California/13Administrative/13Administrative_main.html
- California Fire Code (2013): http://www.ecodes.biz/ecodes_support/Free_Resources/2013California/13Fire/13Fire_main.html
- California Mechanical Code (2013): http://www.iapmo.org/Pages/2013CaliforniaMechanicalCode.aspx
- California Plumbing Code (2013): http://www.iapmo.org/Pages/2013CaliforniaPlumbingCode.aspx
- California Division of Occupational Safety and Health (Cal/OSHA): http://www.dir.ca.gov/DOSH/
- Crane Manufacturer's Association of America: http://www.mhi.org/cmaa
- County of San Bernardino 2007 Development Code: http://www.sbcounty.gov/Uploads/lus/DevelopmentCode/DCWebsite.pdf
- Illuminating Engineering Society of North America (IES) procedures: http://www.ies.org/about/what_is_iesna.cfm
- International Energy Conservation Code (IECC): http://publicecodes.cyberregs.com/icod/iecc/2012/
- California Green Building Standards Code: http://www.ecodes.biz/ecodes_support/Free_Resources/2013California/13Green/13Green_main.html
- Institute of Electrical and Electronic Engineers (IEEE): http://www.ieee.org/
- International Society of Automation (ISA): https://www.isa.org/
- Insulated Cable Engineers Association (ICEA): http://www.icea.net/
- Minimum Design Loads for Building and Other Structures (American Society of Civil Engineers [ASCE] 7-10)
- Mohave County Regulations (including Drainage Design Manual for Mohave County): http://resources.mohavecounty.us/DrainageDesign/DDM/DDM%20for%20Mohave%20County.pdf
- Mohave County Floodplain Administrator requirements: http://www.mohavecounty.us/ContentPage.aspx?id=124&cid=392&page=2&rid=1150
- National Association of Corrosion Engineers: http://www.nace.org
- National Electrical Manufacturers Association (NEMA): http://www.nema.org

- California Electrical Code: http://www.nfpa.org/codes-and-standards/document-information-pages/free-access?mode=view
- National Electrical Code (NEC): http://www.nfpa.org/codes-and-standards/document-information-pages?mode=code&code=70
- National Electrical Safety Code (NESC)
- National Fire Protection Association (NFPA): http://www.nfpa.org/
- National Sanitation Foundation: http://www.nsf.org/
- Occupational Safety and Health Administration (OSHA): https://www.osha.gov/
- PG&E standards
- San Bernardino County Department of Public Health, Division of Environmental Services: http://www.sbcounty.gov/dph/dehs/
- San Bernardino Fire Department/Certified Unified Program Agencies (CUPA) requirements: http://www.sbcfire.org/hazmat/cupa.aspx
- San Bernardino County Floodplain regulations: http://www.sbcounty.gov/dpw/floodcontrol/default.asp
- Uniform Fire Code (UFC) (Local Fire Code): http://www.nfpa.org/codes-and-standards/document-information-pages?mode=code&code=1
- Underwriters Laboratory (UL): http://ul.com/

C.2 Civil

C.2.1 Site Datum

The topographic map (with 1-foot topographic contours) used in the design was based on an aerial survey conducted in 2011 by Toponex. Ground surveys were also conducted in localized areas to support the design. The following data were used to establish control for the project and conduct site survey work:

- Coordinates listed are 1983 State Plane Ground Coordinates, Zone 5 (NAD1983, State Plane, California, V, FIPS, 0405).
- The elevations are based on North American Vertical Datum (NAVD) of 1988 (NAVD88) in U.S. Survey feet.
- Horizontal Coordinate Units = International feet: 1 foot = 0.3048 meter.
- All bearing are grid bearings, distances are ground distances, and coordinates are ground coordinates.

Sufficient monuments currently exist at the site to provide for land survey accuracy, and establishment of additional permanent monuments is not planned. Temporary control points will be placed and surveyed in during construction and will be included in the as-built drawings.

C.2.2 Earthwork

This section describes the design criteria for the movement of soil and rock into forms and structures needed for the project.

- Grading, Paving and Access Roads

  Cut and grading will take place at the site to install new remedy facilities. Access roads are required to access certain project locations for construction and operation and maintenance (O&M). Access roads will be designed to the following standards (barring terrain or cultural, biological or natural resource constraints):

  - Maximum grade ≤ 10 percent (%), with the exception of the access road to IRL-4 and the access road east of Transwestern Bench
  - One way traffic width = 14 feet minimum
  - Two way traffic width = 20 feet minimum (Note that San Bernardino County Code Chapter 5 allows a variance for narrower fire access roads if turnouts [6 feet wide by 50 feet long] are provided about every 600 feet [County Standard 503.1]).

- Cut slopes 1.5:1 (H:V) or flatter
- Fill slopes 2:1 (H:V) or flatter
- Out slope road (1/4 inch per foot) so that drainage flows perpendicular to road centerline
- Roadside ditches (V shaped or trapezoidal) with a minimum top width of 2 feet
- Per San Bernardino County requirements (Section 7 of San Bernardino County Department of Public Works – General Permit Conditions and Trench Specifications: http://www.sbcounty.gov/dpw/operations/pdf/permits/Trench-Specs.pdf): 95% compaction of asphalt pavement, paving base material and the portion of backfill within 6 inches of paving base material. Below 6 inches, 90% compaction.
- Pavement replacement will be in accordance with the California Department of Transportation's (Caltrans') Flexible Pavement Structural Section Design Guide for California Cities and Counties (latest edition).

* Utility trenches will be excavated to a minimum 3 feet deep and 2 feet wide. Utility trenches may include pipes (freshwater, extracted groundwater, carbon-amended water, remedy-produced water, clean in place [CIP], acid, coagulant, caustic, slurry, waste sump, utility, or spare pipes), as well as electrical and instrumentation conduits. Trench cutoff walls with drain systems may be installed at locations where pipe slopes exceed 8%-10% for long runs (300 to 500 feet) to help divert any potential water flow that may undermine the trench section. In areas where utility crossings exist there will be a minimum of 2 feet separation between utilities unless directed otherwise by the utility owner. The location and depth of utilities encountered during construction will be surveyed. The survey data, utility size, and material type will be recorded on as-built documents.
* Pipe and conduit bedding material will be free of rock(s), rubbish, debris, and other objectionable material, and minimum compaction will be 90% to 95% relative density, per ASTM International D-1557 in areas sensitive to settlement. The minimum pipe bedding thickness will be 6 inches and the minimum pipe/conduit backfill zone thickness will be 3 inches. Bedding will be without voids, placed and compacted to the proper depth in 8-inch maximum lifts. The backfill will be placed to final grade to conform to the elevation of the adjoining surface elevation.
* A survey of aboveground and underground utilities will be conducted within all work areas prior to beginning intrusive site work and construction activities. This survey will include, but will not be limited to, the following activities:
  - Notify Underground Service Alert (USA) or "DigAlert" in California, or Blue Stake in Arizona
  - Geophysical survey to identify underground features
  - Excavation to expose and identify known or suspected utilities before excavation. It is Topock Compressor Station policy to minimize operational and safety risks by limiting subsurface intrusion as much as possible, and thus abandoned utilities are typically left in place. Because positive identification of all active and abandoned underground utilities prior to any intrusive activity within the station fence line is impossible, Compressor Station protocol requires all intrusive work be performed by hydro vacuum or hand excavation methods.

    As described during the October 24, 2011 site visit with the DTSC and the DOI, PG&E policy requires all excavations in the vicinity of existing infrastructure to be hand dug when within 3 feet of existing infrastructure; in more open areas, hydro vacuum excavation may be used in lieu of hand digging. Depending on the location, density of utilities encountered, and available information regarding a specific location, hand excavation or clearing using the hydro vacuum may be required as deep as 10 feet below ground surface. No power equipment will be used until the excavation has been physically cleared for utilities. A station employee observes each excavation effort and determines when it is safe to proceed with more intrusive methods. PG&E does not have a written procedure for this requirement; however, it is policy and is understood and strictly followed by all station personnel.

- It is preferred that piping installed in utility corridors will be below ground. There are many reasons for this preference, including but not limited to the following:

  a) The NESC considers an aboveground, non-overhead, high voltage electrical supply line to be an example of non-code compliant; therefore, medium and high voltage electrical lines will be placed underground. In addition, aboveground low voltage electrical 480 volt power lines carry the risk of causing electrical injuries from contact, and long runs of exposed electrical conduit also present numerous design and O&M challenges.

     i. It is worth noting that along the Route 66 segment in the upland area, considerations were also given to the piping alignment (underground) to maintain usable road width in narrow stretches of the road. The California/San Bernardino County Fire Code (Chapter 5) requires 26 feet minimum width for vehicle access. Although variances are allowed if turnarounds are available every 600 feet (County Standard 503.1), additional grading and cut backs would be required to create these turnarounds in several narrow road sections or sections with steep ravine. Note that aboveground structures would also require drainage features which adds to the footprint.

  b) Placement of water lines underground (versus aboveground) will not only avoid increased visual impacts, but will also protect the health, safety, and free movement of humans and animals. Underground piping will also enhance the integrity of the remedy infrastructure (e.g., avoid being hit by vehicular traffic), and minimize remedy footprint and future O&M challenges.

  c) Aboveground piping is inherently vulnerable as members of the public have been known to shoot pipes and large rocks or other debris may strike the pipe during a storm event. In addition, aboveground pipe will need periodic re-coating therefore, would require more maintenance compared to underground piping and as such, create more disturbance to nearby habitats as a result of maintenance activities.

  d) However, in certain cases, aboveground installations will be necessary to protect sensitive resources (e.g., crossing of the Colorado River on the Arched Bridge).

  Belowground utility corridors may be constructed with direct burial, pre-cast concrete or cast-in-place utility trenches with lids, or buried directly in the soil. The installation option was selected based on the following criteria subject to constraints for the particular route (e.g., width of usable terrain):

  – Directly buried electrical conduits may be installed beneath other electrical conduits.

  – There must be at least 3 inches of clearance between directly buried water piping. The clearance between directly buried water piping may be increased up to 12 inches.

  – The minimum spacing between directly buried electrical conduit shall be 3 inches or half the diameter of the conduit, whichever is greater.

  – Tracer wire for locating non-metallic pipes or conduit will be installed in the trenches.

  Pipes and conduit will be installed in steel casings when required by BNSF (e.g., for BNSF railroad track crossings). The need for cathodic protection will be evaluated on a case-by-case basis using site conditions and utility requirements. The casing will have centralizers and end caps 10 feet from the end of the casing.

- Trenchless construction will be used underneath the I-40 highway. In this location, horizontal auger boring will be used. The method will be designed such that it complies with relevant guidelines prepared by the Arizona Department of Transportation (ADOT), (see also Section 5.3.2 of the Final BOD Report for encroachment permits).

  – ADOT Policy for Accommodating Utilities on Highway Rights-of-Way, December 2009

Pipes and conduit will be installed in steel casings when required by ADOT. The need for cathodic protection will be evaluated on a case-by-case basis using site conditions and utility requirements. The casing will have centralizers and end caps 10 feet from the end of the casing. Identified spare pipes and conduits will be installed during construction. Exhibit C.2-1 lists minimum depth of cover for trenchless crossings. In some cases, concerns for pavement or railroad settlement or potential for drill fluid "frac-out" may require a thicker cover. Geotechnical borings may be required by ADOT (see Section C.4). If drilling fluids are used, continuous monitoring for frac-out conditions will be performed to prevent harm to human health and the environment caused by the release of such fluids.

- Any earthwork in areas of sensitive habitat (including floodplain and riparian areas, wetlands, and waters of the United States, as well as desert washes and desert riparian) will be subject to the substantive equivalents of Section 404 requirements and the California Department of Fish and Wildlife's Avoidance and Minimization Measures under mitigation measure BIO-1 (see the Mitigation Monitoring and Reporting Program in the EIR [DTSC 2011]).

EXHIBIT C.2-1
Depth of Cover Design Criteria for Trenchless Crossings
Groundwater Remedy Basis of Design Report/Final (100%) Design
PG&E Topock Compressor Station, Needles, California

Transportation Agency	Minimum Depth Of Cover
ADOT	• 3 feet minimum[1] • 6 feet minimum for un-sleeved (uncased) crossings up to 48" diameter • 10 feet minimum for pipelines larger than 48"

[1]Source: Article 3.2.4 of ADOT Policy for Accommodating Utilities on Highway Rights-of-Way

C.2.3 Storm Drainage

Stormwater will be managed to protect new structures and facilities built as part of the remedy. This section describes the design criteria associated with stormwater drainage.

Surfaces will be graded to drain. Culverts or other drainage structures will be used to drain roadside ditches and protect stream crossings. Roof drainage from buildings will be collected in gutters and drained towards drainage systems. Stormwater captured within secondary containment will be managed at the remedy-produced water conditioning system. All drainage features and structures will be sized to meet San Bernardino County requirements for storm frequency and intensity.

- Rainfall intensity based on period equal to time of concentration for the basin being considered and 25-year recurrence interval.
- Minimum velocity for culverts is 2.0 feet per second (fps). Maximum velocity for culverts is 10.0 fps.

During construction, erosion control measures will be implemented in accordance with San Bernardino County requirements and the construction Stormwater Pollution Prevention Plan (SWPPP). The erosion control measures will be tailored to the site to prevent sediment-laden water from leaving the site. The following erosion control measures may be used onsite as appropriate (for details, see the Construction/Remedial Action Work Plan (C/RAWP) for the Final Groundwater Remedy [CH2M HILL 2015]):

- Site development considerations with construction scheduling
- Maintenance of buffer zones
- Disturbed-soil areas with decomposed granite
- Dust control on disturbed areas and access roads
- Diversion of runoff with earthen dikes, brow ditches, and berms to protect excavations

- Energy dissipaters, riprap channel protection, or outlet protection for discharge pipes, channels, and ditches
- Silt fence at limits of clearing
- Temporary sediment basins to protect existing drainage basins and culverts
- Check dams to control velocity along ditches and long longitudinal grades
- Stabilized construction entrance to all paved surfaces
- Materials management with material delivery, storage, and waste management
- Vehicle and equipment management with construction practices, cleaning, fueling, and maintenance

C.2.4 Site Security

In general, the security for remedial facilities located inside the Compressor Station will be provided for by the Compressor Station security system. Remedial facilities located outside of the Compressor Station will be equipped with security features/systems that are consistent with PG&E's current security standards. Such features, as determined necessary and in compliance with project and landowners' requirements, could include, but are not limited to, fencing to protect the equipment and provide safety for personnel and the public; locks to prevent unauthorized access; security devices and instrumentation; security communication systems; alarms to notify PG&E's security operations; and security cameras. Where appropriate, security features like cameras and card readers are noted on the 100% engineering plans/drawings (see Appendix D of this Final BOD Report). Examples of security features to be installed at remedy facilities located at the Transwestern Bench, MW-20 Bench, and HNWR-1A well site are described below. In compliance with the EIR mitigation measure CUL-1a-6, any additional phone calls and alarms associated with remedial activities will not be routed through PG&E's existing alarm system at the Compressor Station.

Transwestern Bench

- A perimeter fence will be installed with a motorized main gate and a personnel gate. The main gate will have a security card reader and camera to monitor and prevent unauthorized access.
- Perimeter cameras will be installed at the Operations Building.
- The Operations Building will have card readers at entrances.

MW-20 Bench

- Each new gate(s) will have a security card reader and camera.
- Additional perimeter cameras will be installed.
- A motorized gate with security card reader and camera will be installed.

HNWR-1A Well Site

- A perimeter fence will be installed along with a security camera to monitor and prevent unauthorized access.
- A gate with a lock and/or card reader will be installed.

Moabi Regional Park Long-Term Remedy Support Area

- A perimeter fence will be installed.
- Gates will include a motorized sliding gate with keypad/card reader entry and swing gates equipped with high security chains and locks.

C.2.5 Concrete Vaults

Concrete vaults will be installed to house mechanical and electrical equipment. Vaults will be precast concrete sections where possible. The vaults will vary in depth depending upon use and location, but to the extent possible they will be designed to be shallow enough that entry would not require a confined space entry procedure (e.g., no greater than 4 feet in depth per OSHA's Safety and Health Regulations for Construction §1926.21[b][6][ii]). Each vault will be equipped with a steel ladder with extension, conforming to Cal/OSHA standards. Well vaults will be designed for an H-20 loading in traffic areas and the lids will be supplied with spring assists for safe opening. Fall protection removable grating (live load 300 pounds per square foot [psf]) will be provided. For non-traffic areas, standard lids (300 psf) will be supplied. All vault lids will be equipped with security locks or other security devices (e.g., embedded locks or 5-point bolts).

C.2.6 Construction in 100-year Floodplain

The 100-year floodplain is defined in the Flood Insurance Rate Map (FIRM), Panel 5705 of 9400 for San Bernardino County, California and Unincorporated Areas, Revised August 28, 2008, and Panel 5675 of 6700 for Mohave County, Arizona and Unincorporated Areas, Revised November 18, 2009 (Map Number 04015C5675G). The base flood elevation shown on the current FIRM is 464 feet NAVD at River Mile 234 of the Colorado River. A review of the Mohave County Flood Insurance Study (FIS) shows that this elevation is specific to the California side of the river only, and is different from information found in the newer FIS for Mohave County, AZ.

The effective FIS for San Bernardino County lists a regulatory base flood elevation of 463.90 feet NAVD. This design uses the more conservative elevation of 464 feet NAVD as the base flood elevation for the project on the California side of the Colorado River. The vertical datum for all flood elevations shown on the San Bernardino County FIRM is NAVD88.

The effective FIS for Mohave County lists a regulatory base flood elevation of 465.3 feet NAVD. This is used as the base flood elevation for the project on the Arizona side of the Colorado River. The vertical datum for all flood elevations shown on the Mohave County FIRM is NAVD88.

In this final design, certain infrastructure (piping) cannot be located outside of the 100-year floodplain as defined by the above baseline flood elevation. PG&E are working with Mohave County Flood Administrator to ensure compliance with the county requirements for construction in the floodplain.

C.3 Structural

This section describes design criteria for physical structures made of wood, concrete, reinforced masonry, and steel. Detailed structural design criteria are shown in Exhibit C.3-1.

C.3.1 Concrete

Minimum requirements are listed below for structural concrete:

- Strength of poured-in-place concrete will be a minimum of 5,000 pounds per square inch (psi) at 28 days for all structures. Lower strengths of 3,000 psi will be used for non-critical structural elements and improvements at TCS evaporation ponds as indicated in the specifications. 2,000 psi will be used for concrete fill, pipe and conduit encasement.
- Cement will be clean, fresh, Type V, low alkali, Portland cement conforming to ASTM C150.
- Aggregate will be non-reactive.
- Cement content for all structures will be a minimum of 7.5 sacks per cubic yard of concrete.
- Slump of concrete will be as low as practicable to produce a dense, well consolidated concrete and not exceed 4 inches unless otherwise authorized by PG&E Project Engineer.
- Finish of formed surfaces will be smooth and free of fins, honeycomb, and segregation.
- When the surfaces have become sufficiently hardened, they will be kept continually moist for a period of not less than seven days. Curing compound conforming to ASTM C309 may be used in-lieu of wetting surfaces only where approved by the Engineer.
- In conformance with the EIR mitigation measures AES-1d and AES-2e, integral color concrete will be used in place of standard gray concrete.

C.3.2 Reinforcing Steel (Minimum Requirements)

Minimum requirements for reinforcing steel are as follows:

- Reinforcing steel will be deformed, grade 60, conforming to ASTM A615, and be free from coating which will reduce the bond.
- Reinforcing steel will be sized in accordance with the Strength Design Method or Alternate method.

- Reinforcing steel splices will be in accordance with the requirements of ACI 318-11.

C.3.3 Dead Loads

Dead loads will consist of gravity loads induced by all structural elements, equipment, piping, and contained liquids.

C.3.4 Live Loads

Live loads for different structural elements are listed below:

- Roof live loads will be designed for a minimum live load of 20 psf.
- Stairs, walkways, and platforms will be designed for a minimum live load of 100 psf.
- Concrete floor on Grade and Grating will conform to the latest edition (2013) of the CBC, but will be a minimum live load of 500 psf, or Wheel Load of 16 kips.
- Elevated Concrete floor – 200 psf or Fork Lift load – 4 kips.
- Live load on aerial crossings (pipe bridges) will be:
  - A minimum concentrated load of 500 pounds at alternate panel point of trusses.
  - A minimum uniform live load of 25 pounds per square foot on walking surfaces.

C.3.5 Seismic Loads

The design will meet CBC (2013) and as amended by San Bernardino County and/or ASCE 7-10 “Minimum Design Loads for Buildings and Other Structures”. In addition, the criteria have been updated to the site-specific location, from Needles, California to the Compressor Station site. Specifically:

- 2013 CBC, Site Class D
- Ss = 0.23 (Compressor Station site)
- S1 = 0.12 (Compressor Station site)
- I = 1.25 (Importance Factor)

C.3.6 Wind Loads

The design will meet CBC (2013) and as amended by San Bernardino County and/or ASCE 7-10 “Minimum Design Loads for Buildings and Other Structures”.

Minimum Wind Load = 20 psf.

EXHIBIT C.3-1
Structural Design Criteria
Groundwater Remedy Basis of Design Report/Final (100%) Design
PG&E Topock Compressor Station, Needles, California

Category	Criteria
General	
Governing Code	CBC (2013) as amended by San Bernardino County, IBC 2012, ASCE 7-10
Concrete: CODE and SPECIFICATION	ACI 318-11, Building Code Requirements for Reinforced Concrete ACI 350-06, Environmental Engineering Concrete Structures
Concrete Masonry Units: SPECIFICATIONS	CBC (2013)
Structural Steel: SPECIFICATIONS	AISC Steel Construction Manual, 14th Edition
Aluminum: SPECIFICATIONS	CBC (2013)

EXHIBIT C.3-1
Structural Design Criteria
Groundwater Remedy Basis of Design Report/Final (100%) Design
PG&E Topock Compressor Station, Needles, California

Category	Criteria
Concrete	
Strength	F’c = 5,000 psi for all structures (pipe bridge foundation and precast concrete containment trench), 3,000 psi for general structural concrete (pump pads, thrust blocks, valve vaults) and improvements at TCS evaporation ponds, and 2,000 psi for concrete fill, pipe/conduit encasement.
Reinforcing	ASTM A615, Grade 60, Type S
Prestressing Strand	ASTM A416
Welded Steel Wire Fabric	ASTM A185 or ASTM A497
Design	Strength Design or Alternate Method
Detailing	ACI-SP66 (04) Manual of Standard Practice for Detailing Concrete Structures
Color	Integral color concrete in place of standard gray color concrete (EIR mitigation measures AES-1d and AES-2e)
Reinforced Masonry	
Concrete Masonry Units	ASTM C90, Grade N, Type I (Unit Compressive Strength f’m = 1,900 psi at 28 days
Mortar for Unit Masonry	ASTM C270, Type M, Minimum Compressive Strength at 28 days = 2,500 psi.
Reinforcing	ASTM A615, Grade 60, Type S
Cold-Drawn Steel Wire	ASTM A 482
Grout	ASTM C476, Minimum Compressive Strength at 28 days = 3,000 psi.
Structural Steel	
Structural “W” Shapes	ASTM A992 (Fy = 50 ksi)
Structural channels. plates, angles, etc.	ASTM A36 (Fy = 36 ksi)
Structural Tubing	ASTM A500, Grade B (Fy = 46 ksi)
Steel Pipes	ASTM A53, Grade B
Stainless Steel	Alloy Types conforming to ASTM A-167 and ASTM A-276.
Plates and Shapes	Type 316 unless otherwise noted
Bolts, Nuts and Washers	Type 316
Welding	AWS E70 Electrodes
High Strength Bolts	ASTM A325N, Type 1, Min 3/4” Diameter
Other Bolts	ASTM A307, Grade A
Anchor Bolts	ASTM A36
Chemical Anchor Bolts	SS Type 316, Threaded Rod with Hilti HIT-HY200 Adhesive, or Equivalent
Expansion Anchors	SS Type 316 Hilti Kwik Bolt TZ, or Equivalent
Timber	
TBD	CBC (2013)
TBD	National Design Specification for Wood Construction

C.4 Geotechnical

A geotechnical data summary is included in Attachment C of this Appendix. The purpose of this geotechnical summary is to provide information on existing site geology and geotechnical data (CH2M HILL 2004, CH2M HILL 2009) in support of the groundwater remedy design and to propose areas where supplemental geotechnical investigation is needed to verify design parameters. Coordination with the Soil RCRA Facility Investigation/Remedial Investigation (RFI/RI) sampling program was conducted in planning of the supplemental geotechnical investigation to minimize the number of boreholes, thereby minimizing ground disturbance. Due to the limited amount of geotechnical data available at the time of this design, assumptions made during the design will be reviewed after receipt of supplemental geotechnical data, currently planned to be collected as part of the forthcoming Soil RFI/RI sampling effort. Any material changes to the design required by this supplemental information will be discussed with the agencies. It is important to note that as PG&E continues to engage in discussions with transportation agencies, counties, and other property owners/land managers to obtain institutional controls, access agreements, and permits, additional geotechnical data may be required to meet specific requirements of agencies and/or property owners/land managers. If determined to be required, the data will be collected during the construction phase.

The geotechnical design criteria presented in Exhibit C.4-1 are based on existing site-specific geologic information and geotechnical data to support foundation and trenching designs, as well as the trenchless crossing of I-40 in Arizona.

EXHIBIT C.4-1
Geotechnical Design Criteria
Groundwater Remedy Basis of Design Report/Final (100%) Design
PG&E Topock Compressor Station, Needles, California

Parameter	Criteria
Moist soil unit weight	120 pounds per cubic foot (pcf)
Shear strength parameters	<u>Cohesionless Soils</u> Friction angle: from 32 to 35 degrees for compacted fill Friction angle: from 28 to 30 degrees for native soils <u>Cohesive Soils</u> Undrained shear strength: from 800 to 1,000 pounds per square foot (psf)
Controlling earthquake magnitudes	Mean earthquake magnitude is 6.6 Modal earthquake magnitude is 7.9
Peak ground acceleration	For structure design is 0.10 g (design value for Site Class D) For liquefaction assessment is 0.15 g (for Site Class D)
Allowable bearing capacity	4,000 psf for structures on the TCS 2,000 psf for structure outside the TCS
Allowable long-term settlement	1 inch
Sliding coefficient of friction	0.45
Lateral soil pressure equivalent fluid unit weight	Active pressure: 45 pounds per cubic foot (pcf) Pressure at rest: 60 pcf. Passive resistance: 175 pcf
Temporary cut and fill slopes	2 Horizontal:1 Vertical
Frost depth	8-10 inches

EXHIBIT C.4-1
Geotechnical Design Criteria
Groundwater Remedy Basis of Design Report/Final (100%) Design
PG&E Topock Compressor Station, Needles, California

Parameter	Criteria
Additional Geotechnical Criteria	

- Soil is corrosive to concrete structures and steel (resistivity > 1,000 ohm-centimeters, sulfate > 2,000 parts per million (ppm) and chloride > 500 ppm).
- Soil profile is classified as Site Class D (stiff soil site), as defined in the CBC (2013).
- Shallow foundations for buildings with support extending a minimum of 2 feet below lowest adjacent grade. Slabs and footings set on a minimum of 6” layer of granular base leveling course.
- Pipe design based on depth of fill, weight of fill, compaction of fill and modulus of soil reaction (E’ = 1,000 psi).
- Native onsite materials may be considered for backfill if they have an expansion index (EI) less than 50 and contain less than 8% fines, as determined by ASTM D4829 and D422.

C.5 Mechanical

This section describes the design criteria associated with key mechanical elements of the project. Mechanical design will follow the California Mechanical Code (2013) unless noted, and fire requirements per the California Fire Code (2013).

C.5.1 Piping

Based on experience with O&M of the Interim Measure facilities, the groundwater in the floodplain has high levels of total dissolved solids, chlorides, sulfate, and other minerals that have caused significant corrosion to iron-based piping material from mild carbon steel to Type 316 stainless steel. Therefore, piping will be designed and installed in accordance with best practices and past site experience for O&M, including use of flanged or union joints for serviceability and isolation valves for systems requiring routine maintenance.

In general, piping materials will be compatible with the characteristic of the conveying fluids and will be single-walled unless the pipe is used to convey: (1) groundwater or remedy-produced water that exhibits the hazardous waste characteristic; or (2) concentrated carbon substrate. In these cases, double-walled piping will be used. Double-walled pipe segments conveying either of the fluids described above will include appropriately designed leak detection systems. Low point sumps/traps with level switches and alarms will be the primary method of detecting leaks. Continuous leak detection systems may be used as an alternative to low point switches if switches are deemed impractical or incompatible with the installation. Pipeline segments installed in belowground concrete trenches (e.g., Pipeline A) will be designed with leak detection at low points (level switch with alarm).Drawing C-07-02 of Appendix D of the Final BOD Report is a pipeline key map that shows the locations of the pipeline segments.

In the case of Pipeline H which connects to well IRL-4 located at the bottom of a wash, double walled pipe segments will be used to convey remedy produced water from the wellhead to a valve vault located on the plateau. As access to this well is difficult and via a steep slope, this containment design is to provide for safe operations during well rehabilitation where acids and chemicals are used. In the event of a leak, the secondary containment will drain to a concrete sump located at the wellhead. The concrete sump will be equipment with a level switch and alarm.

Corrosion Control

For corrosion control, aboveground and belowground steel pipe will be coated. Any steel pipe near the point where it emerges from the ground will be coated. Air-to-soil transition piping is any steel piping located 18" below ground or 6" above ground. Plastic pipe (e.g., HDPE or CPVC or PVC) will be preferentially used when appropriate for corrosion resistance; and steel pipe will be cement mortar-lined to prevent internal corrosion.

Cathodic protection equipment will be applied as follows: steel piping (that is not coated, as described above) and structures will be cathodically protected underground. Piping cathodic protection will conform to National Association of Corrosion Engineers SP0177-2007 Standard Recommended Practice - Mitigation of Alternating Current and Lightning Effects on Metallic Structures and Corrosion Control Systems.

In compliance with the EIR mitigation measures AES-1d and AES-2e, the external coatings used for wells, pipelines, storage tanks, structures, and utilities will consist of muted, earth tone colors that are consistent with the surrounding natural color palette, and matte finishes. Coating materials will be corrosion-resistant to protect the underlying surfaces.

Pressure Loss

For the freshwater and the remedy-produced water piping networks, a hydraulic model built using the EPANET water supply program was used to simulate and optimize the piping design. Attachment B of this Appendix contains more details about the hydraulic modeling.

For the design of the in-situ remediation piping system, to ensure adequate distribution, the pressure loss in the branch distribution piping to each of the injection wells (including frictional losses, and wellhead pressures from drop pipe frictional losses and pressure drop across the foot valve) will be designed to be 10 times higher than the pressure drop in the distribution header. The CIP loop conveyance piping will be designed to operate at a velocity of 3 to 5 fps and will have cleanouts.

C.5.2 Process Equipment

Primary process equipment (substrate dosing pumps, compliance related sensors, safety switches, etc.) will be designed for parallel operation or provide stand-by equipment to provide sufficient redundant capacity.

To the extent practical, all valving, instrumentation, manways, and access ladders for tanks will be located on the northern face (including northeastern face) of the remedial facilities to allow O&M personnel to work on the shady side during O&M activities.

C.5.3 Valves

Valves installed for throttling and flow control will include globe, needle, and diaphragm valves. Isolation valves will include; gate, ball, and butterfly valves. Other valves expected to be included in the remedy system include spring and swing check valves, pressure relief, air relief, variable orifice, foot, and combined air and vacuum relief valves. Carbon substrate storage tanks may include additional safety valves, including emergency ventilation and combination pressure/vacuum relief valves in accordance with applicable standards. Valves will meet PG&E and industry standards appropriate to the application and process conditions.

Exhibit C.5-1 lists potential valve types associated with the major equipment. Valves will meet industry standards appropriate to the application and process conditions.

EXHIBIT C.5-1
Potential Valve Type with Associated Device
Groundwater Remedy Basis of Design Report/Final (100%) Design
PG&E Topock Compressor Station, Needles, California

Equipment	Potential Valve Type
Fresh Water Injection Pumps	Pressure reducing, ball, swing check
Freshwater Extraction Well Pumps	Butterfly valve, swing check, and surge anticipation valve
Riverbank Extraction Pumps	Swing check, globe, butterfly, ball, gate
Transwestern Bench Extraction Pumps	Swing check, globe, ball

EXHIBIT C.5-1
Potential Valve Type with Associated Device
Groundwater Remedy Basis of Design Report/Final (100%) Design
PG&E Topock Compressor Station, Needles, California

Equipment	Potential Valve Type
IRZ Pumps	Swing check, globe, ball, pressure reducing, pressure relief
East Ravine Pumps	Swing check, globe, ball
IRZ Backflush Pumps	Swing check, gate, ball, butterfly
Freshwater Backflush Pumps	Swing check, butterfly, flow control
Carbon Substrate Pumps	Pressure and vacuum relief, solenoid, swing check, motor operate valve, ball
Pipelines	Butterfly, motor-operated valve, combination air release, ball, and gate
Well Maintenance Reagent Pumps	Ball, swing check, solenoid, multi-port, motor-operated valve
Ethanol Storage and Transfer	Pressure and vacuum relief, swing check, solenoid, ball, emergency vent
Process Pumps (Submersible Sump Pumps, Air-operated Diaphragm Pumps, Metering Pumps, Centrifugal Pumps)	Butterfly, swing or other check, motor-operated valve, ball, solenoid, pneumatically actuated valve

C.5.4 Water Storage Tanks

Fixed steel tanks used for storing conditioned remedy-produced water will be designed in accordance with AWWA Standard D-100 (2011). Foundations will be designed in accordance with the structural criteria described in Section C.3 above. Frac tanks used for storing remedy-produced water will be fabricated of welded steel and equipped with axles and wheels to enable them to be moved. Corrosion prevention measures will be applied to all tanks, including internal coatings. Permanent metal tank(s) will also have internal and external cathodic protection except for ethanol tanks mounted on saddle-type supports.

C.5.5 Secondary Containment

Secondary containment systems will be sized and designed in conformance with NFPA standards and California Fire Code (2013). In general, key design criteria are:

- Containment Volume
  - Secondary containment for a single container (tank) will be 110% of the primary container. Secondary containment for multiple containers will be 100% of the largest container's volume or 10% of the aggregate volumes of all containers, whichever is greater. In addition to the aforementioned, secondary containment systems open to rainfall will also be sized to accommodate spillage from the largest single tank at a minimum plus a 24-hour rainfall, as determined by a 25-year storm. All secondary containment systems open to fire sprinkler discharge will also be sized to accommodate the discharge from all sprinkler heads over the secondary containment system for 20 minutes.
- Containment Construction and Drainage
  - Secondary containment will be constructed using materials capable of containing a spill or leak for at least as long as the period between monitoring inspections. Drainage can be accomplished through the use of one of the following methods:
    - Liquid-tight sloped or recessed floors in indoor locations or similar areas in outdoor locations

    - Liquid-tight floors in indoor locations or similar areas in outdoor locations provided with liquid-tight raised or recessed sills or dikes
    - Sumps and collection systems (e.g., collection sump)
    - Drainage systems leading to an approved location
    - Other approved engineered systems
  - Collection systems will be equipped with a monitoring system to monitor level in containment sumps. Upon detection of fluids in the sump an alarm will be initiated to alert the operators of a potential release.
- Overfill Protection
  - A means of providing overfill protection for primary container will be required. This may be an overfill prevention device and/or an attention-getting high level alarm.
- Separation of Materials
  - Materials that in combination may cause a fire or explosion, or the production of a flammable, toxic, or poisonous gas, or the deterioration of a primary or secondary container will be separated in both the primary and secondary containment so as to avoid intermixing.

C.5.5.1 Remedy-produced Water Conditioning Plant and Associated Tank Farm Areas

The Remedy-produced Water Conditioning Plant will contain hazardous materials (caustic, acids, etc.) and the A-side Remedy portion of the plant will process water streams with known or suspected contamination. The tank farm areas associated with the Remedy-produced Water Conditioning Plant will be equipped with the capability for local neutralization using caustic or acids. Therefore, these areas (see Figure 3.5-1 of the Final BOD Report) will be designed with the following secondary containment and monitoring systems:

- Area 1 – The influent storage tank farm area will have secondary containment constructed with concrete, coated with epoxy, and equipped with a collection sump and a sump pump that pumps to either the Influent Storage Tanks or the Compressor Station wastewater tank discharge connection (to be discharged to the existing TCS evaporation ponds). The destination will be selected manually. A level switch mounted in the sump will issue an alarm when liquids are detected.
- Area 2 – The remedy-produced water conditioning system will have secondary containment constructed with concrete, coated with epoxy, and equipped with a sump and a sump pump that pumps to the influent storage tank farm area sump. Sump monitoring will be accomplished via a level switch and alarm.
- Area 3 – The conditioned water tank farm area will have secondary containment constructed with concrete, coated with epoxy, and equipped with a sump and a sump pump that pumps to the Compressor Station wastewater tank discharge connection or the influent storage tank farm area sump. Sump monitoring will be accomplished via a level switch and alarm.

C.5.5.2 Truck Loading/Unloading Areas

There will be two truck loading/unloading stations with one at the MW-20 Bench and one at the Compressor Station. Each truck loading/unloading area will be equipped with a secondary containment system constructed of epoxy-coated concrete, transfer pumps, pipes or hoses for connecting to the trucks, and sumps and sump pumps. The sumps will have level switches that will alarm in the event of a spill. The existing decontamination pad at the Transwestern Bench can also be used as a truck loading station.

C.5.5.3 Equipment Decontamination Pads

Consistent with the EIR mitigation measure CUL-1a-9, the existing decontamination pad at the Transwestern Bench will be reused during remedy implementation as necessary.

Two new equipment decontamination pads will be installed for use by the project – one is located inside TCS, adjacent to the Remedy-produced Water Conditioning Plant, and one is located at Moabi Regional Park, within the long-term remedy support area.

The new decontamination pad inside TCS will be constructed in the footprint of the Contingent Freshwater Pre-Injection Treatment System. It will be equipped with a collection sump and a sump pump that pumps to the influent tank farm of the Remedy-produced Water Conditioning Plant, or to the TCS industrial sewer system connected to the grit tank, wastewater tank, and finally discharged to the TCS evaporation ponds.

C.5.6 Septic and Plumbing System

The bathrooms and sinks in the Operations Building at the Transwestern Bench will be connected to a new holding tank. Sewage generated from the Moabi Regional Park long-term remedy support area will be collected in two 10,000-gallon buried fiberglass-reinforced plastic tanks. The work will follow San Bernardino County Department of Public Health Environmental Services Division requirements.

Fresh water will be supplied for use in the onsite laboratory and sample preparation area in the Remedy-produced Water Conditioning Plant building. Washbasins or sinks in the laboratory will be drained to a double contained tank specifically for storing the fluids. The contained fluids can be disposed of at the Remedy-produced Water Conditioning Plant, or off-site.

The potable water system for the Moabi Regional Park long-term remedy support area will consist of two 5,000-gallon polyethylene tanks connected in series to a skid-mounted booster pump system and pressure (bladder) tank. Potable water will be trucked to the tanks from an offsite source.

The Remedy-produced Water Conditioning building will include rain water downspouts with spill out fittings to outside splash blocks for surface runoff, and plant water piping with wash-down hose bibs and connections for flushing of the chemical feed systems.

Information regarding emergency eyewashes and showers are provided below:

- The station located inside the Remedy-produced Water Conditioning Plant will be in the chemical storage area and near the sample room.
- The station at the MW-20 Bench will be located inside the Carbon Amendment Building.
- The station at the Moabi Regional Park long-term remedy support area will be located inside the workshop building.

C.5.7 Fire Protection Equipment

The Remedy-produced Water Conditioning Plant at the Compressor Station and the Operations Building at the Transwestern Bench are unclassified, as described by NFPA 820; hence, only fire hydrants for fire protection are required. No fire and explosion hazard, materials of construction and ventilation requirements are listed in NFPA 820 for these facilities. The 2013 CBC does not require the buildings to be equipped with sprinklers; however, PG&E risk assessment may require sprinkler systems in the Operations Building on the Transwestern Bench, as well as the Carbon Amendment building on the MW-20 Bench. As a conservative safety measure, fire sprinklers may also be installed in the workshop building at the Moabi Regional Park long-term remedy support area. The PG&E office trailer at the long-term remedy support area may also be equipped with sprinklers.

Portable fire extinguishers will be mounted in buildings in accordance with PG&E requirements and County Fire codes. Portable fire extinguishers will be ABC multipurpose dry chemical type UL-rated 20A:120B:C.

All electrical equipment will have Underwriters Laboratory approval where applicable. Areas of the electrical installation will be classified in accordance by Class, Division, and Group. Specifically, for the IRZ facility at the MW-20 Bench, the following will apply:

- Class I, Division I within a 5-foot radius of the carbon storage tank vents.
- Class I, Division II within a 15-foot radius of the carbon storage tank vents (from vent elevation to ground).

- Class I, Division II from ground surface to 18-inches above grade within a 10-foot radius of the tank footprint.
- Class I, Division II within the carbon amendment building where there are pipes with >10% ethanol.

C.5.8 Heating, Ventilation, and Air Conditioning

The new heating, ventilation, and air conditioning (HVAC) systems in planned remedy facilities are independent of the existing Compressor Station HVAC system. The design criteria for makeup air and temperature control for the laboratory/office and motor control center (MCC) rooms are as follows:

- Office/sampling room: Summer temperature <86 degrees Fahrenheit with no control for humidity. Makeup ventilation rate at 0.15 cubic feet per minute (cfm) per square foot or 15 cfm/person by code requirements.
- MCC Room: Summer temperature <90 degrees Fahrenheit with no control for humidity.

Wall-mounted ductless mini-split heat pumps will serve the rooms. A second, 100% capacity redundant unit will be installed for the office/laboratory space at the TCS and Operations Building at the Transwestern Bench. Wall mounted ductless mini-split heat pumps have two main components: an outdoor compressor/condenser and an indoor air-handling unit. Each unit will be capable of both cooling and heating the space. A conduit that houses the power cable, refrigerant tubing, suction tubing, and a condensate drain links the outdoor and indoor units. The indoor units will be mounted on the upper part of the room wall. Each unit will be sized per the heating and cooling requirements of each room.

For ventilation air in the office/sampling room space, a 60 cfm exhaust fan will be installed with either inlet door louvers or by undercutting the door to transfer outside air from the filter room.

Outside of the office/sampling room and MCC room, the first and second floors of the Remedy-produced Water Conditioning Plant will be naturally ventilated by constructing the building with no walls on three sides of the first floor (north, east and west), a wall on the north side with louvers, and a steel grating on the second floor adjacent to the filters and outside the MCC room and laboratory/office. Evaporative or “swamp” coolers will be used for the maintenance bay area in the workshop building at Moabi Regional Park.

C.5.9 Air Pollution Control

Temporary and permanent mobile and fixed equipment emissions will comply with Clean Air Act - USC §§ 7401, et seq. (National Emission Standards for Hazardous Air Pollutants [NESHAP]); 40 Code of Federal Regulations (CFR) 61; 40 CFR 63 and local air district requirements (e.g., Mojave Desert Air Quality Control District).

C.5.10 Hazardous Materials Storage

The Hazardous Materials Division of the San Bernardino County Fire Department is the Administering Agency and the CUPA for San Bernardino County with responsibility for regulating hazardous materials handlers, hazardous waste generators, underground storage tank facilities, aboveground storage tanks, and stationary sources handling regulated substances. The handling and management of hazardous materials within the remedy facilities (e.g., the remedy-produced water conditioning facility) located within the Compressor Station will be incorporated into the existing Compressor Station Hazardous Materials Business Plan (HMBP). A separate HMBP will cover the handling and management of hazardous materials at remedy facilities located outside of the Compressor Station (e.g., MW-20 Bench).

Chemicals/hazardous materials that are anticipated to be used in remedy processes and stored on site are listed below with location:

- Potential chemicals to be used and stored in the Remedy-produced Water Conditioning Building at the Compressor Station include the following:
  - Caustic (e.g., 25% sodium hydroxide), to be stored in a 550-gallon tank
  - Acid (e.g., 19% hydrochloric acid), to be stored in a 550-gallon tank
  - A coagulant (e.g., Nalco Ultrion 8187) for aiding in settling solids in the Conditioning System

  - A flocculent addition (e.g., Nalco® 7878 Flocculant [anionic type]) to aid in the dewatering of the influent tank bottoms prior to pumping to the liquid phase separators (the need for this dewatering aid and flocculent type would have to be tested during operations)
  - Laboratory reagents (to be used in the sampling room located inside the conditioning building) and related waste
  - Compressed gas cylinders
- Potential chemicals to be used and stored at the carbon amendment facilities include the following:
  - Carbon substrate (95% ethanol) – one 15,000-gallon tank located at the MW-20 Bench
  - Acids, caustics, and/or dispersants for use in the Clean-In-Place (CIP) system at the MW-20 Bench (330-gallon totes or smaller-volume drums). The potential chemicals are hydrochloric, glycolic (hydroxyacetic), and phosphoric acids, sodium hydroxide, and hydrogen peroxide
  - Compressed gas cylinders
- Potential hazardous materials/wastes to be used and stored at the Moabi Regional Park long-term remedy support area include the following:
  - Laboratory reagents (to be used in an onsite laboratory) and related waste
  - Cleaning solutions including solvents used for pumps and equipment
  - Oil used for pumps and equipment
  - Used oil hazardous waste
  - Used solvents hazardous waste
  - Universal waste
  - Compressed gas cylinders

Potential chemicals to be used in well maintenance include hydrochloric acid, sulfamic acid, sulfuric acid, phosphoric acid, hydroxyacetic acid, acetic acid, citric acid, oxalic acid, ascorbic acid, hydrogen peroxide, sodium hypochlorite, sodium hydroxide, chlorine dioxide, potassium hydroxide, polyphosphate, Aqua Clear™ PFD, Rodine-103/Rodine 213, QC-21, CB4, NuWell 120, NuWell 130, nitrogen, and/or carbon dioxide. These materials will be brought on site during the well maintenance/rehabilitation activities, but will not be permanently stored on site.[2]

C.6 Electrical

In this section, the electrical design criteria and goals are described. Electrical systems and equipment will be designed to meet PG&E standards and the California Electrical Code (2013) unless specifically noted. The primary power supply source for the remedy facilities in California will be power generated by the Compressor Station. Other power supply sources include: power provided by Mohave Electric Cooperative for the freshwater supply well in Arizona, power provided by the City of Needles for the long-term remedy support area at Moabi Regional Park, and a new natural gas-fueled reciprocating internal combustion engine electrical power generator and new thermoelectric generators for additional equipment at the TCS evaporation ponds. Secondary power supply will include power generated from small photovoltaic solar panels and from backup generators at the Compressor Station and Moabi Regional Park facilities.

C.6.1 Safety, Availability, Reliability, and Efficiency

Of paramount importance is the need to minimize electrical hazards to operating personnel, including shock, arc flash, electrical fire, and combustion of explosive atmospheres. This is accomplished by applying electrical

[2] For additional details, see the O&M Manual, Volume 1, Section 4, Exhibit 4.2-5.

equipment within its ratings and in accordance with the electrical, fire, and life safety codes listed herein. Every 480 volt and above disconnect will have provisions for lock-out tag-out. This will provide safe working for equipment that may not be in view of the breaker handle. Where possible, the breaker handles will be in view of the connected load for additional safety.

A portable, rental backup generator of similar make and model of the existing generator (Isuzu Model 6WG1X) will be mobilized onsite as needed during project implementation to provide power. A connection panel is included in the final design (see Appendix D of the Final BOD Report, Drawing E-00-61, Detail 4) and space has been reserved for the portable rental generator (see Figure 3.5-1 of the Final BOD Report).

The power distribution system will include energy management features, such as real-time power and energy monitoring, which can be used in conjunction with process data to optimize process efficiency.

C.6.2 Distribution Voltage Selection

The project's standard distribution systems include the following:

- 12.47 kV, ungrounded delta, 3-phase, 3-wire
- 480Y/277 volts solidly grounded wye, 3-phase, 4-wire
- 240/120 volts solidly grounded wye, 1-phase, 3-wire
- 208/120 volts solidly grounded wye, 3-phase, 4-wire

The distribution voltages used throughout the project will be selected to reduce maximum load flows to levels below standard electrical equipment capacity ratings, to increase the distance that it may be transmitted, to reduce fault duty to levels standard electrical equipment withstand and interrupting ratings, and to minimize the cost of the electrical installation. Exhibit C.6-1 lists the equipment utilization voltages.

EXHIBIT C.6-1
Equipment Utilization Voltages
Groundwater Remedy Basis of Design Report/Final (100%) Design
PG&E Topock Compressor Station, Needles, California

Equipment	Volts	Phase
Fluorescent Lighting	120	Single, in office areas
Incandescent Lighting	120	Single
High-Intensity Discharge Lighting	120 or 240	Single
Other lighting	120	Single
Convenience Outlets	120	Single
Motor Control	120	Single
Motors, less than 1/2 horsepower (hp)	120	Single
Motors, 1/2 hp and above	480	Three

C.6.2.1 Voltage Drop

Total voltage drop from the transformer secondary to the point of utilization, including feeder, branch circuit, and transformation, will not exceed:

- Lighting – 3%
- Motors – 5%
- Receptacles – 5%
- Electric Heaters – 5%

Voltage dip calculations will be performed for motor starting whenever an individual motor exceeds 20 horsepower or if the motor is the longest or shortest distance from the transformer.

C.6.2.2 Demand Factors

The demand factors listed in Exhibit C.6-2 will be used for sizing power switchboards, MCCs, panelboards, and transformers. Connected load will be used for circuit and equipment sizing in accordance with NEC requirements. A 10 to 20% spare capacity will be provided at MCCs and panelboards. In accordance with the NEC, where it is unlikely that two or more coincident loads will be in use simultaneously, only the largest load(s) that will be in operation at one time will be used for calculating the total load of a feeder.

C.6.2.3 Metering

Multifunction digital meters will be provided for the MCC in the Remedy-produced Water Conditioning Plant.

C.6.2.4 Branch Circuits

- Connected load and NEC requirements will be used for sizing branch circuit breakers and conductors.
- A minimum wire size of No. 12 American wire gauge (AWG) copper will be used for lighting and receptacle branch circuits. There will be NO common neutral for multiple lighting circuits.
- In general, lighting branch circuit loads will be limited to 1,500 watts. Lighting and receptacle branch circuits will not be combined, and the number of convenience receptacles on any one branch circuit will be limited to five duplex in process areas, and six duplex in office areas.
- The electrical design will include a circuit and raceway schedule providing unique names and termination location information for each power, control, and signal circuit.

EXHIBIT C.6-2
Demand Factors
Groundwater Remedy Basis of Design Report/Final (100%) Design
PG&E Topock Compressor Station, Needles, California

Service	Demand Factor
Lighting	1.0 x Connected Load
Emergency Lighting	1.0 x Connected Load
Air Conditioning Equipment	1.0 x Connected Load
Ventilation Equipment	1.0 x Connected Load
Drainage Pumps and Ejectors	1.0 x Connected Load
Convenience Receptacles	180 VA each [a]
Process Loads	1 x Full Load Amps of loads plus 25% of largest motor

Notes:
a. Apply NEC demand factor of 50% for totals over 10 kW
VA = volt-amperes

C.6.2.5 Panelboards

- Branch circuits or feeders on the drawings will identify the panelboard and device protecting the individual circuit or feeder.
- Each panelboard will be equipped with a minimum of 20% spare breakers with spaces, bus work, and terminations to complete the standard size panelboard.

- Panelboard schedules will be prepared indicating circuit identification, protective device trip rating, number of poles, load in volt-amps by phase, rating of main lugs or main circuit breaker, neutral bus size, ground bus size, and the integrated short circuit rating of the panelboard.

C.6.2.6 Uninterruptible Power Supply

Uninterruptible power supply (UPS) will be provided for each communication panel. The UPS output will be automatically selected through an automatic bypass relay.

C.6.2.7 Motor Control and Protection

Safety interlocks, such as emergency stop pushbuttons, will be hardwired directly to motor control circuits. Process controls and interlocks will be hardwired from Supervisory Control and Data Acquisition (SCADA) system programmable logic controllers (PLCs) to motor starters. Electrical metering data will be transmitted from intelligent motor overloads and relays to the SCADA system over an Ethernet network. Elementary (ladder-type) control diagrams will be prepared for each motor showing control wiring, pilot devices, auxiliary contacts, and external connections. A single diagram will be used for more than one motor having the same control.

In addition, the following guidelines will be used:

- Adjustable overload relays will be provided for all MCC-mounted and remote mounted constant-speed motor controllers. MCC-type construction will be used.
- MCCs located in the same room with the switchboard that powers them will not have a main circuit breaker. MCCs located in areas remote from the common MCC or switchboard that powers them will have a main circuit breaker.
- MCC enclosures will be NEMA 1 gasketed. Circuit breakers 225 amps and smaller and motor starters NEMA 4 and smaller will be the cubicle type with auto disconnect of control and motor power conductors.
- MCCs will include feeder circuit breakers and motor starters. Motor starters for motors up to 25 hp will be the full-voltage, non-reversing, combination type with a magnetic-only circuit breaker. Motor starters for motors larger than 25 hp will be the solid-state, soft-start, reduced-voltage, combination type with a magnetic-only circuit breaker.
- Motor starters will include an ON/OFF/AUTO or HAND/OFF/REMOTE selector switch, GREEN motor ON light, RED motor OFF light, and AMBER abnormal condition, fault, or alarm lights, as required. Lights will be the LED push-to-test type. These devices will be mounted on the front of the motor starter control center cubical.

C.6.2.8 Equipment Identification

Process and instrumentation diagram (P&ID) tag numbers will be used for motors, instrumentation and control devices, and other process equipment shown on electrical drawings. This same numbering method will be used to create unique tags for major electrical distribution equipment.

C.6.3 Electrical Equipment

This section discusses general guidelines for the selection and configuration of electrical equipment.

C.6.3.1 Distribution System Equipment

Equipment will be selected with adequate momentary and interrupting capacity for the point in the system where it is used. Series-rated criteria will not be used, except for self-contained equipment. Where practical, phase and ground fault protective devices and device settings will be selected that will function selectively to disconnect that portion of the system that is malfunctioning, and with as little disturbance to the rest of the system as possible.

Distribution equipment criteria include the following:

- 15 kilovolt (kV)-class metal-clad switchgear will be specified to provide power distribution selection at the front end of the remedy system.

- The switches will be interlocked, so only one power feed will be allowed to connect to the system at any given time. There will not be any provisions or need for paralleling systems.
- 15 kV-class cable will connect the transformers together through underground conduit.
- Sectionalizing equipment will allow for individual transformers to be isolated and replaced or repaired.
- The transformers will be distribution style, similar to those used for commercial buildings. The secondary voltage will be 480/277 volt.
- 480-volt MCCs with combination motor starters of the motor circuit protector (MCP) type rated for the available fault current.
  - Starters that are NEMA size 2 (25 hp) and larger will be the solid-state, soft-start type or adjustable-speed drives.
  - MCCs will be hardwired to the PLC for motor control.
  - Field-mounted, maintained, emergency stop push buttons will be hardwired directly to the motor starter.
  - MCCs will be sized to accept future loads and either allow for space in the structures, or floor space for future sections.
- 480-volt and 240/120-volt power distribution and lighting panelboards with molded case, bolt-in, circuit breakers with integrated short-circuit rating suitable for the available fault current.

C.6.3.2 Raceway Systems

Separate ductbanks will be used for the following systems:

- 12.47-kV power distribution
- 480-volt power wiring and 120-volt control wiring
- Communications systems, including Ethernet, low-voltage signal for fire alarm, telephone and data systems, and fiber optic cabling

Special consideration will be given to separation of raceways involving low-level process control signal wiring and power system wiring to minimize the possibility of interference. General guidelines for raceway sizing, selection, and installation are as follows:

- Conduit sizing will be based on Type THW insulation.
- The following minimum sizes will be used:
  - 3/4-inch minimum diameter for conduit not in ductbanks used within buildings or connected directly to the equipment or device.
  - 1-inch minimum diameter for conduit in ductbanks for field interconnection of equipment or buildings.
- Raceways will be a combination of concealed and exposed in process areas.
- Raceways will be concealed in walls and ceilings in control rooms, offices, and areas that have finished interiors.
- PVC-coated rigid galvanized steel conduit will be used for the transition from underground direct burial and under-slab PVC conduit and concrete-encased (in-floor slab) PVC and rigid galvanized steel conduit to exposed rigid galvanized steel conduit. The transition section will extend from 1 foot below grade or top of floor slab or

the last foot of conduit in the floor slab, to 6 inches out of the floor slab, concrete encasement, or above grade.

- The number of conduit bends will be limited to an equivalent of 270 degrees on long runs without pull boxes.
- PVC-coated rigid galvanized steel conduit and fittings that are resistant to direct sunlight and include an interior urethane coating will be used in exposed corrosive interior and exterior areas. This conduit will also be used for underground direct-burial. Direct buried conduit will have a 3-inch red colored concrete cap.
- PVC Schedule 40 conduit and fittings will be used for under-slab and concrete-encased ductbanks.
- Rigid galvanized steel conduit and fittings will be used when exposed in interior non-corrosive process and non-process areas, pre-cast concrete utility trenches, and in non-corrosive areas outdoors.
- Flexible, nonmetallic, liquid-tight conduit 4 inches or smaller in size will be used for connections to motors, transformers, etc., as required. Fittings will be PVC-coated in wet or corrosive areas. Length of flexible conduit will be limited to 36 inches.
- Underground conduit routes will be identified with nonmetallic warning tape and tracer wire above underground direct-burial conduits.
- Raceways will be tagged with an engraved plastic or nonferrous metal embossed tag attached to the raceway with a stainless steel wiring. Raceway tags as defined in the plans and conduit schedule will be located at each terminus, pullbox, and at minimum intervals of every 50 feet on exposed raceways (in ceiling spaces and surface-mounted).
- Cable trays will be evaluated for use where appropriate.

C.6.3.3 Wire and Cable

- Stranded copper conductors will be used for all except lighting and receptacle wiring. Solid conductors No. 10 AWG and smaller will be used for lighting and receptacle wiring.
- A minimum conductor size of No. 12 AWG will be used for power and lighting branch circuits. Type THHN/THWN-2 insulation will be used for No. 10 AWG and smaller conductors (conduit will be sized for Type THW conductors). Type XHHW-2 insulation will be used for No. 8 AWG and larger conductors (conduit will be sized for THW conductors). Conductor ampacity ratings of 75°C will be used for sizing conductors.
- A minimum conductor size of No. 14 AWG will be used for individual 120-volt control circuits.
- A minimum conductor size of No. 14 AWG will be used for 120-volt control circuits routed in a common conduit with the power conductors to the motor circuit controls. Combining individual motor power and control conductors in a common conduit will be done up to a maximum power conductor size of No. 2 AWG.
- Power and control conductors will be color-coded. Conductors No. 8 AWG and smaller will have colored insulation. Conductors No. 6 AWG and larger will be color-coded with tape at each end and at accessible intermediate points.
- Conductors and control cables will be tagged with a permanent sleeve or nylon marker plate attached with a nylon strap. Conductor tags with an approved tag number will be provided by the Contractor and will be located in accessible locations at each termination.
- Under normal conditions, the maximum wire size will be limited to 500 kcmil. Parallel conductors will be used for circuits requiring greater capacity.
- The 120-volt control circuits will be combined in control cables containing multiple No. 14 AWG stranded copper conductors with type THHN insulation and a common PVC outer jacket.

- A 600-volt multi-circuit control cable will be used where grouping control circuits is practical, and the number of individual wires exceeds six conductors. When selecting control cable size, 25% spare (plus or minus 10%) conductors will be used.
- Multi-conductor control cable color-coding will be ICEA S-61-402 Appendix K, Method 1, Table K-2.
- Low-voltage analog signal circuits will be routed in 600-volt single twisted shielded pair instrumentation control cables. The cables will consist of No. 16 AWG stranded copper conductors with combination PVC/nylon insulation, drain wire, shield, and PVC outer jacket. Signal circuits may be combined in multi-twisted shielded pair instrumentation control cables with common overall shield. The cables will consist of No. 18 AWG minimum stranded copper conductors, with a combination PVC/nylon insulation, pair and common drain wires, pair and common shields, and PVC outer jacket. Instrumentation control cables will be in accordance with ICEA S-82-552. Low-voltage analog signal circuits will not be routed in the same control cable or conduit with 120-volt control or power circuits.
- Adequate separation of power and instrumentation and control (I&C) wiring will be provided to avoid signal interference.
- Shielded power cables will be used between adjustable-frequency drives and the driven motor.

C.6.3.4 Color Coding

Conductor insulation colors will be as shown in Exhibit C.6-3.

EXHIBIT C.6-3
System Color Coding
Groundwater Remedy Basis of Design Report/Final (100%) Design
PG&E Topock Compressor Station, Needles, California

System	Conductor	Color
All Systems	Ground	Green
208Y/120 Volts	Neutral	White
	Phase A	Black
	Phase B	Red
	Phase C	Blue
240/120 Volts	Neutral	White
	Phase L1	Black
	Phase L2	Red
480Y/277 Volts	Neutral	White
	Phase A	Brown
	Phase B	Orange
	Phase C	Yellow
12.47 kV	Phase A	Phase A
	Phase B	Phase B
	Phase C	Phase C

C.6.3.5 Circuit Identification

Circuit names will be assigned based on the device or equipment at the load end of the circuit. Circuits will be identified at each termination and in accessible manholes and pull boxes. Plastic sleeves for conductor No. 3 AWG or smaller and plastic marker plates for larger conductors will be used. For lighting circuits, the panel and circuit number will be identified for each fixture.

C.6.3.6 Enclosures

NEMA 1 enclosures will be used for equipment in electrical rooms and finished areas, while NEMA 12 enclosures will be used for electrical equipment in dry industrial locations. NEMA 3R enclosures will be used for outside and in wet locations, and NEMA 4X enclosures will be used for corrosive locations. NEMA 4 enclosures will be used for underground and in wet locations.

C.6.3.7 Fiber Optic Cabling

Where used, fiber optic cabling will be installed either in conduit (4-inch-diameter minimum with three 1 ¼-inch inner ducts), or in a cable tray. Routing of the raceway system will provide for large-radius turns to prevent breaking of the fiber optic cable.

C.6.3.8 Convenience Receptacles

General-service duplex receptacles will not be spaced more than 25 feet apart in process areas. Receptacles will be surface-mounted on walls or columns. Weatherproof receptacles will be installed in damp areas or areas subject to washdown.

Outlet-mounted ground-fault circuit-interrupters (GFCIs) will be provided where required by the NEC. Panelboard or feed-through-type devices will not be used.

C.6.3.9 Low Voltage AC Induction Motors

Enclosures for both horizontal and vertical motors 25 hp and smaller will be totally enclosed, fan-cooled (TEFC) severe-duty for indoor and outdoor locations. In wet and/or corrosive locations, chemical industry severe-duty (CISD-TEFC) motors will be used. Motors larger than 25 hp will be open drip-proof, unless TEFC or CISD-TEFC is required for specific conditions (evaluated on a case-by-case basis considering cost and required physical protection). Submerged motors will be totally submersible, air- or oil-sealed. Bearings will be rated for 100,000-hour Anti-Friction Bearings Manufacturers' Association (AFBMA) B-10 life.

Alternating current (AC) induction motors will be the premium efficiency type with the following:

- Motors will have a 1.15 service factor at 50 degrees Celsius ambient, except where inverter-duty rated.
- NEMA design letter to fit the application (usually NEMA design B), and locked rotor kV-amps kVA Code G or lower.
- Motor windings will be copper wire.
- Motors 15 hp and larger located in damp or wet areas will be provided with 115-volt space heaters to prevent moisture condensation.
- TEFC motors will be equipped with weep holes and drain plugs to withdraw condensed moisture.
- Motors operated by variable frequency drives (VFDs) will be specified with special provisions for inverter duty operation.

C.6.4 Electrical Systems Analysis

An analysis of the fault current will be made prior to construction. Maximum fault current will be analyzed with sufficient accuracy to establish the required interrupting ratings of circuit protective devices specified.

During construction, a final load flow, short circuit, coordination, and arc flash hazard analysis will be performed by the Project Engineer, based on actual equipment purchased, to establish protective device settings that will result in reasonable selectivity of device operation for both three-phase and ground faults, while minimizing the arc flash hazard to workers. The following protective device characteristics will be specified:

- Protective relay model, pickup, and time delay settings
- Circuit breaker model, frame size, trip unit, trip settings, and time delay settings
- Current transformer ratios

Arc flash labels will be placed on the installed electrical equipment.

C.6.5 Grounding System

An integrated grounding system will be installed throughout the new remedial facilities and interconnected with the existing grounding system at the Compressor Station. A lightning protection system will be connected to the facility ground ring as well as to any exposed metallic surfaces.

Grounding electrode ground mats or embedded rods and cables will be designed for a maximum resistance to ground of 25 ohms. Where more than one rod is required, rods will be installed at least 20 feet apart. A minimum of No. 4/0 AWG stranded bare copper cable will be used for interconnecting to ground rods and footing rebar.

A lightning protection system will be designed with air terminals and separate grounding system on buildings or structures used for O&M and chemical storage, including shade structures. Shade structures, if isolated from electrical equipment, may not be required to have lightning protection.

Equipment Grounding

A separate ground conductor sized in accordance with NEC requirements will be installed in raceways for power feeders and branch circuit raceways for motor control, lighting, and receptacle loads.

Shields of shielded instrumentation cables will be grounded to the ground bus at the power supply for the analog or low-voltage discrete signal circuit. Shielded instrumentation cables will not be grounded at more than one point.

C.6.6 Hazardous and Corrosive Area Definition

Area classification was determined and accounted for in the equipment layout in the drawings.

C.6.7 Energy Efficiency and Lighting

Energy efficiency will be a factor in equipment selection. Motors will be specified to be Premium Efficient per latest NEMA MG 1 standard where possible. Lighting equipment and facilities for safe operations will be designed to be energy efficient and comply with California Title 24 and county lighting ordinances. In compliance with EIR mitigation measure CUL-1a-7, to minimize construction and operations-related lighting impacts, the lighting for the remedy will include the following features: (1) shrouding/shielding for portable lights during construction and operational activities; (2) installation of portable lights at the lowest allowable height and in the smallest number feasible to maintain adequate night lighting for safety; and (3) shielding and orientation of lights such that off-site visibility of light sources, glare, and light from construction activities are minimized to the extent feasible. In addition, no additional permanent poles will be installed for lighting.

C.6.7.1 General Lighting Requirements

Since CUL-1a-7 is not meant to replace or subsume any actions required by the County or state or federal entities with regard to lighting required for minimum security and safety purposes, the following specifications will also be met:

- Construction Industry 29 CFR 1926.56 (lighting safety requirements)
- General Industry 29 CFR 1910.120 (HAZWOPER) (lighting safety requirements)
- San Bernardino County Code Title 8 Section § 83.07.040 Glare and Outdoor Lighting - Mountain and Desert Regions

- Mohave County Outdoor Light Control Ordinance 87-1
- Specific requirements from land owners, if feasible and if not in conflict with the mitigation measures and county codes

The San Bernardino County lighting requirements are divided into two categories: residential and commercial/industrial. Remedy facilities are located both on and outside of PG&E-owned land, as follows:

- PG&E parcel (zoned industrial) – Compressor Station and Transwestern Bench
- Outside of PG&E parcel (zoned recreational) – Federally-owned land (including MW-20 Bench and Moabi Regional Park), the Havasu National Wildlife Refuge, and Fort Mojave Indian Tribe-owned land

PG&E will apply industrial requirements on the PG&E parcel and residential requirements outside of the PG&E parcel. The rationale for installing lights outside of the PG&E parcel is as follows:

Well Sites

- Nighttime access is not necessary; therefore no permanent lights will be installed. No new permanent light poles will be installed.
- Portable or truck-mounted lights can be brought and plugged in locally in the event that an emergency or unforeseen condition occurs.
- At the freshwater supply well site (HNWR-1A), security camera poles will have lights to allow for remote viewing of the well site during night time.

MW-20 Bench

- Similar to the IM-3 Brine Storage Facilities located at the MW-20 Bench, nighttime access is not normally required. Exterior lights will be installed but activated manually.
- No new permanent light poles will be installed.

In both Mohave and San Bernardino Counties, the lighting requirements are intended to reduce glare or other light emissions on adjacent properties. Exhibit C.6-4 lists San Bernardino County shielding requirements for different types of fixtures in residential and commercial areas.

EXHIBIT C.6-4
Shielding Requirements For Outdoor Lighting In the Mountain Region and Desert Region
Groundwater Remedy Basis of Design Report/Final (100%) Design
PG&E Topock Compressor Station, Needles, California

Fixture Lamp Type	Residential Area Shielded	Commercial/Industrial Area Shielded
Low pressure sodium	Fully	Fully
High pressure sodium	Prohibited except fully shielded on streets	Fully
Metal halide	Prohibited	Fully
Fluorescent	Fully	Fully
Quartz	Prohibited	Fully
Incandescent > 60 watts	Fully	Fully
Incandescent 60 watts or less	No requirement	No requirement
Glass tubes filled with neon, argon, or krypton	No requirement	No requirement
Mercury vapor	Prohibited	Fully

EXHIBIT C.6-4
Shielding Requirements For Outdoor Lighting In the Mountain Region and Desert Region
Groundwater Remedy Basis of Design Report/Final (100%) Design
PG&E Topock Compressor Station, Needles, California

Fixture Lamp Type	Residential Area Shielded	Commercial/Industrial Area Shielded
Halogen	Prohibited	Fully
Searchlights for advertising purposes	Prohibited	Prohibited
Laser source light or similar light intensity light for advertising purposes	Prohibited when projected above the horizontal	Prohibited when projected above the horizontal

Source: San Bernardino County Development Code, Ch. 83.07.040 Table 83-7. Note that LED lights (a low energy form) may be suitable for the Remedy. This technology is not covered in the County Code.

Fixtures prohibited by the County Code will not be used on the project. Fixtures planned for use in the remedy project are listed in Exhibit C.6-5. Fixtures used at the Compressor Station will comply with County requirements and follow PG&E standards for energy efficiency and lighting at operating facilities.

EXHIBIT C.6-5
Planned Fixtures for Remedy and Associated County Requirements For Outdoor Lighting
Groundwater Remedy Basis of Design Report/Final (100%) Design
PG&E Topock Compressor Station, Needles, California

Fixture Lamp Type	Shielding Requirement	Type Used in Remedy Project?
Low pressure sodium	Fully	Indoors/Outdoors
Fluorescent	Fully	Indoors
Incandescent > 60 watts	Fully	Indoors
Incandescent 60 watts or less	No requirement	Indoors
LED	No requirement (not covered in the County Code)	Indoors

Source: San Bernardino County Development Code, Ch. 83.07.040 Table 83-7.

The amount of light or the illumination level is based on having sufficient light to do the expected tasks safely. OSHA sets standards for construction activities as shown on Exhibit C.6-6 below.

EXHIBIT C.6-6
Minimum Illumination Intensities
Groundwater Remedy Basis of Design Report/Final (100%) Design
PG&E Topock Compressor Station, Needles, California

Level (foot-candles)	Area of Operation
5	General construction area lighting.
3	General construction areas, concrete placement, excavation and waste areas, access ways, active storage areas, loading platforms, refueling, and field maintenance areas.
5	Indoors: warehouses, corridors, hallways, and exit ways.
5	Tunnels, shafts, and general underground work areas. (Exception: minimum of 10 foot-candles is required at tunnel and shaft heading during drilling, mucking, and scaling. Bureau of Mines approved cap lights shall be acceptable for use in the tunnel heading.)

EXHIBIT C.6-6
Minimum Illumination Intensities
Groundwater Remedy Basis of Design Report/Final (100%) Design
PG&E Topock Compressor Station, Needles, California

Level (foot-candles)	Area of Operation
10	General construction plant and shops (e.g., batch plants, screening plants, mechanical and electrical equipment rooms, carpenter shops, rigging lofts and active store rooms, mess halls, and indoor toilets and workrooms.)
30	First aid stations, infirmaries, and offices.

Source: Safety Lighting Levels During Construction – OSHA 29 CFR 1926.56(a) Table D-3.

For activities and areas not included under the OSHA standard, the ANSI/IES has established recommended illumination levels under Recommended Practice RP-07-01 (see Exhibit C.6-7 below).

EXHIBIT C.6-7
Recommended Illumination Levels per ANSI/IES RP-07-01
Groundwater Remedy Basis of Design Report/Final (100%) Design
PG&E Topock Compressor Station, Needles, California

Category	Description	Level
A	Public spaces	3 fc (30 lux)
B	Simple orientation for short visits	5 fc (50 lux)
C	Working space where simple visual tasks are performed	10 fc (100 lux)
D	Performance of visual tasks of high contrast and large size	30 fc (300 lux)
E	Performance of visual tasks of high contrast and small size, or tasks of low contrast and large size	50 fc (500 lux)
F	Performance of visual tasks of low contrast and small size	100 fc (1,000 lux)
G	Performance of visual tasks of critical importance	300 – 1,000 fc (3,000 – 10,000 lux)

Notes:
fc = foot-candles
1 fc ≈ 10 lux

C.6.7.2 Lighting Calculations

The recommended illumination level (foot-candles) for each space will be calculated in accordance with IES procedures. The following assumptions will be made, unless specific information is available:

Reflectances for finished rooms:

- Ceilings 80% reflectance
- Walls 50% reflectance
- Floors 20% reflectance

Reflectances for unfinished rooms:

- Ceilings 50% reflectance
- Walls 30% reflectance
- Floors 10% reflectance

Maintenance factor (light loss factor):

- Fluorescent lighting 0.80

C.6.7.3 Emergency Lighting System

- Emergency illumination will be provided in appropriate spaces, as required by code, to provide life safety, property, and equipment protection.
- Adequate lighting levels will be provided to maintain safe building egress and critical process plant functions. Emergency lighting will be located near MCCs and any equipment locations that need to be monitored on a continuing basis.
- In large process areas, emergency standby lighting units with a battery pack and two lamps and lighted exit signs with a battery pack will be provided. The battery pack will power the lights for at least 90 minutes.

C.6.7.4 Explosion-Proof Luminaires

Any room or space listed as a hazardous atmosphere area will have explosion-proof-type luminaires UL listed for installation in the hazardous area classifications, as required by Article 500 of the NEC.

C.6.7.5 Nighttime Construction Lighting

The first step will be to determine whether nighttime construction work is required. Nighttime construction-related activities will be limited to work that cannot be disrupted or suspended until the following day, such as, but not limited to, well drilling and development or decommissioning activities. If nighttime construction is required, the following principles will be applied:

- Identify the active area for construction and the applicable lighting standards. Only areas of active construction may be illuminated.
- Obtain portable lighting (including solar-powered). Lights must include shielding/shrouding (e.g., downward facing fixtures with cutoff shields to reduce light diffusion). No permanent poles will be installed for nighttime lighting.
- Install the minimum lighting feasible to maintain adequate night lighting for safety at the lowest allowable height. Orient the lights such that off-site visibility of light sources, glare, and construction activities is limited.
- Assign a responsible member of the construction crew, such as foreman or crew boss, to extinguish the lighting as soon as the nighttime construction work is completed.

C.6.8 Communications

Fiber optic cable or conventional copper wire will be used for sending signals via cable. Wireless communications devices like radio, satellite, or cellular, may be used as appropriate.

C.6.9 Existing Utilities

A utility survey was conducted in early 2012, and utility potholing was conducted in 2013 and 2014 to support the remedy design. A survey of aboveground and underground utilities will be conducted within all work areas prior to beginning intrusive site work and construction activities, including maintaining a minimum 25-foot right-of-way for the L300 gas pipelines located near occupied buildings. Existing engineering drawings have been reviewed to identify areas of potential conflict, but are for planning purposes only and not solely relied upon. See also Section C.2.2, Earthwork.

C.7 Instrumentation and Control

The I&C system for the project will utilize a stand-alone Remedy SCADA system and local PLCs. The Remedy SCADA system will be located at the Operations Building (Transwestern Bench) and will provide monitoring, supervisory control, alarming, and control functions. The Remedy SCADA includes hardware (e.g., servers, PCs, touch screen panels) and software. Historian software will collect, archive, and distribute project-wide raw data and provide access to historical data.

In general, emergency shutdown of equipment due to alarm conditions (low discharge flow, high discharge pressure, motor overload, pump seal water failure, high level vault alarms, etc.) will be hardwired and will occur remotely or be executed locally. These alarm conditions will require manual reset at the SCADA or the local digital controller. In conformance with the EIR mitigation measure CUL-1a-6, all additional phone calls and alarms associated with remediation activities or facilities will not be routed through PG&E's existing alarm system utilized at the Compressor Station. The notification system for remediation-related alerts and/or phone calls will not introduce additional noise to the project area, to the maximum extent feasible, provided there is ongoing compliance with applicable safety regulations or standards of the Federal Energy Regulatory Commission, OSHA, and other agencies.

There are six control nodes equipped with a PLC to control equipment in the field. Node PLCs will have operator interface terminals. The operator interface will include sufficient access to modify system set-points, parameters, alarms limits, and indication of associated process variables and instruments. This data will also be available to the Remedy SCADA system for full remote control, alarming, trending, archiving, etc.

Each PLC switch will be connected to the Operations Building's gigabit capable Ethernet backbone switch. The fiber cable will be run from the Operations Building communication panel to remote communication panels and onto each remote PLC. The fiber cable will be multimode or single mode as applicable, consisting of 12 fibers per cable. All fiber cables will be color coded, labeled and terminated at a fiber interconnect panel.

The system has been designed to allow for isolation/removal of components that could fail from operational sequencing, thereby minimizing downtime. Full redundancy of the Remedy SCADA system was determined to be unnecessary. System outage in individual areas is expected to be repaired and put back into service within two to three days given an appropriate inventory of parts and skilled staff availability.

Power Distribution to Instrument Power Panel

All control power for each node PLC will be supplied by a control panel. The control panel shall be fed from the area primary distribution transformer. All I&C power for field devices or panels will be sourced from the control.

Uninterruptible Power Supply

The UPS will be double conversion "true online" and configured with an automatic bypass switch for battery maintenance. The UPS will provide power to the PLC, 24-volt DC power supply, Digital Input/Digital Output (DI&DO) cards, and analyzer power.

Power System Monitoring/Control from SCADA

Power distribution panels, MCCs, and communications panels will be supplied with digitally networked power metering devices for remote energy monitoring and control. Primary distribution equipment and selected secondary equipment will be supplied with electrically actuated circuit breakers or contactors which will be available for remote position monitoring and alarming as well as remote manual and automatic control via the SCADA system. Automatic sequencing for restarting of equipment after restoration of power will be provided through SCADA.

C.8 Architectural

Building and all infrastructure components will conform to the following. Specifics for the Remedy-produced Water Conditioning Plant and Transwestern Bench Operations Building are noted:

All Buildings (Water Conditioning and Transwestern Bench Operations):

- Exterior finishes: In conformance with the EIR mitigation measure AES-1d and AES-2e, the color of the wells, pipelines, reagent storage tanks, control structures, and utilities shall consist of muted, earth-tone colors that are consistent with the surrounding natural color palette. Matte finishes shall be used to prevent reflectivity along the view corridor. Integral color concrete should be used in place of standard gray concrete.

- The design, location, and physical appearance and character of new construction at the Topock Compressor Station will be consistent with existing buildings in scale, form, materials, and architectural detail.
- In keeping with the Secretary of the Interior's Standards for the Rehabilitation of Historic Buildings, the new construction will be differentiated from existing historic architecture on the property, but will be compatible with the historic materials, features, size, scale and proportion, and massing to protect the integrity of the Topock Compressor Station and its environment.
- Floors: In process areas will be reinforced cast-in-place concrete and aluminum grates where required for liquid containment. In containment areas, a chemical resistant polymer coating will be applied to concrete floor and containment basin surfaces. Six-inch housekeeping pads at equipment locations.
- Doors and frames: Heavy-gauge hollow metal doors and frames will be used. Hardware to be of heavy gauge and made of stainless steel where practical.
- Windows: Aluminum framed windows with a clear anodized finish. Energy efficient insulated tempered glass with a low-E coating. Extensive use of day lighting through windows.
- Louvers: Aluminum drainable louver with a clear anodized finish.
- Fire protection: Fire extinguishers as required per building and fire codes including NFPA 10.
- Pedestrian doors: Field finished with polyurethane and epoxy finish coating.

Specific design features for the Remedy-produced Water Conditioning Plant:

- Doors from the exterior into the facility and the interior door into the groundwater sampling equipment room will receive a tempered glass window.
- Interior finishes: Epoxy paint over gypsum board and concrete masonry unit (CMU). Clear sealer at concrete not covered with polymer containment coating. All paint to be off-white to promote a bright space where light can reach areas behind equipment.
- Overhead sectional doors: An 18-foot wide by 12-foot high heavy-gauge steel overhead sectional door with perforations to allow for air movement. Overhead door to be manually operated.
- Exterior wall assemblies: Exposed concrete on the lower floor. Insulated metal siding on the upper floor with Kynar finishes to match existing adjacent buildings.
- Structural steel framing: Steel framing to be finished with an epoxy primer and polyurethane finish coating at the upper floor of the remedy building. Exposed steel structure of the lower floor of the remedy building to be hot-dip galvanized.
- Interior walls and ceilings: Metal studs with Batt insulation where separating conditioned and non-conditioned spaces. Wall to be built on a concrete curb and receive moisture resistant gypsum board on both sides. Epoxy paint over gypsum board in laboratory room and MCC room, insulation above structural metal deck at metal roof, painted concrete at lower floor ceiling to improve light reflectivity.
- Cabinetry: Wood cabinets with chemical-resistant countertops and stainless steel pulls.
- Floors: Smooth texture and finished with a clear surface sealer to increase the durability of the concrete surface and to maintain a clean, dust-free environment.
- Roof: Insulated metal roof with continuous ridge vent and Kynar light colored finishes to match existing adjacent buildings.
- Fire protection: portable fire extinguishers.

Specific design features for the Transwestern Bench Operations Building:

- Floors: Operations Building to have a utilitarian-level polished concrete floor to minimize life cycle costs.
- Roof: Standing seam metal similar to Remedy-produced Water Conditioning Plant.
- Fire protection: In addition to portable fire extinguishers, an automatic fire sprinkler system is provided.
- Interior wall finish to be semi-gloss sheen over gypsum board. Clear sealer at ground and polished concrete. All paint to be off-white to promote a bright space where light can reach areas behind equipment. Cabinetry to be of plastic laminate covered wood overlay construction with plastic laminate countertops.
- Structural steel framing to be of hot-dip galvanized steel when exposed.

C.9 PG&E Personnel Requirements

PG&E personnel will perform the following activities during construction:

- PG&E personnel, or their designee, will lead TCS-specific safety and biological and cultural sensitivity training for contractors and employees.
- Serve as liaison and primary contact for any agency, tribal, or other third party personnel inspecting and/or monitoring construction and O&M activities.
- Serve as liaison and primary contact for community, stakeholders, agencies, Tribes, members of the press, and others requesting site tours or project-related information.
- Initiate communications with/notifications to agencies, land owners, and others, as required, in the event of emergencies or contingency triggers.
- Attend stand-up tailboard (safety) meetings before the start of work each day to review safety policies and specific hazards likely to be encountered in the day’s activities.
- Sign waste manifest forms and compliance documents that require PG&E certification.
- Monitor for compliance with PG&E safety standards and requirements and contract specifications, terms, and conditions.

C.10 Health and Safety

The project falls under federal OSHA Hazardous Waste Operations and Emergency Response (HAZWOPER) requirements (29 CFR 1910.120) so these procedures must be followed in addition to California and Arizona state requirements.

These requirements are embodied in the project-specific health and safety plan(s) for construction and O&M. In addition, health and safety work plans will be prepared or amended by construction, drilling, and other service contractors working on the project. Existing health and safety plans will be reviewed and amended, as needed, to suit new project requirements and/or conditions. PG&E personnel similarly work under PG&E’s own health and safety requirements. These health and safety plans will be available on site and will describe such things as training, site control, medical surveillance, safety personnel roles and responsibilities, personal protective equipment, exposure monitoring and air sampling programs, heat and cold stress, and site work rules and procedures.

Project-specific health and safety plans for construction and O&M activities are provided in the C/RAWP (CH2M HILL 2015) and Volume 5 of the O&M Manual (Appendix L of the Final BOD Report).

C.11 Noise

- A design margin of 3 to 5 A-weighted decibels (dB[A]) will be considered in all noise design criteria.

- In conformance with the EIR mitigation measures NOISE-3 and CUL-1a-10, the operational noise design criteria for the project will be per San Bernardino County Development Code 83.01.080 for acceptable exterior noise standards for place of worship, which is 55 dB(A) Leq daytime (7 a.m.-10 p.m.) and 45 dB(A) Leq nighttime (10 p.m.-7 a.m.) (Leq is the equivalent average hourly noise level) (see page 4.9-24 of the EIR [DTSC 2011]). The noise measurement locations will be at the edge of the Maze closest to the subject facilities and at the short-term ambient noise measurement locations (ST-1, ST-2, and ST-3) in Exhibit 4.9-2 of the certified EIR (DTSC 2011).
- For remedy facilities in Arizona, the operational noise design criteria will be 60 dB daytime and 50 dB nighttime average at closest residences (per current Mohave General Plan, Exhibit V-5, Maximum Noise Levels for Various Land Use; Freilich, Leitner & Carlisle 2010).
- For remedy facilities on the Refuge, the operational noise design criteria will be 60 dB.
- For remedy facilities located on the Compressor Station and within PG&E property, the operational noise design criteria will be consistent with the noise environment at the Station, per San Bernardino County Development Code 83.01.080 for industrial land use, 70 dB(A).
- The construction noise criteria will conform to San Bernardino Development Code and Mojave County standards, as well as the EIR mitigation measures NOISE-1, -2, and -3. Per San Bernardino County Code Division 3 Chapter 83.01.080, temporary construction, maintenance, repair, or demolition activities between 7:00 a.m. and 7:00 p.m., except on Sundays and federal holidays, are exempt from noise limits.

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Attachment A
Carbon Substrate Selection and Degradation Pathways Design Bulletin
(*on CD-ROM only*)

ARCADIS	TOPIC: **Carbon Substrate Selection and Degradation Pathways Design Bulletin**	
Revision 3 (11/9/2015)	REPORT SECTION: Appendix C	BULLETIN No.:

1. Purpose

The objective of this Design Bulletin is to detail the basis of design for the selection and usage of carbon substrates and their degradation pathways for the In-Situ Reactive Zone (IRZ) at the Pacific Gas & Electric (PG&E) Topock site. There is a wide spectrum of organic carbon substrates available for anaerobic IRZ applications including fermentable soluble substrates such as molasses, lactate, and whey; alcohols such as ethanol and methanol; semi-soluble substrates such as emulsified vegetable oil (EVO); and solids such as chitin and bark mulch.

Selection of the appropriate substrate depends on the balance between the mode of delivery, the substrate properties, and the rate of carbon utilization. Substrates considered for use in the Topock Compressor Station final groundwater remedy are discussed in this Design Bulletin, as well as general degradation pathways. Some information on carbon substrate dosing design is also provided in this Design Bulletin to supplement the thorough treatment of the dosing design in Appendix B (Development of Groundwater Flow, Geochemical, and Solute Transport Models) of the Basis of Design Report/Final (100%) Design Submittal for the Final Groundwater Remedy (Final BOD Report).

2. References

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3. Definitions

C-1	Single carbon compounds
$\boldsymbol{CH_4}$	Methane
$\boldsymbol{C_2H_3O_2^-}$	Acetate
$\boldsymbol{C_2H_6O}$	Ethanol
$\boldsymbol{C_3H_5O_3^-}$	Lactate
$\boldsymbol{C_3H_5O_2^-}$	Propionate
$\boldsymbol{C_{12}H_{22}O_{11}}$	Lactose
$\boldsymbol{CO_2}$	Carbon dioxide
Cr(III)	Trivalent chromium
Cr(VI)	Hexavalent chromium
$\boldsymbol{Cr(OH)_3}$	Chromium hydroxide
$\boldsymbol{e^-}$	Electrons
Fe(II)	Ferrous iron
Fe(III)	Ferric Iron
$\boldsymbol{Fe(OH)_3}$	Ferrihydrite
$\boldsymbol{H^+}$	Hydronium ion
$\boldsymbol{H_2}$	Hydrogen
$\boldsymbol{H_2O}$	Water
$\boldsymbol{H_2S}$	Hydrogen sulfide
$\boldsymbol{HS^-}$	Bisulfide ion
Mn(IV)	Tetravalent manganese
Mn(II)	Divalent manganese
$\boldsymbol{MnO_2}$	Manganese dioxide
$\boldsymbol{NO_3^-}$	Nitrate
$\boldsymbol{NO_2^-}$	Nitrite
$\boldsymbol{N_2}$	Nitrogen
$\boldsymbol{O_2}$	Oxygen
$\boldsymbol{SO_4^{2-}}$	Sulfate

4. Carbon Substrate Selection

Based on the results of the preliminary evaluation, the carbon substrates that were carried forward into remedy design included ethanol (used in the Uplands In-Situ Pilot Test [ARCADIS 2009]), sodium lactate (used in the Floodplains In-Situ Pilot Test [ARCADIS 2007]), EVO, and liquid whey. Each of these carbon substrates were evaluated in the Final Environmental Impact Report (FEIR; DTSC 2011). The selection of the appropriate substrate depended on the balance between the mode of delivery, the substrate properties, and the rate of carbon utilization.

It is anticipated that for most of the final remedy operational period, substrates that are soluble with short biodegradation half lives (i.e., 5 to 20 days), like lactate and ethanol, will be used to facilitate effective distribution and establishment of reducing conditions across the IRZ, with the highest degree of distribution control, given the utilization of the carbon substrates and by-products (discussed below) to completion (i.e., to complete degradation to carbon dioxide and methane). During the 60% design stage, ethanol was selected for use in the ongoing design and for initial use in the final remedy based on additional considerations including substrate cost and PG&E’s greater experience and past successes with ethanol (e.g., at the PG&E Hinkley Compressor Station site). However, carbon substrate selection may change over the lifetime of the project as substrate costing varies. In addition, alternative substrates could be useful for certain situations that arise over the life of the project. For example, EVO may be used during future operational stages of the remedy if a low dosage, slow release reservoir of carbon would be advantageous.

5. Organic Carbon Degradation Pathways

Within an active IRZ, periodic injection activities support the development of a diverse microbial community that utilizes the augmented organic carbon supply via a complex network of degradation pathways. In general, there are two types of processes by which organic carbon substrates are consumed: respiratory processes and fermentation processes. Regardless of the carbon substrate used and the complex network of degradation pathways stimulated, the resultant end products of degradation will include carbon dioxide, methane, and biomass. Eventually, biomass will also decay into carbon dioxide and methane. The following provides an overview of the various degradation pathways that will be stimulated within the IRZs, identifies the typical intermediates that may form, and includes several balanced oxidation-reduction reactions. This list may not be inclusive, considering the complex microbial ecology that will develop within the IRZ, but is intended to provide a basic framework for understanding the carbon degradation pathways.

In respiratory processes, organic carbon substrates are oxidized to carbon dioxide, releasing electrons that in turn reduce terminal electron acceptors (oxygen, nitrate, hexavalent chromium, iron, manganese, and sulfate). In fermentation processes, the organic carbon substrates are both oxidized and reduced via the metabolic pathways. The general pathways and intermediates for organic carbon degradation are shown on Figure 1. As shown on the figure, in the respiratory pathways coupled to reduction of oxygen, nitrate, chromium, iron, manganese and sulfate, the carbon substrate is completely oxidized to carbon dioxide. Consequently, total organic carbon concentrations return to ambient concentrations following IRZ injections.

Fermentation reactions produce additional intermediates such as fatty acids, alcohols, lactate, succinate, and hydrogen from primary fermentation of more complex organic carbon substrates, and acetate and single carbon (C-1) compounds, like formate, from less complex substrates or the intermediates of primary fermentation.

For the IRZs that are part of the final groundwater remedy at the Topock Compressor Station, several organic carbon substrates were considered. For the purposes of this discussion, however, only the four most likely substrates are considered: ethanol, lactate, liquid whey, and EVO. For reference, liquid whey is composed primarily of the disaccharide lactose, and EVO is a triglyceride.

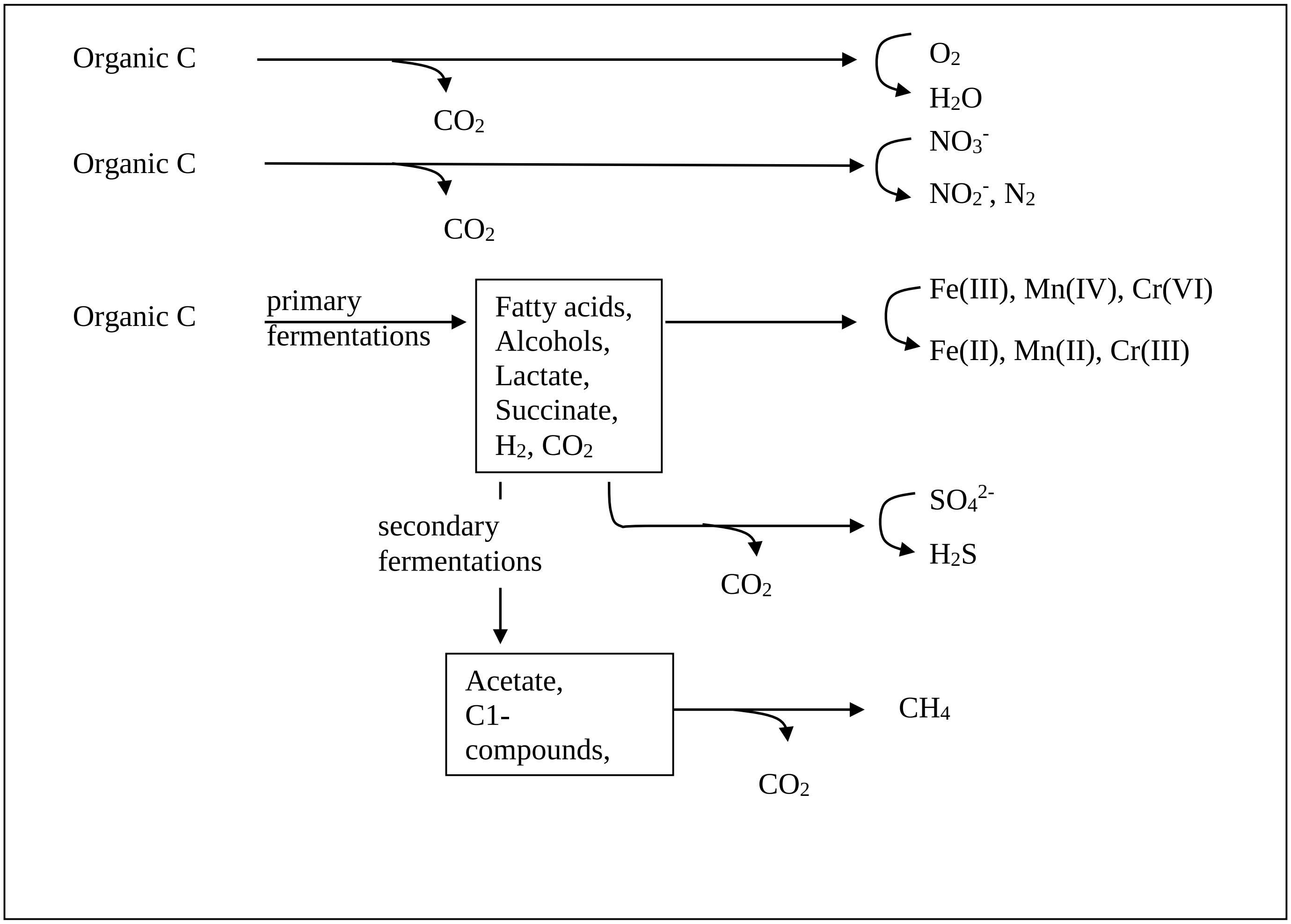

Figure 1: General Degradation Pathways for Organic Carbon Substrates (adapted from Lengeler et al. 1999)

EVO is a slightly different substrate than the others being discussed because it is delivered as a separate phase oil that will sorb to aquifer soils. The triglycerides are first hydrolyzed, releasing glycerol and long chain fatty acids (IES 2006). As the long chain fatty acids are degraded by beta-oxidation, smaller molecules are generated which more easily dissolve into groundwater, such as butyric acid and acetate (IES 2006), as shown on Figure 2.

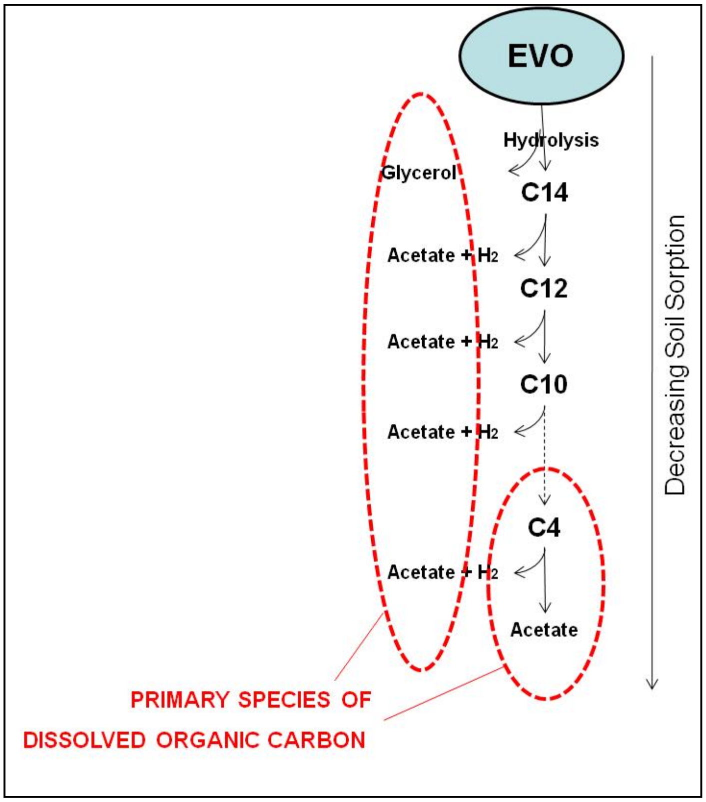

Figure 2: Degradation and Dissolution of EVO

In the next few sections, the general breakdown pathways and balanced reactions for the respiration and fermentation of the various organic carbon substrates are presented. For the purpose of EVO, acetate will be discussed as an example of a dissolved organic compound.

a. Respiratory Processes

In respiratory processes, the oxidation of organic carbon substrates to carbon dioxide is coupled to the reduction of a terminal electron acceptor. Respiratory processes stimulated within an IRZ include aerobic respiration, denitrification, chromium reduction, iron reduction, manganese reduction, and sulfate reduction. The following discussion will provide an overview of the reactions for these respiratory processes.

The following are balanced oxidation half-reactions that release electrons for ethanol, lactate, lactose (from whey), and acetate (a degradation intermediate and one of the primary dissolved constituents released from EVO).

Ethanol	$1/12\ C_2H_6O + 1/4\ H_2O \rightarrow 1/6\ CO_2 + H^+ + e^-$	(1)
Lactate	$1/12\ C_3H_5O_3^- + 1/4\ H_2O \rightarrow 1/4\ CO_2 + 11/12\ H^+ + e^-$	(2)
Lactose	$1/48\ C_{12}H_{22}O_{11} + 13/48\ H_2O \rightarrow 1/4\ CO_2 + H^+ + e^-$	(3)
Acetate	$1/8\ C_2H_3O_2^- + 1/4\ H_2O \rightarrow 1/4\ CO_2 + 7/8\ H^+ + e^-$	(4)

The release of electrons from the oxidation of each substrate is coupled to the reduction of the various terminal electron acceptors. Below are the reduction half reactions for the various terminal electron acceptors. Note, for iron and manganese reduction (Reaction 8 and 9), various mineral phase reactants are possible and one example of each is shown. Similarly for chromium (Reaction 7), several mineral phase products are possible and one example is shown, chromium hydroxide.

Oxygen	$1/4\ O_2 + H^+ + e^- \rightarrow 1/2\ H_2O$	(5)
Nitrate	$1/5\ NO_3^- + 6/5\ H^+ + e- \rightarrow 1/10\ N_2 + 3/5\ H_2O$	(6)
Chromium	$1/3\ Cr^{6+} + H_2O + e^- \rightarrow 1/3\ Cr(OH)_3 + H^+$	(7)
Iron	$Fe(OH)_3 + 3H^+ + e^- \rightarrow Fe^{2+} + 3H_2O$	(8)
Manganese	$1/2\ MnO_2 + 2H^+ + e^- \rightarrow 1/2\ Mn^{2+} + H_2O$	(9)
Sulfate	$1/8\ SO_4^{2-} + 9/8\ H^+ + e^- \rightarrow 1/8\ HS- + 1/2\ H_2O$	(10)

For each substrate being considered, bacteria within the IRZ would couple the oxidation of the organic carbon substrate with the reduction of various electron acceptors. For example, balanced reactions for the coupling of ethanol oxidation with oxygen, iron, and sulfate reduction (Reactions 11, 12 and 13, respectively) are as follows:

Ethanol/Oxygen	$1/12\ C_2H_6O + 1/4\ O_2 \rightarrow 1/6\ CO_2 + 1/4\ H_2O$	(11)
Ethanol/Iron	$1/12\ C_2H_6O + Fe(OH)_3 + 2H^+ \rightarrow Fe^{2+} + 2\ 3/4\ H_2O + 1/6\ CO_2$	(12)
Ethanol/Sulfate	$1/12\ C_2H_6O + 1/8\ SO_4^{2-} + 1/8\ H^+ \rightarrow 1/8\ HS- + 1/4\ H_2O + 1/6\ CO_2$	(13)

The utilization of electron acceptors in the system will generally be governed by the principles of thermodynamic equilibrium and redox kinetics. Dissolved oxygen and nitrate are thermodynamically more favorable electron acceptors than Cr(VI), while Cr(VI) is thermodynamically a more favorable electron acceptor than manganese oxides, iron oxides, and sulfate. However, given the relative availability of the electron acceptors and spatial heterogeneities of the subsurface aquifer environment, many of these reactions can occur simultaneously under field conditions. For example, iron and manganese reduction can proceed concurrently and sulfate reduction can begin before iron oxides are depleted, depending on the strength of the reducing environment. The strength of the reducing environment can be tuned by adjusting the concentration of organic carbon injected. To a large extent, this can help minimize the reduction of manganese, iron, and sulfate while still achieving adequate Cr(VI) reduction and removal. However, in order to create a reducing environment sufficient for the sustained removal of Cr(VI), some manganese, iron, and sulfate reduction will occur. Some iron reduction is actually desirable, as it provides stored Cr(VI) reduction capacity within the aquifer. In fact, abiotic pathways, such as reduction by Fe(II), may be faster than direct biotic mechanisms for Cr(VI) reduction (e.g., Wielinga et al., Environmental Science and Technology, 2001). Iron reduction is expected to occur under active Cr(VI) reducing conditions, producing mixed Fe/Cr precipitates that sequester Cr(VI). Thus, it is anticipated that both Cr(VI) reduction mechanisms will occur simultaneously. These principles are discussed in more detail in Appendix B of the Final BOD Report.

The oxidation-reduction (redox) reactions fostered in the IRZ may temporarily mobilize certain naturally-occurring metals within the treatment zone, including manganese and arsenic. An adaptive operations approach, outlined in Volume 2 of the Operation and Maintenance Manual (Appendix L of the Final BOD Report) will be used to balance carbon dosing to treat Cr(VI) while minimizing manganese and arsenic generation.

b. Fermentative Processes

Fermentative conditions will also develop within the IRZ, as indicated by increased methane concentrations in groundwater in IRZs at the PG&E Hinkley site (ARCADIS 2010). As shown in Figure 1, various organic intermediates and hydrogen can be produced from the fermentation of the organic carbon substrates, but the ultimate end products of reaction are carbon dioxide and methane.

For example, fatty acids have been monitored during IRZ implementation at Hinkley. The most prominent fatty acids detected in IRZ groundwater during both lactate and ethanol applications have been acetate and propionate (ARCADIS 2010). The production of acetate and propionate from lactate and ethanol are well documented fermentation processes.

Propionibacteria produce acetate and propionate from the fermentation of lactate (Lengeler et al. 1999) as follows:

$$3\ C_3H_5O_3^- \rightarrow C_2H_3O_2^- + CO_2 + 2\ C_3H_5O_2^- + H_2O \qquad (14)$$

Ethanol ferments to produce acetate and propionate as follows (Schink et al. 1987):

$$3\ C_2H_6O + 2\ HCO_3^- \rightarrow C_2H_3O_2^- + 2\ C_3H_5O_2^- + H^+ + 3\ H_2O \qquad (15)$$

Finally, the products of fermentation will be used by methanogens to make methane. Acetoclastic methanogens will produce methane from acetate (Lengeler et al. 1999):

$$C_2H_3O_2^- + H^+ \rightarrow CH_4 + CO_2 \qquad (16)$$

Hydrogenotrophic methanogens will produce methane from carbon dioxide and hydrogen (Lengeler et al. 1999):

$$CO_2 + 4\ H_2 \rightarrow CH_4 + 2\ H_2O \qquad (17)$$

6. Dosing Design

The primary design consideration for carbon substrate dosing is the adequate (lateral) distribution of the substrate in the subsurface while minimizing byproduct (reduced manganese and arsenic) production. Concentrations of total organic carbon will be highest at the injection point and will decrease with distance, and the arsenic and manganese generated are a consequence of that distribution of organic carbon, as discussed in detail in Appendix B of the Final BOD Report. As such, the hydraulic, fate and transport, and geochemical models, as well as pilot test data, are being used to guide reagent dosing design, as discussed in Appendix B (Final BOD Report). To optimize the tradeoff between organic carbon distribution and byproduct generation, design parameters such as well spacing, recirculation flow rates, and injection concentrations can be varied. The first step of this process was taken with the reactive transport modeling that supported the IRZ design (Appendix B, Final BOD Report). This optimization process will continue during operation as monitoring data are collected, evaluated, and used to modify operations of the system.

The semi-soluble substrate, EVO, is a special case and is discussed further in this section. As EVO is injected, significant portions of the oil will be retained on the soil. The amount of oil that will be retained per unit volume of aquifer varies with soil type as documented in the Protocol for Enhanced In Situ Bioremediation (IES 2006) and is a lower bound on the amount of oil that will be required to achieve distribution within a given target volume. However, the amount of EVO required to achieve sufficient distribution can be up to an order of magnitude greater than the amount of oil retention reported in the literature, based on field implementation at a number of sites

(Schnobrich et al. 2011). In practice, the required EVO loading must be evaluated on a case-by-case basis to confirm the site-specific degree of droplet retention and to ensure sufficient organic carbon distribution for treatment within the targeted area.

Attachment B
Calculations (*on CD-ROM only*)

- Remedy-produced water pump calculations – Recirculation; conditioned water transfer; filter feed
- Remedy-produced water conditioning process – Eductor calculations
- Remedy-produced water conditioning process – Caustic usage calculations
- Structural calculations for Compressor Station structures
- L-300 pipe load calculations
- Hydraulic analysis of freshwater injection system
- Hydraulic analysis of Inner Recirculation Loop, IRZ Loop, and TCS Recirculation Loop
- Structural calculations for MW-20 Bench and Moabi Regional Park long-term remedy support area structures, and remediation well vaults
- Fire protection plan calculations for Carbon Amendment Building, Operations Building, and Moabi Regional Park Workshop Building
- Sand separator system
- Soluble carbon substrate and emulsified vegetable oil dosing calculations
- Moabi Regional Park CHQ lighting calculations
- Moabi Regional Park CHQ yard piping head loss and tank sizing calculations
- Compressor Station Ponds – Structural calculations
- TEG load calculations for the Compressor Station Ponds

Final (100%) Design Submittal for the Final Groundwater Remedy
PG&E Topock Compressor Station
Needles, California

Remedy Water Pump Calculations

11/18/2015

Prepared for:

Pacific Gas and Electric Company

Reviewed by:

Benjamin Wuerl, P.E.
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Prepared by:

Katie Douglas
Project Civil Engineer
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ARCADIS Design & Consultancy for natural and built assets

Method:

Combination of Hazen Williams and equations from Crane Technical Paper 410.

Equations are listed on "formulas" worksheet

Pipe fitting equivalent lengths are listed on "fittings - Eq. Length" and quantities are entered on the individual worksheet and lookup formulas get correct information

Pipe dimensions for CPVC 80 and SDR 11 HDPE are listed on "pipe guide". Lookup formula gets correct dimension.

Darcy friction factor read by user from "Moody chart"

Miscellaneous equipment losses entered directly into columns AI to AK.

Given Condtions :

Water Temperature 29 C/86 F.

CPVC Sch 80 Piping

Formulas used in Pump Calculations

H=3.023/CC^1.852*(V^1.852/D^1.167)
C=150
D[=]ft
V[=]fps

K	fL/D
L [=]	feet
D [=]	feet
Darcy Eqn	$hL=Kv^2/2g = (fL/D)v^2/2g$

$h_L=0.00259KQ^2/d^4$ Crane Eqn 3-14

Q [=]	gpm
d [=]	inches

Reynolds number Crane Eqn 3-3

$Re=50.6Q\rho/d\mu$

Q [=]	gpm
d [=]	inches
ρ [=]	lbs/cf
μ [=]	cp

$v=0.408Q/d^2$ Crane Eqn 3-2

Q [=]	gpm
d [=]	inches

Recirculation Pumps

	Recirculation Pumps						Quantity						
							Fittings		Tee		Valve		
Section	Segment	Distance	Start	End	Diameter	Q, gpm	90	45	Run	Branch	Butterfly	Globe	Valve
	Suction	58	1	2	6	492	4	0	1	0	0		0
	Discharge	80	2	1	6	492	8		3	2			

Total Elevation Change, ft 3.00 3.00

Temp, C	30	
Temp, F	86	
rho	62.154	rho, lb/cf
mu	0.8032	mu, cP
ε	0.00005	ft
C	150	in Hazen Williams formula

Recirculation Pumps

Equivalent Length												Quantity			
Fittings		Tee		Valve		Equivalent	Hazen Williams		Total		Crane Valve/Fittings			
90	45	Run	Branch	Butterfly	Globe	Length	H, ft/ft	H_L, ft	H_L, ft	Dia, in	Ball	Butterfly	Gate	Check
16.7	8	12.3	32.7	0	190	137.1	0.0267	3.67	4.30	5.348		1		
16.7	8	12.3	32.7	0	190	315.9	0.0267	8.45	11.45	5.348		4		1

Total Friction Loss, ft 15.75

Total Head Loss, ft 85.05

Total Pressure Loss, psi 36.82

Recirculation Pumps

ΣK	h_L, ft	Reynolds No.	Velocity fps	ε / D	f (chart)	Misc Losses
0.63	0.48	360,221	7.02	1.12E-04	0.014	
3.92	3.00	360,221	7.02	1.12E-04	0.014	69.3

69.3

Misc Losses

Eductors 30 psi

Conditioned Water Pump

	Filter Feed Pump B Side						Quantity						
							Fittings		Tee		Valve		
Section	Segment	Distance	Start	End	iamete	Q, gpm	90	45	Run	Branch	Butterfly	Globe	Valve
	Suction	135	1	1	2	35	3	0	2	2	0		0
	Discharge	608	1	28	2	35	6	6	2	5			

Total Elevation Change, ft 2.00 29.00

Temp, C	30	
Temp, F	86	
rho	62.154	rho, lb/cf
mu	0.8032	mu, cP
ε	0.00005	ft
C	150	in Hazen Williams formula

Conditioned Water Pump

Equivalent Length											Quantity			
Fittings		Tee		Valve		Equivalent	Hazen Williams		Total		Crane Valve/Fittings			
90	45	Run	Branch	Butterfly	Globe	Length	H, ft/ft	H_L, ft	H_L, ft	Dia, in	Ball	Butterfly	Gate	Check
5.7	2.6	4	12	0	70	184.1	0.0296	5.45	7.31	1.917	1	2		
5.7	2.6	4	12	0	70	725.8	0.0296	21.50	22.00	1.917	2			1

Total Friction Loss, ft	29.31
Total Head Loss, ft	60.93
Total Pressure Loss, psi	26.38

Conditioned Water Pump

ΣK	h_L, ft	Reynolds No.	Velocity fps	ε / D	f (chart)	Misc Losses
1.86	0.44	71,489	3.89	3.13E-04	0.02	
2.12	0.50	71,489	3.89	3.13E-04	0.02	4.62

4.62

Misc Losses

Flow Meter 2 psi

Filter Feed Pump - A Side

Pump #	Filter Feed Pump A Side		Elevation				Quantity						
							Fittings		Tee		Valve		
Section	Segment	Distance	Start	End	Diameter	Q, gpm	90	45	Run	Branch	Butterfly	Globe	Valve
	Suction	129	1	1	2	35	3	0	5	2	0		0
	Discharge	845	1	5	2	35	10		5	0			

Total Elevation Change, ft 2.00 6.00

Temp, C	30	
Temp, F	86	
rho	62.154	rho, lb/cf
mu	0.8032	mu, cP
ε	0.00005	ft
C	150	in Hazen Williams formula

Filter Feed Pump - A Side

Equivalent Length												Quantity			
Fittings		Tee		Valve		Equivalent	Hazen Williams		Total		Crane Valve/Fittings			
90	45	Run	Branch	Butterfly	Globe	Length	H, ft/ft	H_L, ft	H_L, ft	Dia, in	Ball	Butterfly	Gate	Check
5.7	2.6	4	12	0	70	190.1	0.0296	5.63	6.65	1.917	2	1		
5.7	2.6	4	12	0	70	922	0.0296	27.31	28.09	1.917	7	1		1

Total Friction Loss, ft 34.74
Total Head Loss, ft 57.22
Total Pressure Loss, psi 24.77

Filter Feed Pump - A Side

ΣK	h_L, ft	Reynolds No.	Velocity fps	ε / D	f (chart)	Misc Losses, ft
1.02	0.24	71,489	3.89	3.13E-04	0.02	
3.32	0.78	71,489	3.89	3.13E-04	0.02	18.48

18.48

Misc Losses		
GAC Vessels	2.5	psi
Cartridge Filters	2.5	psi
Flow Meter	2	psi
Static Mixer	1	psi

Filter Feed Pump - B Side

	Filter Feed Pump B Side						Quantity							
							Fittings		Tee		Valve			
Section	Segment	Distance	Start	End	Diameter	Q, gpm	90	45	Run	Branch	Butterfly	Globe	Valve
	Suction	129	1	1	2	35	3	0	5	2	0		0
	Discharge	307	1	19	2	35	10		5	0			

Total Elevation Change, ft 2.00 20.00

Temp, C	30	
Temp, F	86	
rho	62.154	rho, lb/cf
mu	0.8032	mu, cP
ε	0.00005	ft
C	150	in Hazen Williams formula

Filter Feed Pump - B Side

Equivalent Length											Quantity			
Fittings		Tee		Valve		Equivalent	Hazen Williams		Total		Crane Valve/Fittings			
90	45	Run	Branch	Butterfly	Globe	Length	H, ft/ft	H_L, ft	H_L, ft	Dia, in	Ball	Butterfly	Gate	Check
5.7	2.6	4	12	0	70	190.1	0.0296	5.63	6.65	1.917	2	1		
5.7	2.6	4	12	0	70	384	0.0296	11.38	12.16	1.917	7	1		1

Total Friction Loss, ft 18.81
Total Head Loss, ft 55.29
Total Pressure Loss, psi 23.93

Filter Feed Pump - B Side

ΣK	h_L, ft	Reynolds No.	Velocity fps	ε / D	f (chart)	Misc Losses
1.02	0.24	71,489	3.89	3.13E-04	0.02	
3.32	0.78	71,489	3.89	3.13E-04	0.02	18.48

18.48

Misc Losses		
GAC Vessels	2.5	psi
Cartridge Filters	2.5	psi
Flow Meter	2	psi
Static Mixer	1	psi

Final (100%) Design Submittal for the Final Groundwater Remedy
PG&E Topock Compressor Station
Needles, California

Eductor Calculations

11/18/2015

Prepared for:

Pacific Gas and Electric Company

Reviewed by:

Benjamin Wuerl, P.E.
Principal Engineer
Arcadis, U.S., Inc.

Prepared by:

Katie Douglas
Project Civil Engineer
Arcadis U.S., Inc.

REGISTERED PROFESSIONAL ENGINEER
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STATE OF CALIFORNIA

ARCADIS Design & Consultancy for natural and built assets

Basis:

Tank Dimensions 8.5'W X 45'L X 11.2'H
Assume 10' Liquid Depth
Tank Volume: 2800 ft^3
Tank Volume: 20947 gal
Assume 30 minute mix and 1 hour settle and 3 tank turnovers
Induced flow = 2094.7 gpm

Tank width is 8.5' or 102"
Using a 3" eductor
Nozzles Needed = 1.7058 2 nozzles

Pump to handle 492 gpm at 65 psi

Tank Dimensions 8.5'W X 45'L X 11.2'H
Assume 10' Liquid Depth
Tank Volume: 2800 ft^3

Assume normal solids of 60 ppm
Solids Volume Equi 0.168 ft^3
Assume concentrate to 3% (grit)
5.6 ft^3
Height of settled sol 0.1757 in

Eductor Sizing:

Scenarios: 2", 3", and 4" Eductors
20 psi, 30 psi, 40 psi, and 50 psi drop across Eductors

Eductor Size*	DP*	Max Plume*	Motive Liq. In*	Out of Eductor*	Complete Mix**
2 in	20 psi	23 in	87.2 gpm	436 gpm	1200 gpm
2 in	30 psi	34 in	107 gpm	534 gpm	1200 gpm
3 in	**30 psi**	**51 in**	**246 gpm**	**1228 gpm**	**1200 gpm**
4 in	30 psi	60 in	427 gpm	2136 gpm	1200 gpm
2 in	40 psi	48 in	123 gpm	616 gpm	1200 gpm
3 in	40 psi	73 in	283 gpm	1417 gpm	1200 gpm
3 in	50 psi	99 in	317 gpm	1585 gpm	1200 gpm
4 in	40 psi	95 in	493 gpm	2448 gpm	1200 gpm

* Data from www.1877eductor.com/tank.htm
** Complete mix assumed after 3 tank turnovers .

Based on data above, we can use two 3" nozzle.
However, the plume will not extend the full tank diameter to minimize dead zones.
Pump to handle 492 gpm at 65 psi.

Size IPS		Pressure Difference, PSI											
		10	20	30	40	50	60	70	80	90	100	120	140
	Motive Flow (GPM)	7.1	10.0	12.3	14.2	15.8	17.4	18.7	20.1	21.3	22.4	24.6	26.5
3/8" mnpt	Outlet Flow (GPM)	35	50	61	71	79	87	88	90	91	92	94	96
	Max. Plume Length	4	8	12	16	22	29	36	43	50	58	72	86
	Motive Flow (GPM)	15.4	21.8	26.7	30.8	34.5	37.8	40.8	43.6	46.3	48.8	53.4	57.7
3/4" mnpt	Outlet Flow (GPM)	77	109	134	154	172	189	192	195	197	200	204	209
	Max. Plume Length	5	11	17	24	33	42	53	64	74	85	106	127
	Motive Flow (GPM)	30.8	43.6	53.4	61.6	68.9	75.5	81.5	87.2	92.5	97.5	107	115
1-1/2" fnpt	Outlet Flow (GPM)	154	218	267	306	345	378	384	389	395	400	409	417
	Max. Plume Length	7.5	16	24	34	46	60	75	90	105	120	150	180
	Motive Flow (GPM)	61.6	87.2	107	123	138	151	163	174	185	195	214	231
2" fnpt	Outlet Flow (GPM)	308	436	534	616	689	755	767	778	789	799	818	835
	Max. Plume Length	11	23	34	48	65	85	106	12	148	170	212	255
	Motive Flow (GPM)	142	201	246	283	317	347	375	401	426	449	491	531
3" fnpt	Outlet Flow (GPM)	708	1,003	1,228	1,417	1,585	1,737	1,764	1,790	1,815	1,836	1,880	1,920
	Max. Plume Length	16	34	51	73	99	129	161	193	225	257	322	386
	Motive Flow (GPM)	246	349	427	493	551	604	652	698	740	780	856	920
4" flg	Outlet Flow (GPM)	1232	1744	2136	2448	2760	3024	3072	3112	3160	3200	3272	3336
	Max. Plume Length	22	41	60	95	132	164	196	228	260	295	360	424
6" flg	Motive Flow (GPM)	493	698	854	986	1102	1208	1304	1395	1480	1560	1712	1840
	Outlet Flow (GPM)	2464	3488	4272	4896	5520	6048	6144	6224	6320	6400	6544	6672
8" flg	Motive Flow (GPM)	986	1395	1709	1971	2205	2416	2608	2790	2960	3120	3424	3680
	Outlet Flow (GPM)	4928	6976	8544	9792	11040	12096	12384	12448	12640	12800	13088	13344
10" flg	Motive Flow (GPM)	1971	2790	3418	3942	4410	4832	5216	5581	5920	6240	6848	7360
	Outlet Flow (GPM)	9856	13952	17088	19584	22080	24192	24576	24896	25344	25600	26176	26688

**** Pressure is in PSI and Plume Length shown in Feet**

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Final (100%) Design Submittal for the Final Groundwater Remedy
PG&E Topock Compressor Station
Needles, California

Caustic Usage Calculations

11/18/2015

Prepared for:

Pacific Gas and Electric Company

Reviewed by:

Benjamin Wuerl, P.E.
Principal Engineer
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Prepared by:

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ARCADIS Design & Consultancy for natural and built assets

Estimating Caustic Requirement to Raise pH from 2.1 to 6-to-9 Range

Assumptions:

1. Water at pH 2.1 contains no bicarbonate buffering capacity. CO2 is limited by solubility (1,200 g/L) at groundwater temperature (assumed 75F)
2. Secondary buffering agents such as phosphate, boron, di- and tri-valent metals are not present at significant levels.
3. Without buffering, the pH would be difficult to control in the neutral range, but it is assumed a pH between 6 and 9 would be sufficiently precise.
4. If necessary, the Caustic-treated well water could be regulated by adding sodium bicarbonate (needs to be metered) or by passing the water over a limestone bed.
5. Assume specific gravity of the water is 1.00
6. Assume the caustic solution strength is 25 wt-pct, which contains 2.66 lbs NaOH per gallon

Scenario #1: Calculate Caustic Demand for pH Shift with No Buffer Capacity (i.e., no CO2 or precipitating metals in solution)

Inputs:

2.1	Initial pH
7.0	Final (target) pH
700,000	Annual volume of acidified well cleaning wastewater treated (gal)

For initial pH, H+ conc is 10^(-initial pH) mole/L =	10^(-C15)	0.00794328	mol/L
At pH 7.0, H+ conc is 10^(-7.0) mole/L =	10^(-C16)	0.0000001	mol/L
Caustic demand* for pH shift (with no CO2 demand)		0.00794318	mol/L

*The "required" OH equals the amount of H+ that needs to be neutralized in Cell M25.

Convert to engineering units:

Calculation Basis: 100 gal

$$\frac{0.00794318 \text{ mol OH-}}{\text{L}} * \frac{39.996 \text{ g NaOH}}{\text{mol OH}^-} * \frac{3.785 \text{ L}}{\text{gal}} * 100 \text{ gal} * \frac{0.0022046 \text{ lb NaOH}}{\text{gram NaOH}}$$

$$* \frac{1 \text{ gal 25\% NaOH}}{2.66 \text{ lb NaOH}} = \frac{0.099661 \text{ gal 25\% NaOH}}{100 \text{ gal } H_2O}$$

Annual Caustic Demand = **698 gal 25% NaOH/yr (i.e., to treat annual wastewater volume)**

Scenario #2: Calculate Caustic Demand for pH Shift with Buffer Capacity for CO2

Inputs:

300	Assumed CO2 concentration in acidified well cleaning wastewater (mg/L as CO2)

Assumed molar CO2 concentration in acidified water	=	0.006818182 mol/L
Caustic demand to neutralize CO2 to bicarbonate (HCO3-)	=	0.006818182 mol/L
Total caustic demand (sum demand for pH shift and to neutralize CO2)		0.01476136 mol/L

Convert to engineering units:

Calculation Basis: 100 gal

$$\frac{0.01476136 \text{ mol OH-}}{\text{L}} * \frac{39.996 \text{ g NaOH}}{\text{mol OH}^-} * \frac{3.785 \text{ L}}{\text{gal}} * 100 \text{ gal} * \frac{0.0022046 \text{ lb NaOH}}{\text{gram NaOH}}$$

$$* \frac{1 \text{ gal 25\% NaOH}}{2.66 \text{ lb NaOH}} = \frac{0.1852069 \text{ gal 25\% NaOH}}{100 \text{ gal } H_2O}$$

Annual Caustic Demand = **1296 gal 25% NaOH/yr (i.e., to treat annual wastewater volume)**

Use Scenario 2, since the wastewater will not have time to fully dissolve CO2 and will be oxygenated during pumping.

TOPOCK GROUNDWATER REMEDIATION PROJECT

STRUCTURAL CALCULATIONS

100% Design Submittal

Date: November 11, 2015

REGISTERED PROFESSIONAL ENGINEER
VINOD M. BADANI
C-041281
EXP. DATE 3/31/17
CIVIL
STATE OF CALIFORNIA

TABLE OF CONTENTS

TAB NO.1

INFLUENT and CONDITIONED WATER TANK FARM CANOPY

APPENDIX A - CALCULATION COVER SHEET

CALCULATION ID NUMBER	TA03, TA04
REVISION NUMBER	
JOB NUMBER	WW-PEB-2174-043462

TITLE	Topock Influent tank farm & Conditioned Water Tank Farm Canopy

DWGS S-11-01 TO S-11-05

	PAGE	Description
TA03	1 To 3	Influent Tank Farm Design
	4 to 8	Canopy Roof Truss (infl diaph. truss)
	9 To 12	Interior Frame Typical (Frame N)
	13 To 17	Exterior Frame Typical (Frame N2)
	18 To 20	Interior Frame w/ distributed load on col. (Frame N3)
TA04	21 To 35	Water Conditioned Tank Farm double Canopy & Mom. frames
	36	Calc. for frames
	37	Calc. for Double Canopy
	A1, A2	Data Tanks
	A	Deck

Revised dates △1 4/04/14 △2 5/08/14

	initial	date
PREPARED	KD	9/05/12 △1
TITLE		
REVIEWED		
TITLE		

REVISION NOTES	

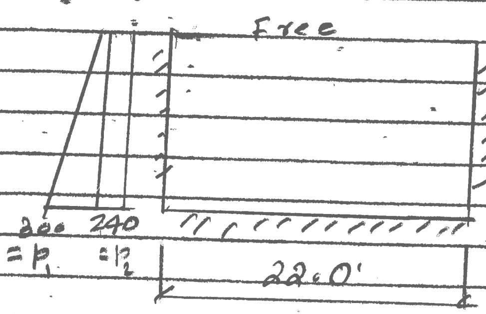
E2 Consulting Engineers, Inc. 1900 Powell Street, Suite 250 Eneryville, CA 94608	Designed By: KD Checked By: Revised By:	Date: 8/31/14 Date: Date:
Project No. WW-PEB-2174-0432062		Sheet No. 1

Project Description Topock Influent Tank Farm/Water Conditioning Tank Farm

Ref. Dwgs. Flr. plan, Fdn plan & Section A (CH2M Hill)
See Appendix-A for Tank data
Objective
1. Design supporting walls to take surcharge & earth loads
2. Design Fdn. for all loads
3. Design conc. slab on Grade for equipment loads

$p_1 = wh = 60 \times 5 = 300$
$p_2 = 4 \times 60 = 240$

$\frac{a}{b} = \frac{11}{5} = 2.2 > 1.5$



Design as a cantiver wall for vertical Reinforcement

$M_{max} = .3 \times \frac{5}{2} \times \frac{5}{3} + .24 \times 5 \times \frac{5}{2} = 4.25'^{k}$

$M_{u\,max} = 4.25 \times 1.7 \times 1.3 = 9.39'^{k}$

$V_{u\,max} = \left[\frac{.3 \times 5}{2} + .24 \times 5\right] \times 1.7 \times 1.3 = 1.95 \times 2.21 = 4.31^{k}$

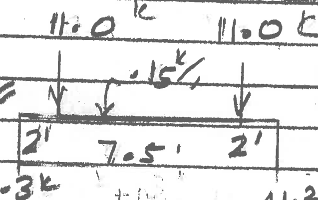
$d_r = (4310)/.85 \times 12 \times 141 = 3''$

$d = 12 - 2 - .5 = 9.5''$ $b = 12''$ $F = .09$

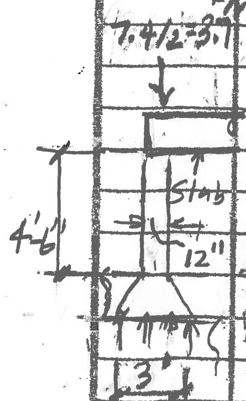
Vert. Reinf. $\frac{M_u}{F} = \frac{9.39}{.09} = 104$ $A_s = .0021 \times 12 \times 9.5 = .24\ in^2$
#5 @ 12" o/c Vert. ea. face

Horiz. Reinf. $M_{u_h} = [.0857 \times .3 \times 5 + .3304 \times .24 \times 5^2] \times 1.7 \times 1.3 = 5.8'^{k}$
$\frac{M_u}{F} = \frac{5.8}{.09} = 65$ $A_{s_h} = .0017 \times 12 \times 9.5 = .193\ in^2$ #4 @ 12" ok
Assume

Top slab (24" slab width for wheel load)

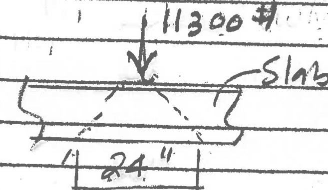


Total wt./' = (21000 × 16 + 18000)/24 = 7375 #/'
Axle Load = 22 k (For wall design)
Load/wheel = 11 k for slab design



12" Slab $v_u = \frac{1.4(300) + 1.7(11000)}{.85 \times 24 \times 9.5} = 98.7\ psi < 2\sqrt{5000} = 141.4\ psi$

$d = 12 - 2.5 = 9.5''$



P = Soil press = $\frac{(3.7 + 2.2)}{3 \times 1}$ (wall + slab) = $1.90\ k/ft^2 < 2.0$ ksf

SLAB REINF

$M_u = 11.3 \times 2 \times 1.6 = 36.2'^{k}$

$d = 9.5''$ $b = 24''$ $F = .18$ $\frac{M_u}{F} = \frac{36.2}{.18} = 201$

$A_s = .0048 \times 24 \times 9.5 = 1.09\ in^2$ #6 @ 10" $A_{s_a} = .44 \times \frac{12}{10} \times 2 = 1.06\ in^2 \approx 1.09$ ok

Use 12" Tk slab w/ #6 @ 10" in short dir.
#6 @ 16" in Long dir.

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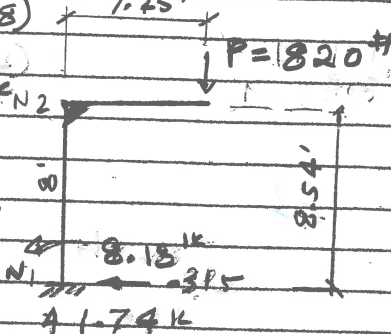
Project No. WW-PEB-2174-043260		Sheet No. 2
Project Description: Topock, Influent Tank Farm Canopy		

Frames @ Canopy (8'-10" spcg.) Interior Fr. 'N', Exterior Fr. N2

See Roof plan (pg-3) & Truss Calc.'s (pgs. 4 To 8)

Two Frames Frame N, & Frame N1 (Ext. Frame N2)

Vert. loads (@ INTERIOR)



$P_{DL+LL} = (6+20)\times 8.83\times 3.5$

$= [6\times 8.83 + 20\times 8.83]\times 3.5$

$= 185 + 618 = 803$# USE 820#

Lateral wind: For Roof Deck Calc. See pg. '3'

$P_W = 20\times 8.83\times 4.0 = 706$# USE 700#

Comb. ASCE 7-10: USE combinations for ASD - ASCE 7-10

2. D + L

6a. D + .75 L + .75 (.6 W)

7. .6 D + .6 W

See computer output for corresponding combination.

Interior Frame-N: See Computer output - pgs 9 To 13

Ext. Fr. N1 (pgs 14 To 20)

Seismic: $V = F\times \frac{S_{DS}}{R}\times W$ $\quad R = 3.5 \quad \Omega = 3.0$

$= 1\times \frac{.406}{3.5}\times W = .116\,W$

Roof $W = 7\times 8.83\times 6 + 7\times 8.83\times 15 = 1,298$#

$V = .116\times 1298 = 151\# < 700\#$ Wind Governs.

Assume: Frame N (Interior Fr.) only takes vert. load, horizontal loads transferred by truss (pg. 4), to Exterior Frame N2 (See sketch pg. 9). For Load combinations see Computer output for Frame N & N1

Max. defl. = .48" = l/213 (HORIZ. Frame N) $\quad \Delta_{max} = .375 = l/232$ (HORIZ. N1)

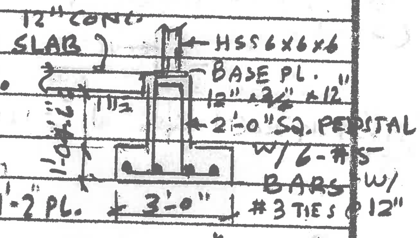
Frame N: Max. vert. defl. = .959" = $\frac{2\times 7.25\times 12}{.959} = \frac{l}{181} < \frac{l}{180}$ OK

Frame N2: $\Delta_{max} = .857$"

Stresses are very low. HSS 6x6x6 for all members

See Computer Calc.'s for code check

Base pl.



MAX. P = 1.74k $\quad$ 12" x 3/4" x 12" Base pl.

$f_p = \frac{P}{A} + \frac{M}{S} = \frac{1.74}{14\times 14} + \frac{8.18\times 12}{\frac{1}{6}\times 14\times 14^2} = .21$

$t_p = 2\times 4.0\sqrt{\frac{.21}{36}} = .61" < .75"$ USE 14 x 3/4" x 1'-2" PL.

Anchor Bolts

4 7/8" Φ 307 A.B.'s $\quad$ Max. Ten/Bolt = $\frac{8.18\times 12}{2\times 11} = 4.4k < 8.3\times\frac{11}{14.5} = 6.3k$

Emb. = 12" $\quad$ Max Shear/Bolt = .315/4 = .1k < 4k ok

Footing 8'-10" col. spacing:

$M_o = .4\times 4 + 8.18 = 9.78$'k Say 10'k $\quad P_{max} = 2.054 + .015\times 7\times 8.83 = 3$k say (siding)

$p = \left[\frac{3.0}{3\times 8.83} + \left(\frac{.15\times 1\times 2 + .15\times 3\times 1}{3}\right)\right] + \frac{10}{\frac{1}{2}\times 8.83\times 3^2} = .113 + .25 + .784 = 1.15 < 4.0$

USE 1' Tk x 3'-0" W x Cont. Ftg. w/ #5 @ 12" Ea. Way

Attn: Vinod 4/09/14

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	Checked By:		Date:
	Reviewed By:		Date:
Project No. WW-PGE-2174			Sheet No. 3
Project Description: Topock Influent Tank Farm Canopy			

Reference:

X-Bracing (See pg-3)

Max. $P_{Br.} = 2.7^k$ (See pg.-6 (computer output))

Try HSS 4 x 2 x 3 $A = 2.06 in^2$ $r = .804"$

$l_{max} = \sqrt{7.0^2 + 8.50^2} = 11.01'$

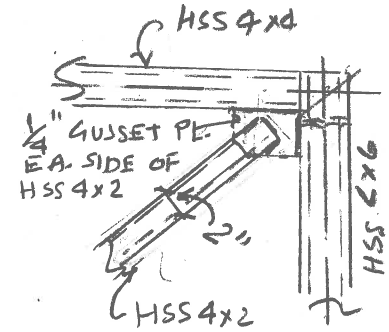
$\frac{Kl}{r_{min.}} = \frac{11.01 \times 12}{.804} = 164 < 300$

$F_a = .6 \times 46 \times 2.06 = 56.8^k > 2.7^k$ OK
(Ten.)

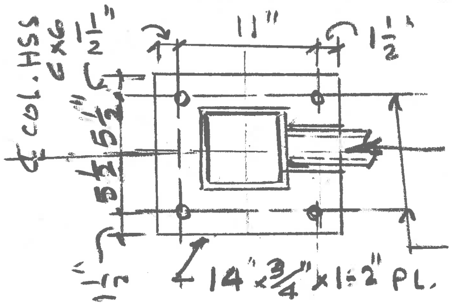
For Single Bracing HSS 4x2x3

$F_a = 5.29 \times 2.06 = 10.9^k > 2.7^k$
(Compn.)

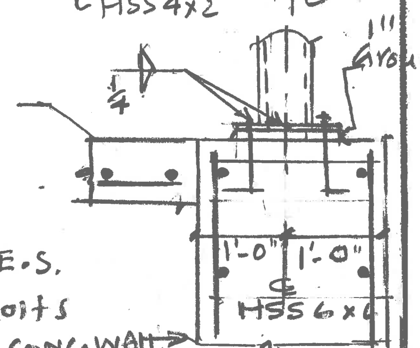
USE HSS 4x2x3 Single Bracing



Base pl. & Anchor Bolts (See pg. 2)



PLAN AT BASE PL.



ELEV. AT BRACE

Roof Deck (See DWG S.11.05) See Attach-A

1 1/2" Deep Roof Deck by Verco (36" wide pnl.)

$w_{DL+LL} = 6 + 20 = 26^{PSF}$ Span = 8'-10" Say 9'
(See pg.9)

18 GA PLB 36

Allow. Load = $63^{PSF} > 26^{PSF}$ OK

$I_d = .305$ $+S_{CA} = .318$ $-S_{CH} = .331$

PLAN AT PEDSTAL

E2 Consulting Engineers, Inc.
1900 Powell Street, Suite 250
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Designed By:	KD	Date:	5/12/14
Checked By:		Date:	
Reviewed By:		Date:	
Project No.	WW-PGE-2174	Sheet No.	3A

Project Description: Topock Influent Tank Farm Canopy

Reference:

Block Wall Design (Infill Wall Spanning Vertically)

Seismic Loads (⊥ar to walls)

Assume the structure to be rigid - 8" TK walls (wt. 77 PSF/')

$V = .3 S_{DS} W I_e$ $\quad S_{DS} = .406 \quad W = 77$ PSF/'

$= .3 \times .406 \times 77 \times 1.25$ $\quad I_e = 1.25$

$= 11.72$ PSF < 20 PSF (wind)

Wind governs — higher than vertical span = 8' say ok

$P_W = .02 \times 8.83 = .177$ k/' (on columns)

(See Frame N3 for Results)

Block Wall (8" TK Grouted @ 16" o/c) wt. of wall = 66 PSF/'

$M_W = (.02 \times 8.83^2)/8 = .195$ 'k $= 2.34$ "k $= 2340$ #" $\quad P_{DL} = 66 \times 8 = 528$#

$V_W = 20 \times 8.83 \times .50 = 88.3$ #/' $\quad$ USE 550#

$f_a = \frac{550}{7.63 \times 12} = 6.0$ PSI $\quad F_a = .25 f'_m \left[1 - \left(\frac{h'}{140r}\right)^2\right]$ $\quad r = \frac{d}{\sqrt{12}} = \frac{8.63}{\sqrt{12}} = 2.49"$

$= .25 \times 1500 \left[1 - \left(\frac{8 \times 12}{140 \times 2.49}\right)^2\right]$

$\frac{f_a}{F_a} = \frac{6}{345.4} = .017$ $\quad = 345.4$ PSI

8" TK wall w/ #5 @ 16" vert. & horiz. Reinf. $\quad \rho = \frac{A_s}{bd} = \frac{.31 \times .75}{8 \times 3.8} = .00765$

$n = \frac{E_s}{E_m} = \frac{29000 \times 10^{-3}}{900 \times 1500} = 21.5$ $\quad n\rho = 21.5 \times .00765 = .1644$

$k = .4312 \quad j = .856 \quad \frac{2}{kj} = 5.41$ $\quad f_b = \frac{2M}{kjbd^2} = \frac{2 \times 2340 \times 5.41}{12 \times 3.8^2} = 146.1$ PSI < 500

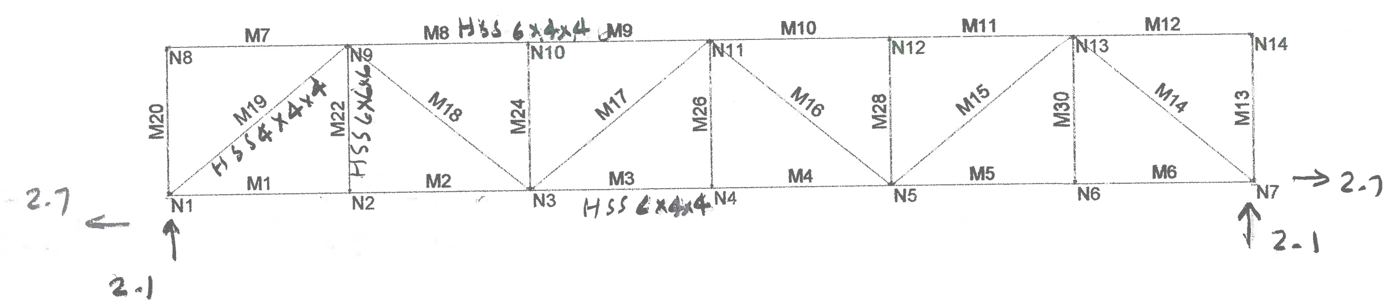
$f_s = \frac{M}{A_s j d} = \frac{2340 \times 12}{.2325 \times .856 \times 3.8} = 3094$ PSI < 24000 ok

$\frac{f_a}{F_a} + \frac{f_b}{F_b} = .017 + \frac{146.1}{500} = .309 < 1.0$

USE 8" Blk wall w/ #5 @ 16" Horiz & Vert. Reinf.

Min. As horiz. $= .002 \times 12 \times 3.8 = .0912$ in² < .2325 in²

wind load → $w_{Bond\ Bm} = .02 \times 8 = .16$ k/' $\quad M = \frac{.16 \times 8.88^2}{8} = 1.56$ 'k $\quad$ 2-#5 in Bond Bm OK by insp.



Results for LC 1, wind ns

e-2	influent farm truss	SK - 2
		June 12, 2014 at 11:52 AM
		infldiaph.truss.r2d

Hot Rolled Steel Properties

	Label	E [ksi]	G [ksi]	Nu	Therm (\1E5 F)	Density[k/ft^3]	Yield[ksi]
1	A36 Gr.36	29000	11154	.3	.65	.49	46
2	A572 Gr.50	29000	11154	.3	.65	.49	50
3	A992	29000	11154	.3	.65	.49	50
4	A500 Gr.B RND	29000	11154	.3	.65	.49	42
5	A500 Gr.B Rect	29000	11154	.3	.65	.49	46
6	A53 Gr.B	29000	11154	.3	.65	.49	35

Hot Rolled Steel Section Sets

	Label	Shape	Type	Design List	Material	Design Rules	A [in2]	I (90,270) [i...	I (0,180) [in4]
1	HR1A	HSS6x6x6	Beam	Tube	A500 Gr.B Rect	Typical	7.58	39.5	39.5
2	HR2	HSS6x4x4	Beam	Tube	A500 Gr.B Rect	Typical	4.3	11.1	20.9
3	HR3	HSS4x4x4	HBrace	Wide Flange	A500 Gr.B Rect	Typical	3.37	7.8	7.8

Joint Coordinates and Temperatures

	Label	X [ft]	Y [ft]	Temp [F]
1	N1	0	0	0
2	N2	8.83	0	0
3	N3	17.66	0	0
4	N4	26.49	0	0
5	N5	35.32	0	0
6	N6	44.15	0	0
7	N7	52.98	0	0
8	N8	0	7.25	0
9	N9	8.83	7.25	0
10	N10	17.66	7.25	0
11	N11	26.49	7.25	0
12	N12	35.32	7.25	0
13	N13	44.15	7.25	0
14	N14	52.98	7.25	0

Joint Boundary Conditions

	Joint Label	X [k/in]	Y [k/in]	Rotation[k-ft/rad]	Footing
1	N1	Reaction	Reaction		
2	N7	Reaction	Reaction		

Member Primary Data

	Label	I Joint	J Joint	Rotate(deg)	Section/Shape	Type	Design List	Material	Design Rules
1	M1	N1	N2		HR2	Beam	Tube	A500 Gr.B ...	Typical
2	M3	N3	N4		HR2	Beam	Tube	A500 Gr.B ...	Typical
3	M4	N4	N5		HR2	Beam	Tube	A500 Gr.B ...	Typical
4	M5	N5	N6		HR2	Beam	Tube	A500 Gr.B ...	Typical
5	M6	N6	N7		HR2	Beam	Tube	A500 Gr.B ...	Typical
6	M7	N8	N9		HR2	Beam	Tube	A500 Gr.B ...	Typical
7	M8	N9	N10		HR2	Beam	Tube	A500 Gr.B ...	Typical
8	M9	N10	N11		HR2	Beam	Tube	A500 Gr.B ...	Typical
9	M10	N11	N12		HR2	Beam	Tube	A500 Gr.B ...	Typical
10	M11	N12	N13		HR2	Beam	Tube	A500 Gr.B ...	Typical
11	M12	N13	N14		HR2	Beam	Tube	A500 Gr.B ...	Typical
12	M13	N14	N7		HR1A	Beam	Tube	A500 Gr.B ...	Typical
13	M14	N7	N13		HR3	HBrace	Wide Flange	A500 Gr.B ...	Typical
14	M15	N13	N5		HR3	HBrace	Wide Flange	A500 Gr.B ...	Typical

Member Primary Data (Continued)

	Label	I Joint	J Joint	Rotate(deg)	Section/Shape	Type	Design List	Material	Design Rules
15	M16	N5	N11		HR3	HBrace	Wide Flange	A500 Gr.B ...	Typical
16	M17	N11	N3		HR3	HBrace	Wide Flange	A500 Gr.B ...	Typical
17	M18	N3	N9		HR3	HBrace	Wide Flange	A500 Gr.B ...	Typical
18	M19	N9	N1		HR3	HBrace	Wide Flange	A500 Gr.B ...	Typical
19	M20	N1	N8		HR1A	Beam	Tube	A500 Gr.B ...	Typical
20	M22	N9	N2		HR1A	Beam	Tube	A500 Gr.B ...	Typical
21	M2	N2	N3		HR2	Beam	Tube	A500 Gr.B ...	Typical
22	M24	N3	N10		HR1A	Beam	Tube	A500 Gr.B ...	Typical
23	M26	N11	N4		HR1A	Beam	Tube	A500 Gr.B ...	Typical
24	M28	N5	N12		HR1A	Beam	Tube	A500 Gr.B ...	Typical
25	M30	N13	N6		HR1A	Beam	Tube	A500 Gr.B ...	Typical

Joint Loads and Enforced Displacements (BLC 1 : wind ns)

	Joint Label	L,D,M	Direction	Magnitude[(k,k-ft), (in,rad), (k*s^2/ft...
1	N1	L	Y	.35
2	N2	L	Y	.7
3	N3	L	Y	.7
4	N4	L	Y	.7
5	N5	L	Y	.7
6	N6	L	Y	.7
7	N7	L	Y	.35

Joint Loads and Enforced Displacements (BLC 2 : wind ew)

	Joint Label	L,D,M	Direction	Magnitude[(k,k-ft), (in,rad), (k*s^2/ft...
1	N1	L	X	.254
2	N8	L	X	.254

Basic Load Cases

	BLC Description	Category	X Gravity	Y Gravity	Joint	Point	Distributed
1	wind ns	None			7		
2	wind ew	None			2		

Load Combinations

	Description	Solve	PD...	SR...	BLC	Factor	BLC	Factor	BLC	Factor	BLC	Factor	BLC	Factor	BLC	Factor	BLC	Factor	BLC	Factor
1	wind ns	Yes	Y		1	1														
2	wind ew	Yes	Y		2	1														

Joint Reactions (By Combination)

	LC	Joint Label	X [k]	Y [k]	MZ [k-ft]
1	1	N1	-2.699	-2.1	0
2	1	N7	2.699	-2.1	0
3	1	Totals:	0	-4.2	
4	1	COG (ft):	X: 26.49	Y: 0	
5	2	N1	-.381	-.035	0
6	2	N7	-.127	.035	0
7	2	Totals:	-.508	0	
8	2	COG (ft):	NC	NC	

Joint Deflections

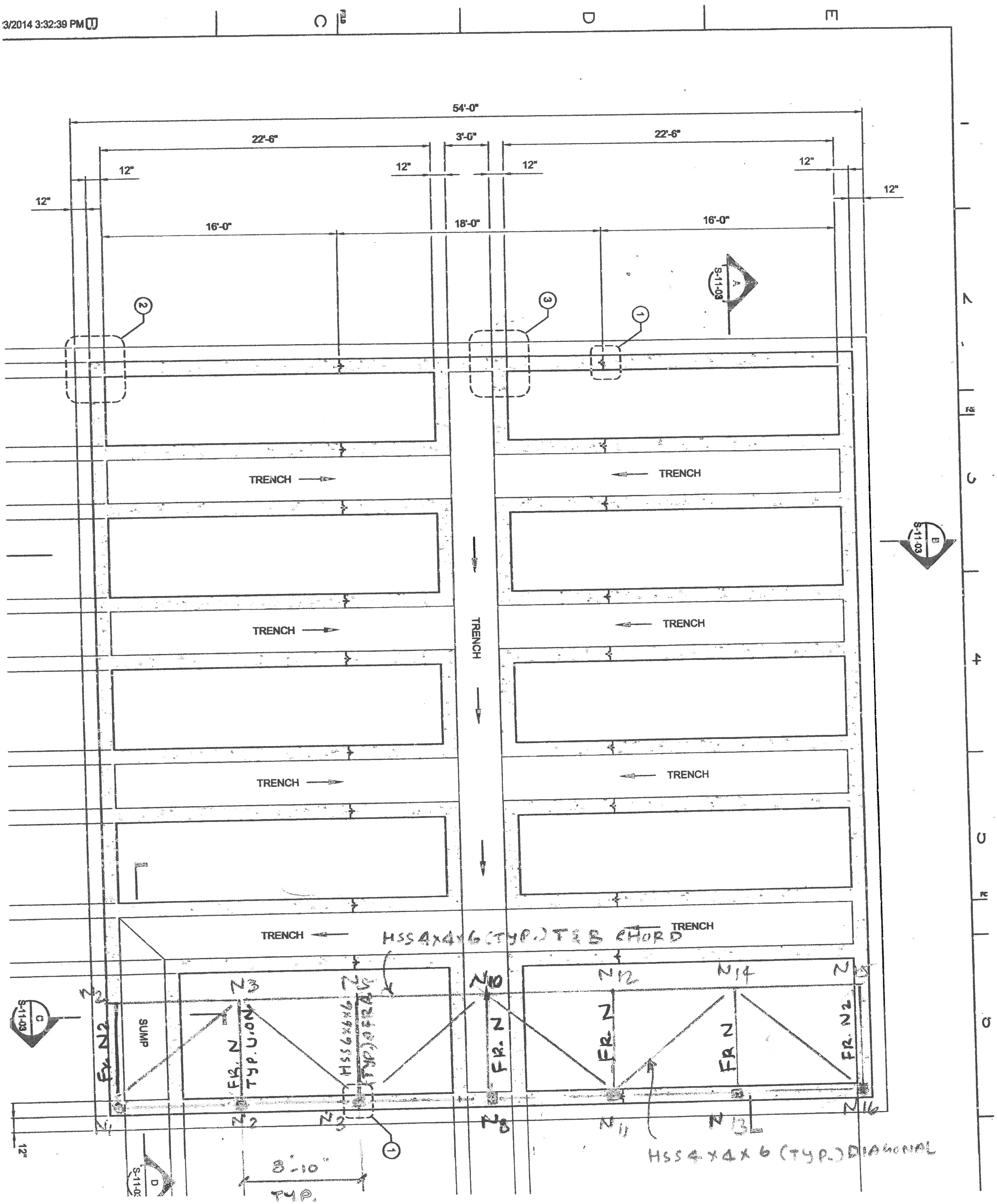
	LC	Joint Label	X [in]	Y [in]	Rotation [rad]
1	1	N1	0	0	1.259e-4
2	1	N2	0	.013	1.275e-4
3	1	N3	0	.025	6.888e-5
4	1	N4	0	.028	0
5	1	N5	0	.025	-6.888e-5
6	1	N6	0	.013	-1.275e-4
7	1	N7	0	0	-1.259e-4
8	1	N8	-.006	0	0
9	1	N9	-.006	.013	1.286e-4
10	1	N10	-.003	.025	6.859e-5
11	1	N11	0	.027	0
12	1	N12	.003	.025	-6.859e-5
13	1	N13	.006	.013	-1.286e-4
14	1	N14	.006	0	0
15	2	N1	0	0	-4.042e-6
16	2	N2	0	0	-3.427e-6
17	2	N3	0	0	-2.837e-7
18	2	N4	0	0	1.209e-6
19	2	N5	0	0	2.022e-6
20	2	N6	0	0	2.218e-6
21	2	N7	0	0	5.647e-7
22	2	N8	0	0	0
23	2	N9	0	0	-3.426e-6
24	2	N10	0	0	-2.825e-7
25	2	N11	0	0	1.209e-6
26	2	N12	0	0	2.022e-6
27	2	N13	0	0	2.218e-6
28	2	N14	0	0	0

Member AISC 13th(360-05): ASD Steel Code Checks

	LC	Member	Shape	UC Max	Loc[ft]	Shear UC	Loc[ft]	Pnc/om [k]	Pnt/om [k]	Mn/om [k-ft]	Cb	Eqn
1	1	M1	HSS6x4x4	.002	8.83	.000	0	88.399	118.443	19.58	1.667	H1-1b
2	1	M3	HSS6x4x4	.009	0	.000	0	88.399	118.443	19.58	1.52	H1-1b
3	1	M4	HSS6x4x4	.009	8.83	.000	0	88.399	118.443	19.58	1.52	H1-1b
4	1	M5	HSS6x4x4	.005	0	.000	0	88.399	118.443	19.58	1.696	H1-1b
5	1	M6	HSS6x4x4	.002	0	.000	0	88.399	118.443	19.58	1.667	H1-1b
6	1	M7	HSS6x4x4	.000	8.83	.000	0	88.399	118.443	19.58	1.667	H1-1b
7	1	M8	HSS6x4x4	.018	8.83	.000	0	88.399	118.443	19.58	1.795	H1-1b
8	1	M9	HSS6x4x4	.018	0	.000	0	88.399	118.443	19.58	1.645	H1-1b
9	1	M10	HSS6x4x4	.018	8.83	.000	0	88.399	118.443	19.58	1.645	H1-1b
10	1	M11	HSS6x4x4	.018	0	.000	0	88.399	118.443	19.58	1.795	H1-1b
11	1	M12	HSS6x4x4	.000	0	.000	0	88.399	118.443	19.58	1.667	H1-1b
12	1	M13	HSS6x6x6	.000	0	.000	0	189.355	208.79	36.267	1	H1-1b
13	1	M14	HSS4x4x4	.015	0	.000	0	53.755	92.826	10.765	1	H1-1b
14	1	M15	HSS4x4x4	.015	0	.000	0	53.755	92.826	10.765	1	H1-1b
15	1	M16	HSS4x4x4	.003	0	.000	0	53.755	92.826	10.765	1	H1-1b
16	1	M17	HSS4x4x4	.003	0	.000	0	53.755	92.826	10.765	1	H1-1b
17	1	M18	HSS4x4x4	.015	0	.000	0	53.755	92.826	10.765	1	H1-1b
18	1	M19	HSS4x4x4	.015	0	.000	0	53.755	92.826	10.765	1	H1-1b
19	1	M20	HSS6x6x6	.000	0	.000	0	189.355	208.79	36.267	1	H1-1b
20	1	M22	HSS6x6x6	.002	0	.000	0	189.355	208.79	36.267	1	H1-1b
21	1	M2	HSS6x4x4	.005	8.83	.000	0	88.399	118.443	19.58	1.696	H1-1b
22	1	M24	HSS6x6x6	.000	0	.000	0	189.355	208.79	36.267	1	H1-1b
23	1	M26	HSS6x6x6	.002	0	.000	0	189.355	208.79	36.267	1	H1-1b
24	1	M28	HSS6x6x6	.000	0	.000	0	189.355	208.79	36.267	1	H1-1b

Member AISC 13th(360-05): ASD Steel Code Checks (Continued)

	LC	Member	Shape	UC Max	Loc[ft]	Shear UC	Loc[ft]	Pnc/om [k]	Pnt/om [k]	Mn/om [k-ft]	Cb	Eqn
25	1	M30	HSS6x6x6	.002	0	.000	0	189.355	208.79	36.267	1	H1-1b
26	2	M1	HSS6x4x4	.000	8.83	.000	0	88.399	118.443	19.58	1.667	H1-1b
27	2	M3	HSS6x4x4	.000	0	.000	0	88.399	118.443	19.58	2.157	H1-1b
28	2	M4	HSS6x4x4	.000	8.83	.000	0	88.399	118.443	19.58	2.185	H1-1b
29	2	M5	HSS6x4x4	.001	0	.000	0	88.399	118.443	19.58	2.251	H1-1b
30	2	M6	HSS6x4x4	.001	0	.000	0	88.399	118.443	19.58	1.667	H1-1b
31	2	M7	HSS6x4x4	.001	8.83	.000	0	88.399	118.443	19.58	1.667	H1-1b
32	2	M8	HSS6x4x4	.001	8.83	.000	0	88.399	118.443	19.58	1.434	H1-1b
33	2	M9	HSS6x4x4	.001	0	.000	0	88.399	118.443	19.58	2.157	H1-1b
34	2	M10	HSS6x4x4	.001	8.83	.000	0	88.399	118.443	19.58	2.185	H1-1b
35	2	M11	HSS6x4x4	.001	0	.000	0	88.399	118.443	19.58	2.251	H1-1b
36	2	M12	HSS6x4x4	.000	0	.000	0	88.399	118.443	19.58	1.667	H1-1b
37	2	M13	HSS6x6x6	.000	0	.000	0	189.355	208.79	36.267	1	H1-1b
38	2	M14	HSS4x4x4	.001	0	.000	0	53.755	92.826	10.765	1	H1-1b
39	2	M15	HSS4x4x4	.000	0	.000	0	53.755	92.826	10.765	1	H1-1b
40	2	M16	HSS4x4x4	.001	0	.000	0	53.755	92.826	10.765	1	H1-1b
41	2	M17	HSS4x4x4	.000	0	.000	0	53.755	92.826	10.765	1	H1-1b
42	2	M18	HSS4x4x4	.001	0	.000	0	53.755	92.826	10.765	1	H1-1b
43	2	M19	HSS4x4x4	.000	0	.000	0	53.755	92.826	10.765	1	H1-1b
44	2	M20	HSS6x6x6	.000	0	.000	0	189.355	208.79	36.267	1	H1-1b
45	2	M22	HSS6x6x6	.000	0	.000	0	189.355	208.79	36.267	1	H1-1b
46	2	M2	HSS6x4x4	.000	8.83	.000	0	88.399	118.443	19.58	1.434	H1-1b
47	2	M24	HSS6x6x6	.000	0	.000	0	189.355	208.79	36.267	1	H1-1b
48	2	M26	HSS6x6x6	.000	0	.000	0	189.355	208.79	36.267	1	H1-1b
49	2	M28	HSS6x6x6	.000	0	.000	0	189.355	208.79	36.267	1	H1-1b
50	2	M30	HSS6x6x6	.000	0	.000	0	189.355	208.79	36.267	1	H1-1b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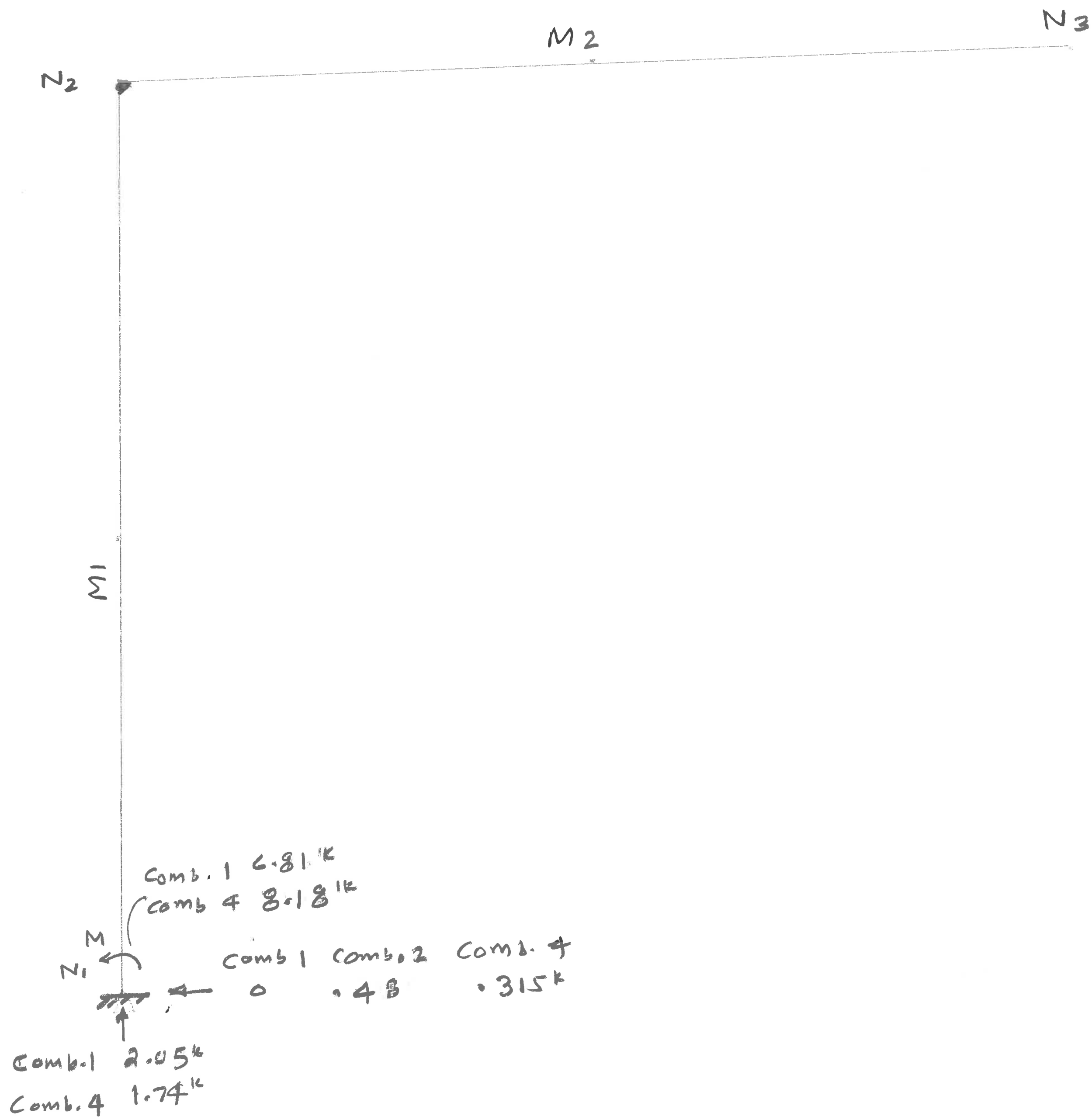


e2		SK - 1
kd	topock Influent Farm canopy	Apr 2, 2014 at 11:37 AM
ww-peg-2174-043062	FRAME N, Interior column	topockifc.frameN.r2d

Assumption - Block wall spanning vertically

Hot Rolled Steel Properties

	Label	E [ksi]	G [ksi]	Nu	Therm (\1E5 F)	Density[k/ft^3]	Yield[ksi]
1	A36 Gr.36	29000	11154	.3	.65	.49	36
2	A572 Gr.50	29000	11154	.3	.65	.49	50
3	A992	29000	11154	.3	.65	.49	50
4	A500 Gr.42	29000	11154	.3	.65	.49	42
5	A500 Gr.46	29000	11154	.3	.65	.49	46

Hot Rolled Steel Section Sets

	Label	Shape	Type	Design List	Material	Design Rules	A [in2]	I (90,270) [i...	I (0,180) [in4]
1	HR2	HSS6x6x6	Beam	Tube	A500 Gr.46	Typical	7.58	39.5	39.5

Joint Coordinates and Temperatures

	Label	X [ft]	Y [ft]	Temp [F]
1	N1	0	0	0
2	N2	0	8	0
3	N3	7.25	8.54	0

Joint Boundary Conditions

	Joint Label	X [k/in]	Y [k/in]	Rotation[k-ft/rad]	Footing
1	N1	Reaction	Reaction	Reaction	

Member Primary Data

	Label	I Joint	J Joint	Rotate(deg)	Section/Shape	Type	Design List	Material	Design Rules
1	M1	N1	N2		HR2	Beam	Tube	A500 Gr.46	Typical
2	M2	N2	N3		HR2	Beam	Tube	A500 Gr.46	Typical

Joint Loads and Enforced Displacements (BLC 1 : dl)

	Joint Label	L,D,M	Direction	Magnitude[(k,k-ft), (in,rad), (k*s^2/ft...
1	N3	L	Y	-.2
2	N2	L	Y	-.2

Joint Loads and Enforced Displacements (BLC 2 : ll)

	Joint Label	L,D,M	Direction	Magnitude[(k,k-ft), (in,rad), (k*s^2/ft...
1	N3	L	Y	-.63
2	N2	L	Y	-.63

Joint Loads and Enforced Displacements (BLC 3 : wind)

	Joint Label	L,D,M	Direction	Magnitude[(k,k-ft), (in,rad), (k*s^2/ft...
1	N2	L	X	.7

Joint Loads and Enforced Displacements (BLC 4 : -wind)

	Joint Label	L,D,M	Direction	Magnitude[(k,k-ft), (in,rad), (k*s^2/ft...
1	N2	L	X	-.7

Joint Loads and Enforced Displacements (BLC 5 :)

	Joint Label	L,D,M	Direction	Magnitude[(k,k-ft), (in,rad), (k*s^2/ft...
1	N3	L	Y	-.32
2	N2	L	Y	-.32

Basic Load Cases

	BLC Description	Category	X Gravity	Y Gravity	Joint	Point	Distributed
1	dl	None		-1	2		
2	ll	None			2		
3	wind	None			1		
4	-wind	None			1		
5		None			2		

Load Combinations

	Description	Solve	PD...	SR...	BLC	Factor	BLC	Factor	BLC	Factor	BLC	Factor	BLC	Factor	BLC	Factor	BLC	Factor	BLC	Factor
1	dl+ll	Yes	Y		1	1	2	1												
2	dl+wind	Yes	Y		1	.6	3	.6												
3	dl-wind	Yes	Y		1	.6	4	.6												
4	dl+ll+wind	Yes	Y		1	1	2	.75	3	.45										
5	-ll+dl+wind	Yes	Y		1	1	5	1	4	.5										

Joint Reactions

	LC	Joint Label	X [k]	Y [k]	MZ [k-ft]
1	1	N1	0	2.054	6.812
2	1	Totals:	0	2.054	
3	1	COG (ft):	X: 3.261	Y: 7.841	
4	2	N1	-.42	.476	4.65
5	2	Totals:	-.42	.476	
6	2	COG (ft):	X: 2.683	Y: 7.16	
7	3	N1	.42	.476	-2.085
8	3	Totals:	.42	.476	
9	3	COG (ft):	X: 2.683	Y: 7.16	
10	4	N1	-.315	1.739	8.179
11	4	Totals:	-.315	1.739	
12	4	COG (ft):	X: 3.195	Y: 7.763	
13	5	N1	.35	1.434	1.68
14	5	Totals:	.35	1.434	
15	5	COG (ft):	X: 3.103	Y: 7.656	

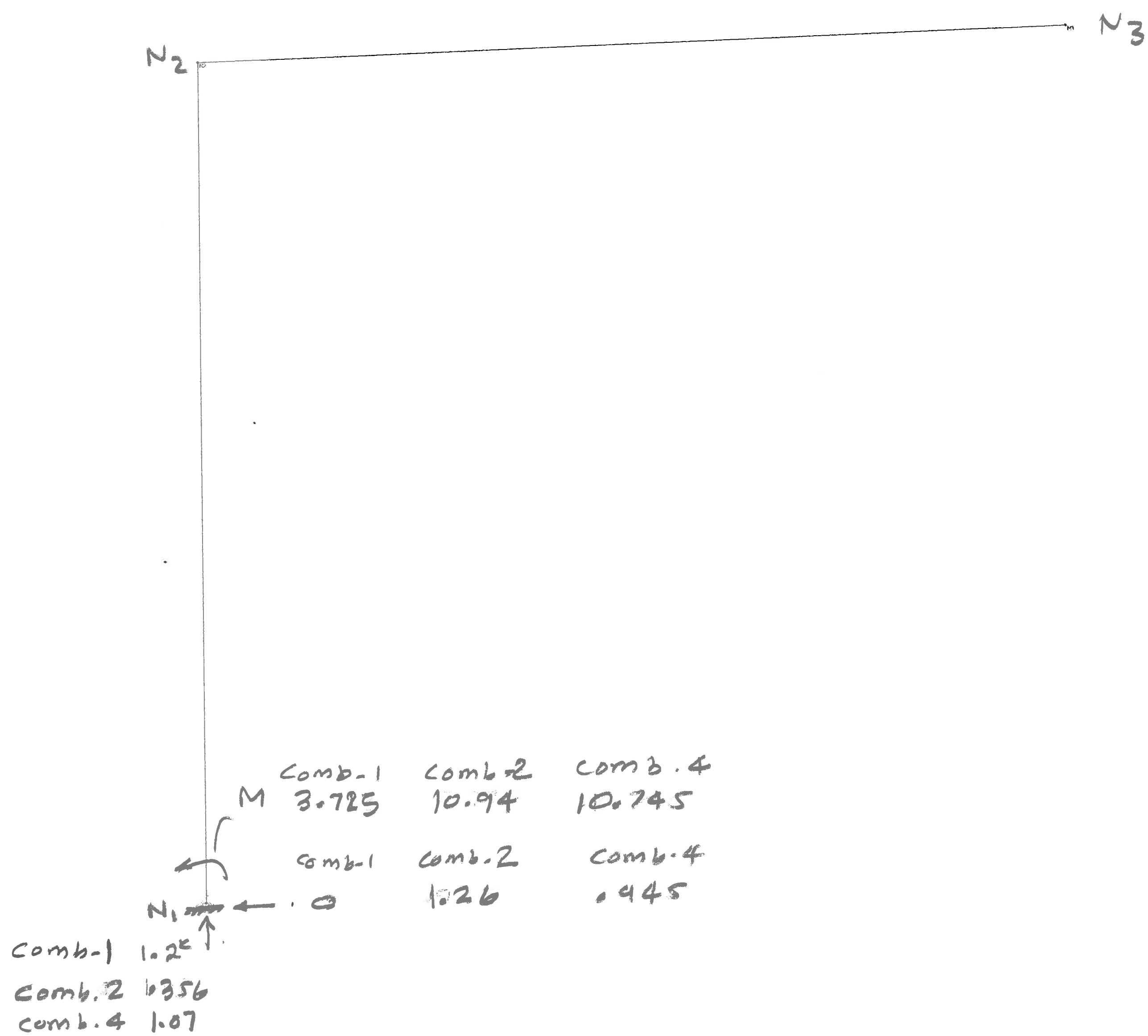
Joint Deflections (By Combination)

	LC	Joint Label	X [in]	Y [in]	Rotation [rad]
1	1	N1	0	0	0
2	1	N2	.409	0	-8.497e-3
3	1	N3	.48	-.959	-1.22e-2
4	2	N1	0	0	0
5	2	N2	.214	0	-3.726e-3
6	2	N3	.241	-.364	-4.379e-3
7	3	N1	0	0	0
8	3	N2	-.059	0	5.076e-4
9	3	N3	-.06	.005	-1.446e-4
10	4	N1	0	0	0
11	4	N2	.442	0	-8.637e-3
12	4	N3	.511	-.932	-1.168e-2
13	5	N1	0	0	0
14	5	N2	.156	0	-3.855e-3
15	5	N3	.192	-.479	-6.269e-3

Member AISC 13th(360-05): ASD Steel Code Checks

	LC	Member	Shape	UC Max	Loc[ft]	Shear UC	Loc[ft]	Pnc/om [k]	Pnt/om [k]	Mn/om [k-ft]	Cb	Eqn
1	1	M1	HSS6x6x6	.193	0	.000	0	185.372	208.79	36.267	1.006	H1-1b
2	1	M2	HSS6x6x6	.185	0	.018	0	189.253	208.79	36.267	1.716	H1-1b
3	2	M1	HSS6x6x6	.130	0	.007	0	185.372	208.79	36.267	1.409	H1-1b
4	2	M2	HSS6x6x6	.035	0	.004	0	189.253	208.79	36.267	1.832	H1-1b
5	3	M1	HSS6x6x6	.059	0	.007	0	185.372	208.79	36.267	2.195	H1-1b
6	3	M2	HSS6x6x6	.035	0	.004	0	189.253	208.79	36.267	1.832	H1-1b
7	4	M1	HSS6x6x6	.230	0	.006	0	185.372	208.79	36.267	1.147	H1-1b
8	4	M2	HSS6x6x6	.154	0	.015	0	189.253	208.79	36.267	1.726	H1-1b
9	5	M1	HSS6x6x6	.126	8	.006	0	185.372	208.79	36.267	1.332	H1-1b
10	5	M2	HSS6x6x6	.123	0	.012	0	189.253	208.79	36.267	1.742	H1-1b

(13)



Results for LC 1, di4

e2	topock Influent Farm canopy	SK - 1
kd	Frame N2 Exterior column	Apr 2, 2014 at 12:08 PM
ww-peg-2174-043062		topockifc.frameN1.r2d

(14)

Assumption Block wall spanning Vertically & Lateral loads applied directly @ Joints

Hot Rolled Steel Properties

	Label	E [ksi]	G [ksi]	Nu	Therm (\1E5 F)	Density[k/ft^3]	Yield[ksi]
1	A36 Gr.36	29000	11154	.3	.65	.49	36
2	A572 Gr.50	29000	11154	.3	.65	.49	50
3	A992	29000	11154	.3	.65	.49	50
4	A500 Gr.42	29000	11154	.3	.65	.49	42
5	A500 Gr.46	29000	11154	.3	.65	.49	46

Hot Rolled Steel Section Sets

	Label	Shape	Type	Design List	Material	Design Rules	A [in2]	I (90,270) [i...	I (0,180) [in4]
1	HR2	HSS6x6x6	Beam	Tube	A500 Gr.46	Typical	7.58	39.5	39.5
2	HR3	HSS6x6x6	Beam	Tube	A500 Gr.46	Typical	7.58	39.5	39.5

Joint Coordinates and Temperatures

	Label	X [ft]	Y [ft]	Temp [F]
1	N1	0	0	0
2	N2	0	8	0
3	N3	7.25	8.54	0

Joint Boundary Conditions

	Joint Label	X [k/in]	Y [k/in]	Rotation[k-ft/rad]	Footing
1	N1	Reaction	Reaction	Reaction	

Member Primary Data

	Label	I Joint	J Joint	Rotate(deg)	Section/Shape	Type	Design List	Material	Design Rules
1	M1	N1	N2		HR3	Beam	Tube	A500 Gr.46	Typical
2	M2	N2	N3		HR2	Beam	Tube	A500 Gr.46	Typical

Joint Loads and Enforced Displacements (BLC 1 : dl)

	Joint Label	L,D,M	Direction	Magnitude[(k,k-ft), (in,rad), (k*s^2/ft...
1	N3	L	Y	-.1
2	N2	L	Y	-.1

Joint Loads and Enforced Displacements (BLC 2 : ll)

	Joint Label	L,D,M	Direction	Magnitude[(k,k-ft), (in,rad), (k*s^2/ft...
1	N3	L	Y	-.315
2	N2	L	Y	-.315

Joint Loads and Enforced Displacements (BLC 3 : wind)

	Joint Label	L,D,M	Direction	Magnitude[(k,k-ft), (in,rad), (k*s^2/ft...
1	N2	L	X	2.1

Joint Loads and Enforced Displacements (BLC 4 : -wind)

	Joint Label	L,D,M	Direction	Magnitude[(k,k-ft), (in,rad), (k*s^2/ft...
1	N2	L	X	-2.1

Joint Loads and Enforced Displacements (BLC 5 : -ll)

	Joint Label	L,D,M	Direction	Magnitude[(k,k-ft), (in,rad), (k*s^2/ft...
1	N3	L	Y	.315

Joint Loads and Enforced Displacements (BLC 5 : -ll) (Continued)

	Joint Label	L,D,M	Direction	Magnitude[(k,k-ft), (in,rad), (k*s^2/ft...
2	N2	L	Y	.315

Basic Load Cases

	BLC Description	Category	X Gravity	Y Gravity	Joint	Point	Distributed
1	dl	None		-1	2		
2	ll	None			2		
3	wind	None			1		
4	-wind	None			1		
5	-ll	None			2		

Load Combinations

	Description	Solve	PD...	SR...	BLC	Factor	BLC	Factor	BLC	Factor	BLC	Factor	BLC	Factor	BLC	Factor	BLC	Factor	BLC	Factor
1	dl+ll	Yes	Y		1	1	2	1												
2	dl+wind	Yes	Y		1	.6	3	.6												
3	dl-wind	Yes	Y		1	.6	4	.6												
4	dl+ll+wind	Yes	Y		1	1	2	.75	3	.45										
5	-ll+dl+wind	Yes	Y		1	1	5	.5	4	.5										

Joint Reactions

	LC	Joint Label	X [k]	Y [k]	MZ [k-ft]
1	1	N1	0	1.224	3.725
2	1	Totals:	0	1.224	
3	1	COG (ft):	X: 3.014	Y: 7.55	
4	2	N1	-1.26	.356	10.942
5	2	Totals:	-1.26	.356	
6	2	COG (ft):	X: 2.365	Y: 6.786	
7	3	N1	1.26	.356	-9.252
8	3	Totals:	1.26	.356	
9	3	COG (ft):	X: 2.365	Y: 6.786	
10	4	N1	-.945	1.066	10.745
11	4	Totals:	-.945	1.066	
12	4	COG (ft):	X: 2.924	Y: 7.444	
13	5	N1	1.05	.279	-8.145
14	5	Totals:	1.05	.279	
15	5	COG (ft):	X: .943	Y: 5.11	

Joint Deflections (By Combination)

	LC	Joint Label	X [in]	Y [in]	Rotation [rad]
1	1	N1	0	0	0
2	1	N2	.224	0	-4.661e-3
3	1	N3	.263	-.524	-6.64e-3
4	2	N1	0	0	0
5	2	N2	.46	0	-7.408e-3
6	2	N3	.51	-.669	-7.812e-3
7	3	N1	0	0	0
8	3	N2	-.358	0	5.286e-3
9	3	N3	-.391	.435	4.882e-3
10	4	N1	0	0	0
11	4	N2	.497	0	-8.716e-3
12	4	N3	.561	-.857	-1.037e-2
13	5	N1	0	0	0
14	5	N2	-.325	0	4.954e-3

Joint Deflections (By Combination) (Continued)

	LC	Joint Label	X [in]	Y [in]	Rotation [rad]
15	5	N3	-.357	.428	4.934e-3

Member AISC 13th(360-05): ASD Steel Code Checks

	LC	Member	Shape	UC Max	Loc[ft]	Shear UC	Loc[ft]	Pnc/om [k]	Pnt/om [k]	Mn/om [k-ft]	Cb	Eqn
1	1	M1	HSS6x6x6	.106	0	.000	0	185.372	208.79	36.267	1.004	H1-1b
2	1	M2	HSS6x6x6	.102	0	.011	0	189.253	208.79	36.267	1.758	H1-1b
3	2	M1	HSS6x6x6	.303	0	.022	0	185.372	208.79	36.267	1.585	H1-1b
4	2	M2	HSS6x6x6	.023	0	.003	0	189.253	208.79	36.267	1.931	H1-1b
5	3	M1	HSS6x6x6	.256	0	.022	0	185.372	208.79	36.267	1.774	H1-1b
6	3	M2	HSS6x6x6	.023	0	.003	0	189.253	208.79	36.267	1.932	H1-1b
7	4	M1	HSS6x6x6	.299	0	.017	0	185.372	208.79	36.267	1.396	H1-1b
8	4	M2	HSS6x6x6	.086	0	.009	0	189.253	208.79	36.267	1.776	H1-1b
9	5	M1	HSS6x6x6	.225	0	.018	0	185.372	208.79	36.267	1.703	H1-1b
10	5	M2	HSS6x6x6	.007	0	.002	0	189.253	208.79	36.267	2.725	H1-1b

Note: Calc.'s based on Block wall spanning horizontally apply loads to col. (as distributed load), Based on results columns not affected with respect to size and outputs for Frame N & N2 are OK (18)

Hot Rolled Steel Properties

	Label	E [ksi]	G [ksi]	Nu	Therm (\1E5 F)	Density[k/ft^3]	Yield[ksi]
1	A36 Gr.36	29000	11154	.3	.65	.49	36
2	A572 Gr.50	29000	11154	.3	.65	.49	50
3	A992	29000	11154	.3	.65	.49	50
4	A500 Gr.42	29000	11154	.3	.65	.49	42
5	A500 Gr.46	29000	11154	.3	.65	.49	46

Hot Rolled Steel Section Sets

	Label	Shape	Type	Design List	Material	Design Rules	A [in2]	I (90,270) [i...	I (0,180) [in4]
1	HR2	HSS6x6x6	Beam	Tube	A500 Gr.46	Typical	7.58	39.5	39.5

Joint Coordinates and Temperatures

	Label	X [ft]	Y [ft]	Temp [F]
1	N1	0	0	0
2	N2	0	8	0
3	N3	7.25	8.54	0

Joint Boundary Conditions

	Joint Label	X [k/in]	Y [k/in]	Rotation[k-ft/rad]	Footing
1	N1	Reaction	Reaction	Reaction	

Member Primary Data

	Label	I Joint	J Joint	Rotate(deg)	Section/Shape	Type	Design List	Material	Design Rules
1	M1	N1	N2		HR2	Beam	Tube	A500 Gr.46	Typical
2	M2	N2	N3		HR2	Beam	Tube	A500 Gr.46	Typical

Joint Loads and Enforced Displacements (BLC 1 : dl)

	Joint Label	L,D,M	Direction	Magnitude[(k,k-ft), (in,rad), (k*s^2/ft...
1	N3	L	Y	-.2
2	N2	L	Y	-.2

Joint Loads and Enforced Displacements (BLC 2 : ll)

	Joint Label	L,D,M	Direction	Magnitude[(k,k-ft), (in,rad), (k*s^2/ft...
1	N3	L	Y	-.63
2	N2	L	Y	-.63

Joint Loads and Enforced Displacements (BLC 5 : .5 ll)

	Joint Label	L,D,M	Direction	Magnitude[(k,k-ft), (in,rad), (k*s^2/ft...
1	N3	L	Y	-.32
2	N2	L	Y	-.32

Member Distributed Loads (BLC 3 : wind)

	Member Label	Direction	Start Magnitude[k/ft,F]	End Magnitude[k/ft,F]	Start Location[ft,%]	End Location[ft,%]
1	M1	x	.177	.177	0	8

Member Distributed Loads (BLC 4 : -wind)

Member Label	Direction	Start Magnitude[k/ft,F]	End Magnitude[k/ft,F]	Start Location[ft,%]	End Location[ft,%]

Member Distributed Loads (BLC 4 : -wind) (Continued)

	Member Label	Direction	Start Magnitude[k/ft,F]	End Magnitude[k/ft,F]	Start Location[ft,%]	End Location[ft,%]
1	M1	X	-.177	-.177	0	8

Basic Load Cases

	BLC Description	Category	X Gravity	Y Gravity	Joint	Point	Distributed
1	dl	None		-1	2		
2	ll	None			2		
3	wind	None					1
4	-wind	None					1
5	.5 ll	None			2		

Load Combinations

	Description	Solve	PD...	SR...	BLC	Factor	BLC	Factor	BLC	Factor	BLC	Factor	BLC	Factor	BLC	Factor	BLC	Factor	BLC	Factor
1	dl+ll	Yes	Y		1	1	2	1												
2	dl+wind	Yes	Y		1	.6	3	.6												
3	dl-wind	Yes	Y		1	.6	4	.6												
4	dl+ll+wind	Yes	Y		1	1	2	.75	3	.45										
5	.5 ll+dl- col w...	Yes	Y		1	1	5	1	4	.75										
6	.5ll +dl+col w...	Yes	Y		1	1	5	1	3	.75										

Joint Reactions (By Combination)

	LC	Joint Label	X [k]	Y [k]	MZ [k-ft]
1	1	N1	0	2.054	6.812
2	1	Totals:	0	2.054	
3	1	COG (ft):	X: 3.261	Y: 7.841	
4	2	N1	0	-.373	1.278
5	2	Totals:	0	-.373	
6	2	COG (ft):	X: -3.423	Y: -.032	
7	3	N1	.85	.476	-2.122
8	3	Totals:	.85	.476	
9	3	COG (ft):	X: 2.683	Y: 7.16	
10	4	N1	0	1.102	5.621
11	4	Totals:	0	1.102	
12	4	COG (ft):	X: 5.043	Y: 9.94	
13	5	N1	1.062	1.434	.23
14	5	Totals:	1.062	1.434	
15	5	COG (ft):	X: 3.103	Y: 7.656	
16	6	N1	0	.372	4.482
17	6	Totals:	0	.372	
18	6	COG (ft):	X: 11.966	Y: 18.095	

Joint Deflections (By Combination)

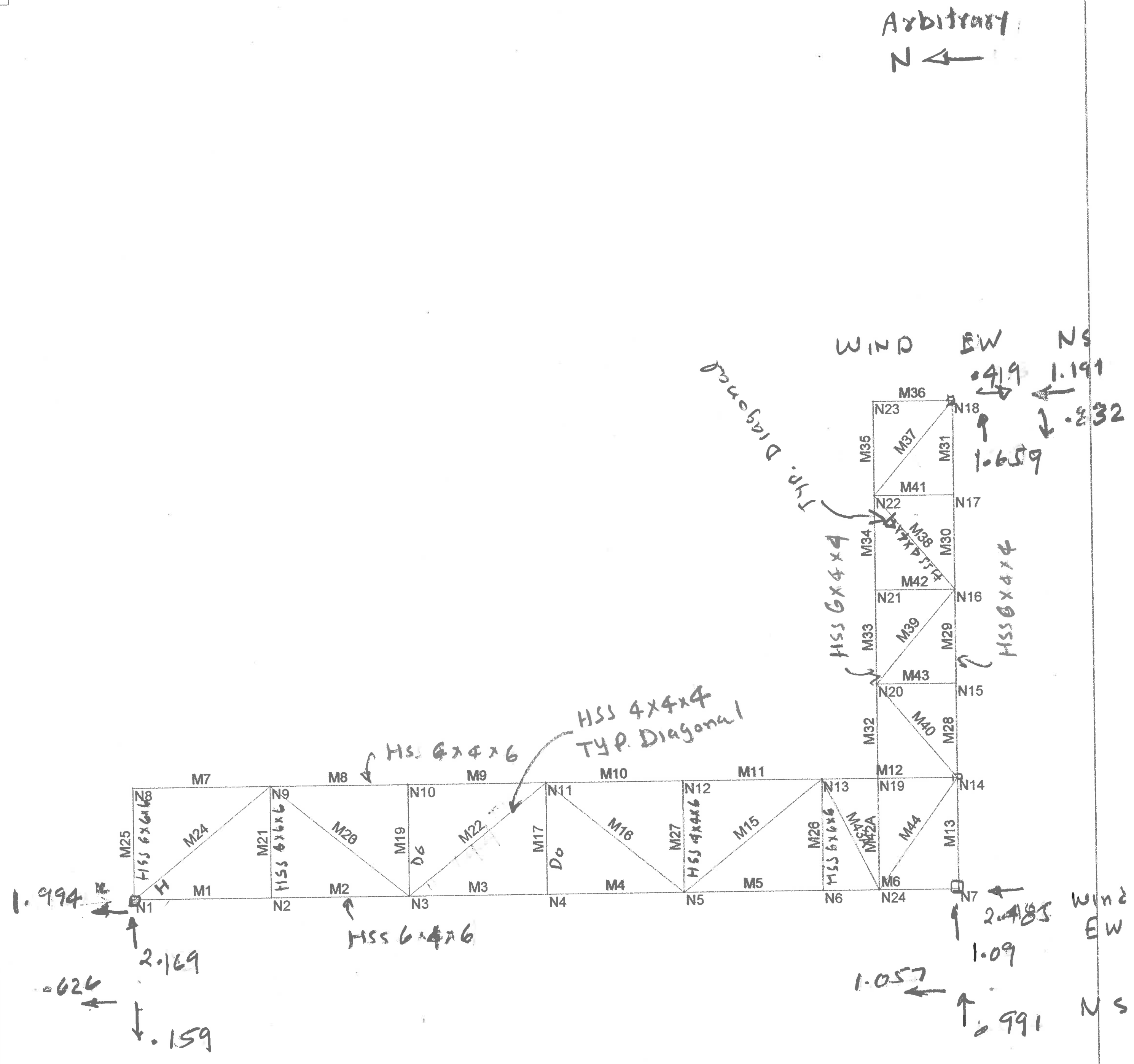
	LC	Joint Label	X [in]	Y [in]	Rotation [rad]
1	1	N1	0	0	0
2	1	N2	.409	0	-8.497e-3
3	1	N3	.48	-.959	-1.22e-2
4	2	N1	0	0	0
5	2	N2	.077	0	-1.607e-3
6	2	N3	.09	-.179	-2.259e-3
7	3	N1	0	0	0
8	3	N2	-.026	0	-1.815e-4
9	3	N3	-.022	-.055	-8.339e-4
10	4	N1	0	0	0

Joint Deflections (By Combination) (Continued)

	LC	Joint Label	X [in]	Y [in]	Rotation [rad]
11	4	N2	.338	0	-7.029e-3
12	4	N3	.397	-.792	-1.008e-2
13	5	N1	0	0	0
14	5	N2	.14	0	-3.833e-3
15	5	N3	.176	-.477	-6.247e-3
16	6	N1	0	0	0
17	6	N2	.27	0	-5.617e-3
18	6	N3	.317	-.632	-8.031e-3

Member AISC 13th(360-05): ASD Steel Code Checks (By Combination)

	LC	Member	Shape	UC Max	Loc[ft]	Shear UC	Loc[ft]	Pnc/om [k]	Pnt/om [k]	Mn/om [k-ft]	Cb	Eqn
1	1	M1	HSS6x6x6	.193	0	.000	0	185.372	208.79	36.267	1.006	H1-1b
2	1	M2	HSS6x6x6	.185	0	.018	0	189.253	208.79	36.267	1.716	H1-1b
3	2	M1	HSS6x6x6	.036	8	.000	0	185.372	208.79	36.267	1	H1-1b
4	2	M2	HSS6x6x6	.035	0	.004	0	189.253	208.79	36.267	1.832	H1-1b
5	3	M1	HSS6x6x6	.060	0	.015	0	185.372	208.79	36.267	2.189	H1-1b
6	3	M2	HSS6x6x6	.035	0	.004	0	189.253	208.79	36.267	1.832	H1-1b
7	4	M1	HSS6x6x6	.158	0	.000	0	185.372	208.79	36.267	1.004	H1-1b
8	4	M2	HSS6x6x6	.154	0	.015	0	189.253	208.79	36.267	1.726	H1-1b
9	5	M1	HSS6x6x6	.126	7.917	.019	0	185.372	208.79	36.267	1.277	H1-1b
10	5	M2	HSS6x6x6	.123	0	.012	0	189.253	208.79	36.267	1.742	H1-1b
11	6	M1	HSS6x6x6	.126	8	.000	0	185.372	208.79	36.267	1.003	H1-1b
12	6	M2	HSS6x6x6	.123	0	.012	0	189.253	208.79	36.267	1.742	H1-1b



Total Load to be Resisted by Blk Wall

EW Dir. V = 4.92^{k}
NS Dir. V = 2.874^{k}
} Design walls in EW Dir for Max V = 4.92^{k}

e2	Conditioned water Tank Farm. ~~Influent~~ farm double canopy roof	SK - 1
		June 11, 2014 at 12:46 PM
		infllcanopy.diaph.r2d

Hot Rolled Steel Properties

	Label	E [ksi]	G [ksi]	Nu	Therm (\1E5 F)	Density[k/ft^3]	Yield[ksi]
1	A36 Gr.36	29000	11154	.3	.65	.49	36
2	A572 Gr.50	29000	11154	.3	.65	.49	50
3	A992	29000	11154	.3	.65	.49	50
4	A500 Gr.B RND	29000	11154	.3	.65	.49	42
5	A500 Gr.B Rect	29000	11154	.3	.65	.49	46
6	A53 Gr.B	29000	11154	.3	.65	.49	35

Hot Rolled Steel Section Sets

	Label	Shape	Type	Design List	Material	Design Rules	A [in2]	I (90,270) [i...	I (0,180) [in4]
1	HR1	HSS4x4x4	HBrace	Wide Flange	A500 Gr.B Rect	Typical	3.37	7.8	7.8
2	HR2	HSS6x6x6	Beam	Tube	A500 Gr.B Rect	Typical	7.58	39.5	39.5
3	HR3	HSS6x4x6	Beam	Tube	A500 Gr.B Rect	Typical	6.18	14.9	28.3

Joint Coordinates and Temperatures

	Label	X [ft]	Y [ft]	Temp [F]
1	N1	0	0	0
2	N2	8.5	0	0
3	N3	17	0	0
4	N4	25.5	0	0
5	N5	34	0	0
6	N6	42.5	0	0
7	N7	51	0	0
8	N8	0	6.917	0
9	N9	8.5	6.917	0
10	N10	17	6.917	0
11	N11	25.5	6.917	0
12	N12	34	6.917	0
13	N13	42.5	6.917	0
14	N14	51	6.917	0
15	N15	51	12.75	0
16	N16	51	18.583	0
17	N17	51	24.416	0
18	N18	51	30.249	0
19	N19	46	6.917	0
20	N20	46	12.75	0
21	N21	46	18.583	0
22	N22	46	24.416	0
23	N23	46	30.249	0
24	N24	46	0	0

Member Primary Data

	Label	I Joint	J Joint	Rotate(deg)	Section/Shape	Type	Design List	Material	Design Rules
1	M1	N1	N2		HR3	Beam	Tube	A500 Gr.B ...	Typical
2	M2	N2	N3		HR3	Beam	Tube	A500 Gr.B ...	Typical
3	M3	N3	N4		HR3	Beam	Tube	A500 Gr.B ...	Typical
4	M4	N4	N5		HR3	Beam	Tube	A500 Gr.B ...	Typical
5	M5	N5	N6		HR3	Beam	Tube	A500 Gr.B ...	Typical
6	M6	N6	N7		HR3	Beam	Tube	A500 Gr.B ...	Typical
7	M7	N8	N9		HR3	Beam	Tube	A500 Gr.B ...	Typical
8	M8	N9	N10		HR3	Beam	Tube	A500 Gr.B ...	Typical
9	M9	N10	N11		HR3	Beam	Tube	A500 Gr.B ...	Typical
10	M10	N11	N12		HR3	Beam	Tube	A500 Gr.B ...	Typical

Member Primary Data (Continued)

	Label	I Joint	J Joint	Rotate(deg)	Section/Shape	Type	Design List	Material	Design Rules
11	M11	N12	N13		HR3	Beam	Tube	A500 Gr.B ...	Typical
12	M12	N13	N14		HR3	Beam	Tube	A500 Gr.B ...	Typical
13	M13	N14	N7		HR3	Beam	Tube	A500 Gr.B ...	Typical
14	M15	N13	N5		HR1	HBrace	Wide Flange	A500 Gr.B ...	Typical
15	M16	N5	N11		HR1	HBrace	Wide Flange	A500 Gr.B ...	Typical
16	M17	N11	N4		HR2	Beam	Tube	A500 Gr.B ...	Typical
17	M19	N10	N3		HR2	Beam	Tube	A500 Gr.B ...	Typical
18	M20	N3	N9		HR1	HBrace	Wide Flange	A500 Gr.B ...	Typical
19	M21	N9	N2		HR2	Beam	Tube	A500 Gr.B ...	Typical
20	M22	N11	N3		HR1	HBrace	Wide Flange	A500 Gr.B ...	Typical
21	M24	N9	N1		HR1	HBrace	Wide Flange	A500 Gr.B ...	Typical
22	M25	N1	N8		HR2	Beam	Tube	A500 Gr.B ...	Typical
23	M26	N6	N13		HR2	Beam	Tube	A500 Gr.B ...	Typical
24	M27	N5	N12		HR2	Beam	Tube	A500 Gr.B ...	Typical
25	M28	N14	N15		HR3	Beam	Tube	A500 Gr.B ...	Typical
26	M29	N15	N16		HR3	Beam	Tube	A500 Gr.B ...	Typical
27	M30	N16	N17		HR3	Beam	Tube	A500 Gr.B ...	Typical
28	M31	N17	N18		HR3	Beam	Tube	A500 Gr.B ...	Typical
29	M32	N19	N20		HR3	Beam	Tube	A500 Gr.B ...	Typical
30	M33	N20	N21		HR3	Beam	Tube	A500 Gr.B ...	Typical
31	M34	N21	N22		HR3	Beam	Tube	A500 Gr.B ...	Typical
32	M35	N22	N23		HR3	Beam	Tube	A500 Gr.B ...	Typical
33	M36	N23	N18		HR3	Beam	Tube	A500 Gr.B ...	Typical
34	M37	N18	N22		HR1	HBrace	Wide Flange	A500 Gr.B ...	Typical
35	M38	N22	N16		HR1	HBrace	Wide Flange	A500 Gr.B ...	Typical
36	M39	N16	N20		HR1	HBrace	Wide Flange	A500 Gr.B ...	Typical
37	M40	N20	N14		HR1	HBrace	Wide Flange	A500 Gr.B ...	Typical
38	M41	N17	N22		HR3	Beam	Tube	A500 Gr.B ...	Typical
39	M42	N16	N21		HR3	Beam	Tube	A500 Gr.B ...	Typical
40	M43	N15	N20		HR3	Beam	Tube	A500 Gr.B ...	Typical
41	M42A	N19	N24		HR2	Beam	Tube	A500 Gr.B ...	Typical
42	M43A	N13	N24		HR1	HBrace	Wide Flange	A500 Gr.B ...	Typical
43	M44	N24	N14		HR1	HBrace	Wide Flange	A500 Gr.B ...	Typical

Joint Loads and Enforced Displacements (BLC 1 : wind - ns)

	Joint Label	L,D,M	Direction	Magnitude[(k,k-ft), (in,rad), (k*s^2/ft...
1	N7	L	X	.3
2	N14	L	X	.6
3	N15	L	X	.564
4	N16	L	X	.564
5	N17	L	X	.564
6	N18	L	X	.282

Joint Loads and Enforced Displacements (BLC 2 : wind - ew)

	Joint Label	L,D,M	Direction	Magnitude[(k,k-ft), (in,rad), (k*s^2/ft...
1	N1	L	Y	-.41
2	N2	L	Y	-.82
3	N3	L	Y	-.82
4	N4	L	Y	-.82
5	N5	L	Y	-.82
6	N6	L	Y	-.58
7	N24	L	Y	-.41
8	N17	L	Y	-.24

Basic Load Cases

	BLC Description	Category	X Gravity	Y Gravity	Joint	Point	Distributed
1	wind - ns	None			6		
2	wind - ew	None			8		

Load Combinations

	Description	Solve	PD...	SR...	BLC	Factor	BLC	Factor	BLC	Factor	BLC	Factor	BLC	Factor	BLC	Factor	BLC	Factor	BLC	Factor
1	wind ns	Yes	Y		1	1														
2	wind ew	Yes	Y		2	1														

Joint Reactions

	LC	Joint Label	X [k]	Y [k]	MZ [k-ft]
1	1	N1	-.626	-.159	0
2	1	N7	-1.057	.991	0
3	1	N18	-1.191	-.832	0
4	1	Totals:	-2.874	0	
5	1	COG (ft):	NC	NC	
6	2	N1	1.994	2.169	0
7	2	N7	-2.485	1.092	0
8	2	N18	.491	1.659	0
9	2	Totals:	0	4.92	
10	2	COG (ft):	X: 25.498	Y: 1.191	

Joint Deflections (By Combination)

	LC	Joint Label	X [in]	Y [in]	Rotation [rad]
1	1	N1	0	0	-1.146e-6
2	1	N2	0	0	2.937e-6
3	1	N3	0	0	2.965e-6
4	1	N4	0	.001	5.98e-7
5	1	N5	0	.002	-4.363e-6
6	1	N6	0	0	-1.321e-5
7	1	N7	0	0	-1.215e-5
8	1	N8	0	0	-4.248e-6
9	1	N9	0	0	2.41e-6
10	1	N10	0	0	3.057e-6
11	1	N11	0	.001	5.91e-7
12	1	N12	.001	.002	-4.409e-6
13	1	N13	.002	0	-1.289e-5
14	1	N14	.002	0	-2.558e-5
15	1	N15	.005	0	-1.607e-5
16	1	N16	.005	0	7.139e-6
17	1	N17	.003	0	3.136e-5
18	1	N18	0	0	3.931e-5
19	1	N19	.002	0	-2.013e-5
20	1	N20	.004	0	-2.012e-5
21	1	N21	.005	0	8.523e-6
22	1	N22	.003	-.001	2.802e-5
23	1	N23	0	-.001	8.593e-6
24	1	N24	0	0	-1.035e-5
25	2	N1	0	0	-8.707e-5
26	2	N2	0	-.012	-8.056e-5
27	2	N3	0	-.02	-3.823e-5
28	2	N4	.001	-.021	9.148e-6
29	2	N5	.002	-.017	5.392e-5

Joint Deflections (By Combination) (Continued)

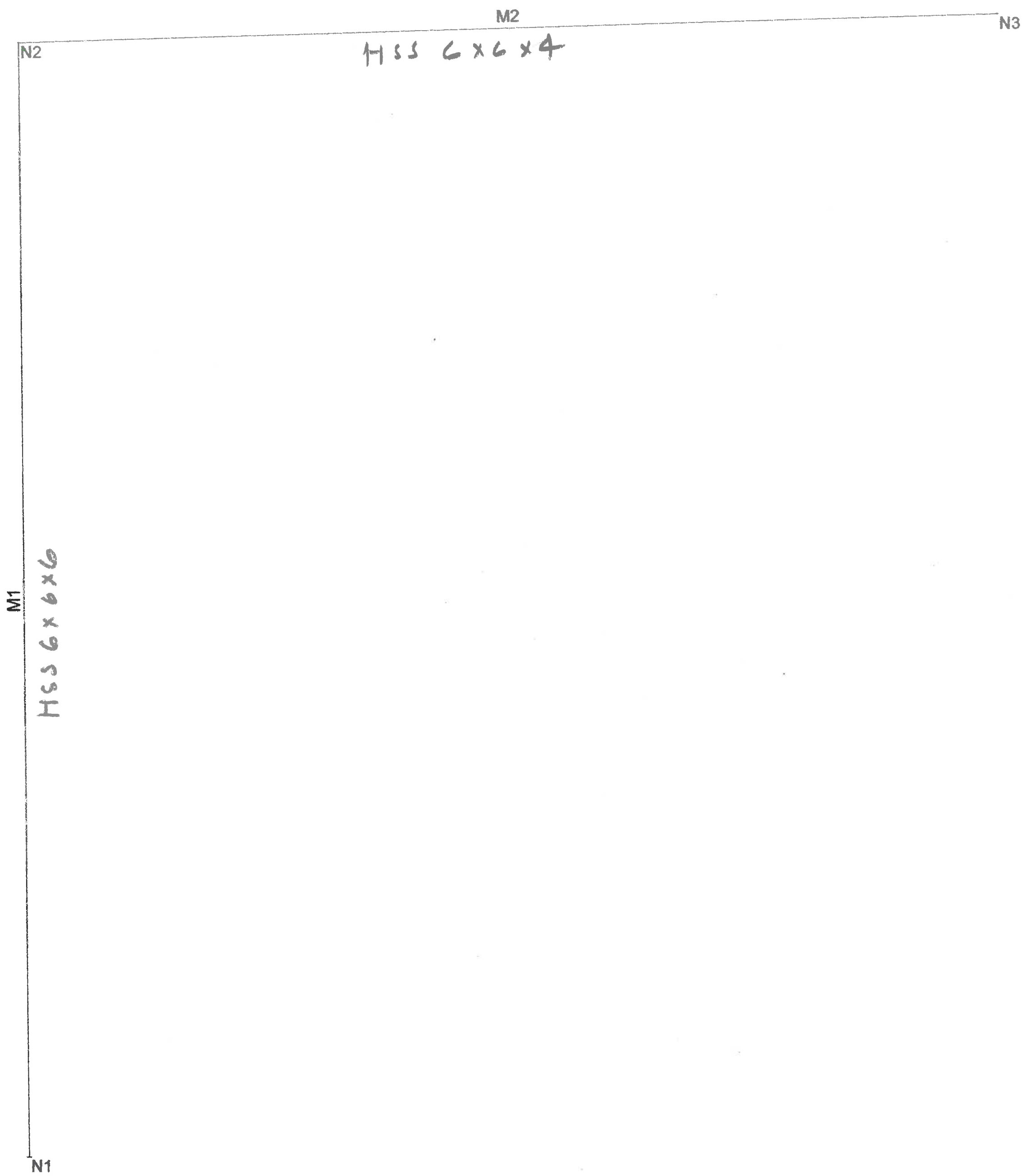
	LC	Joint Label	X [in]	Y [in]	Rotation [rad]
30	2	N6	.001	-.007	7.81e-5
31	2	N7	0	0	3.84e-5
32	2	N8	.004	0	-3.741e-5
33	2	N9	.004	-.011	-7.297e-5
34	2	N10	.003	-.02	-3.967e-5
35	2	N11	0	-.021	9.994e-6
36	2	N12	0	-.017	5.035e-5
37	2	N13	-.002	-.007	9.46e-5
38	2	N14	-.002	0	1.205e-5
39	2	N15	-.002	0	4.772e-6
40	2	N16	-.002	0	-7.576e-6
41	2	N17	0	0	-9.04e-6
42	2	N18	0	0	5.35e-7
43	2	N19	-.002	-.002	5.157e-5
44	2	N20	-.002	-.001	-3.615e-6
45	2	N21	-.002	0	-6.242e-6
46	2	N22	0	0	-7.863e-6
47	2	N23	0	0	1.201e-5
48	2	N24	0	-.003	6.713e-5

Member AISC 14th(360-10): ASD Steel Code Checks

	LC	Member	Shape	UC Max	Loc[ft]	Shear UC	Loc[ft]	Pnc/om [k]	Pnt/om [k]	Mn/om [k-ft]	Cb	Eqn
1	1	M1	HSS6x4x6	.001	0	.000	0	127.34	170.228	27.315	1.973	H1-1b
2	1	M2	HSS6x4x6	.002	0	.000	0	127.34	170.228	27.315	2.272	H1-1b
3	1	M3	HSS6x4x6	.000	8.5	.000	0	127.34	170.228	27.315	2.099	H1-1b
4	1	M4	HSS6x4x6	.001	8.5	.000	0	127.34	170.228	27.315	2.212	H1-1b
5	1	M5	HSS6x4x6	.002	8.5	.000	0	127.34	170.228	27.315	1.531	H1-1b
6	1	M6	HSS6x4x6	.004	8.5	.000	3.542	127.34	170.228	27.315	2.128	H1-1b
7	1	M7	HSS6x4x6	.000	8.5	.000	0	127.34	170.228	27.315	1.667	H1-1b
8	1	M8	HSS6x4x6	.002	0	.000	0	127.34	170.228	27.315	2.264	H1-1b
9	1	M9	HSS6x4x6	.001	8.5	.000	0	127.34	170.228	27.315	2.024	H1-1b
10	1	M10	HSS6x4x6	.003	8.5	.000	0	127.34	170.228	27.315	2.212	H1-1b
11	1	M11	HSS6x4x6	.003	8.5	.000	0	127.34	170.228	27.315	1.499	H1-1b
12	1	M12	HSS6x4x6	.006	8.5	.000	3.542	127.34	170.228	27.315	2.094	H1-1b
13	1	M13	HSS6x4x6	.005	6.917	.000	0	140.458	170.228	27.315	2.18	H1-1b
14	1	M15	HSS4x4x4	.001	0	.000	0	56.155	92.826	10.765	1	H1-1b
15	1	M16	HSS4x4x4	.002	0	.000	0	56.155	92.826	10.765	1	H1-1b
16	1	M17	HSS6x6x6	.000	6.917	.000	0	191.023	208.79	36.267	2.273	H1-1b
17	1	M19	HSS6x6x6	.000	0	.000	0	191.023	208.79	36.267	2.271	H1-1b
18	1	M20	HSS4x4x4	.002	0	.000	0	56.155	92.826	10.765	1	H1-1b
19	1	M21	HSS6x6x6	.000	6.917	.000	0	191.023	208.79	36.267	2.26	H1-1b
20	1	M22	HSS4x4x4	.001	0	.000	0	56.155	92.826	10.765	1	H1-1b
21	1	M24	HSS4x4x4	.001	0	.000	0	56.155	92.826	10.765	1	H1-1b
22	1	M25	HSS6x6x6	.000	0	.000	0	191.023	208.79	36.267	1.667	H1-1b
23	1	M26	HSS6x6x6	.000	6.917	.000	0	191.023	208.79	36.267	2.262	H1-1b
24	1	M27	HSS6x6x6	.000	0	.000	0	191.023	208.79	36.267	2.272	H1-1b
25	1	M28	HSS6x4x6	.003	5.833	.000	0	148.478	170.228	27.315	2.228	H1-1b
26	1	M29	HSS6x4x6	.002	5.833	.000	0	148.478	170.228	27.315	1.483	H1-1b
27	1	M30	HSS6x4x6	.002	0	.000	0	148.478	170.228	27.315	1.661	H1-1b
28	1	M31	HSS6x4x6	.003	0	.000	0	148.478	170.228	27.315	2.236	H1-1b
29	1	M32	HSS6x4x6	.004	5.833	.000	0	148.478	170.228	27.315	2.273	H1-1b
30	1	M33	HSS6x4x6	.006	5.833	.000	0	148.478	170.228	27.315	1.551	H1-1b
31	1	M34	HSS6x4x6	.007	0	.000	0	148.478	170.228	27.315	2.153	H1-1b
32	1	M35	HSS6x4x6	.002	0	.000	0	148.478	170.228	27.315	1.667	H1-1b
33	1	M36	HSS6x4x6	.002	5	.000	0	153.96	170.228	27.315	1.667	H1-1b
34	1	M37	HSS4x4x4	.009	0	.000	0	72.509	92.826	10.765	1	H1-1b

Member AISC 14th(360-10): ASD Steel Code Checks (Continued)

	LC	Member	Shape	UC Max	Loc[ft]	Shear UC	Loc[ft]	Pnc/om [k]	Pnt/om [k]	Mn/om [k-ft]	Cb	Eqn
35	1	M38	HSS4x4x4	.003	0	.000	0	72.509	92.826	10.765	1	H1-1b
36	1	M39	HSS4x4x4	.002	0	.000	0	72.509	92.826	10.765	1	H1-1b
37	1	M40	HSS4x4x4	.008	0	.000	0	72.509	92.826	10.765	1	H1-1b
38	1	M41	HSS6x4x6	.004	0	.000	0	153.96	170.228	27.315	2.254	H1-1b
39	1	M42	HSS6x4x6	.000	5	.000	0	153.96	170.228	27.315	2.22	H1-1b
40	1	M43	HSS6x4x6	.004	5	.000	0	153.96	170.228	27.315	2.251	H1-1b
41	1	M42A	HSS6x6x6	.002	6.917	.000	0	191.023	208.79	36.267	2.155	H1-1b
42	1	M43A	HSS4x4x4	.001	0	.000	0	72.185	92.826	10.765	1	H1-1b
43	1	M44	HSS4x4x4	.003	0	.000	0	68.434	92.826	10.765	1	H1-1b
44	2	M1	HSS6x4x6	.004	8.5	.000	0	127.34	170.228	27.315	2.258	H1-1b
45	2	M2	HSS6x4x6	.004	8.5	.000	0	127.34	170.228	27.315	2.164	H1-1b
46	2	M3	HSS6x4x6	.005	0	.000	0	127.34	170.228	27.315	1.131	H1-1b
47	2	M4	HSS6x4x6	.006	0	.000	0	127.34	170.228	27.315	1.715	H1-1b
48	2	M5	HSS6x4x6	.009	0	.000	0	127.34	170.228	27.315	2.225	H1-1b
49	2	M6	HSS6x4x6	.011	3.453	.002	0	127.34	170.228	27.315	2.725	H1-1b
50	2	M7	HSS6x4x6	.002	8.5	.000	0	127.34	170.228	27.315	1.667	H1-1b
51	2	M8	HSS6x4x6	.016	8.5	.000	0	127.34	170.228	27.315	2.199	H1-1b
52	2	M9	HSS6x4x6	.014	0	.000	0	127.34	170.228	27.315	1.393	H1-1b
53	2	M10	HSS6x4x6	.012	0	.000	0	127.34	170.228	27.315	1.651	H1-1b
54	2	M11	HSS6x4x6	.014	0	.000	0	127.34	170.228	27.315	2.183	H1-1b
55	2	M12	HSS6x4x6	.012	3.453	.003	0	127.34	170.228	27.315	2.764	H1-1b
56	2	M13	HSS6x4x6	.005	0	.000	0	140.458	170.228	27.315	1.022	H1-1b
57	2	M15	HSS4x4x4	.013	0	.000	0	56.155	92.826	10.765	1	H1-1b
58	2	M16	HSS4x4x4	.010	0	.000	0	56.155	92.826	10.765	1	H1-1b
59	2	M17	HSS6x6x6	.003	0	.000	0	191.023	208.79	36.267	2.262	H1-1b
60	2	M19	HSS6x6x6	.002	0	.000	0	191.023	208.79	36.267	2.263	H1-1b
61	2	M20	HSS4x4x4	.008	0	.000	0	56.155	92.826	10.765	1	H1-1b
62	2	M21	HSS6x6x6	.006	6.917	.001	0	191.023	208.79	36.267	2.252	H1-1b
63	2	M22	HSS4x4x4	.002	0	.000	0	56.155	92.826	10.765	1	H1-1b
64	2	M24	HSS4x4x4	.024	0	.000	0	56.155	92.826	10.765	1	H1-1b
65	2	M25	HSS6x6x6	.003	0	.000	0	191.023	208.79	36.267	1.667	H1-1b
66	2	M26	HSS6x6x6	.008	6.917	.001	0	191.023	208.79	36.267	2.249	H1-1b
67	2	M27	HSS6x6x6	.003	0	.001	0	191.023	208.79	36.267	2.261	H1-1b
68	2	M28	HSS6x4x6	.003	0	.000	0	148.478	170.228	27.315	2.217	H1-1b
69	2	M29	HSS6x4x6	.002	0	.000	0	148.478	170.228	27.315	1.975	H1-1b
70	2	M30	HSS6x4x6	.004	0	.000	0	148.478	170.228	27.315	2.263	H1-1b
71	2	M31	HSS6x4x6	.004	5.833	.000	0	148.478	170.228	27.315	2.057	H1-1b
72	2	M32	HSS6x4x6	.012	0	.001	0	148.478	170.228	27.315	2.163	H1-1b
73	2	M33	HSS6x4x6	.003	5.833	.000	0	148.478	170.228	27.315	1.052	H1-1b
74	2	M34	HSS6x4x6	.005	0	.000	0	148.478	170.228	27.315	2.263	H1-1b
75	2	M35	HSS6x4x6	.000	0	.000	0	148.478	170.228	27.315	1.667	H1-1b
76	2	M36	HSS6x4x6	.001	5	.000	0	153.96	170.228	27.315	1.667	H1-1b
77	2	M37	HSS4x4x4	.004	0	.000	0	72.509	92.826	10.765	1	H1-1b
78	2	M38	HSS4x4x4	.005	0	.000	0	72.509	92.826	10.765	1	H1-1b
79	2	M39	HSS4x4x4	.004	0	.000	0	72.509	92.826	10.765	1	H1-1b
80	2	M40	HSS4x4x4	.005	0	.000	0	72.509	92.826	10.765	1	H1-1b
81	2	M41	HSS6x4x6	.002	0	.000	0	153.96	170.228	27.315	2.264	H1-1b
82	2	M42	HSS6x4x6	.002	0	.000	0	153.96	170.228	27.315	2.263	H1-1b
83	2	M43	HSS6x4x6	.003	5	.000	0	153.96	170.228	27.315	2.228	H1-1b
84	2	M42A	HSS6x6x6	.009	6.917	.001	0	191.023	208.79	36.267	2.23	H1-1b
85	2	M43A	HSS4x4x4	.014	0	.000	0	72.185	92.826	10.765	1	H1-1b
86	2	M44	HSS4x4x4	.002	0	.000	0	68.434	92.826	10.765	1	H1-1b



Results for LC 1, dl+ll

e2	Water conditioning topock Influent Farm double canopy	SK - 1
kd		June 12, 2014 at 5:31 PM
ww-peg-2174-043062		topockifcdblew.frame.r2d

Hot Rolled Steel Properties

	Label	E [ksi]	G [ksi]	Nu	Therm (\1E5 F)	Density[k/ft^3]	Yield[ksi]
1	A36 Gr.36	29000	11154	.3	.65	.49	36
2	A572 Gr.50	29000	11154	.3	.65	.49	50
3	A992	29000	11154	.3	.65	.49	50
4	A500 Gr.42	29000	11154	.3	.65	.49	42
5	A500 Gr.46	29000	11154	.3	.65	.49	46

Hot Rolled Steel Section Sets

	Label	Shape	Type	Design List	Material	Design Rules	A [in2]	I (90,270) [i...	I (0,180) [in4]
1	HR1A	HSS6x6x6	Column	Wide Flange	A500 Gr.46	Typical	7.58	39.5	39.5
2	HR2	HSS6x6x4	Beam	Tube	A500 Gr.46	Typical	5.24	28.6	28.6

Joint Coordinates and Temperatures

	Label	X [ft]	Y [ft]	Temp [F]
1	N1	0	0	0
2	N2	0	8	0
3	N3	7	8.139	0

Joint Boundary Conditions

	Joint Label	X [k/in]	Y [k/in]	Rotation[k-ft/rad]	Footing
1	N1	Reaction	Reaction	Reaction	

Member Primary Data

	Label	I Joint	J Joint	Rotate(deg)	Section/Shape	Type	Design List	Material	Design Rules
1	M1	N1	N2		HR1A	Column	Wide Flange	A500 Gr.46	Typical
2	M2	N2	N3		HR2	Beam	Tube	A500 Gr.46	Typical

Joint Loads and Enforced Displacements (BLC 1 : dl)

	Joint Label	L,D,M	Direction	Magnitude[(k,k-ft), (in,rad), (k*s^2/ft...
1	N3	L	Y	-.2
2	N2	L	Y	-.2

Joint Loads and Enforced Displacements (BLC 2 : ll)

	Joint Label	L,D,M	Direction	Magnitude[(k,k-ft), (in,rad), (k*s^2/ft...
1	N3	L	Y	-.595
2	N2	L	Y	-.595

Joint Loads and Enforced Displacements (BLC 3 : wind)

	Joint Label	L,D,M	Direction	Magnitude[(k,k-ft), (in,rad), (k*s^2/ft...
1	N2	L	X	.7

Joint Loads and Enforced Displacements (BLC 4 : -wind)

	Joint Label	L,D,M	Direction	Magnitude[(k,k-ft), (in,rad), (k*s^2/ft...
1	N2	L	X	-.7

Joint Loads and Enforced Displacements (BLC 5 : -ll)

	Joint Label	L,D,M	Direction	Magnitude[(k,k-ft), (in,rad), (k*s^2/ft...
1	N2	L	Y	.595

Joint Loads and Enforced Displacements (BLC 5 : -ll) (Continued)

	Joint Label	L,D,M	Direction	Magnitude[(k,k-ft), (in,rad), (k*s^2/ft...
2	N3	L	Y	.595

Basic Load Cases

	BLC Description	Category	X Gravity	Y Gravity	Joint	Point	Distributed
1	dl	None		-1	2		
2	ll	None			2		
3	wind	None			1		
4	-wind	None			1		
5	-ll	None			2		

Load Combinations

	Description	Solve	PD...	SR...	BLC	Factor	BLC	Factor	BLC	Factor	BLC	Factor	BLC	Factor	BLC	Factor	BLC	Factor	BLC	Factor
1	dl+ll	Yes	Y		1	1	2	1												
2	dl+wind	Yes	Y		1	.6	3	.6												
3	dl-wind	Yes	Y		1	.6	4	.6												
4	dl+ll+wind	Yes	Y		1	1	2	.75	3	.45										
5	-ll+dl+wind	Yes	Y		1	1	5	.5	4	1										

Joint Reactions (By Combination)

	LC	Joint Label	X [k]	Y [k]	MZ [k-ft]
1	1	N1	0	1.921	6.093
2	1	Totals:	0	1.921	
3	1	COG (ft):	X: 3.124	Y: 7.632	
4	2	N1	-.42	.439	4.472
5	2	Totals:	-.42	.439	
6	2	COG (ft):	X: 2.512	Y: 6.921	
7	3	N1	.42	.439	-2.261
8	3	Totals:	.42	.439	
9	3	COG (ft):	X: 2.512	Y: 6.921	
10	4	N1	-.315	1.624	7.564
11	4	Totals:	-.315	1.624	
12	4	COG (ft):	X: 3.055	Y: 7.552	
13	5	N1	.7	.136	-5.847
14	5	Totals:	.7	.136	
15	5	COG (ft):	X: -1.803	Y: 1.903	

Joint Deflections (By Combination)

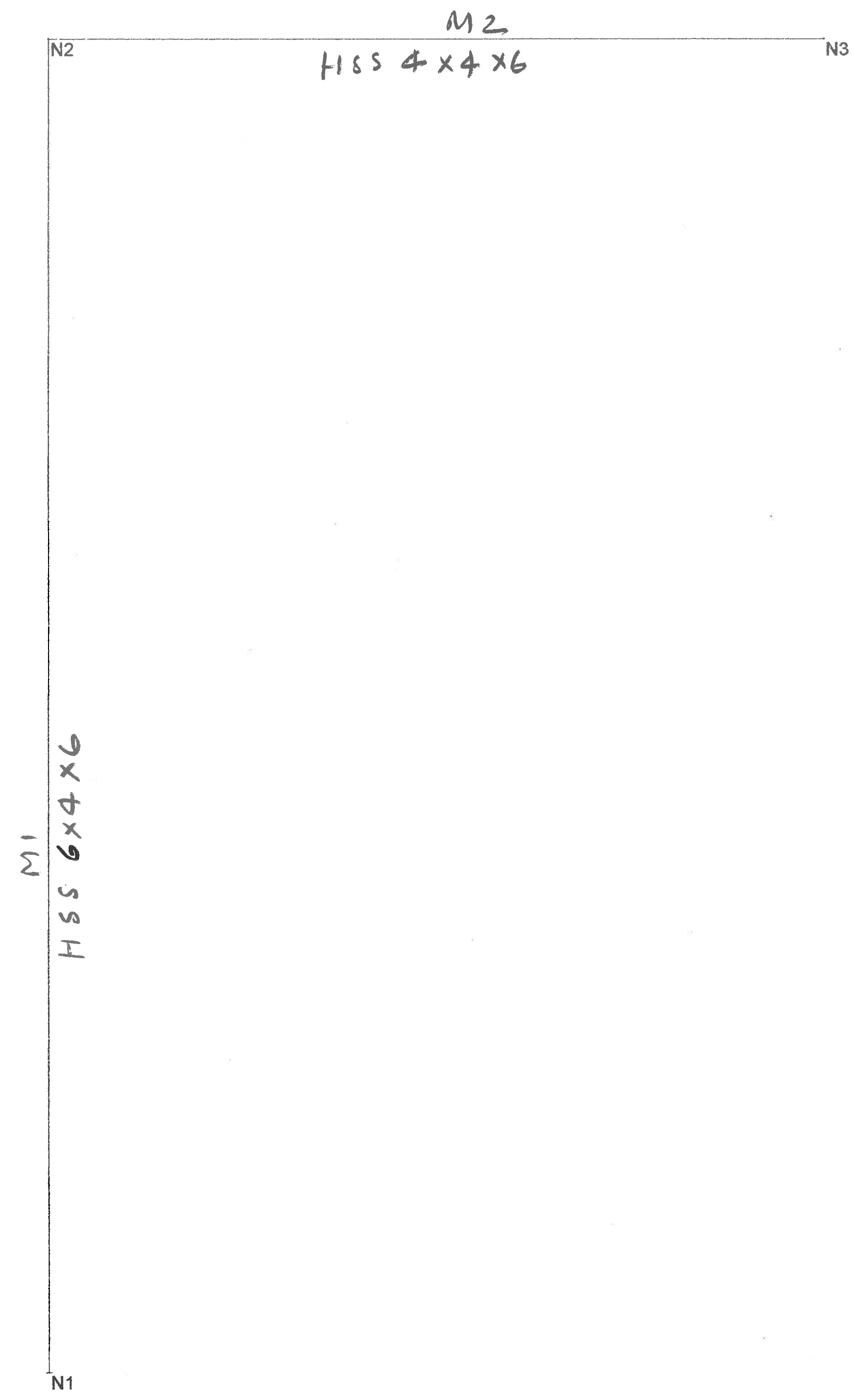
	LC	Joint Label	X [in]	Y [in]	Rotation [rad]
1	1	N1	0	0	0
2	1	N2	.366	0	-7.603e-3
3	1	N3	.384	-.893	-1.205e-2
4	2	N1	0	0	0
5	2	N2	.203	0	-3.504e-3
6	2	N3	.21	-.339	-4.275e-3
7	3	N1	0	0	0
8	3	N2	-.07	0	7.286e-4
9	3	N3	-.07	.016	-4.234e-5
10	4	N1	0	0	0
11	4	N2	.405	0	-7.874e-3
12	4	N3	.422	-.871	-1.153e-2
13	5	N1	0	0	0
14	5	N2	-.242	0	3.829e-3

Joint Deflections (By Combination) (Continued)

	LC	Joint Label	X [in]	Y [in]	Rotation [rad]
15	5	N3	-.249	.337	4.126e-3

Member AISC 13th(360-05): ASD Steel Code Checks (By Combination)

	LC	Member	Shape	UC Max	Loc[ft]	Shear UC	Loc[ft]	Pnc/om [k]	Pnt/om [k]	Mn/om [k-ft]	Cb	Eqn
1	1	M1	HSS6x6x6	.173	0	.000	0	185.372	208.79	36.267	1.006	H1-1b
2	1	M2	HSS6x6x4	.234	0	.023	0	132.309	144.335	25.709	1.702	H1-1b
3	2	M1	HSS6x6x6	.125	0	.007	0	185.372	208.79	36.267	1.431	H1-1b
4	2	M2	HSS6x6x4	.043	0	.005	0	132.309	144.335	25.709	1.787	H1-1b
5	3	M1	HSS6x6x6	.064	0	.007	0	185.372	208.79	36.267	2.172	H1-1b
6	3	M2	HSS6x6x4	.043	0	.005	0	132.309	144.335	25.709	1.787	H1-1b
7	4	M1	HSS6x6x6	.213	0	.006	0	185.372	208.79	36.267	1.16	H1-1b
8	4	M2	HSS6x6x4	.193	0	.019	0	132.309	144.335	25.709	1.709	H1-1b
9	5	M1	HSS6x6x6	.162	0	.012	0	185.372	208.79	36.267	1.621	H1-1b
10	5	M2	HSS6x6x4	.010	1.532	.002	7.001	132.309	144.335	25.709	1.18	H1-1b



Results for LC 1, dl+ll

e2	water conditioning	SK - 1
kd	topock ~~Influent~~ Farm double canopy	June 13, 2014 at 3:12 PM
ww-peg-2174-043062		topockifcdblew.frame1.r2d

Company	: e2		June 16, 2014
Designer	: kd		10:01 AM
Job Number	: ww-peg-2174-043062	topock Influent Farm double canopy	Checked By:_____

Hot Rolled Steel Properties

	Label	E [ksi]	G [ksi]	Nu	Therm (\1E5 F)	Density[k/ft^3]	Yield[ksi]
1	A36 Gr.36	29000	11154	.3	.65	.49	36
2	A572 Gr.50	29000	11154	.3	.65	.49	50
3	A992	29000	11154	.3	.65	.49	50
4	A500 Gr.42	29000	11154	.3	.65	.49	42
5	A500 Gr.46	29000	11154	.3	.65	.49	46

Hot Rolled Steel Section Sets

	Label	Shape	Type	Design List	Material	Design Rules	A [in2]	I (90,270) [i...	I (0,180) [in4]
1	HR1A	HSS6x4x6	Column	Tube	A500 Gr.46	Typical	6.18	14.9	28.3
2	HR2	HSS4x4x6	Beam	Tube	A500 Gr.46	Typical	4.78	10.3	10.3

Joint Coordinates and Temperatures

	Label	X [ft]	Y [ft]	Temp [F]
1	N1	0	0	0
2	N2	0	8.625	0
3	N3	5	8.625	0

Joint Boundary Conditions

	Joint Label	X [k/in]	Y [k/in]	Rotation[k-ft/rad]	Footing
1	N1	Reaction	Reaction	Reaction	

Member Primary Data

	Label	I Joint	J Joint	Rotate(deg)	Section/Shape	Type	Design List	Material	Design Rules
1	M1	N1	N2		HR1A	Column	Tube	A500 Gr.46	Typical
2	M2	N2	N3		HR2	Beam	Tube	A500 Gr.46	Typical

Joint Loads and Enforced Displacements (BLC 3 : wind)

	Joint Label	L,D,M	Direction	Magnitude[(k,k-ft), (in,rad), (k*s^2/ft...
1	N2	L	X	.5

Joint Loads and Enforced Displacements (BLC 4 : -wind)

	Joint Label	L,D,M	Direction	Magnitude[(k,k-ft), (in,rad), (k*s^2/ft...
1	N2	L	X	-.5

Member Distributed Loads (BLC 1 : dl)

	Member Label	Direction	Start Magnitude[k/ft,F]	End Magnitude[k/ft,F]	Start Location[ft,%]	End Location[ft,%]
1	M2	Y	-.04	-.04	0	5

Member Distributed Loads (BLC 2 : ll)

	Member Label	Direction	Start Magnitude[k/ft,F]	End Magnitude[k/ft,F]	Start Location[ft,%]	End Location[ft,%]
1	M2	Y	-.12	-.12	0	5

Member Distributed Loads (BLC 5 : -ll)

	Member Label	Direction	Start Magnitude[k/ft,F]	End Magnitude[k/ft,F]	Start Location[ft,%]	End Location[ft,%]
1	M2	Y	.12	.12	0	5

Basic Load Cases

	BLC Description	Category	X Gravity	Y Gravity	Joint	Point	Distributed
1	dl	None		-1			1
2	ll	None					1
3	wind	None			1		
4	-wind	None			1		
5	-ll	None					1

Load Combinations

	Description	Solve	PD...	SR...	BLC	Factor	BLC	Factor	BLC	Factor	BLC	Factor	BLC	Factor	BLC	Factor	BLC	Factor	BLC	Factor
1	dl+ll	Yes	Y		1	1	2	1												
2	dl+wind	Yes	Y		1	.6	3	.6												
3	dl-wind	Yes	Y		1	.6	4	.6												
4	dl+ll+wind	Yes	Y		1	1	2	.75	3	.45										
5	-ll+dl+wind	Yes	Y		1	1	5	.5	4	1										

Joint Reactions

	LC	Joint Label	X [k]	Y [k]	MZ [k-ft]
1	1	N1	0	1.063	2.232
2	1	Totals:	0	1.063	
3	1	COG (ft):	X: 2.073	Y: 7.889	
4	2	N1	-.3	.278	3.016
5	2	Totals:	-.3	.278	
6	2	COG (ft):	X: 1.52	Y: 6.935	
7	3	N1	.3	.278	-2.169
8	3	Totals:	.3	.278	
9	3	COG (ft):	X: 1.52	Y: 6.935	
10	4	N1	-.225	.913	3.803
11	4	Totals:	-.225	.913	
12	4	COG (ft):	X: 2.003	Y: 7.768	
13	5	N1	.5	.163	-4.362
14	5	Totals:	.5	.163	
15	5	COG (ft):	X: -.287	Y: 3.818	

Joint Deflections

	LC	Joint Label	X [in]	Y [in]	Rotation [rad]
1	1	N1	0	0	0
2	1	N2	.218	0	-4.195e-3
3	1	N3	.218	-.353	-6.408e-3
4	2	N1	0	0	0
5	2	N2	.211	0	-3.252e-3
6	2	N3	.211	-.215	-3.675e-3
7	3	N1	0	0	0
8	3	N2	-.129	0	1.653e-3
9	3	N3	-.129	.08	1.229e-3
10	4	N1	0	0	0
11	4	N2	.308	0	-5.326e-3
12	4	N3	.308	-.404	-7.162e-3
13	5	N1	0	0	0
14	5	N2	-.287	0	4.17e-3
15	5	N3	-.287	.252	4.217e-3

Member AISC 13th(360-05): ASD Steel Code Checks

	LC	Member	Shape	UC Max	Loc[ft]	Shear UC	Loc[ft]	Pnc/om [k]	Pnt/om [k]	Mn/om [k-ft]	Cb	Eqn
1	1	M1	HSS6x4x6	.086	0	.000	0	126.25	170.228	27.315	1.005	H1-1b
2	1	M2	HSS4x4x6	.150	0	.026	0	117.669	131.665	14.668	2.326	H1-1b
3	2	M1	HSS6x4x6	.112	0	.005	0	126.25	170.228	27.315	1.524	H1-1b
4	2	M2	HSS4x4x6	.029	0	.005	0	117.669	131.665	14.668	2.326	H1-1b
5	3	M1	HSS6x4x6	.081	0	.005	0	126.25	170.228	27.315	1.915	H1-1b
6	3	M2	HSS4x4x6	.029	0	.005	0	117.669	131.665	14.668	2.326	H1-1b
7	4	M1	HSS6x4x6	.143	0	.004	0	126.25	170.228	27.315	1.262	H1-1b
8	4	M2	HSS4x4x6	.125	0	.021	0	117.669	131.665	14.668	2.326	H1-1b
9	5	M1	HSS6x4x6	.160	0	.009	0	126.25	170.228	27.315	1.655	H1-1b
10	5	M2	HSS4x4x6	.003	0	.001	0	117.669	131.665	14.668	2.326	H1-1b

E2 Consulting Engineers, Inc. 1900 Powell Street, Suite 250 Emeryville, CA 94608	Designed By:	KD	Date: 6/16/14
	Checked By:		Date:
	Reviewed By:		Date:
Project No. WW-PGE-2174			Sheet No. 36
Project Description:	Water Conditioned Tank Farm double Canopy.		

Reference:

Frames @ Double Canopy (L shaped) Only Interior Frame

Frame EW Dir. (pgs 28 TO 31)

Vertical gr. load: $P_{(DL+LL)} = (6+20) \times 8.50 \times 3.5$
$= 180 + 595 = 775^{\#}$ USE $795^{\#}$

Lateral Load: $P_W = 20 \times 8.50 \times 4.0 = 680^{\#}$ USE $700^{\#}$

wind Governs by insp.

For Load combinations see computer printout.

Results (See computer printouts)

Max DL+LL Defl. $= .893"$ $\frac{2 \times 7 \times 12}{.893} = 188 < \frac{l}{180}$ ok

HSS 6x6x6 ok for column & beam

Horiz. Defl. (LC-4 DL+LL+wind) $= .422 = \frac{l}{227} < \frac{l}{200}$ ok

Base pl. (Try 14"x14"x 3/4" PL.)

Max. $P = 1.92^k$ USE 2.2^k $\frac{P}{A} + \frac{M}{S} = \frac{2.2}{14 \times 14} + \frac{6.1 \times 12}{\frac{1}{6} \times 14 \times 14^2} = .16$
$M = 6.093^{k}$ USE $6.1^{\prime k}$

$t_p = 2 \times 4 \times \sqrt{\frac{.16}{36}} = .53"$

Try 4 - 7/8"Φ A.B.'s (A-307) $T = \frac{6.1 \times 12}{2 \times 11} = 3.33^k$

$V = .7/4 = .175^k$

$\frac{T}{T_A} + \frac{V}{V_A} = \frac{3.33}{6.3} + \frac{.175}{4} = .572 < 1.0$ (LC-5)

USE 14" x 3/4" x 1'-2" Base pl. w/ 4 - 7/8"Φ x12" (Emb.) A.B.'s

Footing 3'-0" W x 1'-0" TK Ftg. w/ #5 @ 12" (Same as Influent Farm)

Frame 1 NS Dir. (pgs 32 to 35)

$w_{(DL+LL)} = (6+20) \times 5.84 = 35 + 117 = 152^{\#/\prime}$ USE $.16^{k/\prime}$

$P_W = 20 \times 5.84 \times 4.31 = 503^{\#}$ USE $.5^k$

Results: $\Delta_{DL+LL} = .353" = l/170$ ok $\Delta^{(Vert.)}_{(LC-4)} = .404$ $\Delta^{(Horiz)}_{(LC4)} = .308$ $l/336$ ok

HSS 6x6x6 (Col.) & HSS 6x6x4 (Bm.) ok

E2 Consulting Engineers, Inc. 1900 Powell Street, Suite 250 Emeryville, CA 94608	Designed By:	KD.	Date: 6/16/19
	Checked By:		Date:
	Reviewed By:		Date:
Project No. WW-PGE-2174			Sheet No. 37
Project Description: Conditioned Water Tank Farm ; Blk wall & Bracing			

Reference:

Block Wall

Parallal to wall

Max Shear = 4.92^k (wind NS Dir.) $\quad v/_{l\,(NS)} = \dfrac{4920}{.8 \times 51} = 120.6\ \#/'$

$V_{EW} = 2.874^k \quad v/_{l\,(EW)} = \dfrac{2874}{.8 \times 30} = 120\ \#/'$

$F_v = \dfrac{120.6}{7.12} = 10.05^{PSI} < 1.0\sqrt{1500} = 38.72^{PSI}$ ok

Perpendicular to wall

Refer to Pg 3A Influent Farm Tank

$V_W = 88.3\ \#/'$ $\quad F_v = \dfrac{88.3}{12 \times 3.8} = 1.94^{PSI}$ very small ok

X-Bracing

Max $P_{Br.} = 2.153^k$ $\quad$ Try HSS 4x2x3 $\quad A = 2.06^{in^2} \quad r = .804''$

$l_{max.} = \sqrt{7.0^2 + 8.14^2} = 10.74'$ $\quad \dfrac{Kl}{r} = \dfrac{10.74 \times 12}{.804} = 160 < 300$

$F_a = .6 \times 46 \times 2.06 = 56.8^k > 2.153^k$ ok

$F_{a\,(Tens)} = 5.2 \times 2.06 = 10.7^k > 2.153^k$ ok

USE HSS 4x2x3 Single Bracing

Tom Appendix-A
707-974-0660
pg. A-1

DenBeste Manufacturing, Inc.
31162 Shelby Lane
Shafter, CA 92362
Tel (661) 746-2079

Portable Liquid Storage Tank, 21,000 Gallon Capacity

Features:

- **All 1/4" Steel Plate Construction**
- **Smooth Interior Walls**
- **Contoured Full Drain Bottoms**
- **Static Liquid Level Gauges**
- **Integrated Stairways with Larger Walkways and Platforms**
- **Safety Harness Clips for Worker Safety**
- **Lifting Eyes for Difficult Tank Placement**
- **ABS Braking Systems**
- **Multiple Options Available**

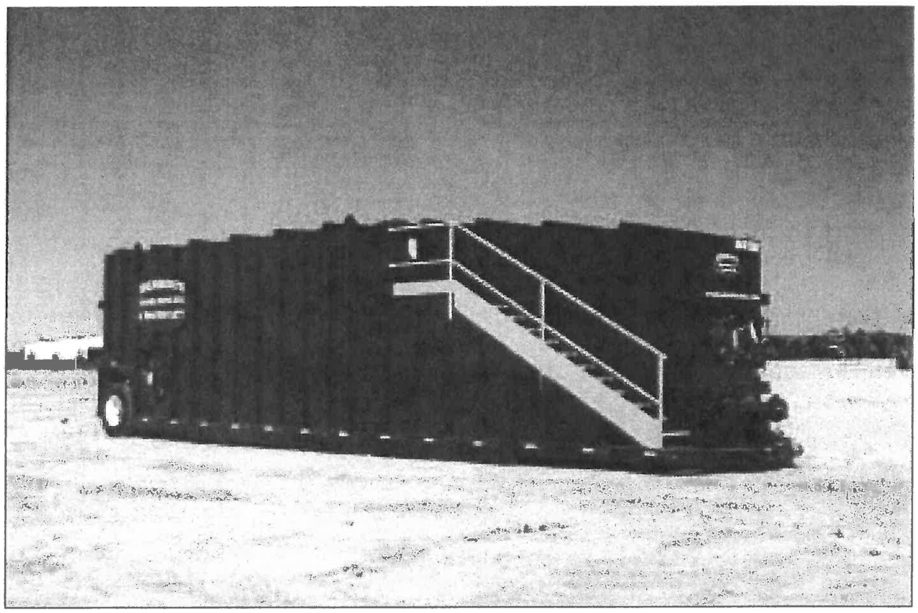
Specifications:

Length:	**45 ft. (540 inches)**
Width:	**8 ft. 5 inches (102 inches)**
Height:	**11 ft. (133 inches)**
Capacity:	**500.9 bbl (21,037 Gals)**
Operating Specs:	**Max Pressure Rating 1 P.S.I. / Max Vacuum Rating 0.25 P.S.I.**
Side Wall:	**1/4" A36 Steel Plate**
Floor:	**1/4" A36 Steel Plate**
Roof:	**1/4" A36 Steel Plate**
Exterior Supports:	**6" x 3" x 3/16" Formed Channel Sides and Roof**
Main Rails:	**12" x 3" - 20.7 # Structural Channel**
Manways:	**3 – 20" Manways, Located in Front, Top & Rear. 1 – 26" Manway on the Side. Equipped with Buna-N Gaskets**
Relief Valve:	**Blaylock Pressure / Vacuum Valve Model LL10 16 oz / in? Pressure – 0.4 oz / in? Vacuum**
Metering Gauge:	**2 – 8" Stainless Steel Float Balls**
Drain Valves:	**4" Butterfly Valves Front and Rear**
Fill Lines:	**3" Sch 80 Front Fill Line W/Cap** **3" Sch 80 Rear Fill Line W/Cap**
Gel Line:	**4" Gel line with Butterfly Valve**
Manifold:	**8" Front Manifold with Hammer Lock Fittings**
Suspension:	**Spring – 22.5 K Capacity**
Axle:	**5" rd, 77.5" track, 22.5K Capacity**
Wheels & Tires:	**8.25 x 22.5 Steel Wheels with 11R22.5 – 14 ply tires**
Lights:	**D.O.T. Approved Lights**
Blast:	**Interior – SSPC-SP10** **Exterior – SSPC- SP6**

A-2

Interior Paint:	**100% Solids Epoxy – Gray (25 to 30 mils) Carboline Phenoline # 309**
Exterior Paint:	**Polyurethane 6 – 9 Mils**

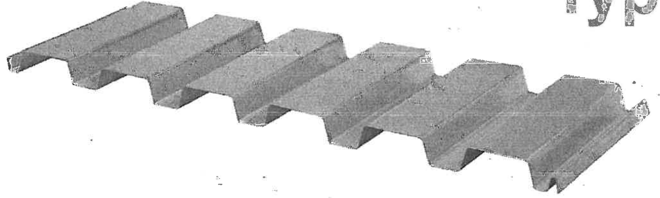
- **Maximum specific gravity of fluid to be stored in tank is S.G. 1.92 or 16 pounds per gallon**
- **Maximum fluid temperature to be stored in tank is to be no greater than 180° F. Minimum fluid temperature is to be no less than -40° F.**
- **Steel tanks are not rated for either pressure or vacuum. All tanks must be vented.**
- **Minimum PH value to be stored in "coated" tank is 3. Maximum PH value to be stored in "coated" tank is 12.**



21,000 Gallon Closed Top Tank, Vapor Secure, Epoxy Lined Tank

ATTACH.

Type PLB™-36 or HSB®-36



1½" Deep Roof Deck
Primer Painted or Galvanized

VERTICAL LOADS

Allowable Uniform Loads (psf)

SPAN	GAGE		4'-0"	5'-0"	5'-6"	6'-0"	6'-6"	7'-0"	7'-6"	8'-0"	8'-6"	9'-0"	9'-6"	10'-0"	10'-6"	11'-0"	11'-6"	12'-0"
SINGLE	22	Stress	185	118	98	82	70	60	53	46	41	37	33	30				
		L/240	185	95	71	55	43	34	28	23	19	16	14	12				
	20	Stress	223	149	123	104	88	76	66	58	52	46	41	37	34	31	28	26
		L/240	229	117	88	68	53	43	35	29	24	20	17	15	13	11	10	8
	18	Stress	300	204	168	141	120	104	90	80	70	63	56	51	46	42	38	35
		L/240	♦♦♦	160	120	93	73	58	47	39	33	27	23	20	17	15	13	12
	16	Stress	300	259	214	180	153	132	115	101	89	80	72	65	59	53	49	45
		L/240	♦♦♦	200	150	116	91	73	59	49	41	34	29	25	22	19	16	14
DOUBLE	22	Stress	194	124	103	86	73	63	55	49	43	38	34	31				
		L/240	♦♦♦	♦♦♦	♦♦♦	♦♦♦	♦♦♦	♦♦♦	♦♦♦	♦♦♦	♦♦♦	♦♦♦	♦♦♦	30				
	20	Stress	244	156	129	108	92	80	69	61	54	48	43	39	35	32	30	27
		L/240	♦♦♦	♦♦♦	♦♦♦	♦♦♦	♦♦♦	♦♦♦	♦♦♦	♦♦♦	♦♦♦	♦♦♦	43	37	32	27	24	21
	18	Stress	300	212	175	147	125	108	94	83	73	65	59	53	48	44	40	37
		L/240	♦♦♦	♦♦♦	♦♦♦	♦♦♦	♦♦♦	♦♦♦	♦♦♦	♦♦♦	♦♦♦	♦♦♦	56	48	42	36	32	28
	16	Stress	300	262	217	182	155	134	117	103	91	81	73	66	60	54	50	46
		L/240	♦♦♦	♦♦♦	♦♦♦	♦♦♦	♦♦♦	♦♦♦	♦♦♦	♦♦♦	♦♦♦	♦♦♦	70	60	52	45	40	35
TRIPLE	22	Stress	243	155	128	108	92	79	69	61	54	48	43	39				
		L/240	♦♦♦	♦♦♦	♦♦♦	♦♦♦	86	69	56	46	39	33	28	24				
	20	Stress	300	195	161	136	116	100	87	76	68	60	54	49	44	40	37	34
		L/240	♦♦♦	♦♦♦	♦♦♦	132	104	83	68	56	47	39	33	29	25	21	19	17
	18	Stress	300	265	219	184	157	135	118	103	92	82	73	66	60	55	50	46
		L/240	♦♦♦	♦♦♦	♦♦♦	175	138	110	90	74	62	52	44	38	33	28	25	22
	16	Stress	300	300	271	228	194	167	146	128	113	101	91	82	74	68	62	57
		L/240	♦♦♦	♦♦♦	♦♦♦	218	172	137	112	92	77	65	55	47	41	35	31	27

SPAN (ft-in.)

Notes:
1. Stress = Uniform load which produces maximum allowable stress in deck.
2. L/240 = Uniform load which produces L/240 deflection in deck.
3. Self-weight of the deck should be included when determining dead load.
4. The symbol ♦♦♦ indicates allowable uniform load based on deflection exceeds allowable uniform load based on stress.

TAB NO.2

a. REMEDY PRODUCED WATER CONDITIONING
b. PLANT SWITCH GEAR CANOPY

APPENDIX A - CALCULATION COVER SHEET

CALCULATION ID NUMBER	TA01
REVISION NUMBER	
JOB NUMBER	WW-PEB-2174-0430602

TITLE	Topock Water Conditioning Plant, Needles, CA

PAGE NO.	Item
1	Design Criteria & Loads
2 To 5	Roof Framing
6 To 9	Concrete Floor Framing
10, 11	Basement Concrete walls For Earth Loads
12 To 17	Lateral loads and Analysis upper steel Frames
18 To 23	Lateral loads, Analysis, Shear Walls, Lower building
△1 24 To 25, 25A	Footings & Retaining walls
17A To 17C	Appendix to page 17 (Anchor Bolts)
26 - 26-6	Steel Moment Frame
27 - 27-6	Col. line-B Braced Frame
28 - 28-5	Col. line-A Braced Frame
29 - 29-6	Concrete Moment Frame line (4)
Attach- 1A	Deck

DWGS
S-12-01 TO
S-12-20

	initial	date
PREPARED	KD	3/06/14 10/15/15
TITLE		
REVIEWED		
TITLE		

REVISION NOTES △1	Revise Calc.'s 6/27/14

E2 Consulting Engineers, Inc. 1900 Powell Street, Suite 250 Eneryville, CA 94608	Designed By: KD	Date: 5/30/12
	Checked By:	Date:
	Revised By:	Date:
Project No. WW-PEB-2174-043062		Sheet No. 1

Project Description: Topock Ground water Remediation proj. Design Criteria

All Buildings including
- Water treatment & maintenance facility (water conditioning plant)
- Hazardous waste storage & operations Bldg.

References
AWAA Standard D-100-11 For Tank Design
IBC 2009/CBC 2010 As amended by San Bernardino County
ASCE 7-10 For Loads & load combinations
ACI 318-11 For Concrete
AISC 13nth Edition For Steel
Moments & Reactions for Rectangular plates, U.S Dept of interior

Seismic Data*
$S_s = .434 (.22)$ $S_1 = .205 (.12)$ $F_a = 1.4$, $F_v = 2.0$ (2.315)
$S_{MS} = F_a \times S_s = 1.4 \times .434 = .608$ $S_{M1} = F_v S_1 = 2 \times .205 = .41 (.28)$
$S_{DS} = .667 \times .608 = .406 (.247)$ $S_{D1} = .667 \times .41 = .273 (.187)$
Seismic Category - D (Table 1613.5.6 IBC) Occupancy Type III (Table 1604.5, IBC)
Table 1.5.1 ASCE 7/10

Concrete Data
$f'_c = 5.0^{ksi}$ $f_y = 60^{ksi}$

Structural Steel
$F_y = 50^{ksi}$ (WF shapes) $F_y = 36^{ksi}$ (for channels, plates etc)

Soil Data
No Soil Report available.
Allow. Bearing Pressure for Ftg = 2.0 k/ft² Friction Factor = .35
~~Capacity of drilled piers axial = 30k~~
~~uplift = 25k~~
~~Lateral = 13k~~

* Seismic Data in Bracket is new Revised Data. It has been used for lower Concrete Bldg. Upper Steel Bldg. uses higher seismic factors.

Design Loads Floor

1st Flr	DL 12" Conc. Slab	=	150 PSF
	LL	=	500
	TL		650 PSF
2nd Flr	DL 12" Conc. Slab	=	150 PSF
	LL	=	200
	TL		350 PSF

In addition The floors shall be checked for concentrated loads from equipments, Cranes or trucks.

Misc. All Basement walls
Design for 60 pcf at rest press.
Design for 2'0" Soil Surcharge (For trucks)

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Project No. WW-PEG-2124-043062		Sheet No. 2

Project Description Topock Water Conditioning Plant Roof Framing

Roof Loads

DL = 10.0 PSF
Mech. etc. = 20.0 (USE 50% of this for Seismic DL)
LL = 20.0
TL 50.0 PSF

Decking

for Roof purlins @ 5'-0" w/ $1\frac{1}{2}$" HSB 36 Deck by Verco (18 GA.) OR EQ

Allow load = 180 PSF > 50 PSF OK
USE 18 GA. $1\frac{1}{2}$" Decking see Attach. A

purlins P-1
Between (4) & (5)

$l = 29.5'$

$w_{TL} = (.05) \times 5 + .02 = .27^{k/l}$

$R = .27 \times \frac{29.5}{2} = 3.93^k$

$M = \frac{.27 \times 29.5^2}{8} = 29.37^{lk}$ $S_x = \frac{29.37 \times 12}{.6 \times 50} = 11.75\ in^3$

Try W 12x19 $I_x = 130\ in^4$

$\Delta_{TL} = \frac{5}{384} \times \frac{.27 \times 29.5^4}{29000 \times 130} \times 1728 = 1.22'' = \frac{l}{290} < \frac{l}{240}$

USE W 12x19 purlins w/ ½ span filler strut in between purlins

Purlins P-2 (Bet.'n (3) & (4))

$l = 21.5'$ P-2

$w_{TL} = .27^{k/l}$ $R = .27 \times 21.5 \times .5 = 2.9^k$

$M = \frac{.27 \times 21.5^2}{8} = 15.6^{lk}$ Try W 12x14 $I = 88.6$

$\Delta_{TL} = \frac{5}{384} \times \frac{.27 \times 21.5^4}{29000 \times 130} \times 1728 = .384'' = \frac{l}{749} < \frac{l}{240}$ ok

USE W 12x19

Purlins P-3 @ (A) & (B)

$l_x = 21.5$, $l_y = 12.5$

$w_y = .02 \times 4 = .08^{k/l}$ $M_y = \frac{.08 \times 17.5^2}{8} = 3.06^{lk}$

$w_x = .05 \times 2.5 + .02 + .01 \times 7 = .22^{k/l}$ $M_x = \frac{.22 \times 29.5^2}{8} = 23.93^{lk}$

W 12x22, $S_x = 25.4\ in^3$, $S_y = 2.31$

$f_{bx} + f_{by} = \frac{23.93 \times 12}{25.4} + \frac{3.06 \times 12}{2.31} = 11.31 + 15.9 = 27.22^{ksi} < 30^{ksi}$

~~W 12x22 O.K.~~

USE W 12x40 @ Braced Frame (see pg 16)

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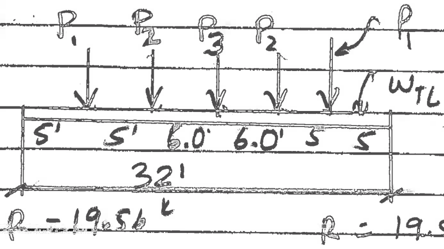
Project No. WW-PEG-2124-043062		Sheet No. 3

Project Description Topock Water Conditioning plant Roof framing

Roof Girders

Col. line ④

$l = 32'$



$P_1 = 3.93 + 2.9 = 6.83^k$

$P_3 = 3.93 \times \frac{6}{5} + 2.9 \times \frac{6}{5} = 8.2^k$

$P_2 = 3.93 \times \frac{5.5}{5} + 2.9 \times \frac{5.5}{5} = 7.51^k$

$w_{TL} = .01 \times \frac{14}{2} + .07 = .14^{k/'}$

$R = 6.83 + 7.51 + \frac{8.2}{2} + .14 \times 16 = 19.56^k$

$M_{max} = 19.56 \times 16 - 6.83 \times 11 - 7.51 \times 6 - .14 \times \frac{16^2}{2} = 174.85^{1k}$

Try W 18x60 $S = 108\ in^3$ $I = 984\ in^4$

$f_{bx} = \frac{175 \times 12}{108} = 12^{ksi} < 50^{ksi}$ $W_{eq.} = \frac{175 \times 8}{(32)^2} = 1.367^{k/'}$

$\Delta_{TL} = \frac{5}{384} \times \frac{1.367 \times 32^4}{29000 \times 984} \times 1728 = 1.13'' = \frac{l}{340} < \frac{l}{240}$ ok

USE W 18x60

Col. line ⑤

Girder ($l = 32'$)

P_1', P_2' & P_3' are 58% of P_1, P_2, P_3 for interior girders.

Design for 60% of Moment for girders col line ② & ③

$M_x = .6 \times 175 = 105^{1k}$ $P_y = .02 \times 16 \times 7 = 2.24^k$

Also Design for My due to wind $w_y = .02 \times 7 = .14^{k/'}$

$M_y = .14 \times \frac{32^2}{8} = 17.92^{1k}$ or $M_y = \frac{P_y l}{4} = \frac{2.24 \times 32}{4} = 17.92^{1k}$

W 18x60 $S_y = 13.3\ in^3$ $I_y = 50.1\ in^4$

$f_b = f_{bx} + f_{by} = \frac{105 \times 12}{108} + \frac{17.92 \times 12}{13.3} = 11.67 + 16.17 = 27.84^{ksi} < 30^{ksi}$

$\Delta_{TL} = \frac{105}{175} \times 1.13 = 0.68''$

USE W 18x60

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Project No. WW-PEA-2124-043062		Sheet No. 4

Project Description Topock Water Conditioning plant Roof framing

Girt G-1A Line ④ ⑤

$l = 16.0'$ Try MC 10 Girts @ 4'-3" o/c

$w_W = .02 \times 4.25 = .085^{k/'}$

$M_W = (.085 \times 16^2)/8 = 2.72^{1k}$ $R = .085 \times 8 = .68^k$

MC 10x22 For $l_u = 16$ $M_A = (28.4)/1.67 = 17.0^{1k} >> 2.72^{1k}$ OK

Lines Ⓐ & Ⓑ G-1B: $l = 21.5'$ $M_W = (.085 \times 21.5^2)/8 = 4.91^{1k}$ USE MC 10x22 $M_A = 12^{1k} > 4.91^{1k}$

G-1: $l = 29.5'$ $M_W = \frac{.085 \times 29.5^2}{8} = 9.25^{1k}$ $R = .085 \times \frac{29.5}{2} = 1.254^k$

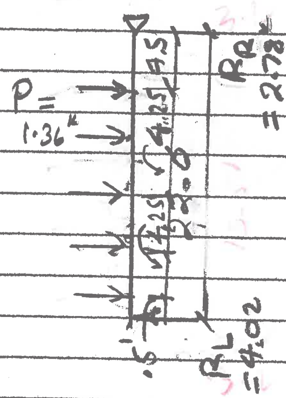
Try MC 10x28.5 $l_u = 29.5'$ $M_A = \frac{24.4}{1.67} = 14.6^{1k} > 9.25^{1k}$ OK

USE MC10x28.5' for $l = 29.5'$

USE MC 10x22 for $l = 21.5'$ And $l = 16'$

Middle Column @ lines ③ & ⑤

$h = 22.0'$ Try W 10x22 Col. $S_x = 23.2\ in^3$



$P = .68 \times 2 = 1.36^k$

$R_L \times 22 = 1.36(4.5 + 8.75 + 13 + 17.25 + 21.5)$

$R_L = 4.02^k$ $R_R = 6.8 - 4.02 = 2.78^k$

$M_{max} = 2.78 \times 8.75 - 1.36 \times 4.25 = 18.55^{1k}$ say 19^{1k}

$f_{bx} = (19 \times 12)/23.2 = 9.82^{ksi} < .6 \times 50$ OK

Col. does not take vertical loads

See Conn. below to beam above

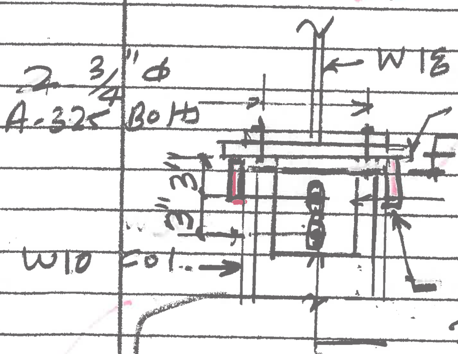
P_{max} due to weight of siding + framing

$= .015 \times 16 \times 20 = 4.8^k$ say 5^k $f_a = \frac{5}{6.49} = .77^{ksi}$ small

5^k is transferred to W10 thru Girts

USE W x 10 x 45

See pg. 16 (Mom. Fr. Analysis)



L 8x6x3/8 Ea. Side LLV Vert. welded to Col.

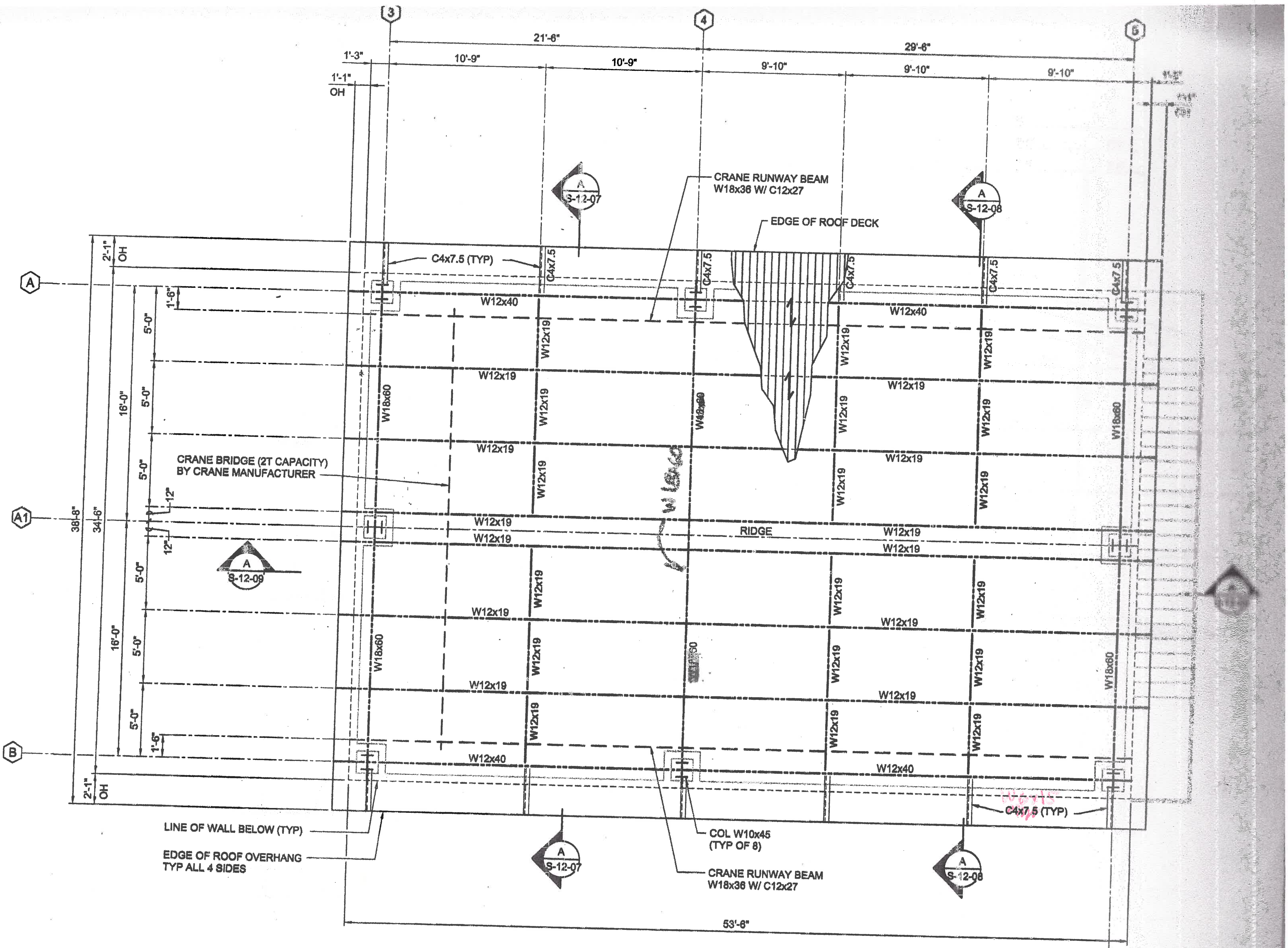
w/ 2 - 7/8" x 1 1/2" Vert. holes

3"x6"x1/2" PL. EA. SIDE WELDED TO CAP PL.

2 - 3/4" ϕ A-325 Bolts

For Mom. frame columns see pg. 15 and 16 (W10x45)

See Sect. A / S-12-13 for Alternate Detail



3
4
6
A
A1
B
21'-6"
29'-6"
1'-3"
1'-1"
OH
10'-9"
10'-9"
9'-10"
9'-10"
9'-10"
38'-8"
34'-6"
16'-0"
16'-0"
5'-0"
1'-6"
12"
2'-1"
53'-6"
CRANE RUNWAY BEAM
W18x36 W/ C12x27
EDGE OF ROOF DECK
C4x7.5 (TYP)
C4x7.5
W12x40
W12x19
W18x60
CRANE BRIDGE (2T CAPACITY)
BY CRANE MANUFACTURER
RIDGE
A
S-12-07
S-12-08
S-12-09
LINE OF WALL BELOW (TYP)
EDGE OF ROOF OVERHANG
TYP ALL 4 SIDES
COL W10x45
(TYP OF 8)

pg. 5

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	Checked By:		Date:
	Reviewed By:		Date:
			Sheet No. 6
Project No.	WW-PEG-2124-04362		
Project Description:	Topock Remedy Bldg.		

Reference:

2nd floor Structural Slab (Clear Span = 5.5')

Note: All Conc. beams except conc. frame @ line (4) are designed for $M = \frac{w\ell^2}{8}$ (Including the slab)

$w_u = (1.4 \times .15 + 1.7 \times .2) = .21 + .34 = .55^{k/'}$

$M_u = \frac{.55 \times 5.5^2}{8} = 2.08^{'k}$ $R = .55 \times \frac{5.5}{2} = 1.51^k$

Calculate capacity (Mom. & Shear) for slab, Try #5@12"

$f_y = 60^{ksi}$, $f'_c = 5^{ksi}$

$\phi M_n = A_s f_y (d - \frac{a}{2})$ $a = \frac{A_s f_y}{.85 f'_c b} = \frac{.31 \times 60}{.85 \times 5 \times 12} = .365$

$= \frac{.31 \times 60}{12} (10 - \frac{.365}{2})$ $d = 12 - 1.5 - .5 = 10"$

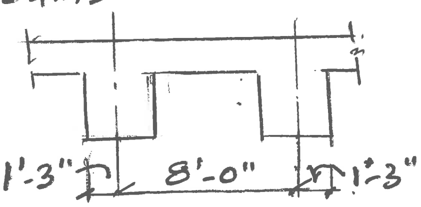
$= 15.22^{'k} > 2.08^{'k}$ ok

$\phi V_n = .85 \times 2\sqrt{5000} \times 12 \times 10 \times 10^{-3} = 14.42^k > 1.51 \times \frac{5.5}{2} = 4.15^k$ ok

USE 12" Conc. slab w/ #5 @ 12" o/c

Beams

B-1 (Int. Bm)



B-1 $\ell_c = 29.5 - 1.25 - .75 = 27.5'$

$w_u = 1.4 (.15 \times 5.5 + .15 \times 2.5 \times 3.5) + 1.7 (.2 \times 5.5)$

$= 1.4 (2.1375) + 1.7 (1.1) =$

$= 2.993 + 1.87 = 4.863^{k/'}$

$M_u = \frac{4.863 \times 27.5^2}{8} = 459.7^{'k}$ $b = 30$, $d = 36 - 1.5 - .5 = 34"$, $F = 2.89$

$\frac{M_u}{F} = \frac{459.7}{2.89} = 159$ $A_s = .003 \times 30 \times 34 = 3.06^{in^2}$

USE 5-#8 T & B

$V_u = 4.863 \times 27.5 \times .5 = 66.87^k$

V @ dist d $= 66.87 - 4.863 \times \frac{34}{12} = 53.1^k$

$V_n = 2\sqrt{5000} \times 30 \times 34 \times 10^{-3} = 144.25^k$ No Stirrups Reqd.

Min. $A_v = \frac{50 b_w s}{f_y} = \frac{50 \times 30 \times 12}{60000} = .3^{in^2}$ USE 36"x30" Bm. w/ 5-#8 @ T&B w/ #4 Stirrups @ 16" o/c ($\frac{d}{2} = 17"$)

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			Sheet No. 7
Project No.	WW-PEB-2174-043062		
Project Description:	Topock Remedy Bldg.		

Reference:

B-1B (Ext. Bm)

B-1A ($l_c = 27.5'$)

$w_{u_1} = 1.4\,(.15 \times \frac{5.5}{2} + .15 \times 2.5 \times 3.0) + 1.7\,(.2 \times \frac{5.5}{2})$

$= .577 + 1.575 + .935 = 3.087^{k/'}$ Say $3.1^{k/'}$

$M_{u_1} = \frac{3.10 \times 27.5^2}{8} = 293^{'k}$ $\quad \frac{M_u}{F} = \frac{293}{2.89} = 101$

$A_s = .0019 \times 30 \times 34 = 1.94\ in^2$ 5-#7 Bars @ T & B

$< 3.0\ in^2$ ok

$V_{u_1} = 3.1 \times 27.5 \times .5 = 42.62^k$

$\phi V_{n_1} = .85 \times 2\sqrt{5000} \times 30 \times 34 \times 10^{-3} = .85 \times 144.25 = 122.6^k > 42.62^k$

No Stirrups Reqd., USE Min. #4 @ 16" O/C

B-2 Int. Bm

B-2 ($l_c = 21.5 - 2.5 = 19'$)

$w_{u_2} = 4.86^{k/'}$ (Same as B-1)

$M_{u_2} = \frac{4.86 \times 19^2}{8} = 219.3^{'k}$ $\quad \frac{M_u}{F} = \frac{219.3}{2.89} = 75.9$

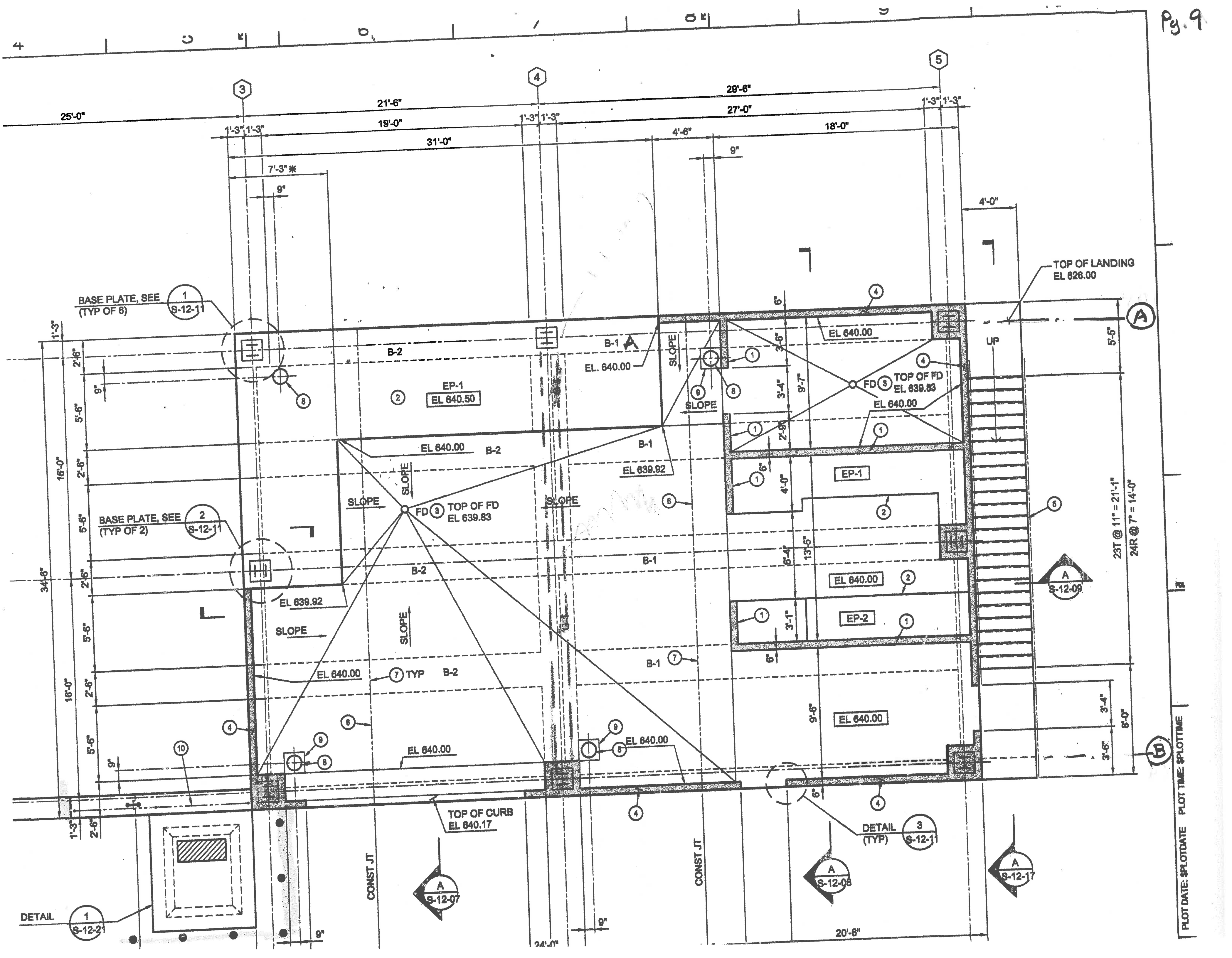
$A_s = .0017 \times 30 \times 34 = 1.73\ in^2$ 5-#7 Bars T & B

$V_{u_2} = 4.86 \times 21.5 \times .5 = 52.25^k$

$\phi V_{n_2} = 122.6^k$ (Same as B-1B)

$> 52.25^k$

No Stirrups Reqd. USE Min. #4 @ 16" O/C



Pg. 9
TOP OF LANDING
EL 626.00
BASE PLATE, SEE (TYP OF 6) 1 S-12-11
BASE PLATE, SEE (TYP OF 2) 2 S-12-11
EP-1
EL 640.50
EP-2
EL 640.00
EL 639.92
FD 3 TOP OF FD EL 639.83
SLOPE
UP
B-1
B-2
TOP OF CURB
EL 640.17
DETAIL (TYP) 3 S-12-11
DETAIL 1 S-12-2
CONST JT
A S-12-07
A S-12-08
A S-12-09
A S-12-17
23T @ 11" = 21'-1"
24R @ 7" = 14'-0"
PLOT DATE: $PLOTDATE PLOT TIME: $PLOTTIME

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Project No. WW-PEG-2124-043062		Sheet No. 10

Project Description Basement Wall Design / Concrete Wall Supports

Wall W-1 @ line-B

South wall (Bet.'n line (3) & (5))

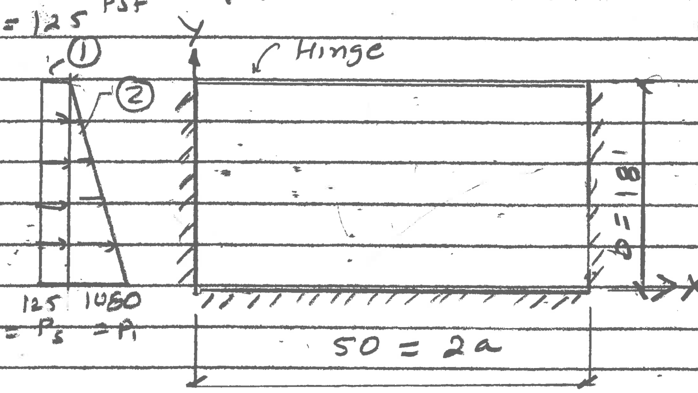
Assume wall hinged on Top, two sides & bottom fixed

For wall designation see sketch pg. 21

P_s = Surcharge = 250 x .50 = 125 psf

P_1 = .5 x 120 x 18 = 1080 psf

$\frac{a}{b} = \frac{25}{18}$ = 1.39 Say 1.50



Loading Type

Calculate Mom. & Reactions

(1)

M_{1x} = .0531 x .125 x 18² = 2.15 ᵏ

R_{1x} = .5302 x .125 x 18 = 1.193

M_{1y} = .1194 x .125 x 18² = 4.84 ᵏ

R_{1y} = .6252 x .125 x 18 = 1.407

(2)

M_{2x} = .0262 x 1.08 x 18² = 9.17 ᵏ

R_{2x} = .2208 x 1.08 x 18 = 4.292 ᵏ

M_{2y} = .0637 x 1.08 x 18² = 22.29 ᵏ

R_{2y} = .3997 x 1.08 x 18 = 7.77 ᵏ

M_{Tx} = 2.15 + 9.17 = 11.32 ᵏ

M_{ux} = 1.7(11.32) = 19.24 ᵏ

R_{Tx} = 1.193 + 4.292 = 5.485 ᵏ

M_{Ty} = 4.84 + 22.29 = 27.13 ᵏ

R_{Ty} = 1.407 + 7.77 = 9.177 ᵏ

M_{uy} = 1.7 (27.12) = 46.10 ᵏ

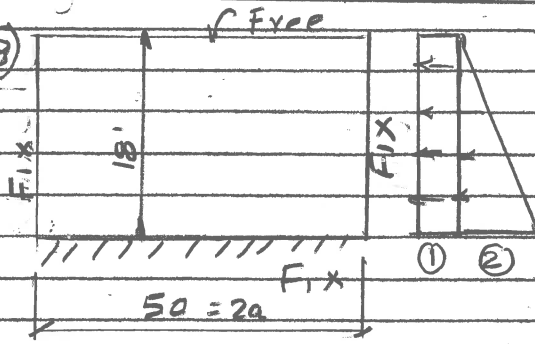
R_{uy} = 1.7 (9.177) = 15.6 ᵏ

$d_y = \frac{15600}{.85 \times 141 \times 12}$ = 10.85" 15" Tk wall ok USE 18" Tk walls

Wall W-2

South wall (Future Bldg. bet'n (1) & (3))

$\frac{a}{b} = \frac{25.0}{18}$ = 1.39 USE 1.5



(1) & (2)

M_{1x} = .3304 x .125 x 18² = 13.38 ᵏ

M_{2x} = .0857 x 1.08 x 18² = 29.99

R_{1x} = 1.6267 x .125 x 18 = 3.66

R_{1y} = 1.0123 x .125 x 18 = 2.28

M_{1y} = .3508 x .125 x 18² = 14.21

M_{2y} = .1262 x 1.08 x 18² = 44.16

R_{2x} = .3127 x 1.08 x 18 = 6.08

R_{2y} = .5047 x 1.08 x 18 = 9.81

M_{Tx} = 13.38 + 29.99 = 43.37 ᵏ M_{Ty} = 44.16 + 14.21 = 58.37 ᵏ

R_{Tx} = 3.66 + 6.08 = 9.74 R_{Ty} = 9.81 + 2.28 = 12.09 ᵏ

M_{uy} = 1.7 x 58.37 = 99.23 ᵏ R_{uy} = 1.7 x 12.09 = 20.553 ᵏ

$d_y = \frac{20.553}{.85 \times 12 \times .141}$ = 14.3" USE 24" Tk walls

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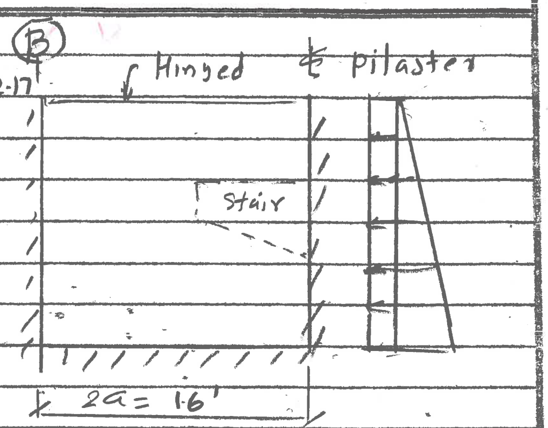
Project No. WW-PEG-2124-043062		Sheet No. 11
Project Description: Basement Wall Design		

Wall W-3

East Wall (col-line 5) See Dwg. 5-12-17



$\frac{a}{b} = \frac{8}{18} = .44$ ~~USE .50~~

(1)

$M_{1x} = .0572 \times .125 \times 18^2 = 2.32^{1k}$

$R_{1x} = .4751 \times .125 \times 18 = 1.069^k$

$M_{1y} = .0512 \times .125 \times 18^2 = 2.07^{1k}$

$R_{1y} = .4525 \times .125 \times 18 = 1.02^k$

(2)

$M_{2x} = .0269 \times 1.08 \times 18^2 = 9.413^{1k}$

$R_{2x} = .2450 \times 1.08 \times 18 = 4.763^k$

$M_{2y} = .0320 \times 1.08 \times 18^2 = 11.20$ ''

$R_{2y} = .3225 \times 1.08 \times 18 = 6.269$

$M_{Tx} = 2.32 + 9.413 = 11.733^{1k}$ $M_{Ty} = 2.07 + 11.20 = 13.27^{1k}$

$M_{uy} = 13.27 \times 1.7 = 22.56^{1k}$ $R_{uy} = (1.02 + 6.27) \times 1.7 = 12.39^{1k}$

$d_r = \frac{12390}{.85 \times 141 \times 12} = 8.62'' < 15.0''$ (used) OK

Reinforcements

W-1 Line B between (3) & (5)

$d = 18 - 2 - .50 = 15.5''$ $b = 12''$ $F = .24$

Max $M_{uy} = 46.10^{1k}$ $K_n = \frac{46.1}{.24} = 192$

$f_c' = 5^{ksi}$ $f_y = 60^{ksi}$

$A_{sv} = .0038 \times 12 \times 15.5 = .707 \text{ in}^2$ #8 @ 12" o/c Vert. outside face

$M_{ux} = 1.7 \times 11.32 = 19.24^{1k}$ say 20^k $K_n = \frac{20.0}{.225} = 89$

for b = 12 & d = 18 − 2 − 1 = 15"

$A_{sh} = .0017 \times 12 \times 15.0 = .31 \text{ in}^2$ 2-#6 @ 15" o/c

$A_{sm}(min) = .0025 \times 12 \times 15 = .45^{in^2} < 2 \times .44 \times \frac{12}{15} = .704^{in^2}$ (towards earth)

USE 18" TK walls w/ #8 @ 12" vert. bars outside face
#8 @ 12" vert. bars inside face
#6 @ 15" Horiz. bars ea. face

(Line-5) W-3

$d = 18 - 2 - .50 = 15.5$ $b = 12''$ $F = .24$

vert. → Rebars $K_n = \frac{22.56}{.24} = 94$ $A_{sv} = .0018 \times 12 \times 15.5 = .335 \text{ in}^2$
#6 @ 12" vert. outside face

Horiz. → Rebars $d = 18 - 2 - 1 = 15''$ $b = 12''$ $F = .225$ $M_{ux} = 1.7 \times 9.413 = 16.0^{1k}$

$K_n = (16)/.225 = 71$ $A_{sh} = .0017 \times 12 \times 15 = .306 \text{ in}^2$ #6 @ 15"

USE #6 @ 12" ea. face vert. bars & #6 @ 15" horiz. bars

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Project No. WW-PEH-2124-043062		Sheet No. 12

Project Description Lateral Loads, Topock Water Conditioning plant

Lateral Loads

Seismic — Moment frames above El. 14.0' are primarily single story frames carrying 20 PSF Dead Load from Roof

Lower portion from El. 14'-0" to El. 0'-0" shall be analysed as separate building from above using different seismic factors. All forces from above including vertical loads & horizontal shear acting at el. 14'-0"

Slope of Roof is 4:1

12.3.3.4 Design forces for all connections & collectors shall be 1.25 times the seismic force for above frames (over el. 14'-0")

Redundancy factor ρ

$\rho = 1.3$ for all moment & Braced frames

Load Combinations (ASCE 7-10)

For Mom. Frames & Braced frames Combinations w/ Allowable Stress Design

12.4.3.2 Comb. 5 — $(1.0 + .14 S_{DS}) D + .7 \Omega_o Q_E$ OR $(1+.057)D + 2.1 Q_E$

Mom. Fr's Comb. 8 — $(.6 - .14 S_{DS}) D + .7 \Omega_o Q_E$ OR $(.6 - .057)D + 2.1 Q_E$

Ordinary Moment frames NS Dir

Table 12-2-1 $R = 3.5$ $\Omega_o = 3$ $C_d = 3$ $\delta_x = \frac{C_d \delta_{xe}}{I} = \frac{3}{1.25} \delta_{xe} = 2.4 \delta_{xe}$

Braced Frames

Table 12-2-1 $R = 3.25$ $\Omega_o = 2$ $C_d = 3.25$

Braced Fr's Comb. 5 $(1 + .057)D + 1.4 \Omega Q_E = 1.057 D + 1.4 Q_E$

Comb. 8 $(.6 - .057) D + 1.4 \Omega Q_E = .543 D + 1.4 Q_E$

Using Equivalent Lateral procedure

$V = C_s W$ $I = 1.25$ $R = 3.5$ (Ordinary Mom. Fr.)

$C_s = \frac{S_{DS}}{(R/I)} = \frac{.406}{(3.5/1.25)} = .145$ $C_{s\,max} = \frac{.5 S_{D1}}{T(R/I)}$

$T = C_t h_n^x = .028 \times (21)^{.8} = .32$ $T_{Br.Fr.} = .02 \times (21)^{.75} = .196$ sec

(Mom. Fr's) $C_{s\,max} = \frac{.5 \times .271}{.32 (2.8)} = .152$ (Mom. Fr's) Crane

$C_{s\,max}$ (For Braces) $= \frac{.5 \times .271}{.196 (3.25/1.25)} = .265$

NS Dir $W = .02 \times 25 \times 35 + .75 \times 4.0 + .01 \times 10.5 \times 25 = 23.12^k$

$V_{NS} = .152 \times 23.12 \times 1.3 = 4.6^k$ USE 4.6^k / Mom. Fr. Say 5^k

EW Dir $V_{EW} = .265 \times 23.12 \times 1.3 = 9.1^k$ USE 9.1^k / Br. Fr.

Wind $V_{NS} = .024 (\frac{21}{2} + 5.4) \times 25 = 9.5^k = P_W$ $V_{EW} = .024 \times 23.7 (\frac{34}{2}) = 4.83^k = P_W$

See pg. 16 for Wind Pressure calc. — Design for seismic in both directions. Check w/ wind loads applied in separate load cases See pg. 14

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Project Description Lateral Loads Topock W.C. plant

Lateral Loads Contd.

Seismic: Lower Structure is concrete slab & beam at 2nd flr and concrete shear walls under 2nd flr resisting lateral loads. Shear walls shall be designed to carry loads from

- Moment Frames & braced frames (all lateral loads)
- Columns Supporting Roof DL + LL as well as Crane loads.

From Table 12.2-1 Get design factors for Ordinary Reinforced concrete shear walls

$S_{DS} = .247$, $S_{D1} = .187$ $S_{MS} = .37$ & $S_{M1} = .28$

$R = 4$ $\Omega_o = 2.50$ $C_d = 4$

$V = C_s W$ $C_s = \frac{S_{DS}}{(R/I)} = \frac{.247}{(4/1.25)} = .0773$

$C_{s\,max.} = \frac{.5 S_{D1}}{T(R/I)} = \frac{.5 \times .187}{T \times 3.2} = \frac{.0292}{T} = \frac{.0292}{.1448} = .202$

Sect. 12.8.2.1

$T_a = C_t h_n^x = .02 \times 14^{.75} = .1448$ USE T = .1448 sec. (Eq. 12.8-7)

$W = .15 \times 1 \times 50 \times 34 + .15 \times 34 \times 3 \times \frac{14}{2} \times 1.5 + .15 \times 50 \times 3 \times 3 \times 2.5 + 255 + 160.7 + 168.8 = 585^k$ (Slab; Walls; Bms)

$V = .202\,W = .202 \times 505 \times 1.10 = 112.2^k$

~~$V_{Tot.}$ = Upper struct Shear + Lower struct. Shear~~

$V_{Tot.} = 5.0 \times 2 + 112.2 = 122.2^k$ (Mom Fr.'s) USE 125^k

Line A: For Conc. Structure combinations w/ Strength Design

12.4.3.2

~~5 $(1.2 + .2 S_{DS})D + \Omega_o Q_E = (1.2 + .2 \times .406) \times D + 2.5 Q_E$~~

~~7 $(.9 - .2 S_{DS})D + \Omega_o Q_E = (.9 - .2 \times .406) \times D + 2.5 Q$~~

Final equations are

~~Use for Shear Walls~~:

Comb. 5 $(1.2 + .0812)D + 2.5 Q_E = 1.281\,D + 2.5 Q_E$

Comb. 7 $(.9 - .0812)D + 2.5 Q_E = 0.819\,D + 2.5 Q_E$

~~Calculate T_a based on Eq. 12.8-9 ASCE 7-10~~

Walls line ③: $D_i = 17$, $h_n = 14'$, $A_b = 7$, Fdn Area $A_b = 76.5$, Bldg Area $A_b = 1700$

$T_a = \frac{.0019}{\sqrt{C_W}} \times h_n$ (Eq. 12.8-10) $C_W = \frac{100}{A_B} \sum_{i=1}^{n} \left(\frac{h_n}{h_i}\right)^2 \frac{A_i}{\left[1 + .83\left(\frac{h_i}{D_i}\right)^2\right]}$ (A_i – Shear Area)

$= \frac{.0019}{\sqrt{6.384}} \times 14$ $= \frac{100}{2 \times 34 \times 10.5} \left[\frac{1.5 \times 17 + 1.5 \times 34}{\left(1 + .83\left(\frac{14}{17}\right)^2\right)}\right]$

$= .0105$ sec. $= 6.384$

$T = .0105 \times 1.5 = .016$ sec. Too Small Use other method

$T_a = .1N = .1 \times 1 = .1$ sec. (Eq. 12.8-8) $T = C_u T_a = 1.5 \times .1 = .15$ sec. (Table 12.8-1)

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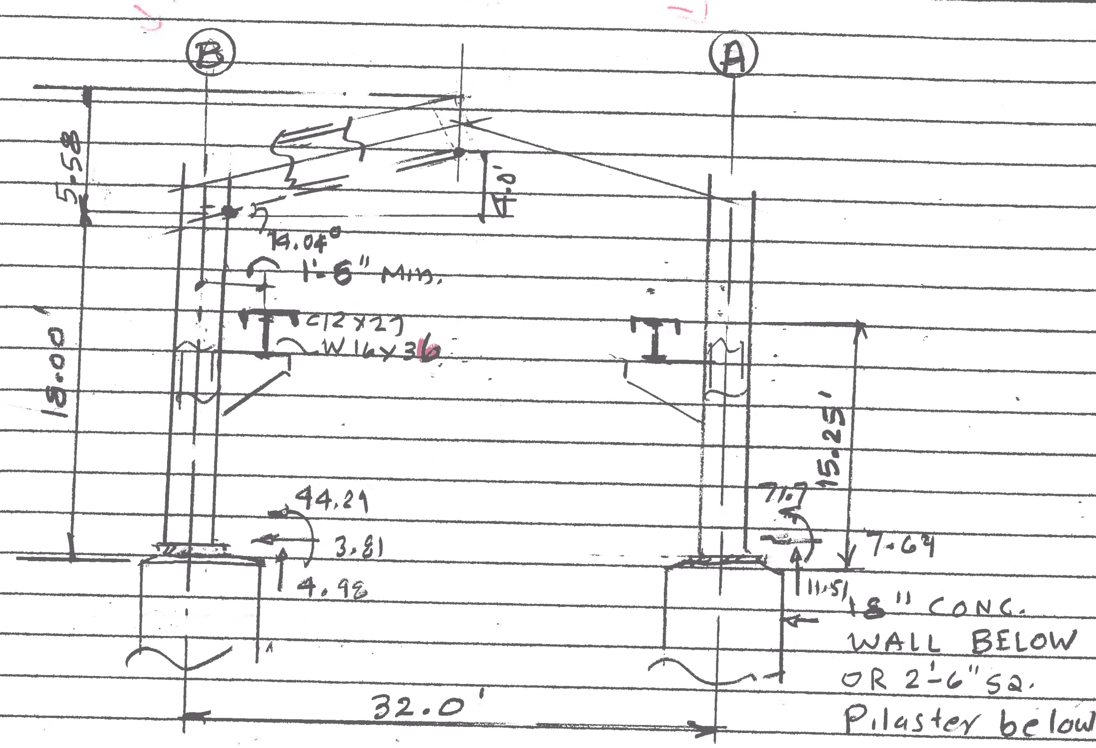
Project No. WW-PEG-2174-043062

Project Description: Frame @ Col. line (3) Load Combinations



Following Load combinations for Frame Design considered

$Q_E = Q_\ell$ = Seismic P_W = wind

Include Roof DL

DL = .02 x 25 = .50 k/'

See pg. 12 for Seismic (Q_ℓ) & Wind (P_W)

Q_ℓ = 5.0 (Mom. Fr.), Q_ℓ = 9.1k (Br. Fr.)

P_W = 5k (Br. Fr.), P_W = 10.0 (Mom. Fr.)

1. D + L
2. 1.057 D + 2.1 Q_ℓ
3. .543 D + 2.1 Q_ℓ
4. Roof D + WIND P_W
5. Roof D + .75 L + .75 P_W
6. Roof D + Crane (D+L) + 2.1 Q_ℓ

Assume crane is not operating during earthquake. Hence no impact nor horiz. loads due to operation

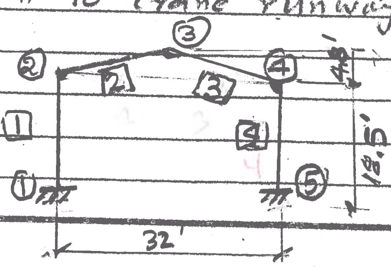
Crane Loads (2 T capacity) Single Girder/Wheel Crane

Assume DL = 1k (including bridge girder & crane)

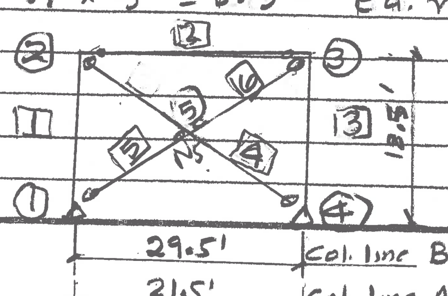
Crane D+L = 1 + 4 = 5k

⊥ar to crane runway = .2 x 5 = 1.0k 0.5k ea. beam

|| al to crane runway = .1 x 5 = 0.5k ea. runway bm.



ALL MOM. CONN.'s



ALL PIN CONN.'s

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Project No. WW-PEG-2174-043062		Sheet No. 15

Project Description: Crane Runway Design.

Single Bridge (Girder) $l = 32 - 2\times1.5 = 29'$

$P = (1.0 + 4)\times1.25 = 6.25^k$ $R_{(max.)} = \frac{6.25\times27.5}{29} = 5.93^k$

$M = \frac{6.25\times29}{4} = 45.3^{'k}$

for $l_u = 27.5'$ Bm W 14x48 $M_A = \frac{86}{1.67} = 51.5^{'k}$

Try W 14x61 $I_x = 640$ $I_y = 107$

$S_x = 92.1$ $S_y = 21.5$

$\Delta_A = \frac{29\times12}{600} = 0.58''$ $\Delta_a = \frac{Pl^3}{48EI} = \frac{6.25\times29^3}{48\times29000\times640}\times1728 = .30'' < .58''$

Note: Crane Bridge Girder size for reference only however it shall be designed by Crane Manufacturer.

Crane Runway Beam

Max. Span = 29.5' $P_{max} = 5.93^k$ Say 6^k

$M_{x\,max} = \frac{6\times29.5}{4} = 44.25^{'k}$ $R_{(Max)} = 6^k$ $M_{y\,max} = \frac{1.2\times29.5}{4} = 8.85^{'k}$

C 12x20.7 / W16x36

Try W 16x36 w/ C 12x20.7 CH. (AISC-pg. 1-112)

$I = 670\ in^4$, $S_{1\,(BOT.)} = 62.8$ $S_{2\,(TOP)} = 123$ $S_y = 25.6$ $I_y = 153$

$r = 6.34$

$A = 16.69\ in^2$

$f_{bx\,(BOT.)} = \frac{44.25\times12}{62.8} = 8.45^{ksi}$ $f_{by\,(TOP)} = \frac{8.85\times12}{25.6} = 4.15^{ksi}$

$f_{bx} + f_{by} = 8.45 + 4.15 = 12.6^{ksi} < .6F_y$ ok

$\Delta_{max} = \frac{6\times(29.5)^3}{48\times29000\times670}\times1728 = .285'' < \frac{l}{600} = .59''$ ok

Crane Col (WIND + Crane) pg. 3

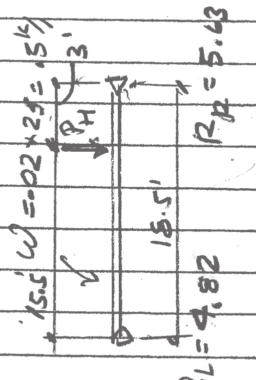
Vert. $P_{max} = 6^k$ (Crane) $+ \frac{20}{2}$ (Roof DL only) $= 16^k = P_V$

Horiz. $P_H = .2\times6 = 1.2^k$ $W_W = .5^{k/'}$

$R_R = \frac{.5\times18.5}{2} + \frac{1.2\times15.5}{18.5} = 5.63^k$ $R_L = 4.82^k$

$M_{max} = 4.82\times\frac{9.64}{2} = 23.23^{'k}$

$P_D = 16^k$



Include Crane LL: Crane col. - W10x45

See computer output for various combinations.

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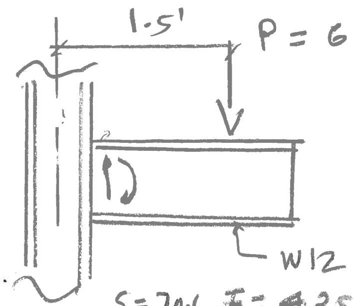
Project No. WW-PEG-2174			Sheet No. 158
Project Description: Crane Runway Design, Misc. Supports			

Reference:

Crane Runway Bm. Support



$S_x = 70.6$, $I_x = 425$
$S_y = 19.2$, $I_y = 95.8$

$M_{max} = 1.5 \times 6 = 9^{'k}$

(W12)

$\Delta_{xx} = \frac{PL^3}{3EI} = \frac{6 \times 1.5^3}{3 \times 29000 \times 425} \times 1728 = .001''$ very small

$f_{bx} = \frac{9 \times 12}{70.6} = 1.53^{ksi}$ very small

Δ_{yy} all small ok by insp.

W 12x53 ok

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Project No. WW-PEG-2124-043062		Sheet No. 16

Project Description Topock W.C. plant, Frames sizes & checks (outputs)

N-S Dir — Typical Mom. Fr.

(Topockgwr. mom. fr.)

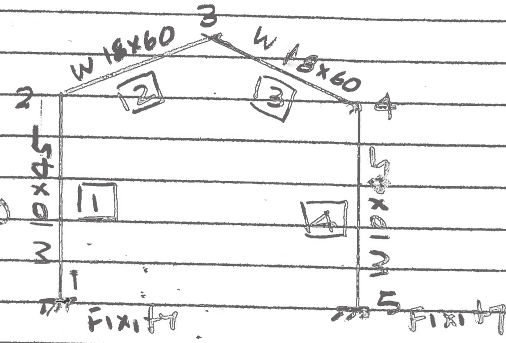
For size checks see page 26

Steel code checks (outputs)

Displacement (see Joint deflections)

Max. Defl. (JT. 4, Load case 6)

= 1.26" = δ_{xe} = Defl. by elastic An.



Max. Defl. $\delta_e = 2.4\,\delta_{xe}$ (pg. 12)

$= 2.4 \times 1.26 = 3.024" < .015 \times 18.5 \times 12 = 3.33"$ (Table 12-12-1 ASCE 7/10)

Assume $\rho = 1.0$ for Drift Calculations.

~~Design pilaster below for~~

Mom. Fr. Only — $M = 71.7^k$ $V_{max} = 7.69^k$ $R_{max} = 11.51^k$

(Topock wcp. braced frame A)

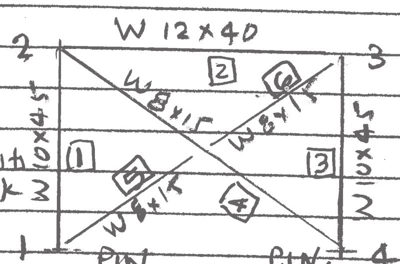
E-W Dir — Braced Frames

Line A — $V_{max} = 19.26^k$ $R_{max} = 21.13^k$

$R_{uplift} = 16.62^k \downarrow$ 12-1¼" φ A-36 Bolts & 24"x24" Basepl. - ok

Line B — $V_{max} = 19.28^k$ $R_{max} = 16.62^k$

$R_{uplift} = 12.11^k$ 12-1¼" φ A 36 A.B.'s w/ 24x24x1½ pl. ok (See page 22)



Wind Loads (see chapter 28, Part-2

Sect. 28.5 — Risk catagory II V = 110 mph.

Table 28.6.1 (pg. 304) Exp C, V = 110 mph $P_{s30} = 17.5$ PSF ($\theta = 18.4°$)

Wind press. — $P_w = P_s = \lambda K_{zt} P_{s30}$ (Eq. 28.6-1 pg. 306)

$P_{s30} = 17.5$ (Table 28.6.1) $\lambda = 1.35$ (pg. 305) (Mean ht. 25') $K_{zt} = 1.0$

$P_s = 1.35 \times 1 \times 17.5 = 23.6$ PSF Use 24 PSF

~~See output for Mom. Fr. w/ Comb Stiffness~~ — ~~Topock conc. Frame (4)~~ ~~For All loads see computer printout~~

~~Stiffness of Fr. = $\frac{1}{\Delta} = \frac{1}{.378} = 2.646$ → see note below~~

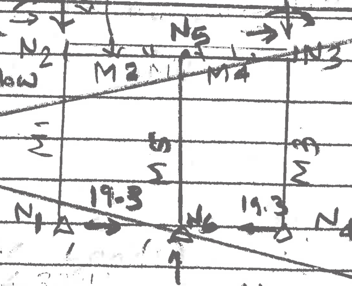
~~(Load comb. - 5)~~

~~Max. Reactions (DL+LL) $R_{max} = 45.6^k$ $V_{max} = 19.3^k$~~

~~Comb-3 DL + Seis. $V_{max} = 17.6^k$ $R_{max} = 108.3^k$ / 147.1^k~~

~~Note: $\Delta = \frac{100}{17.6} \times .092 = .829"$~~

~~Converted to reflect defl. for 100^k load~~



USE SHEAR WALLS @ COL. LINES (3), (4) & (5) See Calc's pg. 15

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Project Description Topock Steel Mom. fr. Base pl. & Anchor Bolts

Loads from pg.-26 computer output for Stl. Mom. frame
Also see Braced frame line-B

Load comb (5): $P_{max} = 22.55^k$ $M_{max} = 70.46^{'k}$ $V_{max} = 8.32^k$

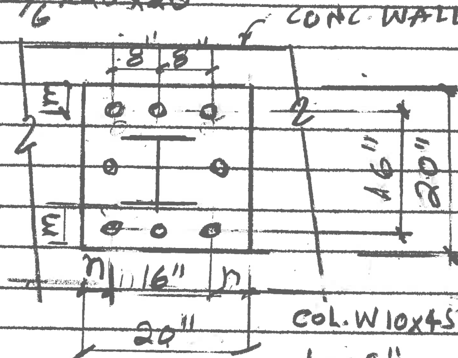
Base pl. (20" x 20" x 1" tk trial size)

$\frac{P}{A} = \frac{22.6}{20 \times 20} = .0565^{ksi}$ $\frac{M}{S} = \frac{70.46 \times 12}{1/6 \times 20 \times 20^2} = .634^{ksi}$

$f_p = .0565 + .634 = .69^{ksi}$

$n = \frac{B - .8 b_f}{2} = \frac{20 - .8 \times 8}{2} = 6.8''$

$m = \frac{N - .95 d}{2} = \frac{20 - .95 \times 10}{2} = 5.25''$



$t_{min} = 2m\sqrt{\frac{f_p}{F_y}}$ $F_y = 36^{ksi}$

↓ is used since this comp'n occurs in that direction.

$= 2 \times 5.25\sqrt{.69/36} = 1.45''$ (See calc's below for 24" x 24" pl.) *

$f'_c = 5^{ksi}$
$f_y = 60^{ksi}$

Anchor Bolts

Steel Mom. Frame

Max. Ten./Bolt $= T = \frac{70.46 \times 12}{16 \times 3} = 17.62^k$

Max Shear/Bolt $= V = \frac{8.32}{8} = 1.04^k$

Try $1\frac{1}{4}''\phi \times 18''$ A-36 Anchor Bolts [Table 3, 5, 6 Attached)

~~Allow. $T_a = 19.6^k$ for $E_d = 8.9''$ & $S_{de} = 19.8$ c/c bolts~~

~~$V_a = 10.2^k$ $m_t = 4.3$ = Edge dist. for tension~~

~~Due to overlapping cones. Since $S_d = 8'' < 19.8''$ (Arbitrary)~~
~~Increase embedment to 18" & Reduce cone area to 80%~~

~~$\frac{V}{V_a} + \frac{T}{T_a} = \frac{1.04}{10.2 \times .8} + \frac{17.62}{19.8 \times .8} = 1.23 \approx 1.2$ (20% increase for seismic or wind loads OK)~~

USE 24" x 24" x $1\frac{1}{2}''$ Base pl. w/ 8 - $1\frac{1}{4}''\phi \times 18''$ A. B.'s or

* $f_p = \frac{22.6}{24 \times 24} + \frac{70.46 \times 12}{1/6 \times 24 \times 24^2} = .406^{ksi}$ $t_{min} = 2 \times 7.25\sqrt{\frac{.406}{36}} = 1.54''$

$1\frac{1}{2}''$ Tk pl. OK

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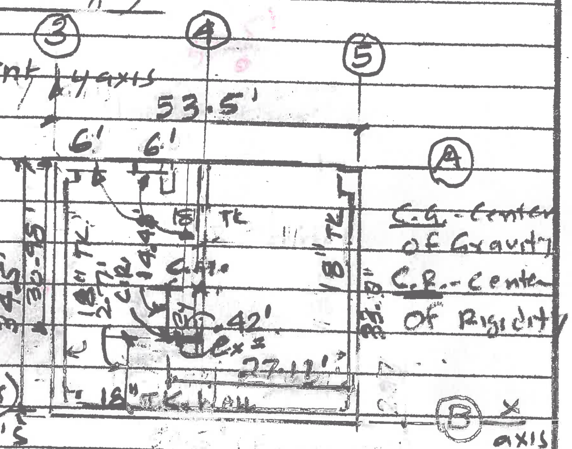
Project No. WW-PEG-2124-043062		Sheet No. 18

Project Description: Lateral Analysis, Topock W.C. plant, Shear Walls

Lateral Analysis (Lower Building)

0 Assume portion bet'n ③ & ④ is built now - Referred to as current Bldg

N S DIR. Distribute Shears



Diaph. @ 2nd Flr. is rigid diaph.
Assume C.G. of Floor in the center of floor in both direction
See charts for values of Δ_F
See attachments
Compute V_d and V_T (Torsional Shears)
R_x & R_y are stiffness in x & y dir.'s

Wall line	Ht.	d (Length)	h/d	Δ_F	R	Σ R
3	13'	34.5'	.377	.119	8.40	
5	13'	34.5	.377	.119	8.40	
4	13'	34.5	.377	.119	8.40	25.20 (ΣRy)
A	13	6.0	2.17	1.673	.598	
A	13	6.0	2.17	1.673	.598	
B	13	53.5	.243	.073	13.70	
						14.896 (ΣRx)

Locate C.R. of Floor w.r.t. front wall & Left wall (line 3)

$\bar{X} = \frac{8.40 \times 52.25 + 8.4 \times 26.75}{25.20} = 26.33'$ (From Y axis) $\quad e_x = \frac{53.5}{2} - 26.33 = .42'$

$\bar{Y} = \frac{2 \times .598 \times 34.5}{14.896} = 2.77'$ (From X axis) $\quad e_y = \frac{34.5}{2} - 2.77 = 14.48'$

Torsional Moments

$T_{NS} = V_T \times e_x = 125 \times .42 = 52.5^{1K}$ (pg 13) $\quad \frac{T_{NS}}{J} = \frac{52.5}{13202} = .04$

$T_{EW} = 125 \times 14.48 = 1810^{1K}$ $\quad \frac{T_{EW}}{J} = \frac{1810}{13202} = .137$

Torsional Shears

$J = X_R Y_R^2 + Y_R X_R^2 = .598(30.98)^2 \times 2 + 13.7 \times (2.02)^2 + 8.4 \times .42^2$
$+ 8.40(26.33)^2 + 8.40(27.11)^2 = 130202\ ft^2$

wall ③ $V_{T3} = .04 \times 8.4 \times 26.33 = 8.85^k$

$V_{T5} = .04 \times 8.4 \times 27.11 = 9.11^k$ $\quad V_{T4} = .04 \times 8.4 \times .42 = .14^k$

Wall Ⓐ $V_{TA} = .137 \times .598 \times 30.98 = 2.54^k$ $\quad V_{TB} = .137 \times 13.7 \times 2.02 = 3.79$

Formula for shears: NS DIR. $V_T = \frac{T_{NS}}{J} \times R_y X_R$ $\quad$ EW DIR $V_T = \frac{T_{EW}}{J} \times R_x Y_R$

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Project Description Lateral Analysis, Shear Walls Topock W.C. plant

Lateral Analysis Shear Walls

For ΣR_x & ΣR_y & V_T see pg. 17

Wall direct Shears + Torsional shear = V

Wall Line	Wall R_x or R_y	$\frac{R_x}{\Sigma R_x}$ or $\frac{R_y}{\Sigma R_y}$	V_d Direct Shear	V_T Torsional pg. 18	$V = Q_E$	$V' = \frac{2.5\,Q_E}{.80\,l}$	v ksi
(3)	8.4	.333	41.63	8.85k	50.48	5.72	.044
(4)	8.4	.334	41.75	.14	41.89	4.73	.036
(5)	8.4	.333	41.63	9.11	50.74	5.75	.044
(A)	.598	.04	5.0	2.54	7.54	4.91	.038
(B)	13.79	.92	115.0	3.79	118.79	8.67	.067

~~for shear & torsion $\Phi = .75$ ACI 9.3.2.3~~

$\lambda = 1.0$

ACI 11.9.5 — ~~Allow. Shear $V_{all} = 2\lambda\sqrt{f_c'}\,hd$~~ ~~$= 2\times1\sqrt{5000}\times.8l$~~ $hd = .8\,l_w$

$d = 18 - 2.5 = 15.5''$

~~$v = \frac{V_u}{\Phi} = \frac{2.5V/l}{.8\times.75\times12\times18} = 0.00772\,V'$~~ where $V \to$ kips, $l \to$ ft

Allow. $v_c = 2\sqrt{5000} = 141.42^{psi} > v$ (Table above) ok

11.9.9.1 — ~~No shear reinforcement reqd.~~

R 11.9.9 — $\frac{h_w}{l_w} = \frac{14}{53} = .26 < .5$ ~~provide vert. Reinf. equal to~~ horiz. reinf.

Min. vert. reinf. $= .0025\times12\times18 = .54\ in^2$

#6 @ 18" ea. face $A_{sa} = .44\times\frac{12}{18}\times2 = .587\ in^2$

Min. horiz. reinf. $= .0025\times12\times18 = .54$

#6 @ 18" e.a. face $A_{sa} = .587 > .54\ in^2$ ok

Provide Reinf. based on overturning for short walls

DL on walls + Seismic as per Combinations 5 & 7 page 13

Line (A) — ~~$M_o = 2.5\times7.54\times14 = 263.9^{1k}$~~ ~~$M_R = .819(.225\times14\times\frac{6^2}{2}) = 56.7^{1k}$~~

See comb.'n pg. 13 — ~~$M_o - M_R = 263.9 - .9\times56.2 = 213.32$~~

$P_{uplift} = (213.3)/.8\times6 = 44.2^k$ $P_c = \frac{263.9}{.8\times6} + 1.28\times.225\times14\times6 = 47.1^k$

Line (3) — $M_o = 2.5\times50.48\times14 = 1766.8^{1k}$ $M_R = .819(.225\times14\times\frac{33^2}{2}) = 1404.7^{1k}$

$P_u = \frac{(1766.8 - .9\times1404.7)}{.8\times33.0} = 19.04^k$ $P_c = \frac{1766.8}{.8\times33} + 1.28\times.225\times14\times3 = 79.0^k$

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Project No. WN-PEG-2124-043062		Sheet No. 20

Project Description: Lateral Analysis, Shear wall columns Topock w.c. plant

Line (A) Pilasters

Try pilaster 18 x 24" as conc. wall

Line (A) See pg. 18 for forces

$\phi P_n = .55\phi f_c' A_g \left[1 - \left(\frac{k l_c}{32h}\right)^2\right]$ $l_c = 14'$ $k = 2$, $h = 18"$

$= .55 \times .7 \times 5 \times 18 \times 24 \left[1 - \left(\frac{2 \times 14 \times 12}{32 \times 18}\right)^2\right]$ $A_g = 18" \times 24"$

$= .55 \times .7 \times 5 \times 18 \times 24 [1 - .34]$

$= 548.62^k > 67 + 12$ (Roof) $= 79^k$

USE 6 - #6 vert. Bars in 18"x24" pilaster

6 - #6 Ten. cap. = .90 x 6 x .44 x 60 = 142.6^k > 44.2^k

Line (3) See pg 18: To accomodate Base pl. from from above 30" width is required so Try 30"x30" pilasters

$\phi P_n = .55 \times .7 \times 5 \times 30 \times 30 \left[1 - \left(\frac{2 \times 14 \times 12}{32 \times 30}\right)^2\right]$

$= 1732.5 [1 - (.34)^2]$ (Roof DL + Seis.)

$= 1520.3^k > 79.0 + 12 = 91^k$

9 - #8 Bars for pilaster.

Ten. Cap. = .9x9x.79x60 = 384 > 19^k (pg. 19)

Min. A for col. = .01x30x30 = 9.0 in² 12-#8 Bars reqd.

USE 12 - #8 BARS for 30"x30" col. w/ #4 Ties @ 12" o/c

Line (5) See pg 11:

$M_o = 2.5 \times 50.74 \times 14 = 1775.9^{k'}$ $M_R = .819(.225 \times 14 \times 33^2)/2 = 1404.7^{k'}$

$P_u = \frac{(1775.9 - .9 \times 1404.7)}{.8 \times 33.0} = 19.04^k$

$P_c = 79 + 12 = 91^k$ (see pg. 19 for Line (3))

Ten. is very small

USE 30"30" Pilaster OR column w/ 12 - #8 BARS

See Details 4/S-12-11 And 2/S-12-16, provide #4 Ties @ 12"

(See pg. 11) Other Reinf. - for shear wall also a Retaining Wall (pg. 11)

2 - #6 @ 12" vert Reinf. 2-#6 @ 15" horiz. bars

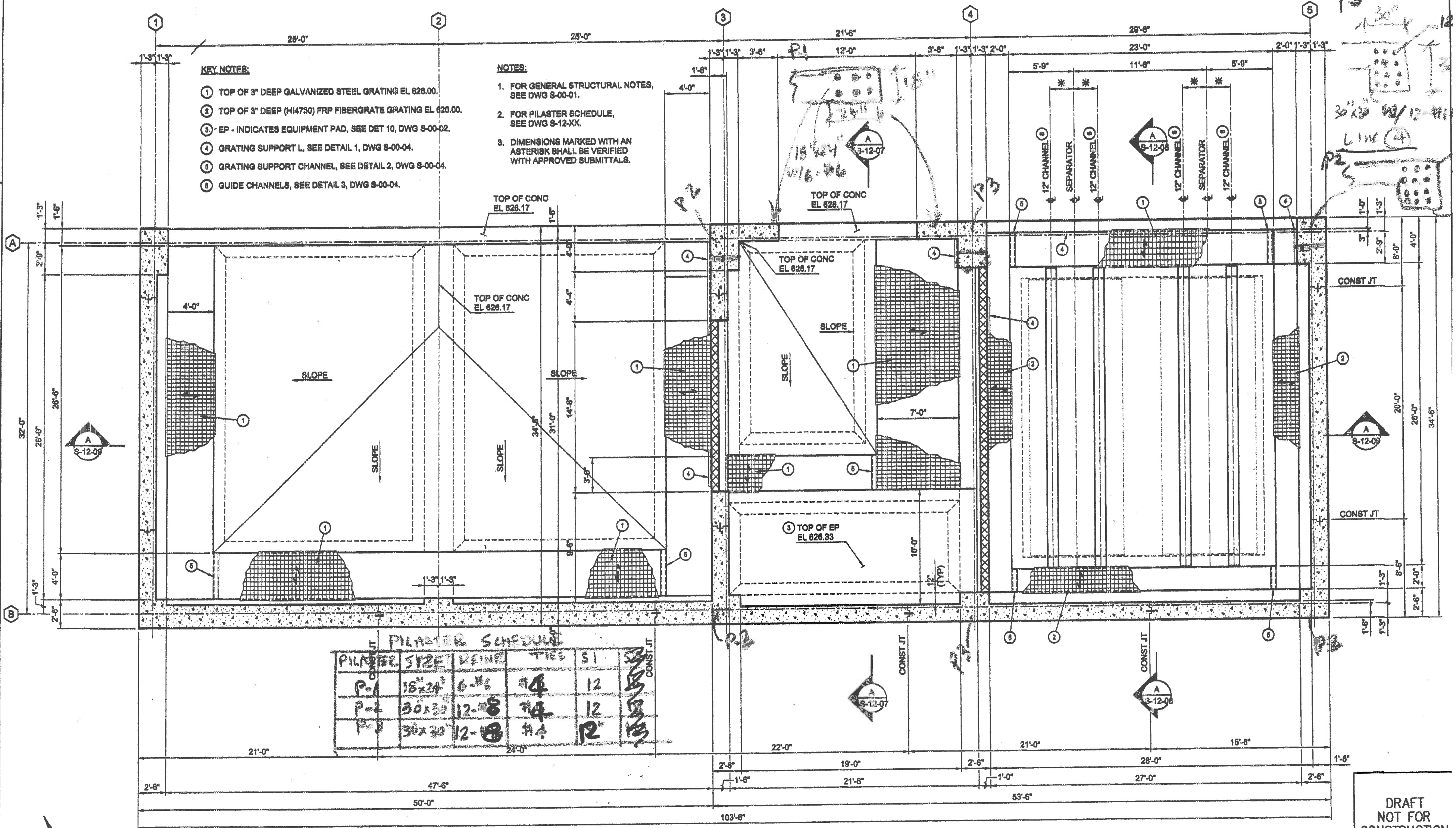
2 #6 @ 15" vert. bars

Line (B) (see pg. 10) See page 10 & 11 for Basement Retaining wall Calc's

9 - #8 Bars in pilaster 30"x30" vert. Reinf. - But #9 @ 12" (O.F.)

7 # @ 15" Horiz. Reinf ea. face (E.F.) #9 @ 18" (I.F.)

pg-21



KEY NOTES:

1. TOP OF 3" DEEP GALVANIZED STEEL GRATING EL 626.00.
2. TOP OF 3" DEEP (HI4730) FRP FIBERGRATE GRATING EL 626.00.
3. EP - INDICATES EQUIPMENT PAD, SEE DET 10, DWG S-00-02.
4. GRATING SUPPORT L, SEE DETAIL 1, DWG S-00-04.
5. GRATING SUPPORT CHANNEL, SEE DETAIL 2, DWG S-00-04.
6. GUIDE CHANNELS, SEE DETAIL 3, DWG S-00-04.

NOTES:

1. FOR GENERAL STRUCTURAL NOTES, SEE DWG S-00-01.
2. FOR PILASTER SCHEDULE, SEE DWG S-12-XX.
3. DIMENSIONS MARKED WITH AN ASTERISK SHALL BE VERIFIED WITH APPROVED SUBMITTALS.

PILASTER SCHEDULE

PILASTER	SIZE	REINF	TIES	S1	S2
P-1	18"x24"	6-#6	#4	12	[illegible]
P-2	30x30	12-#8	#4	12	[illegible]
P-3	30x30	12-#8	#4	12"	[illegible]

FIRST FLOOR PLAN

1/4" = 1'-0"

DRAFT NOT FOR CONSTRUCTION

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CH2MHILL.

REVISIONS

TOPOCK GROUNDWATER REMEDIATION PROJECT
REMEDY - PRODUCED WATER CONDITIONING PLANT
FIRST FLOOR PLAN
GAS TRANSMISSION & DISTRIBUTION
PACIFIC GAS AND ELECTRIC COMPANY
SAN FRANCISCO, CALIFORNIA

DSGN KJD | DRN WTH | CHKD VMB | DATE 4/5/13

S-12-02

C:\CAD\dwg\Topock\drawings\Structural\E2-S-XXX-1202.dwg, 2/23/2014 3:53:45 PM

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	Checked By:	Date:
	Revised By:	Date:
Project No. WW-PEB-2124-043062		Sheet No. 23

Project Description Topock W.C. plant, Foundation Design

~~**Footings (Concrete Frame columns)**~~

~~Max $P_u = 243.5^k$ Say 250^k $P = \frac{250}{1.6} = 156.2^k$~~

~~Allow. Soil press = 4^{KSF} $A_r = \frac{156.2}{4} = 39.06\ ft^2$~~

~~Size Reqd = $\sqrt{39.06} = 6.25$ ft.~~

~~Try 7-0" SQ. Ftg. Conc. Col. Size - 2.5' SQ.~~

~~WT. OF FTG. = 7.0 x 7.0 x 2 x .15 = 14.7^k~~

~~$p = \frac{(156.3+14.7)}{7.0 \times 7.0} = 3.5^{KSF}$ OK~~

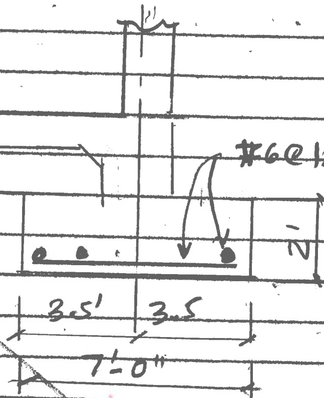
~~7'-0" SQ. FTG. Preferred.~~

~~$M_u = \frac{3.5 \times 1.6 \times 2.25^2}{2} = 14.2^{1k}$ @ Face of col.~~

~~Try #6 @ 12" o/c d = 24 - 3.5 = 21.5"~~

~~$\phi M_n = .9 \times .44 \times \frac{60}{12}\left(21.5 - \frac{.44 \times 60}{5 \times 12 \times 2}\right)$~~

~~$= 42^{1k} > 14.2$ OK~~



~~Check Shear~~

~~$v = \frac{3.5 \times 1.6 \times 2.25 \times 10^3}{12 \times 21.5 \times .85} = 57.5^{psi} < 2\sqrt{5000} = 141.4^{psi}$~~

~~Punching Shear @ dist. d/2 $= \frac{250000}{4 \times 21.5 \times 21.5 \times .85} = 159.1^{psi} < 4 \times \sqrt{5000}$ OK~~

~~USE 7'-0" SQ. FTG. W/ #6 @ 12" Ea. Way~~

Footings (Shear Walls Lines ③ ④ ⑤) COL. LINE A (current)

Max $P_{Footing} = \frac{P}{2} + .15 \times 2.5 \times 4 \times 8.5 + .15 \times 2 \times 8.5 \times 8.5 = 91 + 12.75 + 21.7 = 125.5^k$ USE 130^k

(29-20) Pedestal Ftg.

Soil press. $p = \frac{130}{6 \times 6} = 3.6^{KSF} < 4$ KSF OK.

$V_u = 3.60 \times 1.6 \times 1.75 = 16.08^{k}$ $v_u = \frac{10080}{.85 \times 12 \times 21.5} = 46.2 < 141.4$ OK

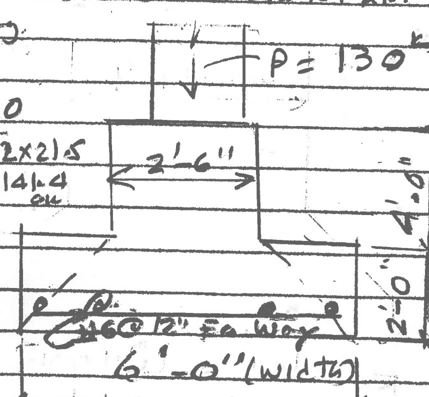
$M_u = 3.6 \times 1.6 \times 1.75^2 \times .5 = 8.82^{1k}$

$= 8.82^{1k}$

$\phi M_n = .9 \times .44 \times \frac{60}{12}\left(21.5 - \frac{.44 \times 60}{5 \times 12 \times 2}\right)$

$= 42^{1k} > 8.82^{1k}$

USE 6'-0" Continuous FTG Min. W/ #6 @ 12" Ea. Way



See Fdn. plan

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Project No.	WW-PEB-2124-043062	Sheet No. 24

Project Description Topock W.C. plant Fdn. Design

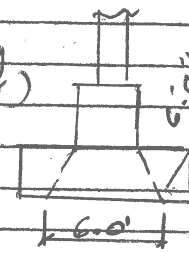
Footings (Shear wall line A)

Assume Cantilever Ret. wall for future building

Ref. Dwg. S12-07 Max. P_c @ pilaster = 103.6^k (18"x24" pilaster)

Try 6'-0" wide x 6'-0" Long Ftg.

$p = \frac{(103.6)/1.4}{6.0 \times 6.0} = 2.06^{KSF} < 4.0^{KSF}$



#6@12" Ea. Way @ bottom of Ftg.

Col. line 'B' WALL-A Footing & Cantilevered Retaining Wall OTM Design)

Level Backfill

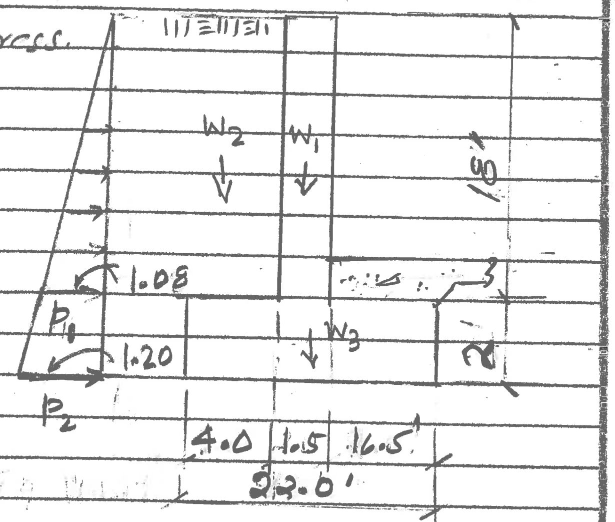
Design for 60 pcf. lateral press.

conc. $f_c' = 5^{ksi}$ $f_y = 60^{ksi}$

$P_1 = 60 \times 18 = 1080$ PSF

$P_2 = 60 \times 20 = 1200$ PSF

No Surcharge on the wall



Stability

$W_1 = 18 \times 1.5 \times .15 = 4.05^k$

$W_2 = 18 \times 4.0 \times .11 = 7.90^k$

$W_3 = 22.0 \times 2.0 \times .15 = 6.60$

$\Sigma W = 18.55^k$

@ FTG $M_O = 1.08 \times \frac{18}{2}(\frac{18}{3}+2) = 77.76^{1k}$

@ STEM $M_{OS} = 1.08 \times 18 \times .5 \times 18 \times .333 = 58.32^{1k}$ $V_S = 1.08 \times 18 \times .5 = 9.72$

M_R is very large ok by insp.

Soil press. is also ok by insp

STEM Design $M_{us} = 1.7 \times 58.32 = 99.15^{1k}$ $V_{us} = 1.7 \times 9.72 = 16.52^k$ $d = 18 - 2.5 = 15.5"$

Try #9 @ 8" o/c vert. Reinf. $v_u = \frac{16520}{.85 \times 15.5 \times 12} = 104.5^{PSI} < 2\sqrt{5000} = 141.4^{PSI}$ ok

$\phi M_n = .9 A_s f_y (d - \frac{a}{2})$ $a = \frac{A_s f_y}{f_c' b} = \frac{1.5 \times 60}{5 \times 12} = 1.5"$ ~~#4@8" Vert~~

$= \frac{.9 \times 1.5 \times 60}{12}(15.5 - \frac{1.5}{2})$

$= 99.56^{1k} > 99.15^{1k}$ USE #9@8" Soil Side & #8@12" Far side

Horiz Reinf. Min. $A_s = .0025 \times 18 \times 12 = .54^{in^2}$ #5@12" Ea. Face $A_{s_a} = 2 \times .31 = .62 in^2$ ok

~~Sliding~~ Sliding Resist. = $P_f + P_p = .35 \times 18.55 + .3 \times 6 \times \frac{6}{2} = 6.49 + 5.4 = 11.89^k > 9.72$ ok

Footing Reinf. $M_u = 1.4[(.11 \times 18 + .15 \times 2) \times \frac{4^2}{2}] = 25.54^{1k}$ (DL soil) $A_s = .002 \times 12 \times 15.5 = .37 in^2$

USE #6@12" @ T & B EA. WAY @ Footing

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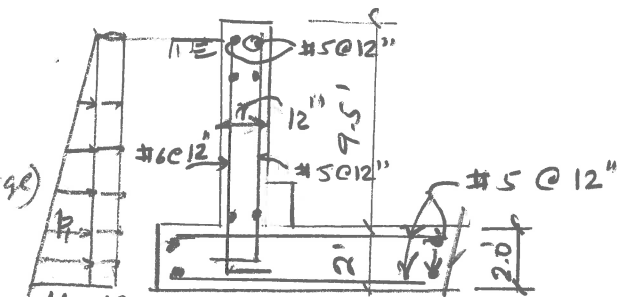
	Checked By:		Date:
	Reviewed By:		Date:
Project No.	WW PEB - 2174		Sheet No. 25
Project Description:	Topock Tank Area Retaining Walls		

Reference:

See sketch pg. 25A for Reference

Walls 'B' & 'C' Design



WALL 'B'

$p_1 = 60 \times 9 = 540$ PSF

$p_2 = 60 \times 11 = 660$ PSF

$p_3 = 60 \times 2 = 120$ PSF (surcharge)

STEM

$M_{O_1} = .54 \times \frac{9}{2} \times \frac{9}{3} + .12 \times 9 \times 4.5$

$= 7.29 + 4.86 = 12.15^{1k}$ (.66 = p_2, .12 = p_3)

FTG.

$M_{O_2} = .66 \times 11.5 \times .5 \times \frac{11.5}{3} + .12 \times 11.5 \times \frac{11.5}{2} = 14.55 + 7.94 = 22.49^{1k}$

Since Ftg is continuous mat No overturning Factor of Safety need to be calculated & soil press. is also ok by insp.

STEM Reinf.

$M_{O_{1u}} = 1.7 \times 12.15 = 20.66^{1k}$ $d = 18 - 2 - .5 = 15.5''$ (#6 @ 12")

$\phi M_n = .9 \times .44 \times \frac{60}{12} \left(15.5 - \frac{.5 A_s f_y}{.85 f_c' b}\right)$ $\frac{A_s f_y}{.85 f_c' b} = \frac{.44 \times 60}{.85 \times 5 \times 12} = .52''$

$= 30.18^{1k} > 20.66^{1k}$

Vert. Reinf. - USE #6 @ 12" Soil Side, & #5 @ 12" Far Side

Min. Horiz. Reinf. $= .0025 \times 12 \times 12 = .36 \text{ in}^2$ — #4 @ 12" Ea. Face

$A_{sa} = 2 \times .2 = .4 \text{ in}^2$

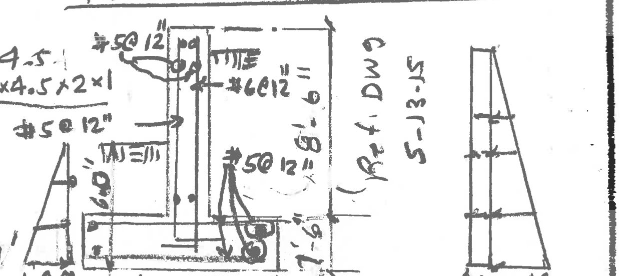
Footing min. $A = .002 \times 24 \times 12 = .576 \text{ in}^2$ — #6 @ 12" Ea way T & B $A_{sa} = 2 \times .31 = .62 \text{ in}^2 > .576$ ok

Wall 'C' Ht. of Stem 10.5' Ht. for design = 10'

Wall 'C' is similar to wall 'B' except Overturning design is required.

Stem wall Reinf. - Same as wall 'B'. Vert. Reinf. #6 @ 12" Soil side & #5 @ 12" F.S.

Horiz. Reinf. #4 @ 12" Ea. Face



$M_{O_2} = .48 \times \frac{9.5}{2} \times \frac{9.5}{3} + .12 \times 9.5 \times \frac{9.5}{2} = 12.64^{1k}$

$M_R = .15 \times 8.5 \times 1 \times 3 + .15 \times 6 \times 1.5 \times 3 + .11 \times 8 \times 3 \times 4.5$ (+ .11 × 4.5 × 2 × 1)

$= 1.275 \times 3 + 1.35 \times 3 + 2.64 \times 4.5 + .99 \times 1$

$= 20.75^{1k}$

$F.S. = (20.75/12.64) = 1.64 > 1.50$

$\bar{X} = \frac{M_R - M_O}{\Sigma W} = \frac{20.75 - 12.64}{6.255} = 1.29'$, $3\bar{X} = 3.89'$

$p = \frac{2 \times \Sigma W}{3 \times \bar{X} \times b} = \frac{2 \times 6.255}{3.89 \times 1} = 3.22$ ksf say 3.2 < 4.0 ksf ok

$V = .48 \times \frac{9.5}{2} + .12 \times 9.5 = 3.42^k$

Sliding Resist $= P_f + P_p = .35 \times 6.255 + .3 \times 6.0 \times \frac{6.0}{2} = 2.19 + 5.4 = 8.09^k > 3.42^k$ ok

FTG. Reinf. $M_u = \left(\frac{3.2 + 1.13}{2}\right) \times 2^2/2 \times 1.7 = 7.36^{1k}$ #5 @ 12" Ea. way @ BOT.

25A

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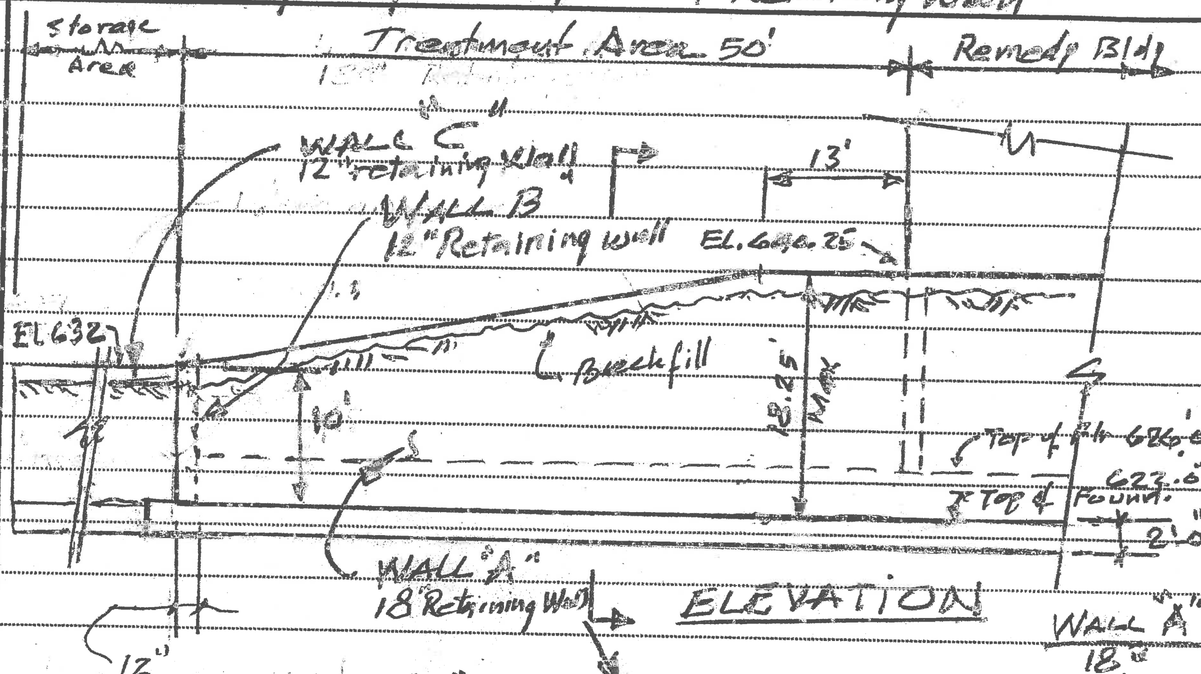
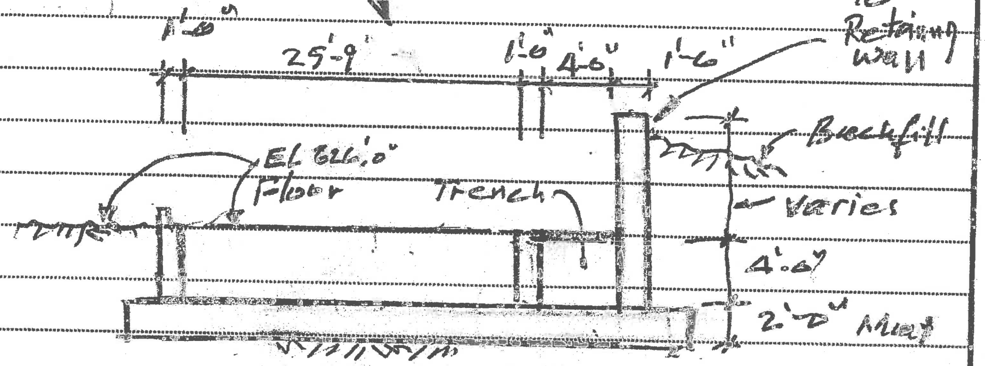
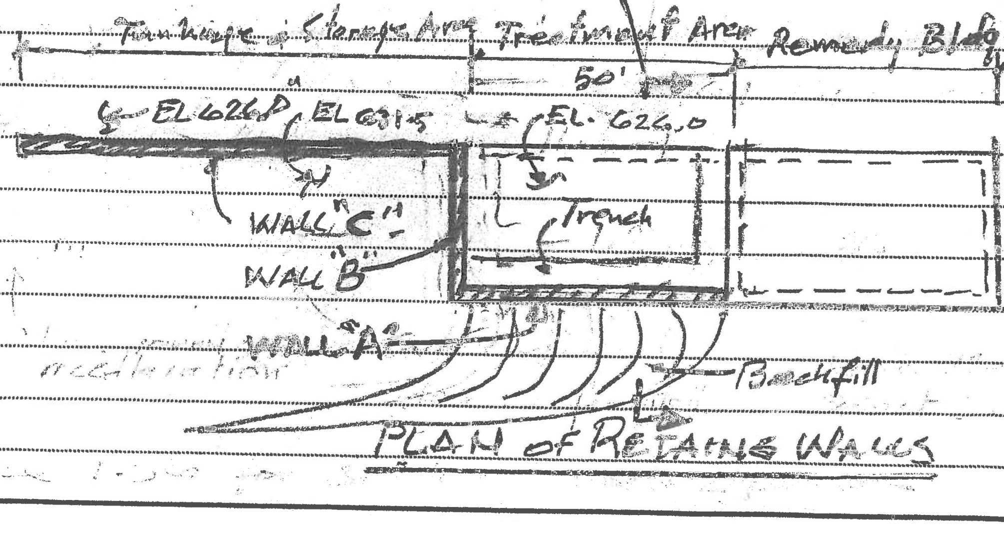
	Checked By:		Date:
	Reviewed By:		Date:
Project No.	W.W.W. PGE 2174		Sheet No. 2 of
Project Description:	Topock Ground Water Remediation Remedy Bldg Tankage Area Retaining Wall		

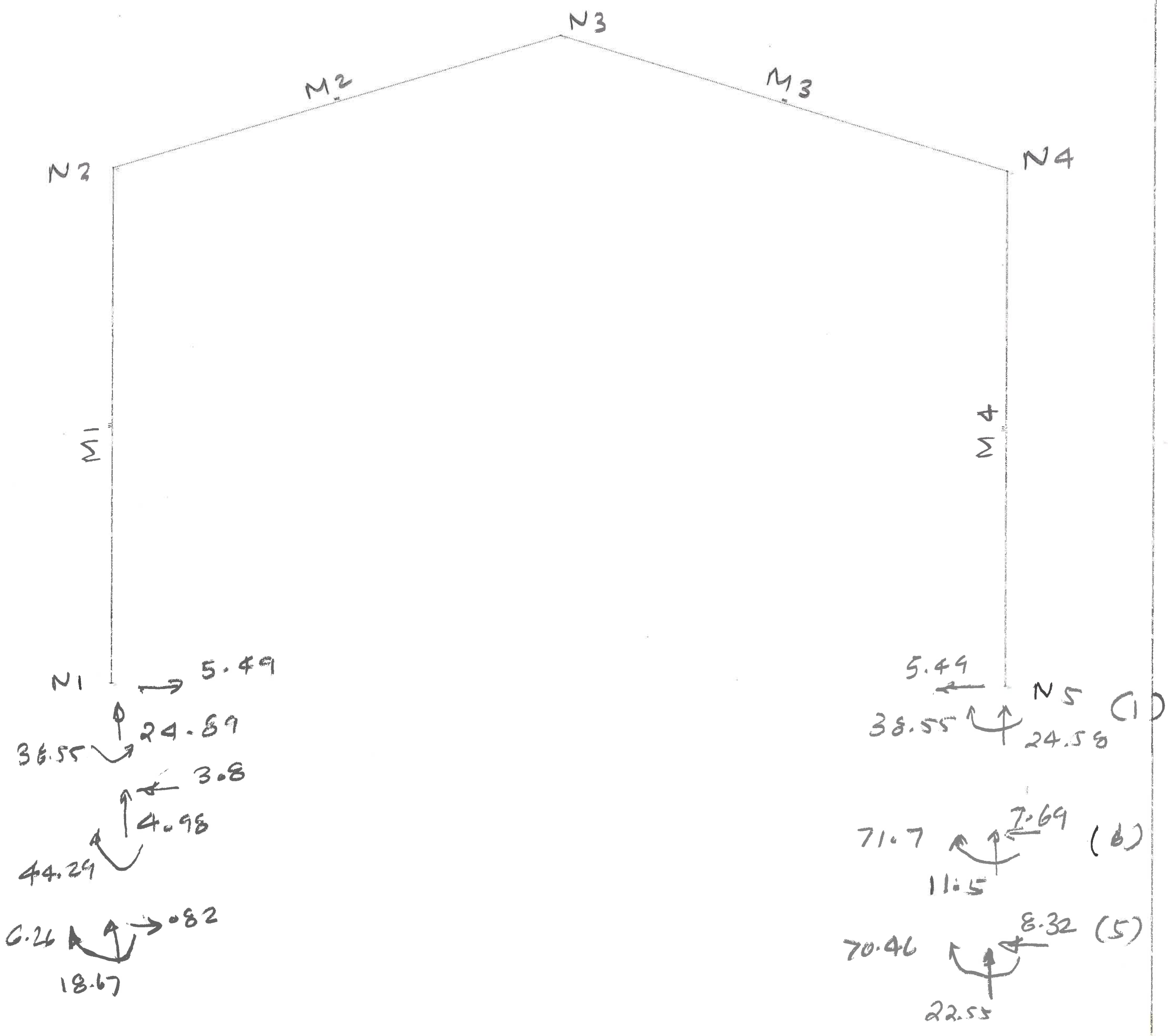
Reference:







For Load Comb. See pg. 2 of this Output



e-2	Steel	SK - 1
kd	topock water conditioning structure mom.frame	July 27, 2012 at 9:23 AM
ww-peg-2174-043062		topockgwr.momfr.r2d

Joint Loads and Enforced Displacements (BLC 3 : ql-seismic)

	Joint Label	L,D,M	Direction	Magnitude[(k,k-ft), (in,rad), (k*s^...
1	N2	L	X	2.5
2	N4	L	X	2.5

Joint Loads and Enforced Displacements (BLC 4 : P wind)

	Joint Label	L,D,M	Direction	Magnitude[(k,k-ft), (in,rad), (k*s^...
1	N2	L	X	5
2	N4	L	X	5

Joint Loads and Enforced Displacements (BLC 5 : P crane)

	Joint Label	L,D,M	Direction	Magnitude[(k,k-ft), (in,rad), (k*s^...
1	N2	L	X	.5
2	N4	L	X	.5

Joint Loads and Enforced Displacements (BLC 6 : M crane)

	Joint Label	L,D,M	Direction	Magnitude[(k,k-ft), (in,rad), (k*s^...
1	N2	L	M	-6.75

Basic Load Cases

	BLC Description	Category	X Gravity	Y Gravity	Joint	Point	Distributed
1	d	None					2
2	l	None					2
3	ql-seismic	None			2		
4	P wind	None			2		
5	P crane	None			2		
6	M crane	None			1		

Member Primary Data

	Label	I Joint	J Joint	Rotate(deg)	Section/Shape	Type	Design List	Material	Design Rules
1	M1	N1	N2		W10X45	Column	Wide Flange	A572 Gr.50	Typical
2	M2	N2	N3		W18X60	Beam	Wide Flange	A572 Gr.50	Typical
3	M3	N3	N4		W18X60	Beam	Wide Flange	A572 Gr.50	Typical
4	M4	N4	N5		W10X45	Column	Wide Flange	A572 Gr.50	Typical

Joint Boundary Conditions

	Joint Label	X [k/in]	Y [k/in]	Rotation[k-ft/rad]	Footing
1	N1	Reaction	Reaction	Reaction	
2	N5	Reaction	Reaction	Reaction	

Hot Rolled Steel Section Sets

	Label	Shape	Type	Design List	Material	Design Rules	A [in2]	I (90,270) [i...	I (0,180) [in4]
1	HR1A	W10X45	Column	Wide Flange	A572 Gr.50	Typical	13.3	53.4	248
2	HR2	W18X60	Beam	Wide Flange	A572 Gr.50	Typical	17.6	50.1	984

Member AISC 13th(360-05): ASD Steel Code Checks

	LC	Member	Shape	UC Max	Loc[ft]	Shear UC	Loc[ft]	Pnc/om [k]	Pnt/om [k]	Mn/om [...	Cb	Eqn
1	1	M1	W10X45	.543	18.5	.078	0	162.302	398.204	136.976	2.194	H1-1b
2	1	M2	W18X60	.379	15.312	.148	0	187.409	526.946	301.27	1.484	H1-1b
3	1	M3	W18X60	.379	1.392	.146	16.53	187.409	526.946	301.318	1.484	H1-1b

Member AISC 13th(360-05): ASD Steel Code Checks (Continued)

	LC	Member	Shape	UC Max	Loc[ft]	Shear UC	Loc[ft]	Pnc/om [k]	Pnt/om [k]	Mn/om [...	Cb	Eqn
4	1	M4	W10X45	.542	0	.078	0	162.302	398.204	136.976	2.194	H1-1b
5	2	M1	W10X45	.304	0	.048	0	162.302	398.204	136.976	2.191	H1-1b
6	2	M2	W18X60	.234	9.918	.034	0	187.409	526.946	215.148	1.059	H1-1b
7	2	M3	W18X60	.236	16.704	.069	16.53	187.409	526.946	306.886	2.501	H1-1b
8	2	M4	W10X45	.533	0	.103	0	162.302	398.204	136.976	2.267	H1-1b
9	3	M1	W10X45	.337	0	.061	0	162.302	398.204	136.976	2.221	H1-1b
10	3	M2	W18X60	.175	4.872	.020	16.53	187.409	526.946	215.852	1.063	H1-1b
11	3	M3	W18X60	.193	16.704	.044	16.53	187.409	526.946	306.886	2.408	H1-1b
12	3	M4	W10X45	.456	18.5	.089	0	162.302	398.204	136.976	2.264	H1-1b
13	4	M1	W10X45	.201	0	.028	0	162.302	398.204	136.976	2.166	H1-1b
14	4	M2	W18X60	.196	11.31	.036	0	187.409	526.946	223.128	1.099	H1-1b
15	4	M3	W18X60	.188	16.704	.061	16.53	187.409	526.946	306.886	2.237	H1-1b
16	4	M4	W10X45	.424	0	.080	0	162.302	398.204	136.976	2.26	H1-1b
17	5	M1	W10X45	.204	18.5	.011	0	162.302	398.204	136.976	1.38	H1-1b
18	5	M2	W18X60	.385	13.746	.110	0	187.409	526.946	255.808	1.26	H1-1b
19	5	M3	W18X60	.311	16.704	.135	16.53	187.409	526.946	306.886	1.696	H1-1b
20	5	M4	W10X45	.700	0	.120	0	162.302	398.204	136.976	2.235	H1-1b
21	6	M1	W10X45	.339	0	.054	0	162.302	398.204	136.976	2.194	H1-1b
22	6	M2	W18X60	.253	8.7	.028	0	187.409	526.946	211.352	1.041	H1-1b
23	6	M3	W18X60	.250	16.704	.069	16.53	187.409	526.946	306.886	2.592	H1-1b
24	6	M4	W10X45	.565	0	.110	0	162.302	398.204	136.976	2.27	H1-1b

Joint Coordinates and Temperatures

	Label	X [ft]	Y [ft]	Temp [F]
1	N1	0	0	0
2	N2	0	18.5	0
3	N3	16	23.3	0
4	N4	32	18.5	0
5	N5	32	0	0

Hot Rolled Steel Properties

	Label	E [ksi]	G [ksi]	Nu	Therm (\1E5 F)	Density[k/ft^3]	Yield[ksi]
1	A36 Gr.36	29000	11154	.3	.65	.49	36
2	A572 Gr.50	29000	11154	.3	.65	.49	50
3	A992	29000	11154	.3	.65	.49	50
4	A500 Gr.42	29000	11154	.3	.65	.49	42
5	A500 Gr.46	29000	11154	.3	.65	.49	46

Load Combinations

	Description	Solve	PDe...	SR...	BLC	Factor	BLC	Factor	BLC	Factor	BLC	Factor	BLC	Factor	BLC	Factor	BLC	Factor	BLC	Factor
1	d+l	Yes	Y		1	1	2	1												
2	d+ql	Yes	Y		1	1.057	3	2.1												
3	d1+ql	Yes	Y		1	.543	3	2.1												
4	d+Pw	Yes	Y		1	1	4	.75												
5	d+.75l+.75Pw	Yes	Y		1	1	2	.75	4	.75										
6	d+Pc+ql	Yes	Y		1	1	3	2.1	5	1	6	1								

Joint Reactions (By Combination)

	LC	Joint Label	X [k]	Y [k]	MZ [k-ft]
1	1	N1	5.493	24.894	-38.549
2	1	N5	-5.493	24.576	38.542
3	1	Totals:	0	49.47	

Joint Reactions (By Combination) (Continued)

	LC	Joint Label	X [k]	Y [k]	MZ [k-ft]
4	1	COG (ft):	X: 15.897	Y: 20.9	
5	2	N1	-3.33	5.921	39.204
6	2	N5	-7.17	11.509	66.308
7	2	Totals:	-10.5	17.43	
8	2	COG (ft):	X: 15.897	Y: 20.9	
9	3	N1	-4.272	1.673	45.461
10	3	N5	-6.228	7.281	59.387
11	3	Totals:	-10.5	8.954	
12	3	COG (ft):	X: 15.897	Y: 20.9	
13	4	N1	-1.925	6.264	24.844
14	4	N5	-5.575	10.226	50.469
15	4	Totals:	-7.5	16.49	
16	4	COG (ft):	X: 15.897	Y: 20.9	
17	5	N1	.82	18.674	6.261
18	5	N5	-8.32	22.551	70.464
19	5	Totals:	-7.5	41.225	
20	5	COG (ft):	X: 15.897	Y: 20.9	
21	6	N1	-3.808	4.983	44.291
22	6	N5	-7.692	11.507	71.697
23	6	Totals:	-11.5	16.49	
24	6	COG (ft):	X: 15.897	Y: 20.9	

Load Combination Design

	Description	ASIF	CD	ABIF	Service	Hot Rolled	Cold Form...	Wood	Concrete	Masonry	Footings	Aluminum
1	d+l					Yes	Yes	Yes	Yes	Yes	Yes	Yes
2	d+ql					Yes	Yes	Yes	Yes	Yes	Yes	Yes
3	d1+ql					Yes	Yes	Yes	Yes	Yes	Yes	Yes
4	d+Pw					Yes	Yes	Yes	Yes	Yes	Yes	Yes
5	d+.75l+.75Pw					Yes	Yes	Yes	Yes	Yes	Yes	Yes
6	d+Pc+ql					Yes	Yes	Yes	Yes	Yes	Yes	Yes

Joint Deflections (By Combination)

	LC	Joint Label	X [in]	Y [in]	Rotation [rad]
1	1	N1	0	0	0
2	1	N2	-.261	-.018	-5.875e-3
3	1	N3	0	-.899	2.512e-7
4	1	N4	.261	-.018	5.876e-3
5	1	N5	0	0	0
6	2	N1	0	0	0
7	2	N2	.968	-.004	-3.715e-3
8	2	N3	1.061	-.316	7.555e-4
9	2	N4	1.151	-.008	4.172e-4
10	2	N5	0	0	0
11	3	N1	0	0	0
12	3	N2	1.006	-.001	-2.7e-3
13	3	N3	1.054	-.162	7.507e-4
14	3	N4	1.1	-.005	-5.769e-4
15	3	N5	0	0	0
16	4	N1	0	0	0
17	4	N2	.67	-.005	-3.13e-3
18	4	N3	.757	-.299	5.393e-4
19	4	N4	.843	-.007	7.766e-4
20	4	N5	0	0	0
21	5	N1	0	0	0
22	5	N2	.553	-.013	-6.092e-3

Joint Deflections (By Combination) (Continued)

	LC	Joint Label	X [in]	Y [in]	Rotation [rad]
23	5	N3	.771	-.749	5.495e-4
24	5	N4	.988	-.016	3.695e-3
25	5	N5	0	0	0
26	6	N1	0	0	0
27	6	N2	1.082	-.004	-4.031e-3
28	6	N3	1.174	-.313	8.788e-4
29	6	N4	1.263	-.008	1.955e-4
30	6	N5	0	0	0

Member Section Forces

	LC	Member Label	Sec	Axial[k]	Shear[k]	Moment[k-ft]
1	1	M1	1	24.894	-5.539	-38.549
2			2	24.894	-5.539	-12.93
3			3	24.894	-5.539	12.69
4			4	24.894	-5.539	38.309
5			5	24.894	-5.539	63.928
6	1	M2	1	12.414	22.33	63.928
7			2	10.614	16.33	-16.798
8			3	8.814	10.33	-72.468
9			4	7.014	4.33	-103.08
10			5	5.306	-1.361	-108.67
11	1	M3	1	5.215	1.666	-108.67
12			2	7.015	-4.334	-103.098
13			3	8.815	-10.334	-72.47
14			4	10.615	-16.334	-16.785
15			5	12.323	-22.026	63.924
16	1	M4	1	24.576	5.539	63.924
17			2	24.576	5.539	38.308
18			3	24.576	5.539	12.691
19			4	24.576	5.539	-12.925
20			5	24.576	5.539	-38.542
21	2	M1	1	5.921	3.371	39.204
22			2	5.921	3.371	23.614
23			3	5.921	3.371	8.023
24			4	5.921	3.371	-7.568
25			5	5.921	3.371	-23.159
26	2	M2	1	3.541	5.125	-23.159
27			2	2.906	3.011	-40.148
28			3	2.272	.897	-48.31
29			4	1.638	-1.217	-47.643
30			5	1.036	-3.222	-38.159
31	2	M3	1	2.642	-2.134	-38.159
32			2	3.276	-4.248	-24.832
33			3	3.911	-6.362	-2.676
34			4	4.545	-8.476	28.309
35			5	5.146	-10.482	68.11
36	2	M4	1	11.509	7.266	68.11
37			2	11.509	7.266	34.506
38			3	11.509	7.266	.901
39			4	11.509	7.266	-32.703
40			5	11.509	7.266	-66.308
41	3	M1	1	1.673	4.284	45.461
42			2	1.673	4.284	25.646
43			3	1.673	4.284	5.831
44			4	1.673	4.284	-13.984
45			5	1.673	4.284	-33.799

Member Section Forces (Continued)

	LC	Member Label	Sec	Axial[k]	Shear[k]	Moment[k-ft]
46	3	M2	1	1.417	1.322	-33.799
47			2	1.091	.236	-37.053
48			3	.766	-.85	-35.771
49			4	.44	-1.936	-29.955
50			5	.131	-2.966	-19.609
51	3	M3	1	1.742	-2.408	-19.609
52			2	2.068	-3.494	-7.284
53			3	2.394	-4.58	9.576
54			4	2.72	-5.666	30.971
55			5	3.029	-6.696	56.895
56	3	M4	1	7.281	6.286	56.895
57			2	7.281	6.286	27.825
58			3	7.281	6.286	-1.246
59			4	7.281	6.286	-30.317
60			5	7.281	6.286	-59.387
61	4	M1	1	6.264	1.955	24.844
62			2	6.264	1.955	15.802
63			3	6.264	1.955	6.761
64			4	6.264	1.955	-2.281
65			5	6.264	1.955	-11.322
66	4	M2	1	3.548	5.481	-11.322
67			2	2.948	3.481	-30.034
68			3	2.348	1.481	-40.394
69			4	1.748	-.519	-42.401
70			5	1.179	-2.417	-36.067
71	4	M3	1	2.318	-1.382	-36.067
72			2	2.918	-3.382	-26.12
73			3	3.518	-5.382	-7.821
74			4	4.118	-7.382	18.831
75			5	4.687	-9.279	53.824
76	4	M4	1	10.226	5.637	53.824
77			2	10.226	5.637	27.75
78			3	10.226	5.637	1.677
79			4	10.226	5.637	-24.396
80			5	10.226	5.637	-50.469
81	5	M1	1	18.674	-.746	6.261
82			2	18.674	-.746	9.709
83			3	18.674	-.746	13.158
84			4	18.674	-.746	16.607
85			5	18.674	-.746	20.056
86	5	M2	1	9.743	16.615	20.056
87			2	8.243	11.615	-38.89
88			3	6.743	6.615	-76.956
89			4	5.243	1.615	-94.141
90			5	3.82	-3.128	-90.472
91	5	M3	1	4.934	-.591	-90.472
92			2	6.434	-5.591	-77.562
93			3	7.934	-10.591	-43.771
94			4	9.434	-15.591	10.9
95			5	10.857	-20.335	86.425
96	5	M4	1	22.551	8.48	86.425
97			2	22.551	8.48	47.202
98			3	22.551	8.48	7.98
99			4	22.551	8.48	-31.242
100			5	22.551	8.48	-70.464
101	6	M1	1	4.983	3.847	44.291
102			2	4.983	3.847	26.499

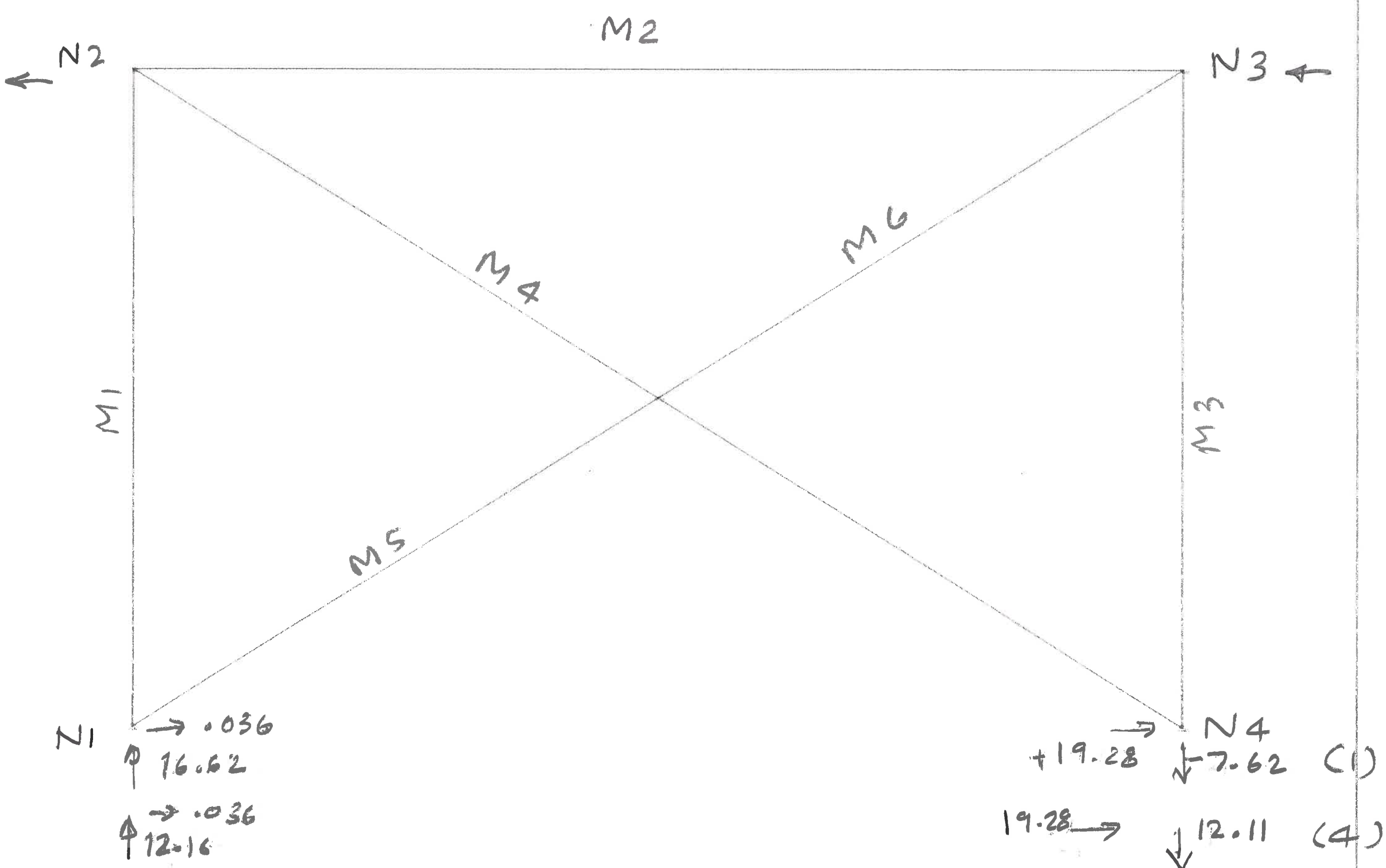
Member Section Forces (Continued)

	LC	Member Label	Sec	Axial[k]	Shear[k]	Moment[k-ft]
103			3	4.983	3.847	8.707
104			4	4.983	3.847	-9.085
105			5	4.983	3.847	-26.877
106	6	M2	1	3.292	4.22	-33.627
107			2	2.692	2.22	-47.074
108			3	2.092	.22	-52.168
109			4	1.492	-1.78	-48.91
110			5	.923	-3.677	-37.311
111	6	M3	1	2.797	-2.577	-37.311
112			2	3.397	-4.577	-22.374
113			3	3.997	-6.577	.916
114			4	4.597	-8.577	32.558
115			5	5.167	-10.474	72.542
116	6	M4	1	11.507	7.797	72.542
117			2	11.507	7.797	36.482
118			3	11.507	7.797	.422
119			4	11.507	7.797	-35.637
120			5	11.507	7.797	-71.697

Material Takeoff

	Material	Size	Pieces	Length[ft]	Weight[K]
1	Hot Rolled Steel				
2	A572 Gr.50	W10X45	2	37	1.7
3	A572 Gr.50	W18X60	2	33.4	2
4	Total HR Steel		4	70.4	3.7

Col line (B) - Braced Frame



E2	Frame B ~~Frame A~~ topock wcs braced frame	SK - 1
kd		July 27, 2012 at 9:14 AM
ww-peg-2174-043062		topockwcp. braced frame A.r2d

Joint Coordinates and Temperatures

	Label	X [ft]	Y [ft]	Temp [F]
1	N1	0	0	0
2	N2	0	18.5	0
3	N3	29.5	18.5	0
4	N4	29.5	0	0
5	N5	14.75	9.25	0

Member Primary Data

	Label	I Joint	J Joint	Rotate(deg)	Section/Shape	Type	Design List	Material	Design Rules
1	M1	N1	N2		W10x45	Column	Wide Flange	A572 Gr.50	DR1
2	M2	N2	N3		W12x40	Beam	Wide Flange	A572 Gr.50	DR1
3	M3	N3	N4		W10x45	Column	Wide Flange	A572 Gr.50	DR1
4	M4	N4	N2		W6x15	VBrace	Wide Flange	A572 Gr.50	DR1
5	M5	N1	N5		W6x15	VBrace	Wide Flange	A572 Gr.50	DR1
6	M6	N5	N3		W6x15	VBrace	Wide Flange	A572 Gr.50	DR1

Joint Loads and Enforced Displacements (BLC 1 : d)

	Joint Label	L,D,M	Direction	Magnitude[(k,k-ft), (in,rad), (k*s^2/ft...
1	N2	L	Y	-5
2	N3	L	Y	-8

Joint Loads and Enforced Displacements (BLC 2 : Pcr)

	Joint Label	L,D,M	Direction	Magnitude[(k,k-ft), (in,rad), (k*s^2/ft...
1	N2	L	Y	-5
2	N3	L	Y	-5

Joint Loads and Enforced Displacements (BLC 3 : ql)

	Joint Label	L,D,M	Direction	Magnitude[(k,k-ft), (in,rad), (k*s^2/ft...
1	N2	L	X	-4.6
2	N3	L	X	-4.6

Joint Loads and Enforced Displacements (BLC 4 : Pw)

	Joint Label	L,D,M	Direction	Magnitude[(k,k-ft), (in,rad), (k*s^2/ft...
1	N2	L	X	-2.5
2	N3	L	X	-2.5

Hot Rolled Steel Section Sets

	Label	Shape	Type	Design List	Material	Design Rules	A [in2]	I (90,270) [i...	I (0,180) [in4]
1	HR1A	W12x40	Beam	Wide Flange	A572 Gr.50	DR1	11.7	44.1	307
2	HR2	W10x45	Column	Wide Flange	A572 Gr.50	DR1	13.3	53.4	248
3	HR3	W6x15	VBrace	Wide Flange	A572 Gr.50	DR1	4.43	9.32	29.1

Basic Load Cases

	BLC Description	Category	X Gravity	Y Gravity	Joint	Point	Distributed
1	d	None			2		
2	Pcr	None			2		
3	ql	None			2		
4	Pw	None			2		

Load Combinations

	Description	Solve	PD...	SR...	BLC	Factor	BLC	Factor	BLC	Factor	BLC	Factor	BLC	Factor	BLC	Factor	BLC	Factor	BLC	Factor
1	d+Pcr+ql	Yes	Y		DL	1.057	2	.9	3	2.1										
2	d+Pcr+ql	Yes	Y		DL	.543	2	.9	3	2.1										
3	d+PwPcr	Yes	Y		DL	1	2	.9	4	.75										
4	d+ql	Yes	Y		DL	.543	3	2.1												
5	d+Pw	Yes	Y		DL	1	4	.75												

Joint Reactions (By Combination)

	LC	Joint Label	X [k]	Y [k]	MZ [k-ft]
1	1	N1	.036	16.62	0
2	1	N4	19.284	-7.62	0
3	1	Totals:	19.32	9	
4	1	COG (ft):	X: 14.75	Y: 18.5	
5	2	N1	.036	16.62	0
6	2	N4	19.284	-7.62	0
7	2	Totals:	19.32	9	
8	2	COG (ft):	X: 14.75	Y: 18.5	
9	3	N1	.006	6.853	0
10	3	N4	3.744	2.147	0
11	3	Totals:	3.75	9	
12	3	COG (ft):	X: 14.75	Y: 18.5	
13	4	N1	.038	12.116	0
14	4	N4	19.282	-12.116	0
15	4	Totals:	19.32	0	
16	4	COG (ft):	NC	NC	
17	5	N1	.006	2.352	0
18	5	N4	3.744	-2.352	0
19	5	Totals:	3.75	0	
20	5	COG (ft):	NC	NC	

Joint Deflections

	LC	Joint Label	X [in]	Y [in]	Rotation [rad]
1	1	N1	0	0	0
2	1	N2	-.117	-.012	0
3	1	N3	-.127	-.003	0
4	1	N4	0	0	0
5	1	N5	-.027	.043	1.728e-4
6	2	N1	0	0	0
7	2	N2	-.117	-.012	0
8	2	N3	-.127	-.003	0
9	2	N4	0	0	0
10	2	N5	-.027	.043	1.728e-4
11	3	N1	0	0	0
12	3	N2	-.024	-.005	0
13	3	N3	-.026	-.003	0
14	3	N4	0	0	0
15	3	N5	-.005	.008	4.091e-5
16	4	N1	0	0	0
17	4	N2	-.115	-.009	0
18	4	N3	-.125	0	0
19	4	N4	0	0	0
20	4	N5	-.027	.043	1.636e-4
21	5	N1	0	0	0
22	5	N2	-.022	-.002	0
23	5	N3	-.024	0	0

Joint Deflections (Continued)

	LC	Joint Label	X [in]	Y [in]	Rotation [rad]
24	5	N4	0	0	0
25	5	N5	-.005	.008	3.176e-5

Load Combination Design

	Description	ASIF	CD	ABIF	Service	Hot Rolled	Cold Form...	Wood	Concrete	Masonry	Footings	Aluminum
1	d+Pcr+ql					Yes	Yes	Yes	Yes	Yes	Yes	Yes
2	d+Pcr+ql					Yes	Yes	Yes	Yes	Yes	Yes	Yes
3	d+PwPcr					Yes	Yes	Yes	Yes	Yes	Yes	Yes
4	d+ql					Yes	Yes	Yes	Yes	Yes	Yes	Yes
5	d+Pw					Yes	Yes	Yes	Yes	Yes	Yes	Yes

Member Section Forces

	LC	Member Label	Sec	Axial[k]	Shear[k]	Moment[k-ft]
1	1	M1	1	16.589	0	0
2			2	16.589	0	0
3			3	16.589	0	0
4			4	16.589	0	0
5			5	16.589	0	0
6	1	M2	1	9.664	0	0
7			2	9.664	0	0
8			3	9.664	0	0
9			4	9.664	0	0
10			5	9.664	0	0
11	1	M3	1	4.5	0	0
12			2	4.5	0	0
13			3	4.5	0	0
14			4	4.5	0	0
15			5	4.5	0	0
16	1	M4	1	-22.78	.016	0
17			2	-22.78	.016	-.14
18			3	-22.806	-.016	-.281
19			4	-22.806	-.016	-.14
20			5	-22.806	-.016	0
21	1	M5	1	.058	0	0
22			2	.058	0	0
23			3	.058	0	0
24			4	.058	0	0
25			5	.058	0	0
26	1	M6	1	0	0	0
27			2	0	0	0
28			3	0	0	0
29			4	0	0	0
30			5	0	0	0
31	2	M1	1	16.589	0	0
32			2	16.589	0	0
33			3	16.589	0	0
34			4	16.589	0	0
35			5	16.589	0	0
36	2	M2	1	9.664	0	0
37			2	9.664	0	0
38			3	9.664	0	0
39			4	9.664	0	0
40			5	9.664	0	0
41	2	M3	1	4.5	0	0
42			2	4.5	0	0

Member Section Forces (Continued)

	LC	Member Label	Sec	Axial[k]	Shear[k]	Moment[k-ft]
43			3	4.5	0	0
44			4	4.5	0	0
45			5	4.5	0	0
46	2	M4	1	-22.78	.016	0
47			2	-22.78	.016	-.14
48			3	-22.806	-.016	-.281
49			4	-22.806	-.016	-.14
50			5	-22.806	-.016	0
51	2	M5	1	.058	0	0
52			2	.058	0	0
53			3	.058	0	0
54			4	.058	0	0
55			5	.058	0	0
56	2	M6	1	0	0	0
57			2	0	0	0
58			3	0	0	0
59			4	0	0	0
60			5	0	0	0
61	3	M1	1	6.848	0	0
62			2	6.848	0	0
63			3	6.848	0	0
64			4	6.848	0	0
65			5	6.848	0	0
66	3	M2	1	1.876	0	0
67			2	1.876	0	0
68			3	1.876	0	0
69			4	1.876	0	0
70			5	1.876	0	0
71	3	M3	1	4.5	0	0
72			2	4.5	0	0
73			3	4.5	0	0
74			4	4.5	0	0
75			5	4.5	0	0
76	3	M4	1	-4.422	.004	0
77			2	-4.422	.004	-.031
78			3	-4.426	.004	-.062
79			4	-4.426	-.004	-.031
80			5	-4.426	-.004	0
81	3	M5	1	.009	0	0
82			2	.009	0	0
83			3	.009	0	0
84			4	.009	0	0
85			5	.009	0	0
86	3	M6	1	0	0	0
87			2	0	0	0
88			3	0	0	0
89			4	0	0	0
90			5	0	0	0
91	4	M1	1	12.085	0	0
92			2	12.085	0	0
93			3	12.085	0	0
94			4	12.085	0	0
95			5	12.085	0	0
96	4	M2	1	9.66	0	0
97			2	9.66	0	0
98			3	9.66	0	0
99			4	9.66	0	0

Member Section Forces (Continued)

	LC	Member Label	Sec	Axial[k]	Shear[k]	Moment[k-ft]
100			5	9.66	0	0
101	4	M3	1	0	0	0
102			2	0	0	0
103			3	0	0	0
104			4	0	0	0
105			5	0	0	0
106	4	M4	1	-22.772	.016	0
107			2	-22.772	.016	-.136
108			3	-22.797	.016	-.272
109			4	-22.797	-.016	-.136
110			5	-22.797	-.016	0
111	4	M5	1	.057	0	0
112			2	.057	0	0
113			3	.057	0	0
114			4	.057	0	0
115			5	.057	0	0
116	4	M6	1	0	0	0
117			2	0	0	0
118			3	0	0	0
119			4	0	0	0
120			5	0	0	0
121	5	M1	1	2.348	0	0
122			2	2.348	0	0
123			3	2.348	0	0
124			4	2.348	0	0
125			5	2.348	0	0
126	5	M2	1	1.875	0	0
127			2	1.875	0	0
128			3	1.875	0	0
129			4	1.875	0	0
130			5	1.875	0	0
131	5	M3	1	0	0	0
132			2	0	0	0
133			3	0	0	0
134			4	0	0	0
135			5	0	0	0
136	5	M4	1	-4.421	.003	0
137			2	-4.421	.003	-.026
138			3	-4.425	-.003	-.053
139			4	-4.425	-.003	-.026
140			5	-4.425	-.003	0
141	5	M5	1	.008	0	0
142			2	.008	0	0
143			3	.008	0	0
144			4	.008	0	0
145			5	.008	0	0
146	5	M6	1	0	0	0
147			2	0	0	0
148			3	0	0	0
149			4	0	0	0
150			5	0	0	0

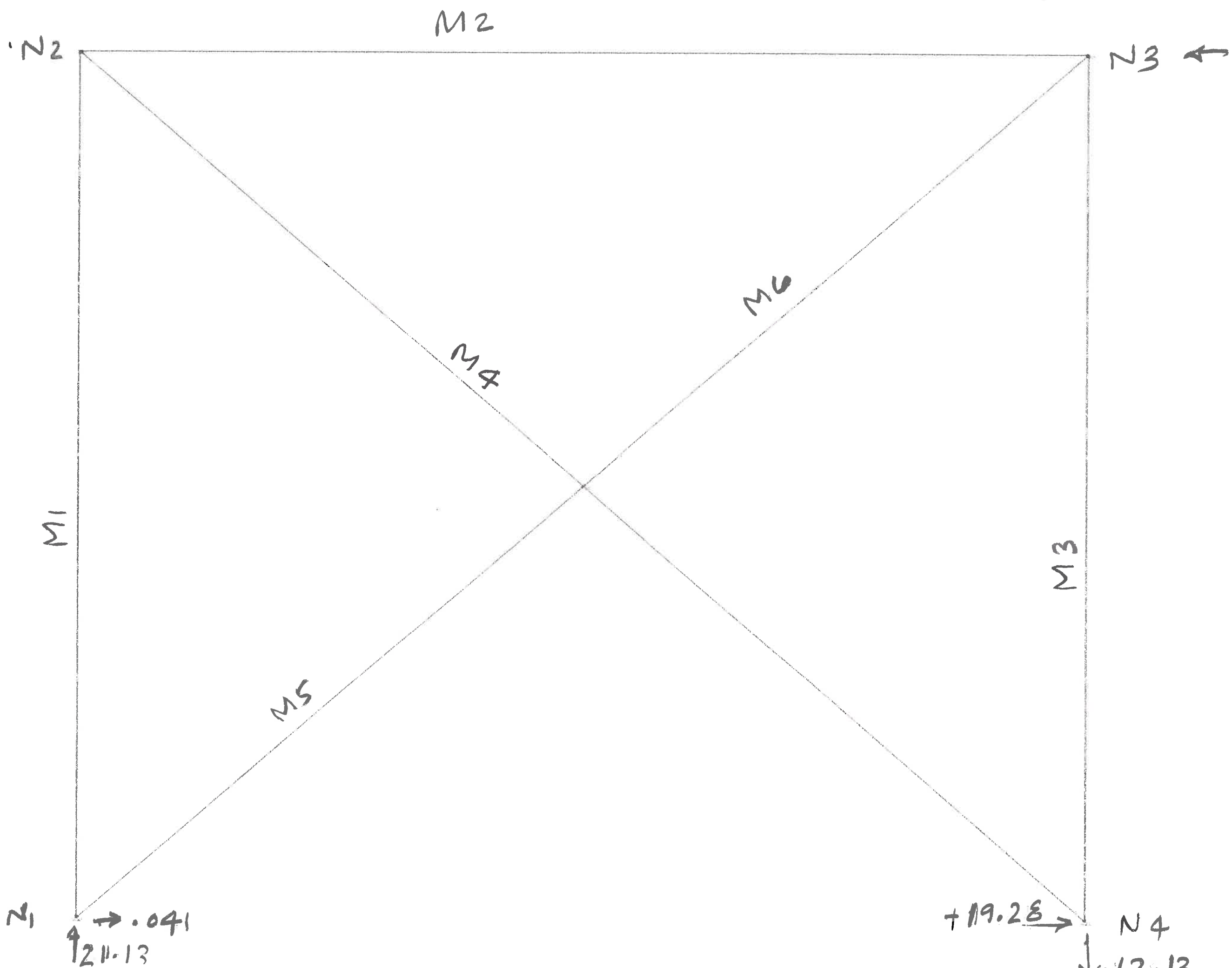
Member AISC 13th(360-05): ASD Steel Code Checks

	LC	Member	Shape	UC Max	Loc[ft]	Shear UC	Loc[ft]	Pnc/om [k]	Pnt/om [k]	Mn/om [k-ft]	Cb	Eqn
1	1	M1	W10x45	.051	0	.000	0	162.302	398.204	107.502	1	H1-1b
2	1	M2	W12x40	.091	0	.000	0	52.895	350.299	58.061	1	H1-1b

Member AISC 13th(360-05): ASD Steel Code Checks (Continued)

	LC	Member	Shape	UC Max	Loc[ft]	Shear UC	Loc[ft]	Pnc/om [k]	Pnt/om [k]	Mn/om [k-ft]	Cb	Eqn
3	1	M3	W10x45	.014	0	.000	0	162.302	398.204	107.502	1	H1-1b
4	1	M4	W6x15	.117	17.41	.001	17.41	8.023	132.635	9.084	1.316	H1-1b
5	1	M5	W6x15	.001	0	.000	0	32.093	132.635	15.745	1	H1-1b
6	1	M6	W6x15	.000	0	.000	0	32.093	132.635	15.745	1	H1-1a
7	2	M1	W10x45	.051	0	.000	0	162.302	398.204	107.502	1	H1-1b
8	2	M2	W12x40	.091	0	.000	0	52.895	350.299	58.061	1	H1-1b
9	2	M3	W10x45	.014	0	.000	0	162.302	398.204	107.502	1	H1-1b
10	2	M4	W6x15	.117	17.41	.001	17.41	8.023	132.635	9.084	1.316	H1-1b
11	2	M5	W6x15	.001	0	.000	0	32.093	132.635	15.745	1	H1-1b
12	2	M6	W6x15	.000	0	.000	0	32.093	132.635	15.745	1	H1-1a
13	3	M1	W10x45	.021	0	.000	0	162.302	398.204	107.502	1	H1-1b
14	3	M2	W12x40	.018	0	.000	0	52.895	350.299	58.061	1	H1-1b
15	3	M3	W10x45	.014	0	.000	0	162.302	398.204	107.502	1	H1-1b
16	3	M4	W6x15	.024	17.41	.000	0	8.023	132.635	9.084	1.316	H1-1b
17	3	M5	W6x15	.000	0	.000	0	32.093	132.635	15.745	1	H1-1b
18	3	M6	W6x15	.000	0	.000	0	32.093	132.635	15.745	1	H1-1a
19	4	M1	W10x45	.037	0	.000	0	162.302	398.204	107.502	1	H1-1b
20	4	M2	W12x40	.091	0	.000	0	52.895	350.299	58.061	1	H1-1b
21	4	M3	W10x45	.000	0	.000	0	162.302	398.204	107.502	1	H1-1b
22	4	M4	W6x15	.116	17.41	.001	0	8.023	132.635	9.084	1.316	H1-1b
23	4	M5	W6x15	.001	0	.000	0	32.093	132.635	15.745	1	H1-1b
24	4	M6	W6x15	.000	0	.000	0	32.093	132.635	15.745	1	H1-1a
25	5	M1	W10x45	.007	0	.000	0	162.302	398.204	107.502	1	H1-1b
26	5	M2	W12x40	.018	0	.000	0	52.895	350.299	58.061	1	H1-1b
27	5	M3	W10x45	.000	0	.000	0	162.302	398.204	107.502	1	H1-1b
28	5	M4	W6x15	.022	17.41	.000	17.41	8.023	132.635	9.084	1.316	H1-1b
29	5	M5	W6x15	.000	0	.000	0	32.093	132.635	15.745	1	H1-1b
30	5	M6	W6x15	.000	0	.000	0	32.093	132.635	15.745	1	H1-1a

Col. line - (A) Braced frame



.043 + 16.62 (case 4)

+ 19.28 - 16.62 (case 4)

d + Pc + 9x.

E2	LINE A	SK - 1
kd	topock wcs braced frame	July 27, 2012 at 8:59 AM
ww-peg-2174-043062		topockwcp. braced frame.r2d

Joint Coordinates and Temperatures

	Label	X [ft]	Y [ft]	Temp [F]
1	N1	0	0	0
2	N2	0	18.5	0
3	N3	21.5	18.5	0
4	N4	21.5	0	0
5	N5	10.75	9.25	0

Member Primary Data

	Label	I Joint	J Joint	Rotate(deg)	Section/Shape	Type	Design List	Material	Design Rules
1	M1	N1	N2		W10x45	Column	Wide Flange	A572 Gr.50	DR1
2	M2	N2	N3		W12x40	Beam	Wide Flange	A572 Gr.50	DR1
3	M3	N3	N4		W10x45	Column	Wide Flange	A572 Gr.50	DR1
4	M4	N4	N2		W6x15	VBrace	Wide Flange	A572 Gr.50	DR1
5	M5	N1	N5		W6x15	VBrace	Wide Flange	A572 Gr.50	DR1
6	M6	N5	N3		W6x15	VBrace	Wide Flange	A572 Gr.50	DR1

Joint Loads and Enforced Displacements (BLC 1 : d)

	Joint Label	L,D,M	Direction	Magnitude[(k,k-ft), (in,rad), (k*s^2/ft...
1	N2	L	Y	-5
2	N3	L	Y	-8

Joint Loads and Enforced Displacements (BLC 2 : Pcr)

	Joint Label	L,D,M	Direction	Magnitude[(k,k-ft), (in,rad), (k*s^2/ft...
1	N2	L	Y	-5
2	N3	L	Y	-5

Joint Loads and Enforced Displacements (BLC 3 : ql)

	Joint Label	L,D,M	Direction	Magnitude[(k,k-ft), (in,rad), (k*s^2/ft...
1	N2	L	X	-4.6
2	N3	L	X	-4.6

Joint Loads and Enforced Displacements (BLC 4 : Pw)

	Joint Label	L,D,M	Direction	Magnitude[(k,k-ft), (in,rad), (k*s^2/ft...
1	N2	L	X	-2.5
2	N3	L	X	-2.5

Hot Rolled Steel Section Sets

	Label	Shape	Type	Design List	Material	Design Rules	A [in2]	I (90,270) [i...	I (0,180) [in4]
1	HR1A	W12x26 40	Beam	Wide Flange	A572 Gr.50	DR1	7.65	17.3	204
2	HR2	W10x45	Column	Wide Flange	A572 Gr.50	DR1	13.3	53.4	248
3	HR3	W6x15	VBrace	Wide Flange	A572 Gr.50	DR1	4.43	9.32	29.1

Basic Load Cases

	BLC Description	Category	X Gravity	Y Gravity	Joint	Point	Distributed
1	d	None			2		
2	Pcr	None			2		
3	ql	None			2		
4	Pw	None			2		

Load Combinations

	Description	Solve	PD...	SR...	BLC	Factor	BLC	Factor	BLC	Factor	BLC	Factor	BLC	Factor	BLC	Factor	BLC	Factor	BLC	Factor
1	d+Pcr+ql	Yes	Y		DL	1.057	2	.9	3	2.1										
2	d+Pcr+ql	Yes	Y		DL	.543	2	.9	3	2.1										
3	d+PwPcr	Yes	Y		DL	1	2	.9	4	.75										
4	d+ql	Yes	Y		DL	.543	3	2.1												
5	d+Pw	Yes	Y		DL	1	4	.75												

Joint Reactions (By Combination)

	LC	Joint Label	X [k]	Y [k]	MZ [k-ft]
1	1	N1	.041	21.13	0
2	1	N4	19.279	-12.13	0
3	1	Totals:	19.32	9	
4	1	COG (ft):	X: 10.75	Y: 18.5	
5	2	N1	.041	21.13	0
6	2	N4	19.279	-12.13	0
7	2	Totals:	19.32	9	
8	2	COG (ft):	X: 10.75	Y: 18.5	
9	3	N1	.009	7.728	0
10	3	N4	3.741	1.272	0
11	3	Totals:	3.75	9	
12	3	COG (ft):	X: 10.75	Y: 18.5	
13	4	N1	.043	16.623	0
14	4	N4	19.277	-16.623	0
15	4	Totals:	19.32	0	
16	4	COG (ft):	NC	NC	
17	5	N1	.008	3.227	0
18	5	N4	3.742	-3.227	0
19	5	Totals:	3.75	0	
20	5	COG (ft):	NC	NC	

Joint Deflections

	LC	Joint Label	X [in]	Y [in]	Rotation [rad]
1	1	N1	0	0	0
2	1	N2	-.124	-.015	0
3	1	N3	-.132	-.003	0
4	1	N4	0	0	0
5	1	N5	-.028	.032	2.72e-4
6	2	N1	0	0	0
7	2	N2	-.124	-.015	0
8	2	N3	-.132	-.003	0
9	2	N4	0	0	0
10	2	N5	-.028	.032	2.72e-4
11	3	N1	0	0	0
12	3	N2	-.026	-.006	0
13	3	N3	-.028	-.003	0
14	3	N4	0	0	0
15	3	N5	-.005	.006	6.291e-5
16	4	N1	0	0	0
17	4	N2	-.121	-.012	0
18	4	N3	-.129	0	0
19	4	N4	0	0	0
20	4	N5	-.028	.032	2.594e-4
21	5	N1	0	0	0
22	5	N2	-.024	-.002	0
23	5	N3	-.025	0	0

Joint Deflections (Continued)

	LC	Joint Label	X [in]	Y [in]	Rotation [rad]
24	5	N4	0	0	0
25	5	N5	-.005	.006	5.035e-5

Load Combination Design

	Description	ASIF	CD	ABIF	Service	Hot Rolled	Cold Form...	Wood	Concrete	Masonry	Footings	Aluminum
1	d+Pcr+ql					Yes	Yes	Yes	Yes	Yes	Yes	Yes
2	d+Pcr+ql					Yes	Yes	Yes	Yes	Yes	Yes	Yes
3	d+PwPcr					Yes	Yes	Yes	Yes	Yes	Yes	Yes
4	d+ql					Yes	Yes	Yes	Yes	Yes	Yes	Yes
5	d+Pw					Yes	Yes	Yes	Yes	Yes	Yes	Yes

Member Section Forces

	LC	Member Label	Sec	Axial[k]	Shear[k]	Moment[k-ft]
1	1	M1	1	21.078	0	0
2			2	21.078	0	0
3			3	21.078	0	0
4			4	21.078	0	0
5			5	21.078	0	0
6	1	M2	1	9.664	0	0
7			2	9.664	0	0
8			3	9.664	0	0
9			4	9.664	0	0
10			5	9.664	0	0
11	1	M3	1	4.499	0	0
12			2	4.499	0	0
13			3	4.499	0	0
14			4	4.499	0	0
15			5	4.499	0	0
16	1	M4	1	-25.463	.027	0
17			2	-25.463	.027	-.19
18			3	-25.475	-.027	-.38
19			4	-25.475	-.027	-.19
20			5	-25.475	-.027	0
21	1	M5	1	.08	0	0
22			2	.08	0	0
23			3	.08	0	0
24			4	.08	0	0
25			5	.08	0	0
26	1	M6	1	0	0	0
27			2	0	0	0
28			3	0	0	0
29			4	0	0	0
30			5	0	0	0
31	2	M1	1	21.078	0	0
32			2	21.078	0	0
33			3	21.078	0	0
34			4	21.078	0	0
35			5	21.078	0	0
36	2	M2	1	9.664	0	0
37			2	9.664	0	0
38			3	9.664	0	0
39			4	9.664	0	0
40			5	9.664	0	0
41	2	M3	1	4.499	0	0
42			2	4.499	0	0

Member Section Forces (Continued)

	LC	Member Label	Sec	Axial[k]	Shear[k]	Moment[k-ft]
43			3	4.499	0	0
44			4	4.499	0	0
45			5	4.499	0	0
46	2	M4	1	-25.463	.027	0
47			2	-25.463	.027	-.19
48			3	-25.475	-.027	-.38
49			4	-25.475	-.027	-.19
50			5	-25.475	-.027	0
51	2	M5	1	.08	0	0
52			2	.08	0	0
53			3	.08	0	0
54			4	.08	0	0
55			5	.08	0	0
56	2	M6	1	0	0	0
57			2	0	0	0
58			3	0	0	0
59			4	0	0	0
60			5	0	0	0
61	3	M1	1	7.719	0	0
62			2	7.719	0	0
63			3	7.719	0	0
64			4	7.719	0	0
65			5	7.719	0	0
66	3	M2	1	1.876	0	0
67			2	1.876	0	0
68			3	1.876	0	0
69			4	1.876	0	0
70			5	1.876	0	0
71	3	M3	1	4.5	0	0
72			2	4.5	0	0
73			3	4.5	0	0
74			4	4.5	0	0
75			5	4.5	0	0
76	3	M4	1	-4.942	.006	0
77			2	-4.942	.006	-.043
78			3	-4.944	-.006	-.086
79			4	-4.944	-.006	-.043
80			5	-4.944	-.006	0
81	3	M5	1	.013	0	0
82			2	.013	0	0
83			3	.013	0	0
84			4	.013	0	0
85			5	.013	0	0
86	3	M6	1	0	0	0
87			2	0	0	0
88			3	0	0	0
89			4	0	0	0
90			5	0	0	0
91	4	M1	1	16.574	0	0
92			2	16.574	0	0
93			3	16.574	0	0
94			4	16.574	0	0
95			5	16.574	0	0
96	4	M2	1	9.66	0	0
97			2	9.66	0	0
98			3	9.66	0	0
99			4	9.66	0	0

Member Section Forces (Continued)

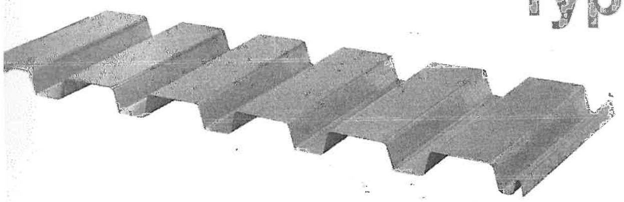
	LC	Member Label	Sec	Axial[k]	Shear[k]	Moment[k-ft]
100			5	9.66	0	0
101	4	M3	1	0	0	0
102			2	0	0	0
103			3	0	0	0
104			4	0	0	0
105			5	0	0	0
106	4	M4	1	-25.454	.026	0
107			2	-25.454	.026	-.182
108			3	-25.465	-.026	-.364
109			4	-25.465	-.026	-.182
110			5	-25.465	-.026	0
111	4	M5	1	.076	0	0
112			2	.076	0	0
113			3	.076	0	0
114			4	.076	0	0
115			5	.076	0	0
116	4	M6	1	0	0	0
117			2	0	0	0
118			3	0	0	0
119			4	0	0	0
120			5	0	0	0
121	5	M1	1	3.22	0	0
122			2	3.22	0	0
123			3	3.22	0	0
124			4	3.22	0	0
125			5	3.22	0	0
126	5	M2	1	1.875	0	0
127			2	1.875	0	0
128			3	1.875	0	0
129			4	1.875	0	0
130			5	1.875	0	0
131	5	M3	1	0	0	0
132			2	0	0	0
133			3	0	0	0
134			4	0	0	0
135			5	0	0	0
136	5	M4	1	-4.941	.005	0
137			2	-4.941	.005	-.035
138			3	-4.943	-.005	-.071
139			4	-4.943	-.005	-.035
140			5	-4.943	-.005	0
141	5	M5	1	.011	0	0
142			2	.011	0	0
143			3	.011	0	0
144			4	.011	0	0
145			5	.011	0	0
146	5	M6	1	0	0	0
147			2	0	0	0
148			3	0	0	0
149			4	0	0	0
150			5	0	0	0

Member AISC 13th(360-05): ASD Steel Code Checks

	LC	Member	Shape	UC Max	Loc[ft]	Shear UC	Loc[ft]	Pnc/om [k]	Pnt/om [k]	Mn/om [k-ft]	Cb	Eqn
1	1	M1	W10x45	.065	0	.000	0	162.302	398.204	107.502	1	H1-1b
2	1	M2	W12x40	.049	0	.000	0	99.582	350.299	87.847	1	H1-1b

Attach 'A'

Type PLB™-36 or HSB®-36



1½" Deep Roof Deck
Primer Painted or Galvanized

VERTICAL LOADS

able Uniform Loads (psf)

GAGE		4'-0"	5'-0"	5'-6"	6'-0"	6'-6"	7'-0"	7'-6"	8'-0"	8'-6"	9'-0"	9'-6"	10'-0"	10'-6"	11'-0"	11'-6"	12'-0"
		SPAN (ft-in.)															
22	Stress	185	118	98	82	70	60	53	46	41	37	33	30				
	L/240	185	95	71	55	43	34	28	23	19	16	14	12				
20	Stress	223	149	123	104	88	76	66	58	52	46	41	37	34	31	28	26
	L/240	229	117	88	68	53	43	35	29	24	20	17	15	13	11	10	8
18	Stress	300	204	168	141	120	104	90	80	70	63	56	51	46	42	38	35
	L/240	◆◆◆	160	120	93	73	58	47	39	33	27	23	20	17	15	13	12
16	Stress	300	259	214	180	153	132	115	101	89	80	72	65	59	53	49	45
	L/240	◆◆◆	200	150	116	91	73	59	49	41	34	29	25	22	19	16	14
22	Stress	194	124	103	86	73	63	55	49	43	38	34	31				
	L/240	◆◆◆	◆◆◆	◆◆◆	◆◆◆	◆◆◆	◆◆◆	◆◆◆	◆◆◆	◆◆◆	◆◆◆	◆◆◆	30				
20	Stress	244	156	129	108	92	80	69	61	54	48	43	39	35	32	30	27
	L/240	◆◆◆	◆◆◆	◆◆◆	◆◆◆	◆◆◆	◆◆◆	◆◆◆	◆◆◆	◆◆◆	◆◆◆	43	37	32	27	24	21
18	Stress	300	212	175	147	125	108	94	83	73	65	59	53	48	44	40	37
	L/240	◆◆◆	◆◆◆	◆◆◆	◆◆◆	◆◆◆	◆◆◆	◆◆◆	◆◆◆	◆◆◆	◆◆◆	56	48	42	36	32	28
16	Stress	300	262	217	182	155	134	117	103	91	81	73	66	60	54	50	46
	L/240	◆◆◆	◆◆◆	◆◆◆	◆◆◆	◆◆◆	◆◆◆	◆◆◆	◆◆◆	◆◆◆	◆◆◆	70	60	52	45	40	35
22	Stress	243	155	128	108	92	79	69	61	54	48	43	39				
	L/240	◆◆◆	◆◆◆	◆◆◆	◆◆◆	86	69	56	46	39	33	28	24				
20	Stress	300	195	161	136	116	100	87	76	68	60	54	49	44	40	37	34
	L/240	◆◆◆	◆◆◆	◆◆◆	132	104	83	68	56	47	39	33	29	25	21	19	17
18	Stress	300	265	219	184	157	135	118	103	92	82	73	66	60	55	50	46
	L/240	◆◆◆	◆◆◆	◆◆◆	175	138	110	90	74	62	52	44	38	33	28	25	22
16	Stress	300	300	271	228	194	167	146	128	113	101	91	82	74	68	62	57
	L/240	◆◆◆	◆◆◆	◆◆◆	218	172	137	112	92	77	65	55	47	41	35	31	27

:
ess = Uniform load which produces maximum allowable stress in deck.
40 = Uniform load which produces L/240 deflection in deck.
f-weight of the deck should be included when determining dead load.
e symbol ◆◆◆ indicates allowable uniform load based on deflection exceeds allowable uniform load based on stress.

APPENDIX A - CALCULATION COVER SHEET

CALCULATION ID NUMBER	TC07
REVISION NUMBER	
JOB NUMBER	WW-PGE-2174

TITLE	Topock - Remediation - Switchgear Canopy

Page	Content	Dwgs
1	General	5-12-22 TO
2	Lateral Analysis for frames & Loads	5-12-25
3.	Roof Framing	
4	Foundation	
—	Attachment - A, Mom. Fr. Line - A	
—	Attach. - B Mom. Frame line - B	
—	Attach. - C Braced Fr.'s Line (1) & (4)	
—	Attach. - D Deck	

	initial	date
PREPARED	KD	7/16/14
TITLE		
REVIEWED		
TITLE		

REVISION NOTES	

E2 Consulting Engineers, Inc.
1900 Powell Street, Suite 250
Emeryville, CA 94608

Designed By:	KD	Date: 7/15/14	
Checked By:		Date:	
Reviewed By:		Date:	
Project No.	WW-PGE-2174	Sheet No.	1
Project Description:	Topock Remediation - Switchgear Canopy		

Reference:

General References

1. CBC 2010
2. ASCE 7-10
3. ACI 318-11

Seismic Data

$S_S = .23$ $S_{MS} = 1.6 \times .23 = .368$

$S_1 = .12$ $S_{M1} = F_v S_1 = 2.318 \times .12 = .28$

$S_{DS} = .267$ $S_{D1} = .187$

Soil Bearing press. = 4000 PSF

Conc. Data

$f'_c = 5.0$ ksi $F_y = 60$ ksi

Related Dwgs.

S-12-21 TO S-12-25

Loads

Roof DL = 10 PSF LL = 20 PSF TL = 30 PSF

Siding DL = 15 PSF

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	Checked By:		Date:
	Reviewed By:		Date:
Project No.	WW-PGE-2174		Sheet No. 2
Project Description:	Topock - Remediation - Switchgear Enclosure		

Reference:

Lateral Analysis

Seismic — Using Equivalent Lateral Procedure

$V = C_s W$ $\qquad S_{DS} = .247 \qquad R = 3.5 \quad \Omega = 3.0$ (Mom. Fr.)

Wt. W — Deck + FRMG = 12 PSF Siding = 15 PSF $\qquad R = 3.25$ (Braced Fr.)

$W = 12 \times 22 \times .012 + 2 \times 6 \times 12 \times .015$ (Roof, Siding)
$= 5.33^k$

$C_s = \frac{S_{DS}}{(R/I)} = \frac{.247}{(3.25/1.25)} = .095$ (Br. Fr.) $\qquad C_{s\,max} = \frac{.5\,S_{D1}}{T(R/I)} = \frac{.5 \times .187}{.204(2.8)} = .164$ (Mom. Fr.)

$T = C_t h_n^x = .028 \times (12)^{.8} = .204$ (Mom. Fr.) $\qquad C_{s\,max} = \frac{.5 \times .187}{.129 \times 2.6} = .279$ (Br. Fr.)

$T = .02 \times (12)^{.75} = .129$ (Br. Frames)

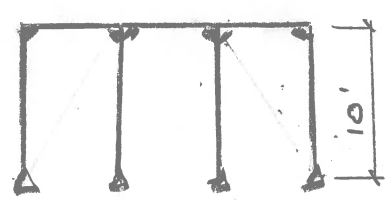
$V = .279 \times 5.33 = 1.49^k$ USE $.75^k$/Frame for Br. Fr.

$V = .164 \times 5.33 = .87^k$ USE $.44^k$/Frame for Mom. Fr.

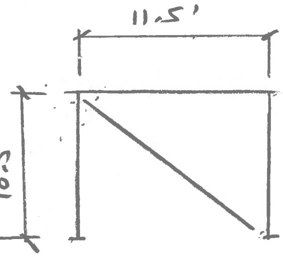
Wind — $V_{EW} = .02(12) \times 6 = 1.44^k$ P/Mom. Frame $= .75^k$/Frame

$V_{NS} = .02(22) \times 6 = 2.64^k$ P/Br. Frame $= 1.35^k$/Frame

Wind governs in both directions.



FRAME LINE-B

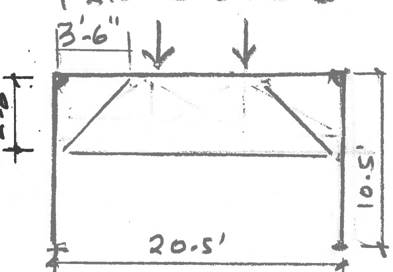


FRAME LINES ① & ④

Basic Loads

1 DL
2 LL (Wind Down)
3 Wind Horiz.
4 Seismic

Note ← May use Cross Bracings. Do not need computer calc.'s. HSS 4x4x4 BRCG ok by insp.



FRAME LINE-A

Load Combination

1. DL + LL (Wind Down) — ① + ②
2. DL + Wind Horiz. — ① + .6 ③
3. DL + Seismic — ① + .7 ④
4. DL + Wind Up + Wind Horiz. — ① + (-.5) ② + .45 ③
5. DL + Wind Down + Wind Horiz. — ① + ② + .45 ③ (.60)

Max. Defl. for Frame Line A = .507" = ℓ/249 < ℓ/200 $\qquad \Delta$ Line B = .473" = ℓ/266 < ℓ/200

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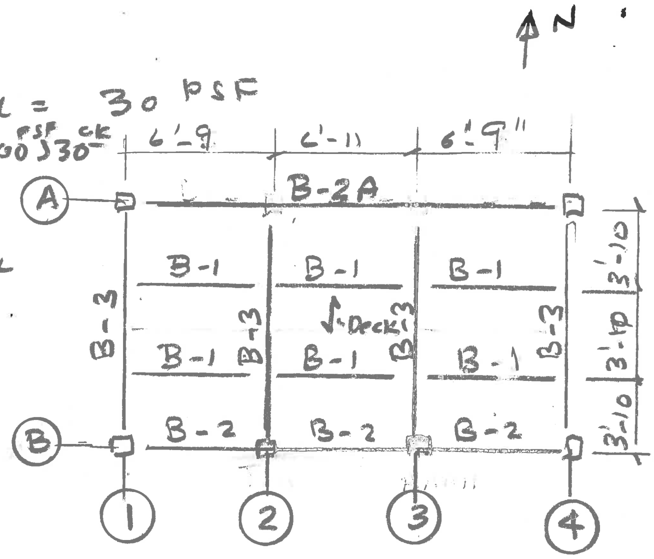
	Checked By:		Date:
	Reviewed By:		Date:
Project No.	WW - PGE - 2174		Sheet No. 3
Project Description:	Topock - Remediation - Switchgear Enclosure		

Reference:

Roof Loads

DL = 10 PSF   LL = 20 PSF   TL = 30 PSF

Roof Deck: $1\frac{1}{2}$" x 36" (pnl.), 18 GA. by Verco Allow. ld. = 300 PSF > 30 ok



B-1, B-2, l = 7.0'

$W_{TL} = (.01 + .02) \times 3.75 = .113^{k/l}$

$M = \frac{.113 \times 7^2}{8} = .692^{1k}$ $R = .395^k$

$S_x = \frac{.692 \times 12}{27.6} = .309^{in^3}$

HSS 4x4x4 $S = 3.90^{in^3}$ $I = 7.8^{in^4}$ $A = 3.37^{in^2}$

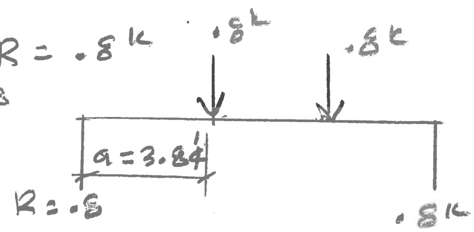
B-3

$l = 11.52'$

$P = 2 \times .395 = .79^k$ say $.8^k$

$M = \frac{.8 \times 11.66}{2} - .8 \times 1.875 = 3.164^{1k}$ $R = .8^k$

$S_x = \frac{3.164 \times 12}{27.6} = 1.375\ in^3 < 8.58\ in^3$



$\Delta = \frac{Pa}{24EI}(3l^2 - 4a^2)$

$= \frac{.8 \times 3.84\,(3 \times 11.52^2 - 4 \times 3.84^2) \times 1728}{24 \times 29000 \times 10.3}$

$= .251" = \frac{l}{550} < \frac{l}{180}$ ok

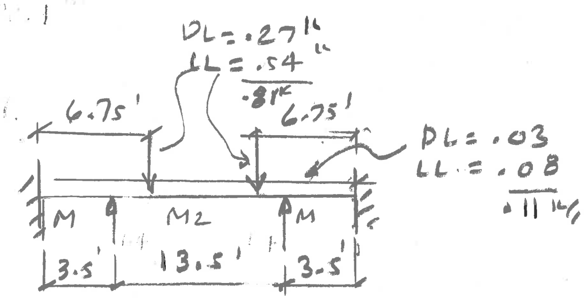
USE HSS 4x4x6   I = 20.9

B-2A

See computer output (Memb. M2) (Attach. - A)

DL+LL

	LC-1	LC-5
Max Design Check =	.196	1.203



USE HSS 6x4x4

Col. & Base plates

Col. Column size is governed by displacement @ Top of frame. See Sht. for frame deflections @ top HSS 4x4x6 is ok

Base pl. Max $P_{DL+LL} = 3.5^k$ $V = .25 \times 2 = .5^k$ Loads are very small

USE 12" x 12" x 3/4" PL. w/ 4 - 3/4" Φ A-307 Bolts.

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	Checked By:		Date:
	Reviewed By:		Date:
Project No. WW-PGE-2174			Sheet No. 4
Project Description: Topock - Remediation . Switchgear Enclosure			

Reference:

Foundation

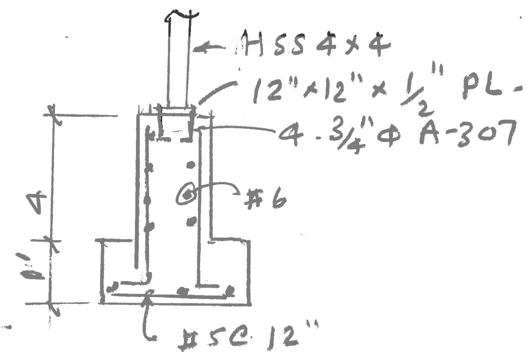
Pedestal

Max. $P = 4^k$ Max $V = .5^k$

Try 1'-6" SQ. PEDSTAL

$M = .5 \times 4 = 2^{1k}$ $V = .5^k$

18" SQ. PED. w/ 8-#6 Bars ok by insp.



Footing

$M = .5 \times 5 = 2.5^{1k}$ $P = 4^k + 1.5 \times 1.5 \times 4 \times .15 + 2.5 \times 2.5 \times 1 \times .15 = 6.3^k$

$S_{FTG.} = \frac{1}{6} \times 2.5 \times 2.5^2 =$

$\frac{P}{A} + \frac{M}{S} = f_p = \frac{6.3}{2.5 \times 2.5} \pm \frac{2.5}{2.6} = 1.0 \pm .96 = 1.96^{ksf}$ (Max.

$< 4^{ksf}$

USE 2'-6" SQ. FTG. w/ 4-#5 Bars Ea. Way

Slab on Grade

12" TK Slab w/ #5 @ 12" Ea. Way

Gr. Bm. (12" x 30")

$w = .015 \times 11 + .15 \times 1 \times 2.5 = .54^{k/}$

USE 12" x 2'-6" deep Gr. Bm. w/ #5 @ 12" Ea Face

& #4 stirrups @ 18" o/c ok by Insp.

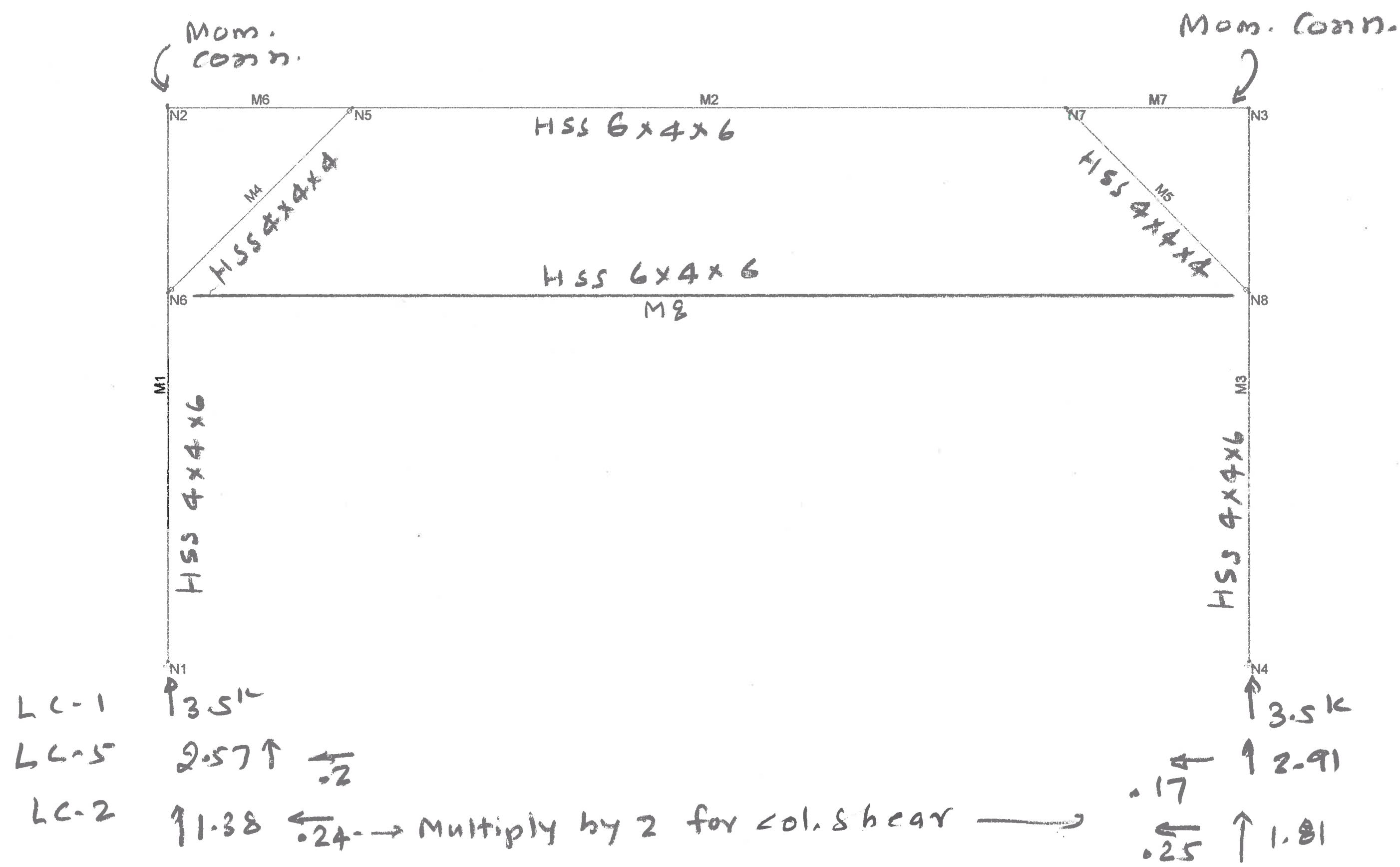
Siding (See dwg. S-12.22)

3/4" Deep x 36" (pnl.) Span = 3'-0" $w_{wind} = 20^{PSF}$

$M = \frac{.020 \times 4^2}{8} = .08^{1k} = 960^{\#''}$ $S_Y = \frac{960}{20000} = .048^{in^3} < .0538^{in^3}$

3/4" x 36" Siding pnl. ok

Attach. A



Results for LC 1, dl+ll

E 2	Switchgear topock moment frame line A	SK - 2
		July 13, 2014 at 10:16 PM
		topockswithgear.momfrb.r2d

Global

Display Sections for Member Calcs	5
Max Internal Sections for Member Calcs	97
Include Shear Deformation?	Yes
Merge Tolerance (in)	.12
P-Delta Analysis Tolerance	0.50%
Include P-Delta for Walls?	Yes
Automaticly Iterate Stiffness for Walls?	Yes
Maximum Iteration Number for Wall Stiffness	3
Gravity Acceleration (ft/sec^2)	32.2
Wall Mesh Size (in)	12
Eigensolution Convergence Tol. (1.E-)	4
Dynamic Solver	Accelerated Solver

Hot Rolled Steel Code	AISC 14th(360-10): ASD
Adjust Stiffness?	Yes(Iterative)
RISAConnection Code	None
Cold Formed Steel Code	AISI S100-10: ASD
Wood Code	AF&PA NDS-12: ASD
Wood Temperature	< 100F
Concrete Code	ACI 318-11
Masonry Code	ACI 530-11: ASD
Aluminum Code	AA ADM1-10: ASD - Building

Number of Shear Regions	4
Region Spacing Increment (in)	4
Concrete Stress Block	Rectangular
Use Cracked Sections?	Yes
Bad Framing Warnings?	No
Unused Force Warnings?	Yes
Min 1 Bar Diam. Spacing?	No
Concrete Rebar Set	REBAR_SET_ASTMA615
Min % Steel for Column	1
Max % Steel for Column	8

Hot Rolled Steel Properties

	Label	E [ksi]	G [ksi]	Nu	Therm (\1E5 F)	Density[k/ft^3]	Yield[ksi]
1	A36 Gr.36	29000	11154	.3	.65	.49	36
2	A572 Gr.50	29000	11154	.3	.65	.49	50
3	A992	29000	11154	.3	.65	.49	50
4	A500 Gr.B RND	29000	11154	.3	.65	.49	42
5	A500 Gr.B Rect	29000	11154	.3	.65	.49	46
6	A53 Gr.B	29000	11154	.3	.65	.49	35

Hot Rolled Steel Section Sets

	Label	Shape	Type	Design List	Material	Design Rules	A [in2]	I (90,270) [i...	I (0,180) [in4]
1	HR1A	HSS4x4x6	Column	Tube	A500 Gr.B Rect	Typical	4.78	10.3	10.3
2	HR2	HSS6x4x4	Beam	Tube	A500 Gr.B Rect	Typical	4.3	11.1	20.9
3	HR3	HSS4x4x4	HBrace	Tube	A500 Gr.B Rect	Typical	3.37	7.8	7.8

Joint Coordinates and Temperatures

	Label	X [ft]	Y [ft]	Temp [F]
1	N1	0	0	0
2	N2	0	10.5	0
3	N3	20.5	10.5	0

Joint Coordinates and Temperatures (Continued)

	Label	X [ft]	Y [ft]	Temp [F]
4	N4	20.5	0	0
5	N5	3.5	10.5	0
6	N6	0	7.83	0
7	N7	17	10.5	0
8	N8	20.5	7.83	0

Joint Boundary Conditions

	Joint Label	X [k/in]	Y [k/in]	Rotation[k-ft/rad]	Footing
1	N1	Reaction	Reaction		
2	N4	Reaction	Reaction		

Member Primary Data

	Label	I Joint	J Joint	Rotate(deg)	Section/Shape	Type	Design List	Material	Design Rules
1	M1	N1	N2		HR1A	Column	Tube	A500 Gr.B ...	Typical
2	M2	N5	N7		HR2	Beam	Tube	A500 Gr.B ...	Typical
3	M3	N3	N4		HR1A	Column	Tube	A500 Gr.B ...	Typical
4	M4	N5	N6		HR3	HBrace	Tube	A500 Gr.B ...	Typical
5	M5	N7	N8		HR3	HBrace	Tube	A500 Gr.B ...	Typical
6	M6	N2	N5		HR2	Beam	Tube	A500 Gr.B ...	Typical
7	M7	N7	N3		HR2	Beam	Tube	A500 Gr.B ...	Typical
8	M8	N6	N8		HR2	Beam	Tube	A500 Gr.B ...	Typical

Joint Loads and Enforced Displacements (BLC 1 : dl)

	Joint Label	L,D,M	Direction	Magnitude[(k,k-ft), (in,rad), (k*s^2/ft...
1	N2	L	Y	-.5
2	N3	L	Y	-.5

Joint Loads and Enforced Displacements (BLC 2 : ll)

	Joint Label	L,D,M	Direction	Magnitude[(k,k-ft), (in,rad), (k*s^2/ft...
1	N2	L	Y	-.54
2	N3	L	Y	-.54

Joint Loads and Enforced Displacements (BLC 3 : wind horiz)

	Joint Label	L,D,M	Direction	Magnitude[(k,k-ft), (in,rad), (k*s^2/ft...
1	N2	L	X	.11
2	N6	L	X	.3
3	N3	L	X	.11
4	N8	L	X	.3

Joint Loads and Enforced Displacements (BLC 4 : seismic)

	Joint Label	L,D,M	Direction	Magnitude[(k,k-ft), (in,rad), (k*s^2/ft...
1	N2	L	X	.21
2	N3	L	X	.21

Member Point Loads (BLC 1 : dl)

	Member Label	Direction	Magnitude[k,k-ft]	Location[ft,%]
1	M2	Y	-.27	3.25
2	M2	Y	-.27	10.25

Member Point Loads (BLC 2 : ll)

	Member Label	Direction	Magnitude[k,k-ft]	Location[ft,%]
1	M2	Y	-.54	3.25
2	M2	Y	-.54	10.25

Member Distributed Loads (BLC 1 : dl)

	Member Label	Direction	Start Magnitude[k/ft,F]	End Magnitude[k/ft,F]	Start Location[ft,%]	End Location[ft,%]
1	M2	Y	-.03	-.03	0	13.5
2	M6	Y	-.03	-.03	0	3.5
3	M7	Y	-.03	-.03	0	3.5

Member Distributed Loads (BLC 2 : ll)

	Member Label	Direction	Start Magnitude[k/ft,F]	End Magnitude[k/ft,F]	Start Location[ft,%]	End Location[ft,%]
1	M2	Y	-.08	-.08	0	13.5
2	M6	Y	-.08	-.08	0	3.5
3	M7	Y	-.08	-.08	0	3.5

Basic Load Cases

	BLC Description	Category	X Gravity	Y Gravity	Joint	Point	Distributed
1	dl	None		-1	2	2	3
2	ll	None			2	2	3
3	wind horiz	None			4		
4	seismic	None			2		

Load Combinations

	Description	Solve	PD...	SR...	BLC	Factor	BLC	Factor	BLC	Factor	BLC	Factor	BLC	Factor	BLC	Factor	BLC	Factor	BLC	Factor
1	dl+ll	Yes	Y		1	1	2	1												
2	dl+wind horiz	Yes	Y		1	1	3	.6												
3	dl+seismic	Yes	Y		1	1	4	.7												
4	dl+wind up	Yes	Y		1	1	3	.45	2	-.5										
5	dl+ll+wind ho...	Yes	Y		1	1	3	.45	2	.6										

Joint Reactions

	LC	Joint Label	X [k]	Y [k]	MZ [k-ft]
1	1	N1	.02	3.499	0
2	1	N4	-.02	3.499	0
3	1	Totals:	0	6.997	
4	1	COG (ft):	X: 10.25	Y: 10.11	
5	2	N1	-.241	1.384	0
6	2	N4	-.251	1.814	0
7	2	Totals:	-.492	3.197	
8	2	COG (ft):	X: 10.25	Y: 9.647	
9	3	N1	-.141	1.442	0
10	3	N4	-.153	1.756	0
11	3	Totals:	-.294	3.197	
12	3	COG (ft):	X: 10.25	Y: 9.647	
13	4	N1	-.185	.492	0
14	4	N4	-.184	.805	0
15	4	Totals:	-.369	1.297	
16	4	COG (ft):	X: 10.25	Y: 8.397	
17	5	N1	-.171	2.571	0
18	5	N4	-.198	2.906	0
19	5	Totals:	-.369	5.477	

Joint Reactions (Continued)

	LC	Joint Label	X [k]	Y [k]	MZ [k-ft]
20	5	COG (ft):	X: 10.25	Y: 10.002	

Joint Deflections

	LC	Joint Label	X [in]	Y [in]	Rotation [rad]
1	1	N1	0	0	1.601e-4
2	1	N2	.002	-.003	1.897e-5
3	1	N3	-.002	-.003	-1.897e-5
4	1	N4	0	0	-1.601e-4
5	1	N5	.002	-.015	-1.305e-3
6	1	N6	-.004	-.003	-2.084e-4
7	1	N7	-.002	-.015	1.305e-3
8	1	N8	.004	-.003	2.084e-4
9	2	N1	0	0	-6.586e-3
10	2	N2	.507	-.001	-8.613e-4
11	2	N3	.505	-.001	-8.71e-4
12	2	N4	0	0	-6.698e-3
13	2	N5	.506	-.044	-9.633e-4
14	2	N6	.474	-.001	-1.941e-3
15	2	N7	.505	.032	-6.163e-5
16	2	N8	.477	-.001	-1.795e-3
17	3	N1	0	0	-4.044e-3
18	3	N2	.32	-.001	-6.606e-4
19	3	N3	.318	-.001	-6.704e-4
20	3	N4	0	0	-4.157e-3
21	3	N5	.319	-.034	-8.206e-4
22	3	N6	.295	-.001	-1.315e-3
23	3	N7	.318	.022	8.106e-5
24	3	N8	.298	-.001	-1.169e-3
25	4	N1	0	0	-4.824e-3
26	4	N2	.368	0	-6.295e-4
27	4	N3	.368	0	-6.251e-4
28	4	N4	0	0	-4.833e-3
29	4	N5	.368	-.028	-3.954e-4
30	4	N6	.346	0	-1.362e-3
31	4	N7	.367	.027	-3.477e-4
32	4	N8	.346	0	-1.352e-3
33	5	N1	0	0	-5.06e-3
34	5	N2	.396	-.002	-6.652e-4
35	5	N3	.393	-.002	-6.919e-4
36	5	N4	0	0	-5.298e-3
37	5	N5	.396	-.041	-1.364e-3
38	5	N6	.368	-.002	-1.613e-3
39	5	N7	.393	.019	5.624e-4
40	5	N8	.373	-.002	-1.305e-3

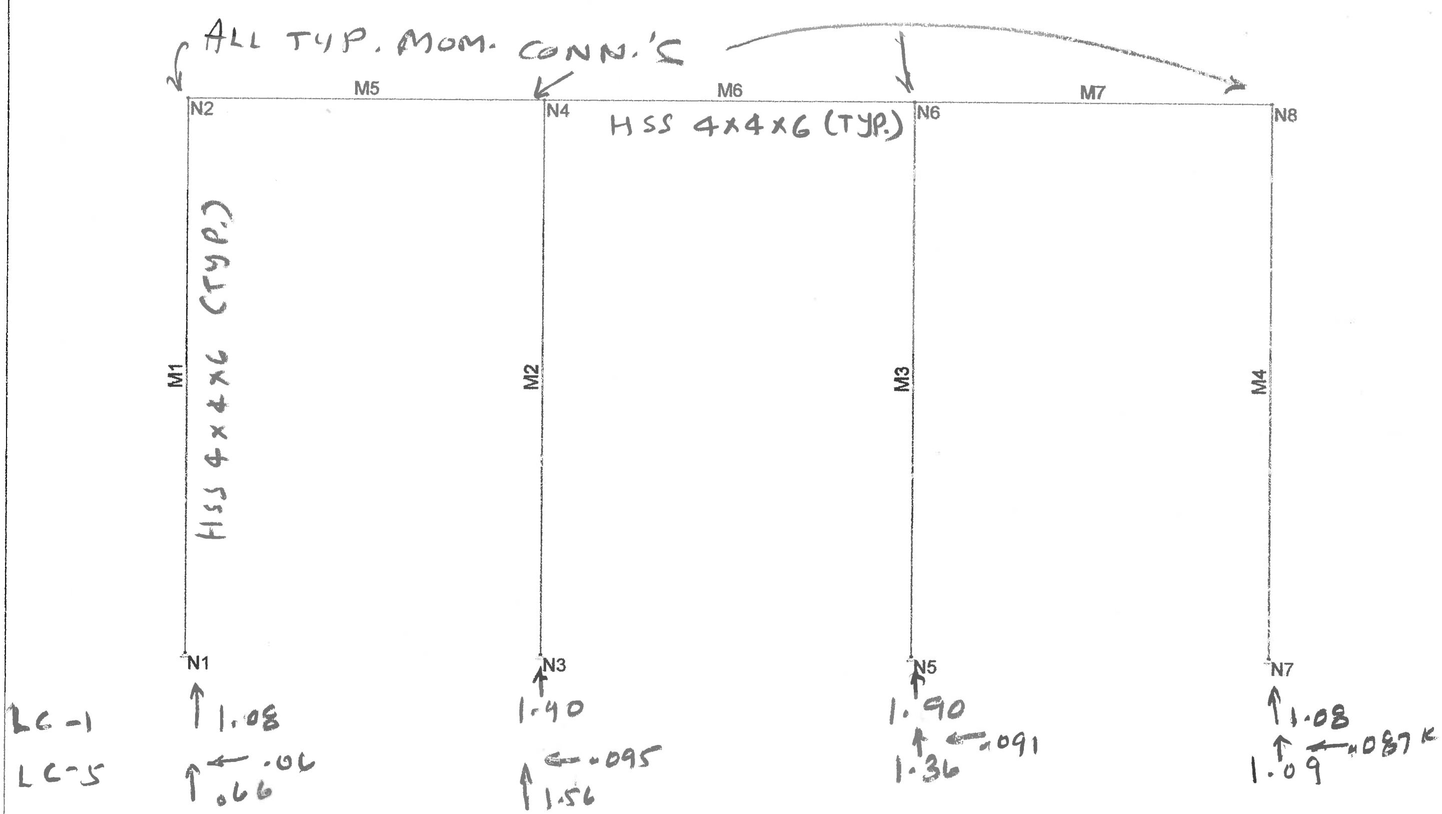
Member AISC 14th(360-10): ASD Steel Code Checks

	LC	Member	Shape	UC Max	Loc[ft]	Shear UC	Loc[ft]	Pnc/om [k]	Pnt/om [k]	Mn/om [k-ft]	Cb	Eqn
1	1	M1	HSS4x4x6	.032	7.766	.007	7.875	80.21	131.665	14.668	2.598	H1-1b
2	1	M2	HSS6x4x4	.196	0	.040	0	59.773	118.443	19.58	1.549	H1-1b
3	1	M3	HSS4x4x6	.032	2.734	.007	0	80.21	131.665	14.668	2.598	H1-1b
4	1	M4	HSS4x4x4	.030	2.247	.001	4.402	85.595	92.826	10.765	1.136	H1-1b
5	1	M5	HSS4x4x4	.030	2.247	.001	4.402	85.595	92.826	10.765	1.136	H1-1b
6	1	M6	HSS6x4x4	.166	3.5	.031	3.5	113.122	118.443	19.58	1.977	H1-1b
7	1	M7	HSS6x4x4	.166	0	.031	0	113.122	118.443	19.58	1.977	H1-1b
8	1	M8	HSS6x4x4	.055	10.25	.004	0	27.57	118.443	19.58	1.136	H1-1b

Member AISC 14th(360-10): ASD Steel Code Checks (Continued)

	LC	Member	Shape	UC Max	Loc[ft]	Shear UC	Loc[ft]	Pnc/om [k]	Pnt/om [k]	Mn/om [k-ft]	Cb	Eqn
9	2	M1	HSS4x4x6	.141	7.766	.029	7.875	80.21	131.665	14.668	1.362	H1-1b
10	2	M2	HSS6x4x4	.142	13.5	.019	13.5	59.773	118.443	19.58	2.315	H1-1b
11	2	M3	HSS4x4x6	.151	2.734	.033	0	80.21	131.665	14.668	1.363	H1-1b
12	2	M4	HSS4x4x4	.004	2.247	.001	0	85.595	92.826	10.765	1.136	H1-1b
13	2	M5	HSS4x4x4	.020	2.247	.001	0	85.595	92.826	10.765	1.136	H1-1b
14	2	M6	HSS6x4x4	.037	0	.009	0	113.122	118.443	19.58	2.362	H1-1b
15	2	M7	HSS6x4x4	.137	0	.026	0	113.122	118.443	19.58	2.188	H1-1b
16	2	M8	HSS6x4x4	.045	10.25	.004	0	27.57	118.443	19.58	1.136	H1-1b
17	3	M1	HSS4x4x6	.086	7.766	.016	7.875	80.21	131.665	14.668	1.362	H1-1b
18	3	M2	HSS6x4x4	.122	13.5	.018	13.5	59.773	118.443	19.58	2.323	H1-1b
19	3	M3	HSS4x4x6	.096	2.734	.021	0	80.21	131.665	14.668	1.364	H1-1b
20	3	M4	HSS4x4x4	.006	2.247	.001	4.402	85.595	92.826	10.765	1.136	H1-1b
21	3	M5	HSS4x4x4	.018	2.247	.001	4.402	85.595	92.826	10.765	1.136	H1-1b
22	3	M6	HSS6x4x4	.021	0	.004	0	113.122	118.443	19.58	1.889	H1-1b
23	3	M7	HSS6x4x4	.115	0	.022	0	113.122	118.443	19.58	2.172	H1-1b
24	3	M8	HSS6x4x4	.045	10.25	.004	0	27.57	118.443	19.58	1.136	H1-1b
25	4	M1	HSS4x4x6	.102	7.875	.022	7.875	80.21	131.665	14.668	1.363	H1-1b
26	4	M2	HSS6x4x4	.058	13.5	.005	13.5	59.773	118.443	19.58	2.268	H1-1b
27	4	M3	HSS4x4x6	.104	2.734	.023	0	80.21	131.665	14.668	1.363	H1-1b
28	4	M4	HSS4x4x4	.007	2.155	.001	0	85.595	92.826	10.765	1.136	H1-1b
29	4	M5	HSS4x4x4	.009	2.247	.001	0	85.595	92.826	10.765	1.136	H1-1b
30	4	M6	HSS6x4x4	.055	3.5	.011	0	113.122	118.443	19.58	2.174	H1-1b
31	4	M7	HSS6x4x4	.060	0	.012	0	113.122	118.443	19.58	2.186	H1-1b
32	4	M8	HSS6x4x4	.040	10.25	.004	0	27.57	118.443	19.58	1.136	H1-1b
33	5	M1	HSS4x4x6	.114	7.766	.019	7.875	80.21	131.665	14.668	1.361	H1-1b
34	5	M2	HSS6x4x4	.203	13.5	.034	13.5	59.773	118.443	19.58	1.993	H1-1b
35	5	M3	HSS4x4x6	.132	2.734	.029	0	80.21	131.665	14.668	1.364	H1-1b
36	5	M4	HSS4x4x4	.017	2.247	.001	4.402	85.595	92.826	10.765	1.136	H1-1b
37	5	M5	HSS4x4x4	.029	2.247	.001	4.402	85.595	92.826	10.765	1.136	H1-1b
38	5	M6	HSS6x4x4	.067	3.5	.011	3.5	113.122	118.443	19.58	1.63	H1-1b
39	5	M7	HSS6x4x4	.185	0	.035	0	113.122	118.443	19.58	2.14	H1-1b
40	5	M8	HSS6x4x4	.051	10.25	.004	0	27.57	118.443	19.58	1.136	H1-1b

Attach. - B



Results for LC 1, dl+ll

E 2	Topock Switchgear Moment Frame lineB	SK - 1
		July 14, 2014 at 1:23 PM
		topoclswitchgear.momfrlineB.r2d

Hot Rolled Steel Properties

	Label	E [ksi]	G [ksi]	Nu	Therm (\1E5 F)	Density[k/ft^3]	Yield[ksi]
1	A36 Gr.36	29000	11154	.3	.65	.49	36
2	A572 Gr.50	29000	11154	.3	.65	.49	50
3	A992	29000	11154	.3	.65	.49	50
4	A500 Gr.B RND	29000	11154	.3	.65	.49	42
5	A500 Gr.B Rect	29000	11154	.3	.65	.49	46
6	A53 Gr.B	29000	11154	.3	.65	.49	35

Hot Rolled Steel Section Sets

	Label	Shape	Type	Design List	Material	Design Rules	A [in2]	I (90,270) [i...	I (0,180) [in4]
1	HR1A	HSS4x4x6	Column	Tube	A500 Gr.B Rect	Typical	4.78	10.3	10.3
2	HR2	HSS4x4x6	Beam	Tube	A500 Gr.B Rect	Typical	4.78	10.3	10.3

Joint Coordinates and Temperatures

	Label	X [ft]	Y [ft]	Temp [F]
1	N1	0	0	0
2	N2	0	10.5	0
3	N3	6.75	0	0
4	N4	6.75	10.5	0
5	N5	13.75	0	0
6	N6	13.75	10.5	0
7	N7	20.5	0	0
8	N8	20.5	10.5	0

Joint Boundary Conditions

	Joint Label	X [k/in]	Y [k/in]	Rotation[k-ft/rad]	Footing
1	N1	Reaction	Reaction		
2	N3	Reaction	Reaction		
3	N5	Reaction	Reaction		
4	N7	Reaction	Reaction		

Member Primary Data

	Label	I Joint	J Joint	Rotate(deg)	Section/Shape	Type	Design List	Material	Design Rules
1	M1	N1	N2		HR1A	Column	Tube	A500 Gr.B ...	Typical
2	M2	N3	N4		HR1A	Column	Tube	A500 Gr.B ...	Typical
3	M3	N5	N6		HR1A	Column	Tube	A500 Gr.B ...	Typical
4	M4	N7	N8		HR1A	Column	Tube	A500 Gr.B ...	Typical
5	M5	N2	N4		HR2	Beam	Tube	A500 Gr.B ...	Typical
6	M6	N4	N6		HR2	Beam	Tube	A500 Gr.B ...	Typical
7	M7	N6	N8		HR2	Beam	Tube	A500 Gr.B ...	Typical

Joint Loads and Enforced Displacements (BLC 1 : dl)

	Joint Label	L,D,M	Direction	Magnitude[(k,k-ft), (in,rad), (k*s^2/ft...
1	N4	L	Y	-.27
2	N6	L	Y	-.27
3	N2	L	Y	-.27
4	N8	L	Y	-.27

Joint Loads and Enforced Displacements (BLC 2 : ll)

Joint Label	L,D,M	Direction	Magnitude[(k,k-ft), (in,rad), (k*s^2/ft...

Joint Loads and Enforced Displacements (BLC 2 : ll) (Continued)

	Joint Label	L,D,M	Direction	Magnitude[(k,k-ft), (in,rad), (k*s^2/ft...
1	N3	L	Y	-.54
2	N6	L	Y	-.54
3	N2	L	Y	-.27
4	N8	L	Y	-.27

Joint Loads and Enforced Displacements (BLC 3 : wind horiz)

	Joint Label	L,D,M	Direction	Magnitude[(k,k-ft), (in,rad), (k*s^2/ft...
1	N2	L	X	.375
2	N8	L	X	.375

Joint Loads and Enforced Displacements (BLC 4 : seismic)

	Joint Label	L,D,M	Direction	Magnitude[(k,k-ft), (in,rad), (k*s^2/ft...
1	N2	L	X	.21
2	N8	L	X	.21

Member Distributed Loads (BLC 1 : dl)

	Member Label	Direction	Start Magnitude[k/ft,F]	End Magnitude[k/ft,F]	Start Location[ft,%]	End Location[ft,%]
1	M5	Y	-.03	-.03	0	6.75
2	M6	Y	-.03	-.03	0	7
3	M7	Y	-.03	-.03	0	6.75

Member Distributed Loads (BLC 2 : ll)

	Member Label	Direction	Start Magnitude[k/ft,F]	End Magnitude[k/ft,F]	Start Location[ft,%]	End Location[ft,%]
1	M5	Y	-.08	-.08	0	6.75
2	M6	Y	-.08	-.08	0	7
3	M7	Y	-.08	-.08	0	6.75

Basic Load Cases

	BLC Description	Category	X Gravity	Y Gravity	Joint	Point	Distributed
1	dl	None		-1	4		3
2	ll	None			4		3
3	wind horiz	None			2		
4	seismic	None			2		

Load Combinations

	Description	Solve	PD...	SR...	BLC	Factor	BLC	Factor	BLC	Factor	BLC	Factor	BLC	Factor	BLC	Factor	BLC	Factor	BLC	Factor
1	dl+ll	Yes	Y		1	1	2	1												
2	dl+wind	Yes	Y		1	1	3	.6												
3	dl+seismic	Yes	Y		1	1	3	.7												
4	dl+wind up	Yes	Y		1	1	3	.45	2	-.5										
5	dl+ll+wind ho...	Yes	Y		1	1	3	.45	2	.6										

Member Section Forces

	LC	Member Label	Sec	Axial[k]	Shear[k]	Moment[k-ft]
1	1	M1	1	1.076	-.016	0
2			2	1.033	-.016	.042
3			3	.99	-.016	.085
4			4	.948	-.016	.127
5			5	.905	-.016	.169
6	1	M2	1	1.372	.003	0

Member Section Forces (Continued)

	LC	Member Label	Sec	Axial[k]	Shear[k]	Moment[k-ft]
7			2	1.329	.003	-.007
8			3	1.287	.003	-.015
9			4	1.244	.003	-.022
10			5	1.201	.003	-.029
11	1	M3	1	1.906	-.003	0
12			2	1.863	-.003	.008
13			3	1.821	-.003	.016
14			4	1.778	-.003	.025
15			5	1.735	-.003	.033
16	1	M4	1	1.078	.016	0
17			2	1.035	.016	-.043
18			3	.992	.016	-.086
19			4	.95	.016	-.13
20			5	.907	.016	-.173
21	1	M5	1	.016	.365	.169
22			2	.016	.152	-.267
23			3	.016	-.061	-.343
24			4	.016	-.274	-.06
25			5	.016	-.487	.583
26	1	M6	1	.013	.444	.554
27			2	.013	.223	-.03
28			3	.013	.002	-.227
29			4	.013	-.219	-.037
30			5	.013	-.44	.54
31	1	M7	1	.016	.485	.572
32			2	.016	.272	-.067
33			3	.016	.059	-.346
34			4	.016	-.154	-.267
35			5	.016	-.367	.173
36	2	M1	1	.295	.097	0
37			2	.252	.097	-.255
38			3	.209	.097	-.51
39			4	.167	.097	-.764
40			5	.124	.097	-1.019
41	2	M2	1	.908	.129	0
42			2	.865	.129	-.339
43			3	.822	.129	-.678
44			4	.78	.129	-1.017
45			5	.737	.129	-1.356
46	2	M3	1	.654	.127	0
47			2	.611	.127	-.333
48			3	.569	.127	-.667
49			4	.526	.127	-1
50			5	.483	.127	-1.333
51	2	M4	1	.855	.109	0
52			2	.812	.109	-.286
53			3	.77	.109	-.572
54			4	.727	.109	-.858
55			5	.684	.109	-1.145
56	2	M5	1	.129	-.146	-1.019
57			2	.129	-.224	-.707
58			3	.129	-.302	-.263
59			4	.129	-.38	.313
60			5	.129	-.458	1.02
61	2	M6	1	.004	.009	-.336
62			2	.004	-.072	-.28
63			3	.004	-.153	-.083

Member Section Forces (Continued)

	LC	Member Label	Sec	Axial[k]	Shear[k]	Moment[k-ft]
64			4	.004	-.234	.256
65			5	.004	-.315	.736
66	2	M7	1	-.12	-.102	-.597
67			2	-.12	-.18	-.359
68			3	-.12	-.258	.01
69			4	-.12	-.336	.512
70			5	-.12	-.414	1.145
71	3	M1	1	.248	.114	0
72			2	.205	.114	-.3
73			3	.163	.114	-.6
74			4	.12	.114	-.9
75			5	.077	.114	-1.2
76	3	M2	1	.929	.15	0
77			2	.886	.15	-.395
78			3	.844	.15	-.79
79			4	.801	.15	-1.185
80			5	.758	.15	-1.58
81	3	M3	1	.633	.148	0
82			2	.59	.148	-.389
83			3	.547	.148	-.779
84			4	.505	.148	-1.168
85			5	.462	.148	-1.557
86	3	M4	1	.902	.126	0
87			2	.859	.126	-.331
88			3	.816	.126	-.662
89			4	.774	.126	-.994
90			5	.731	.126	-1.325
91	3	M5	1	.149	-.193	-1.2
92			2	.149	-.271	-.808
93			3	.149	-.349	-.286
94			4	.149	-.427	.369
95			5	.149	-.505	1.155
96	3	M6	1	.004	-.017	-.425
97			2	.004	-.098	-.325
98			3	.004	-.179	-.083
99			4	.004	-.26	.3
100			5	.004	-.341	.826
101	3	M7	1	-.141	-.149	-.732
102			2	-.141	-.227	-.415
103			3	-.141	-.305	.033
104			4	-.141	-.383	.613
105			5	-.141	-.461	1.325
106	4	M1	1	.118	.075	0
107			2	.075	.075	-.197
108			3	.032	.075	-.395
109			4	-.01	.075	-.592
110			5	-.053	.075	-.79
111	4	M2	1	.579	.095	0
112			2	.536	.095	-.249
113			3	.494	.095	-.498
114			4	.451	.095	-.747
115			5	.408	.095	-.995
116	4	M3	1	.125	.095	0
117			2	.082	.095	-.248
118			3	.039	.095	-.496
119			4	-.003	.095	-.744
120			5	-.046	.095	-.992

Member Section Forces (Continued)

	LC	Member Label	Sec	Axial[k]	Shear[k]	Moment[k-ft]
121	4	M4	1	.53	.077	0
122			2	.488	.077	-.202
123			3	.445	.077	-.403
124			4	.402	.077	-.605
125			5	.359	.077	-.807
126	4	M5	1	.094	-.188	-.79
127			2	.094	-.199	-.463
128			3	.094	-.209	-.119
129			4	.094	-.22	.243
130			5	.094	-.23	.623
131	4	M6	1	0	-.092	-.372
132			2	0	-.103	-.201
133			3	0	-.114	-.011
134			4	0	-.125	.198
135			5	0	-.136	.427
136	4	M7	1	-.094	-.182	-.566
137			2	-.094	-.193	-.25
138			3	-.094	-.203	.085
139			4	-.094	-.214	.437
140			5	-.094	-.224	.807
141	5	M1	1	.661	.067	0
142			2	.619	.067	-.175
143			3	.576	.067	-.35
144			4	.533	.067	-.525
145			5	.491	.067	-.7
146	5	M2	1	1.233	.1	0
147			2	1.19	.1	-.262
148			3	1.147	.1	-.525
149			4	1.105	.1	-.787
150			5	1.062	.1	-1.05
151	5	M3	1	1.359	.096	0
152			2	1.316	.096	-.251
153			3	1.274	.096	-.502
154			4	1.231	.096	-.753
155			5	1.188	.096	-1.003
156	5	M4	1	1.091	.091	0
157			2	1.048	.091	-.239
158			3	1.005	.091	-.478
159			4	.963	.091	-.717
160			5	.92	.091	-.956
161	5	M5	1	.104	.059	-.7
162			2	.104	-.101	-.665
163			3	.104	-.26	-.361
164			4	.104	-.419	.212
165			5	.104	-.578	1.052
166	5	M6	1	.009	.214	.003
167			2	.009	.049	-.228
168			3	.009	-.116	-.169
169			4	.009	-.281	.178
170			5	.009	-.446	.814
171	5	M7	1	-.082	.148	-.19
172			2	-.082	-.011	-.306
173			3	-.082	-.17	-.154
174			4	-.082	-.329	.267
175			5	-.082	-.488	.956

Joint Reactions

	LC	Joint Label	X [k]	Y [k]	MZ [k-ft]
1	1	N1	.016	1.076	0
2	1	N3	-.003	1.912	0
3	1	N5	.003	1.906	0
4	1	N7	-.016	1.078	0
5	1	Totals:	0	5.972	
6	1	COG (ft):	X: 10.25	Y: 8.95	
7	2	N1	-.096	.295	0
8	2	N3	-.125	.908	0
9	2	N5	-.124	.654	0
10	2	N7	-.105	.855	0
11	2	Totals:	-.45	2.712	
12	2	COG (ft):	X: 10.25	Y: 9.177	
13	3	N1	-.113	.248	0
14	3	N3	-.145	.929	0
15	3	N5	-.145	.633	0
16	3	N7	-.121	.902	0
17	3	Totals:	-.525	2.712	
18	3	COG (ft):	X: 10.25	Y: 9.177	
19	4	N1	-.075	.118	0
20	4	N3	-.093	.309	0
21	4	N5	-.094	.125	0
22	4	N7	-.075	.53	0
23	4	Totals:	-.338	1.082	
24	4	COG (ft):	X: 10.25	Y: 9.805	
25	5	N1	-.064	.661	0
26	5	N3	-.095	1.557	0
27	5	N5	-.091	1.359	0
28	5	N7	-.087	1.091	0
29	5	Totals:	-.338	4.668	
30	5	COG (ft):	X: 10.25	Y: 9.003	

Joint Deflections

	LC	Joint Label	X [in]	Y [in]	Rotation [rad]
1	1	N1	0	0	1.794e-4
2	1	N2	0	-.001	-3.566e-4
3	1	N3	0	0	-2.942e-5
4	1	N4	0	-.001	6.33e-5
5	1	N5	0	0	3.59e-5
6	1	N6	0	-.002	-6.781e-5
7	1	N7	0	0	-1.8e-4
8	1	N8	0	-.001	3.665e-4
9	2	N1	0	0	-4.292e-3
10	2	N2	.406	0	-1.068e-3
11	2	N3	0	0	-4.645e-3
12	2	N4	.406	0	-3.553e-4
13	2	N5	0	0	-4.622e-3
14	2	N6	.406	0	-4.033e-4
15	2	N7	0	0	-4.424e-3
16	2	N8	.406	0	-8.026e-4
17	3	N1	0	0	-5.018e-3
18	3	N2	.473	0	-1.223e-3
19	3	N3	0	0	-5.418e-3
20	3	N4	.473	0	-4.185e-4
21	3	N5	0	0	-5.394e-3
22	3	N6	.473	0	-4.665e-4

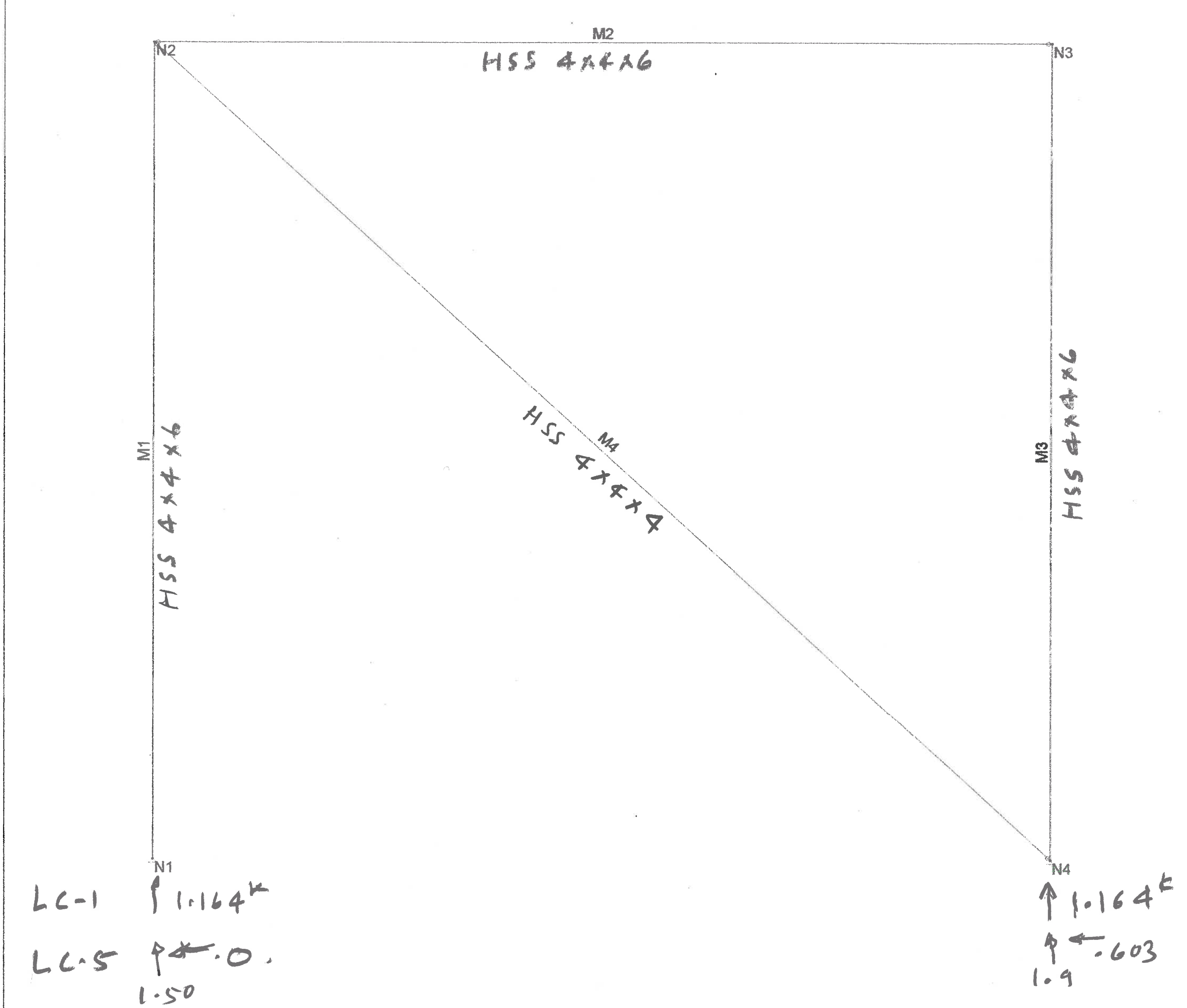
Joint Deflections (Continued)

	LC	Joint Label	X [in]	Y [in]	Rotation [rad]
23	3	N7	0	0	-5.15e-3
24	3	N8	.473	0	-9.585e-4
25	4	N1	0	0	-3.209e-3
26	4	N2	.3	0	-7.11e-4
27	4	N3	0	0	-3.425e-3
28	4	N4	.3	0	-2.757e-4
29	4	N5	0	0	-3.422e-3
30	4	N6	.3	0	-2.822e-4
31	4	N7	0	0	-3.227e-3
32	4	N8	.3	0	-6.751e-4
33	5	N1	0	0	-3.196e-3
34	5	N2	.31	0	-9.816e-4
35	5	N3	0	0	-3.563e-3
36	5	N4	.31	-.001	-2.423e-4
37	5	N5	0	0	-3.515e-3
38	5	N6	.31	-.001	-3.402e-4
39	5	N7	0	0	-3.465e-3
40	5	N8	.31	-.001	-4.417e-4

Member AISC 14th(360-10): ASD Steel Code Checks

	LC	Member	Shape	UC Max	Loc[ft]	Shear UC	Loc[ft]	Pnc/om [k]	Pnt/om [k]	Mn/om [k-ft]	Cb	Eqn
1	1	M1	HSS4x4x6	.017	10.5	.000	0	80.21	131.665	14.668	1.667	H1-1b
2	1	M2	HSS4x4x6	.009	10.5	.000	0	80.21	131.665	14.668	1.667	H1-1b
3	1	M3	HSS4x4x6	.013	10.5	.000	0	80.21	131.665	14.668	1.667	H1-1b
4	1	M4	HSS4x4x6	.017	10.5	.000	0	80.21	131.665	14.668	1.667	H1-1b
5	1	M5	HSS4x4x6	.040	6.75	.014	6.75	107.28	131.665	14.668	1.913	H1-1b
6	1	M6	HSS4x4x6	.038	0	.013	0	105.635	131.665	14.668	2.778	H1-1b
7	1	M7	HSS4x4x6	.039	0	.014	0	107.28	131.665	14.668	1.875	H1-1b
8	2	M1	HSS4x4x6	.070	10.5	.003	0	80.21	131.665	14.668	1.667	H1-1b
9	2	M2	HSS4x4x6	.097	10.5	.004	0	80.21	131.665	14.668	1.667	H1-1b
10	2	M3	HSS4x4x6	.094	10.5	.004	0	80.21	131.665	14.668	1.667	H1-1b
11	2	M4	HSS4x4x6	.082	10.5	.003	0	80.21	131.665	14.668	1.667	H1-1b
12	2	M5	HSS4x4x6	.070	6.75	.013	6.75	107.28	131.665	14.668	1.914	H1-1b
13	2	M6	HSS4x4x6	.050	7	.009	7	105.635	131.665	14.668	2.434	H1-1b
14	2	M7	HSS4x4x6	.078	6.75	.012	6.75	107.28	131.665	14.668	2.594	H1-1b
15	3	M1	HSS4x4x6	.082	10.5	.003	0	80.21	131.665	14.668	1.667	H1-1b
16	3	M2	HSS4x4x6	.112	10.5	.004	0	80.21	131.665	14.668	1.667	H1-1b
17	3	M3	HSS4x4x6	.109	10.5	.004	0	80.21	131.665	14.668	1.667	H1-1b
18	3	M4	HSS4x4x6	.095	10.5	.004	0	80.21	131.665	14.668	1.667	H1-1b
19	3	M5	HSS4x4x6	.082	0	.015	6.75	107.28	131.665	14.668	1.954	H1-1b
20	3	M6	HSS4x4x6	.056	7	.010	7	105.635	131.665	14.668	2.416	H1-1b
21	3	M7	HSS4x4x6	.091	6.75	.014	6.75	107.28	131.665	14.668	2.536	H1-1b
22	4	M1	HSS4x4x6	.054	10.5	.002	0	80.21	131.665	14.668	1.667	H1-1b
23	4	M2	HSS4x4x6	.070	10.5	.003	0	80.21	131.665	14.668	1.667	H1-1b
24	4	M3	HSS4x4x6	.068	10.5	.003	0	80.21	131.665	14.668	1.667	H1-1b
25	4	M4	HSS4x4x6	.057	10.5	.002	0	80.21	131.665	14.668	1.667	H1-1b
26	4	M5	HSS4x4x6	.054	0	.007	6.75	107.28	131.665	14.668	2.16	H1-1b
27	4	M6	HSS4x4x6	.029	7	.004	7	105.635	131.665	14.668	2.309	H1-1b
28	4	M7	HSS4x4x6	.055	6.75	.007	6.75	107.28	131.665	14.668	2.284	H1-1b
29	5	M1	HSS4x4x6	.051	10.5	.002	0	80.21	131.665	14.668	1.667	H1-1b
30	5	M2	HSS4x4x6	.078	10.5	.003	0	80.21	131.665	14.668	1.667	H1-1b
31	5	M3	HSS4x4x6	.076	10.5	.003	0	80.21	131.665	14.668	1.667	H1-1b
32	5	M4	HSS4x4x6	.071	10.5	.003	0	80.21	131.665	14.668	1.667	H1-1b
33	5	M5	HSS4x4x6	.072	6.75	.017	6.75	107.28	131.665	14.668	1.963	H1-1b
34	5	M6	HSS4x4x6	.056	7	.013	7	105.635	131.665	14.668	2.589	H1-1b
35	5	M7	HSS4x4x6	.065	6.75	.014	6.75	107.28	131.665	14.668	2.529	H1-1b

Attach-C



Results for LC 1, dl+ll

E 2	topock switchgear braced frames LINES ① & ④	SK - 1
		July 14, 2014 at 4:21 PM
		topock switchgear braced fr lines 1 ...

Hot Rolled Steel Properties

	Label	E [ksi]	G [ksi]	Nu	Therm (\1E5 F)	Density[k/ft^3]	Yield[ksi]
1	A36 Gr.36	29000	11154	.3	.65	.49	36
2	A572 Gr.50	29000	11154	.3	.65	.49	50
3	A992	29000	11154	.3	.65	.49	50
4	A500 Gr.B RND	29000	11154	.3	.65	.49	42
5	A500 Gr.B Rect	29000	11154	.3	.65	.49	46
6	A53 Gr.B	29000	11154	.3	.65	.49	35

Hot Rolled Steel Section Sets

	Label	Shape	Type	Design List	Material	Design Rules	A [in2]	I (90,270) [i...	I (0,180) [in4]
1	HR1A	HSS4x4x6	Beam	Tube	A500 Gr.B Rect	Typical	4.78	10.3	10.3
2	HR2	HSS4x4x4	HBrace	Wide Flange	A500 Gr.B Rect	Typical	3.37	7.8	7.8

Joint Coordinates and Temperatures

	Label	X [ft]	Y [ft]	Temp [F]
1	N1	0	0	0
2	N2	0	10.5	0
3	N3	11.5	10.5	0
4	N4	11.5	0	0

Joint Boundary Conditions

	Joint Label	X [k/in]	Y [k/in]	Rotation[k-ft/rad]	Footing
1	N1	Reaction	Reaction		
2	N4	Reaction	Reaction		

Member Primary Data

	Label	I Joint	J Joint	Rotate(deg)	Section/Shape	Type	Design List	Material	Design Rules
1	M1	N1	N2		HR1A	Beam	Tube	A500 Gr.B ...	Typical
2	M2	N2	N3		HR1A	Beam	Tube	A500 Gr.B ...	Typical
3	M3	N3	N4		HR1A	Beam	Tube	A500 Gr.B ...	Typical
4	M4	N4	N2		HR2	HBrace	Wide Flange	A500 Gr.B ...	Typical

Joint Loads and Enforced Displacements (BLC 3 : wind horiz)

	Joint Label	L,D,M	Direction	Magnitude[(k,k-ft), (in,rad), (k*s^2/ft...
1	N2	L	X	.67
2	N3	L	X	.67

Joint Loads and Enforced Displacements (BLC 4 : seismic)

	Joint Label	L,D,M	Direction	Magnitude[(k,k-ft), (in,rad), (k*s^2/ft...
1	N2	L	X	.35
2	N3	L	X	.35

Member Point Loads (BLC 1 : dl)

	Member Label	Direction	Magnitude[k,k-ft]	Location[ft,%]
1	M2	Y	-.27	3.83
2	M2	Y	-.27	7.67

Member Point Loads (BLC 2 : ll)

	Member Label	Direction	Magnitude[k,k-ft]	Location[ft,%]
1	M2	Y	-.54	3.83
2	M2	Y	-.54	7.67

Basic Load Cases

	BLC Description	Category	X Gravity	Y Gravity	Joint	Point	Distributed
1	dl	None		-1		2	
2	ll	None				2	
3	wind horiz	None			2		
4	seismic	None			2		

Load Combinations

	Description	Solve	PD...	SR...	BLC	Factor	BLC	Factor	BLC	Factor	BLC	Factor	BLC	Factor	BLC	Factor	BLC	Factor	BLC	Factor
1	dl+ll	Yes	Y		1	1	2	1												
2	dl+wind horiz	Yes	Y		1	1	3	.6												
3	dl+seismic	Yes	Y		1	1	4	.7												
4	dl+ll+wind ho...	Yes	Y		1	1	3	.45	2	-.5										
5	dl+ll+wind ho...	Yes	Y		1	1	3	.45	2	.6										
~~6~~		~~Yes~~	~~Y~~		~~1~~	~~1~~	~~3~~	~~.45~~	~~2~~	~~.6~~										

Duplicate

Joint Reactions (By Combination)

	LC	Joint Label	X [k]	Y [k]	MZ [k-ft]
1	1	N1	0	1.164	0
2	1	N4	0	1.164	0
3	1	Totals:	0	2.327	
4	1	COG (ft):	X: 5.75	Y: 9.327	
5	2	N1	0	-.111	0
6	2	N4	-.804	1.358	0
7	2	Totals:	-.804	1.247	
8	2	COG (ft):	X: 5.75	Y: 8.31	
9	3	N1	0	.176	0
10	3	N4	-.49	1.071	0
11	3	Totals:	-.49	1.247	
12	3	COG (ft):	X: 5.75	Y: 8.31	
13	4	N1	0	-.197	0
14	4	N4	-.603	.904	0
15	4	Totals:	-.603	.707	
16	4	COG (ft):	X: 5.75	Y: 6.639	
17	5	N1	0	.397	0
18	5	N4	-.603	1.498	0
19	5	Totals:	-.603	1.895	
20	5	COG (ft):	X: 5.75	Y: 9.059	
21	6	N1	0	.397	0
22	6	N4	-.603	1.498	0
23	6	Totals:	-.603	1.895	
24	6	COG (ft):	X: 5.75	Y: 9.059	

Joint Deflections

	LC	Joint Label	X [in]	Y [in]	Rotation [rad]
1	1	N1	0	0	7.103e-6
2	1	N2	0	0	7.103e-6
3	1	N3	0	0	7.103e-6
4	1	N4	0	0	7.103e-6

Joint Deflections (Continued)

	LC	Joint Label	X [in]	Y [in]	Rotation [rad]
5	2	N1	0	0	-2.366e-5
6	2	N2	.003	0	-2.366e-5
7	2	N3	.003	0	-2.684e-5
8	2	N4	0	0	-2.684e-5
9	3	N1	0	0	-1.304e-5
10	3	N2	.002	0	-1.304e-5
11	3	N3	.002	0	-1.497e-5
12	3	N4	0	0	-1.497e-5
13	4	N1	0	0	-1.864e-5
14	4	N2	.002	0	-1.864e-5
15	4	N3	.003	0	-2.102e-5
16	4	N4	0	0	-2.102e-5
17	5	N1	0	0	-1.473e-5
18	5	N2	.002	0	-1.473e-5
19	5	N3	.002	0	-1.711e-5
20	5	N4	0	0	-1.711e-5
21	6	N1	0	0	-1.473e-5
22	6	N2	.002	0	-1.473e-5
23	6	N3	.002	0	-1.711e-5
24	6	N4	0	0	-1.711e-5

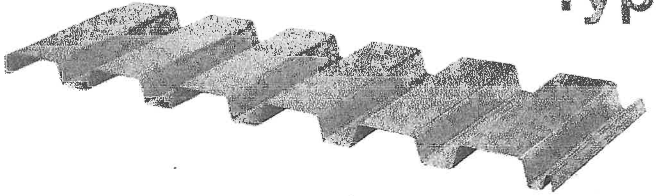
Member AISC 14th(360-10): ASD Steel Code Checks (By Combination)

	LC	Member	Shape	UC Max	Loc[ft]	Shear UC	Loc[ft]	Pnc/om [k]	Pnt/om [k]	Mn/om [k-ft]	Cb	Eqn
1	1	M1	HSS4x4x6	.007	0	.000	0	80.21	131.665	14.668	1	H1-1b
2	1	M2	HSS4x4x6	.230	5.75	.027	0	72.657	131.665	14.668	1.136	H1-1b
3	1	M3	HSS4x4x6	.007	10.5	.000	0	80.21	131.665	14.668	1	H1-1b
4	1	M4	HSS4x4x4	.024	7.624	.003	15.572	33.574	92.826	10.765	1.136	H1-1b
5	2	M1	HSS4x4x6	.001	10.5	.000	0	80.21	131.665	14.668	1	H1-1b
6	2	M2	HSS4x4x6	.090	5.75	.011	0	72.657	131.665	14.668	1.136	H1-1b
7	2	M3	HSS4x4x6	.003	10.5	.000	0	80.21	131.665	14.668	1	H1-1b
8	2	M4	HSS4x4x4	.040	7.624	.003	15.572	33.574	92.826	10.765	1.136	H1-1b
9	3	M1	HSS4x4x6	.001	0	.000	0	80.21	131.665	14.668	1	H1-1b
10	3	M2	HSS4x4x6	.090	5.75	.011	0	72.657	131.665	14.668	1.136	H1-1b
11	3	M3	HSS4x4x6	.003	10.5	.000	0	80.21	131.665	14.668	1	H1-1b
12	3	M4	HSS4x4x4	.034	7.624	.003	15.572	33.574	92.826	10.765	1.136	H1-1b
13	4	M1	HSS4x4x6	.001	10.5	.000	0	80.21	131.665	14.668	1	H1-1b
14	4	M2	HSS4x4x6	.019	5.75	.003	0	72.657	131.665	14.668	1.136	H1-1b
15	4	M3	HSS4x4x6	.002	10.5	.000	0	80.21	131.665	14.668	1	H1-1b
16	4	M4	HSS4x4x4	.036	7.624	.003	15.572	33.574	92.826	10.765	1.136	H1-1b
17	5	M1	HSS4x4x6	.002	0	.000	0	80.21	131.665	14.668	1	H1-1b
18	5	M2	HSS4x4x6	.175	5.75	.020	0	72.657	131.665	14.668	1.136	H1-1b
19	5	M3	HSS4x4x6	.005	10.5	.000	0	80.21	131.665	14.668	1	H1-1b
20	5	M4	HSS4x4x4	.036	7.624	.003	15.572	33.574	92.826	10.765	1.136	H1-1b
21	6	M1	HSS4x4x6	.002	0	.000	0	80.21	131.665	14.668	1	H1-1b
22	6	M2	HSS4x4x6	.175	5.75	.020	0	72.657	131.665	14.668	1.136	H1-1b
23	6	M3	HSS4x4x6	.005	10.5	.000	0	80.21	131.665	14.668	1	H1-1b
24	6	M4	HSS4x4x4	.036	7.624	.003	15.572	33.574	92.826	10.765	1.136	H1-1b

ATTACH-'D'

Type PLB™-36 or HSB®-36

1½" Deep Roof Deck
Primer Painted or Galvanized



VERTICAL LOADS

Allowable Uniform Loads (psf)

Span	Gage		4'-0"	5'-0"	5'-6"	6'-0"	6'-6"	7'-0"	7'-6"	8'-0"	8'-6"	9'-0"	9'-6"	10'-0"	10'-6"	11'-0"	11'-6"	12'-0"
SINGLE	22	Stress	185	118	98	82	70	60	53	46	41	37	33	30				
		L/240	185	95	71	55	43	34	28	23	19	16	14	12				
	20	Stress	223	149	123	104	88	76	66	58	52	46	41	37	34	31	28	26
		L/240	229	117	88	68	53	43	35	29	24	20	17	15	13	11	10	8
	18	Stress	300	204	168	141	120	104	90	80	70	63	56	51	46	42	38	35
		L/240	◆◆◆	160	120	93	73	58	47	39	33	27	23	20	17	15	13	12
	16	Stress	300	259	214	180	153	132	115	101	89	80	72	65	59	53	49	45
		L/240	◆◆◆	200	150	116	91	73	59	49	41	34	29	25	22	19	16	14
DOUBLE	22	Stress	194	124	103	86	73	63	55	49	43	38	34	31				
		L/240	◆◆◆	◆◆◆	◆◆◆	◆◆◆	◆◆◆	◆◆◆	◆◆◆	◆◆◆	◆◆◆	◆◆◆	◆◆◆	30				
	20	Stress	244	156	129	108	92	80	69	61	54	48	43	39	35	32	30	27
		L/240	◆◆◆	◆◆◆	◆◆◆	◆◆◆	◆◆◆	◆◆◆	◆◆◆	◆◆◆	◆◆◆	◆◆◆	43	37	32	27	24	21
	18	Stress	300	212	175	147	125	108	94	83	73	65	59	53	48	44	40	37
		L/240	◆◆◆	◆◆◆	◆◆◆	◆◆◆	◆◆◆	◆◆◆	◆◆◆	◆◆◆	◆◆◆	◆◆◆	56	48	42	36	32	28
	16	Stress	300	262	217	182	155	134	117	103	91	81	73	66	60	54	50	46
		L/240	◆◆◆	◆◆◆	◆◆◆	◆◆◆	◆◆◆	◆◆◆	◆◆◆	◆◆◆	◆◆◆	◆◆◆	70	60	52	45	40	35
TRIPLE	22	Stress	243	155	128	108	92	79	69	61	54	48	43	39				
		L/240	◆◆◆	◆◆◆	◆◆◆	◆◆◆	86	69	56	46	39	33	28	24				
	20	Stress	300	195	161	136	116	100	87	76	68	60	54	49	44	40	37	34
		L/240	◆◆◆	◆◆◆	◆◆◆	132	104	83	68	56	47	39	33	29	25	21	19	17
	18	Stress	300	265	219	184	157	135	118	103	92	82	73	66	60	55	50	46
		L/240	◆◆◆	◆◆◆	◆◆◆	175	138	110	90	74	62	52	44	38	33	28	25	22
	16	Stress	300	300	271	228	194	167	146	128	113	101	91	82	74	68	62	57
		L/240	◆◆◆	◆◆◆	◆◆◆	218	172	137	112	92	77	65	55	47	41	35	31	27

Notes:
Stress = Uniform load which produces maximum allowable stress in deck.
L/240 = Uniform load which produces L/240 deflection in deck.
Self-weight of the deck should be included when determining dead load.
The symbol ◆◆◆ indicates allowable uniform load based on deflection exceeds allowable uniform load based on stress.

TAB NO.3

a. FUTURE FRESHWATER PRE-INJECTION TREATMENT SYSTEM BUILDING
b. OUTDOOR CHEMICAL STORAGE AREA
c. REMEDY FRESHWATER STORAGE TANK (10,000 GALLONS)
d. BACKWASH TANKS and TREATED WATER TANK

APPENDIX A - CALCULATION COVER SHEET

CALCULATION ID NUMBER	TA02
REVISION NUMBER	
JOB NUMBER	WW-PGE-2174

TITLE	Topock Fresh Water Treatment System Bldg.

Pg. NO.	CONTENT	DWGS
1	General & Data	S-13-01 TO S-13-10
2	Lateral Loads	
3,4	Moment Frame & Braced Frame	
5,6,7	Treatment Vessel Tank Design	
8	Foundation for TFWB (Topock Fresh Water Bldg.)	
Appendix	A-1 (Moment Frame) 5 pages	
Appendix	A-2 (Braced Frame) 6 pages	
Appendix	A-3 Data for Vessel tank / Filteration Equip	
Attachments	A, B, C	

	initial	date
PREPARED	KD	5/07/14
TITLE		
REVIEWED		
TITLE		

10/12/15 60% Design

REVISION NOTES	

E2 Consulting Engineers, Inc. 1900 Powell Street, Suite 250 Emeryville, CA 94608	Designed By:	KD	Date: 4/23/14
	Checked By:		Date:
	Reviewed By:		Date:
Project No.	WW-PGE-2174		Sheet No. 1
Project Description:	Topock Fresh Water treatment System Bldg		

Reference:

GENERAL

References

1. AWAA Standard D-100-11 For tank Design
2. CBC 2010
3. ASCE 7-10 For Seismic, wind, Loads etc.
4. ACI 318-11 Conc. Design

Seismic Data

$S_S = .23$ $S_{MS} = 1.6 \times .23 = .368$ USE .37

$S_1 = .12$ $S_{M1} = F_v S_1 = 2.318 \times .12 = .279$ USE .28

$S_{DS} = .247$ $S_{D1} = .187$

Wind - 20 PSF

Soil Bearing = 4000 PSF

Conc. Data

$f_c' = 5.0$ ksi $f_y = 60$ ksi

Floor Loads

Dwg. S-13.03 See Attach 'C'

DL - 5" Conc slab + Deck + Misc.	=	75	PSF
Piping	=	25	
Σ DL	=	100	PSF
LL	=	100	
TL	=	200	PSF

Floor Deck (composite Deck) Span = 5'

18 GA. x 1½" deep x 36

Allow. load = 400 PSF (6' unshored span) > 200 PSF OK

1½" Verco Formlock (6" total TK) - 18 GA x 36" OK

Roof Loads

Dwg. S-13.05 See Attach 'B'

DL - Deck + FRMG.	=	6	
LL	=	20	
TL		26	PSF

Roof Deck (Span = 6')

18 GA, 1½" deep x 36" Deck

Allow Load = 93 PSF (l/240 Defl.) > 20 PSF OK

Verco 18 GA, 1½" deep x 36" OK

Tank Data

See APPENDIX A-3

Equipment on 2nd Flr.

See Appendix A-3

2 Consulting Engineers, Inc. 1900 Powell Street, Suite 250 Emeryville, CA 94608	Designed By:	KD	Date: 4/24/14
	Checked By:		Date:
	Reviewed By:		Date:
Project No.	WW-PGE-2174		Sheet No. 2
Project Description:	Topock Fresh Water treatment System Bldg.		

Reference:

Seismic Loads

Using Equivalent Lateral Procedure

Sect. 12.8 Ref-3

$V = C_s W$ $I = 1.25$ $R = 3.5$ (Ordinary Mom-Fr.'s) $R = 3.25$ (Braced Frames)

NS Dir. Mom. Fr.'s

$W = (.006 \times 14.5 \times 32.5 + .085 \times 14.5 \times 28.5) \times 1.05 = (2.83 + 35.13) \times 1.05 = 39.85^k$ USE 40^k

EW Dir. Br. Fr.'s

$W = (.006 \times 47 \times 32.5 + .085 \times 45 \times 28.5) \times 1.05 = (9.17 + 109.0) \times 1.05 = 124.1^k$ USE 124^k

$C_s = \dfrac{S_{DS}}{(R/I)} = \dfrac{.247}{(3.5/1.25)} = .088$ $C_{s\,max} = \dfrac{.5 S_{D1}}{T(R/I)}$

Table 12-8-2

$T = C_t h_n^x = .028 \times (28)^{.8} = .403$ $T_{EW} = .02 (28)^{.75} = .243$ sec.

Sect. 12.8.2.1 Ref-3 NS

$C_{s\,max}$ (Br. Fr.) $= \dfrac{.5 \times .187}{.243 \times 2.6} = .148 > .088$ $C_{s\,max}$ (Mom. Fr.) $= \dfrac{.5 \times .187}{.403 \times 2.8} = .083$ USE .088 ok

$V_{NS} = .088 \times 40 = 3.52^k$ (Mom. Fr.'s) $V_{EW} = \dfrac{.247}{(3.25/1.25)} \times W = .095 \times 124 = 11.8^k$ (Br. Fr.'s) USE 12^k

Wind Loads

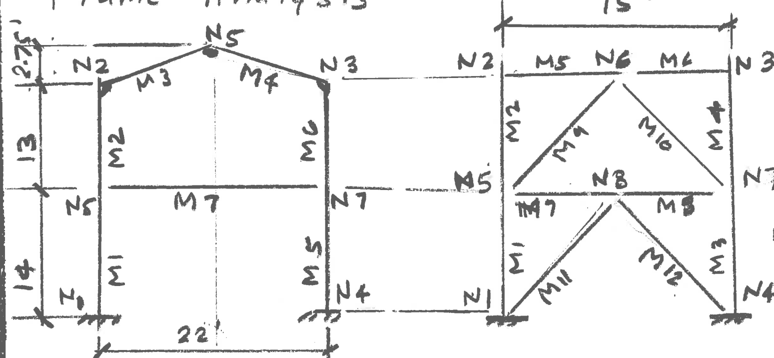
NS Dir. $V_{NS} = .01 (9.25) \times 14.5 + .01 (6.5) \times 14.5 = 2.28^k$ USE $2.5^k < 3^k$

EW Dir. $V_{EW} = .01 (8.0) \times 26 + .01 (6.5) \times 26 = 3.77^k$ USE $4.0^k < 5^k$

Seismic Loads are higher, design for several combinations.

Sect. 12.8.3

Frame Analysis



Moment Frame Braced Frame

Distribute Seismic Force

$C_{vx} = (w_x h_x^k) / \sum_{i=1}^{n} w_i h_i^k$ $k = 1$

$= (2.83 \times 28) / (2.83 \times 28 + 35.13 \times 14)$

$= .139$

Roof NS Dir. $V_R = .139 \times 3.52 = .49^k$ Say $.50^k$

$V_F = 3.52 - .5 = 3.02^k$

Wind N-S $V_r = 1.5^k$ $V_f = 1^k$

Wind EW $V_r = 2.4^k$ $V_f = 1.6^k$

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ct No. WW-PGE-2174			Sheet No. 3
ect Description:	Topock Fresh Water Treatment System Bldg.		

Reference:

Second Floor Loads on Moment Fr. Member

B-1 ($l = 12'$)

$w_{TL} = (.10 \times 4.33 + .10 \times 4.33) = .433 + .433 = .866^{k/'}$

$R = 5.20^k$

B-1A ($l = 7.0$)

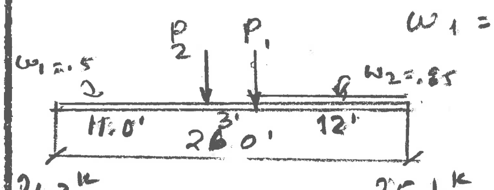
$w_{TL} = .1 \times 5 + .1 \times 5 = 1.0^{k/'}$ $R = 1 \times 3.5 = 3.5^k$

B-1B ($l = 3.0$) $w_{TL} = .866^{k/'}$ $R = 1.3^k$

B-1C ($l = 11.0$) $w_{TL} = .1 \times 3 + .1 \times 3 = .6^{k/'}$ $R = 3.3^k$

B-3 ($l = 26'$) $w_2 = .1 \times 4.25 + .1 \times 4.25 = .85^{k/'}$

$w_1 = .1 \times 2.5 + .1 \times 2.5 = .50^{k/'}$



(B-2) (B-2A)

$P_1 = 9.75 \times 2 = 19.5^k$ $P_2 = 5.6^k \times 2 = 11.2^k$

$R_L \times 26 = .85 \times 12 \times 6 + 19.5 \times 12 + 11.2 \times 13 + .5 \times 11 \times 20.5$

$R_L = 21.3^k$ $R_R = 46.4 - 21.3 = 25.1^k$

$F_y = 50$ ksi

W 16x57 $M_R = 254^{1k} > 165.5^{1k}$

$M_{max} = 25.1 \times 12 - .85 \times 12^2 \times .5 = 240^{1k}$

$\Delta_{TL} = \frac{5}{384} \frac{\times 2.84 \times 26^4 \times 1728}{29000 \times 954} = 1.05''$ ok

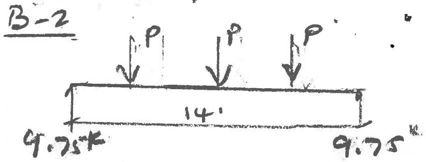
$w_{eq.} = \frac{240 \times 8}{26^2} = 2.84^{k/'}$ USE $w_{DL} = 1.30 \times .85 = 1.2^{k/'}$

$w_{LL} = 1.45$

See computer printout for deflections (App A-1)

Adjustment for piping load = 10 PSF

B-2

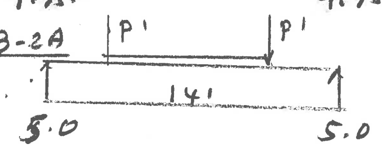


(B-1) (B-1B)

$P = 5.20^k + 1.3 = 6.50^k$

$R = .5 \times 6.50 \times 3 = 9.75^k$

B-2A



(B-1C) (B-1B)

$P' = 3.3 + 1.3 = 4.7^k$

$w = .075 \times 1.5 + .075 \times 1.5 = .225^{k/'}$

$R = 4 + .225 \times 9.4 \times .5 = 5.6^k$

Note: This page Calc's are done to Substantiate the floor loads used in computer analysis of moment frame.

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Project No. WW-PGE-2174			Sheet No. 4
Project Description: Topock Fresh Water Treatment Bldg.			

Reference:

Moment Frame Load Combinations (See computer printout) NS' DIR
APPENDIX A-1

Basic Loads:

DL Roof
Memb's M3 & M4
$.006 \times 14.5 = .087^{k/}$ USE $.1^{k/}$

FLOOR
Memb. M7
See Note pg. 3 USE DL = $1.0^{k/}$

LL Memb's M3 & M4
$.02 \times 14.5 = .29^{k/}$

Memb. M7
$.1 \times 14.5 = 1.45^{k/}$

Seismic Loads (See page 2)
P_S JT. N2 & N3 $= \frac{.44}{2} = .22^k$

P_S JT. N6 & N7 $= \frac{2.56}{2} = 1.28^k$

Wind Loads
P_W JT. N2 & N3 $= \frac{1.5}{2} = .75^k$

P_W JT N6 & N7 $= \frac{1}{2} = .5^k$

Braced Frames IN EW DIR (See Computer output Appendix A-2)

Roof

DL Memb's. M5, M6
$.006 \times 6.25 + .04 = .08^{k/}$

LL ↓ $.02 \times 6.25 = .125^{k/}$
↑ $.01 \times 6.25 = .063$

Floor

Memb's M7, M8
$.085 \times 7.25 = .62^{k/}$
$.10 \times 7.25 = .725^{k/}$

Seismic
P_S JT. N2, N3 $= \frac{.114 \times 6}{2} = .42^k$

P_S JT. N5, N7 $= \frac{.86 \times 6}{2} = 2.58^k$

Wind
P_W JT. N2, N3 $= \frac{.6 \times 4.0}{2} = 1.20^k$

P_W JT N5, N7 $= \frac{.4 \times 4.0}{2} = .80^k$

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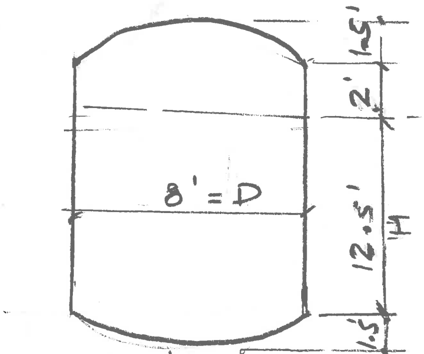
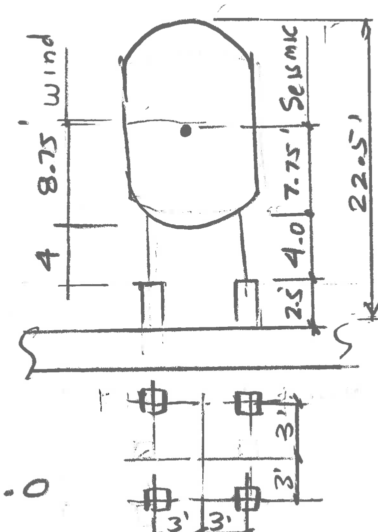
	Reviewed By:		Date:
Project No. WN-PGE-2178			Sheet No. 8
Project Description:	Topock Freshwater Treatment Bldg./Treatment vessel tank		

Reference: **Seismic Loads**





Impulsive Components

$A_i = \dfrac{S_{ai} I_E}{1.4 \times R_I}$ $\quad I_E = 1.25 \quad R_I = 3.0$

For $T_1 < T_s \quad S_{ai} = S_{DS}$

$= \dfrac{.247 \times 1.25}{1.4 \times 3.0} = .074$ $\quad T_1 = C_t h_n^{x} = .02 \times 17^{.75} = .167 < .757$

Impulsive — USE $A_i = .074\,g$ $\quad T_s = \dfrac{.187}{.247} = .757 \quad T_L = 12$ sec.

Eq. 13-16 — $A_{i\,min.} = \dfrac{.36 \times .12 \times 1.25}{3.0} = .018$

$V_i = A_i(W_s + W_r + W_f + W_i)$

W_T = wt. of contents $= 49 HD^2 = 49 \times 13.5 \times 8^2 \times 10^{-3} = 42.34^k$

wt. of Tank shell $= \dfrac{\pi}{4}(8.03125^2 - 8.0^2) \times 14.5 \times .49 + \pi \times 8 \times .03125 \times .49 \times 2$

$= 3.56 + .78 = 4.33^k$

Total wt. $= 42.34 + 4.33 = 46.67^k$ USE 47^k

$V_i = .074 \times 47 = 3.48^k$

Convective — $A_c = \dfrac{S_{ac} I_E}{1.4 R_I} \quad I_E = 1.25 \quad R_I = 1.5 \quad S_{ac} = \dfrac{1.5 \times .187}{T_c}$

Eq. 13-18

$T_c = 2\pi\sqrt{\dfrac{8}{3.68\,g \tanh\left(\frac{3.68 \times 14}{8}\right)}}$ 6.44 $= 2\pi\sqrt{\dfrac{8}{3.68 \times 32.2 \times .9999}} = 1.633$

$S_{ac} = \dfrac{1.5 \times .187}{1.633} = .172$ $\quad A_c = \dfrac{.172 \times 1.25}{1.4 \times 1.5} = .1024$

$V = .1024 \times 47 = 4.81^k$ $\quad$ USE $A_c = .1024\,g$

$M = .1024(42.34 \times 11.75 + 4.66 \times 12) = (497.5 + 53.9)\,.1024 = 56.67^{\prime k}$ (water, shell)

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Project No.			Sheet No. 6
Project Description:	Topock Freshwater treatment Bldg / Treatment Vessel Tank		

Reference:

Calculate uplift on bolts (DL + water + seismic) Tank Full

Design M_{OTM} @ FTG. $= 1.5 \times 56.67 + 1.5 \times 4.81 \times 2 = 99.44'^{k}$

Resisting M_{RM} @ FTG. $= 46.67 \times 5.5 = 256.7'^{k}$ $\quad F.S. = \frac{256.7}{99.44} = 2.58 > 1.5$ ok

No tension in Bolts, Design only for shear

$V_{max} = \frac{5^k}{4} = 1.25^k \quad P_{max} = \frac{47}{4} = 11.75^k$ / PIER

Base Pl.

$p = \frac{11.75}{12 \times 12} = .082^{ksi} \quad M = \frac{.082 \times 6^2}{2} = 1.48'^{k}$

Try 3/4" Pl. $S = \frac{1}{6} \times 1" \times .75^2 = .09375$

$f_b = \frac{1.48}{.09375} = 15.79^{ksi} < 27^{ksi}$ OK

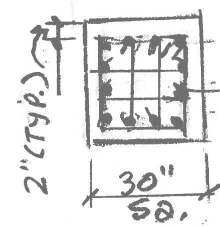
PIER OR PEDESTAL

$M = 56.67'^{k} \quad P = 47^k$

Max P / PEDSTAL (comp.) $= \frac{47}{4} + \frac{56.67}{6' \times 2 \text{ (PED.)}} = 11.75 + 4.75 = 16.5^k$ / PED.

USE 20^k (w conc. PED WT.)

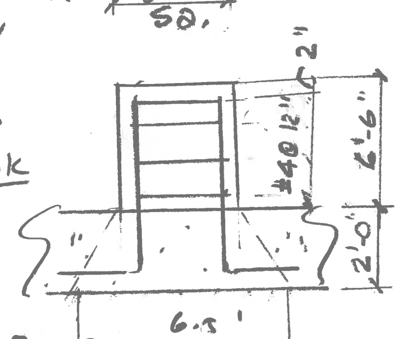
30" x 30" PEDSTALS W/ 12-#6 BARS



$M/\text{PED.} = \frac{5}{4} \times 6.5 \times 1.7 = 13.81'^{k}$

30" x 30" SQ. x 6'-6" High PEDSTAL W/ 12-#6 BARS W/ #4 TIES @ 12" o/c

Ten. $T = \frac{13.81 \times 12}{4 \times 24"} = 1.73^k$ / BAR #6 BARS OK



w/ DL + LL + seismic

f_p (soil press) $= \frac{P}{A} + \frac{M}{S}$

$P = 16.5 + .15 \times 2.5^2 \times 2.5 = 18.84^k$ USE 20^k

$M_o = 99.5'^{k}$

Since Ftg is very large $S_{tributary} = \frac{1}{6} \times 6.5 \times 5.5^2 = 38.73 \text{ ft}^3$

$f_p = \frac{20}{6.5 \times 5.5} + \frac{99.5 \times .5}{38.73} = .47 + 1.28 = 1.75 \text{ ksf} < 4 \text{ ksf}$ OK

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	Checked By:		Date:
	Reviewed By:		Date:
Project No.			Sheet No. 7
Project Description:	Topock FWTB/Treatment Vessel Tank		

Reference:

Wind Loads (Check w/ Tank Empty)

$G = 1.0$ wind vel. $= 100$ mph $q_z = .00256 \times 1.09 \times 1.15 \times 100^2 = 32$ PSF

$P_W = q_z G C_f = 32 \times 1 \times .6 = 19.2$ PSF USE $P_W = 20$ PSF

$P_W = .02 \times 8 \times 17.5 = 2.8^k$ $M_{max} = 2.8 \times 12.75 = 35.7^{1k}$ (M_{OTM})

$P_{DL} = 4.33^k$ Resisting $M = 4.33 \times 2.91 = 12.6^{1k}$

$P_u = \frac{35.7 \times 1.5 - 12.6}{5.82 \times 2} = 3.52^k$ $V/PED. = \frac{2.8}{4} = .7^k$

(@ Bolt w/ 2 PED's)

1" ϕ A.B. (Emb. = 12") $T_{ALL} = 10.9^k$ $V_{ALL} = 5.7^k$ $P_u = \frac{35.7 \times 1.5 - 12.6}{(5.82/.707)} = 4.97^k$ (@ Bolt w/ single PED. acting)

$\frac{T}{T_{ALL}} + \frac{V}{V_{ALL}} = \frac{4.97}{10.9} + \frac{1.4}{5.7} = .70 < 1.33$ ok

$M/PED = .7 \times 6.5 \times 1.7 + \frac{35.7}{2} \times 1.7 = 38.1^{1k}$

$f_p = \frac{P}{A} + \frac{M}{S} =$ $P_{DL} = 4.33 + .15 \times 2.5^2 \times 2.5 = 6.67^k$ USE 7^k

$M = 38.1^{1k}$

$S = \frac{1}{6} \times 5.5 \times 6.5^2 = 38.73$ ft³

$= \frac{7 \times 1.4}{6.5 \times 5.5} + \frac{38.1}{38.73}$

$= .274 + .984 = 1.26$ KSF

Dowels in Pedestal

$Ten\ T = \frac{38.10}{4 \times 24} \times 12 = 4.76^k$ $T_A = .9 \times 60 \times .44 = 23.76^k$ ok

Footing Reint.

@ Face of Ped. $Mu_{DL+Seis.} = 1.75 \times \frac{2.5^2}{2} = 5.47^{1k}$ Try #5 @ 12" Ea. way @ T & B

$Mu_{DL+wind} = \frac{1.26 \times 2.5^2}{2} = 3.94^{1k}$ $d = 24 - 2.5 = 21.5"$

$\phi M_n = .9 \times .31 \times \frac{60}{12} (21.5 - \frac{a}{2})$ $a = \frac{.31 \times 60}{.85 \times 5 \times 12} = .365$

$= 29.73^{1k} > 3.94^{1k}$

wind + DL: Mu bet.'n pedestals $= 1.26 \times \frac{6^2}{10} = 4.54^{1k} < 29.73^{1k}$

USE #5 @ 12" Ea. way @ T & B w/ Mat Ftg.

Seismic + DL: $Mu = \frac{1.75 \times 6^2}{10} = 6.3^{1k} < 29.73^{1k}$

Reference:

1. Foundation for Columns
2. foundation for All FWTB Tanks
3. Foundation for Retaining Wall.
4 Base pl. & Anchor Bolts
5 12" conc. slab on Grade

1 Footings columns

Max P = 10.69 + 38.78 = 49.47^k USE 50^k
Br. Fr. Mom. Fr.

$A_{FTG\ REQ.} = \frac{50}{4.0} = 12.5\ ft^2 \quad b_r = \sqrt{12.5} = 3.53'$ min.

USE 4'-0 SQ. FTG. W/ 5-#4 Ea. Way

ON COL. Line-A (Remedy Bldg.) USE 9'-0" W x cont. Mat. Fdn. ok by insp.

2 & 3 Footing for Tanks & Columns & Retaining Wall

Combine all Footings to provide Mat Foundation

Total DL + LL on Mat FDN. = 2 x 50 + 2 x (25 + 10) + 3 x 47 + 15 = 326^k
(Int. Col.) (Ext. Col.) (Tanks) (FTG)

$p = \frac{326 \times 1.10}{11 \times 48} = .68^{ksf} < 4.0^{ksf}$ ← For Soil + Misc.

Retaining Wall Ftg. adjacent to Mat Ftg. & to be made continuous with Mat Ftg.

Rebars in Mat Ftg.

Min. As on top & Bot. together in both dir. = .01 x 24 x 12 = 2.88 in²/1 Mat

USE #8 @ 12" Ea. Way @ T & B $A_{sa} = .79 \times 4 = 3.16\ in^2 > 2.88\ in^2$

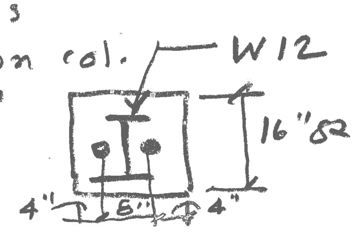
4 Base pl. & A.B.'s

Max. comp.'n P = 38.8^k $f_p = \frac{39}{16 \times 16} = .152^{ksi}$ $t_r = 2 \times 4 \sqrt{\frac{.152}{36}} = .52''$

USE 16"x16"x3/4" Base pl. Try 2 - 1"φ A.B.'s

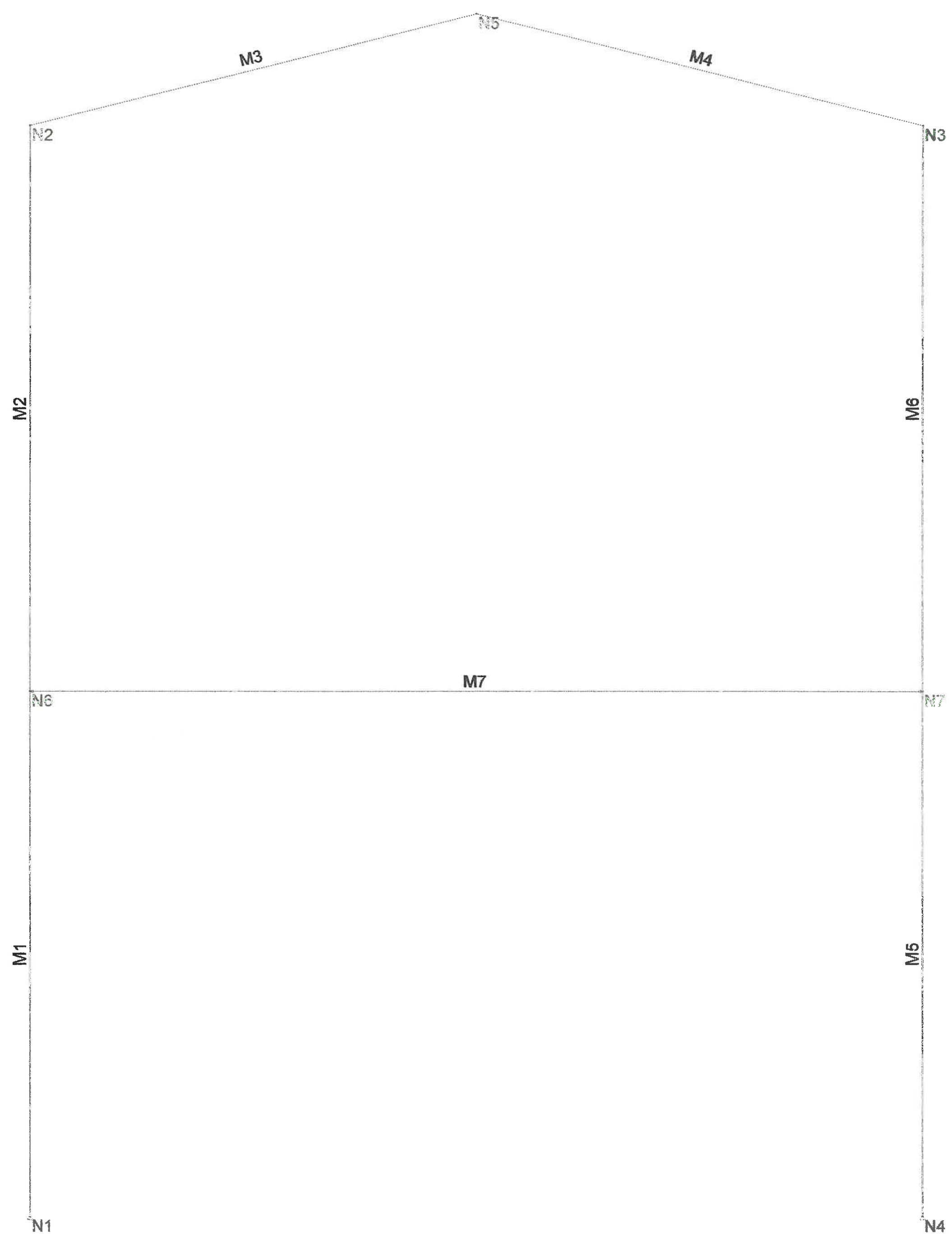
Max Shear V = 1.4^k (dl + seismic) No uplift on col.

2-1"φ A.B.'s A-307 ok by insp. Emb = 15"



5- 12" Conc. Slab on Grade Allow. load = 1100^PSF > 500^PSF OK
See Attach.-A

APP - A.1



Results for LC 1, dl+wind

e2	frwb mom. Fr.	SK - 2
kd	topock ~~electrical panel canopy~~	Apr 27, 2014 at 7:44 PM
ww-peg-2174-043062		topocfwtb.momfrA.r2d

Hot Rolled Steel Properties

	Label	E [ksi]	G [ksi]	Nu	Therm (\1E5 F)	Density[k/ft^3]	Yield[ksi]
1	A36 Gr.36	29000	11154	.3	.65	.49	36
2	A572 Gr.50	29000	11154	.3	.65	.49	50
3	A992	29000	11154	.3	.65	.49	50
4	A500 Gr.42	29000	11154	.3	.65	.49	42
5	A500 Gr.46	29000	11154	.3	.65	.49	46

Hot Rolled Steel Section Sets

	Label	Shape	Type	Design List	Material	Design Rules	A [in2]	I (90,270) [i...	I (0,180) [in4]
1	HR1A	W12x53	Beam	Wide Flange	A572 Gr.50	Typical	15.6	95.8	425
2	HR2	W16x67	Beam	Wide Flange	A572 Gr.50	Typical	19.6	119	954

Joint Coordinates and Temperatures

	Label	X [ft]	Y [ft]	Temp [F]
1	N1	0	0	0
2	N2	0	27	0
3	N3	26	27	0
4	N4	26	0	0
5	N5	13	29.75	0
6	N6	0	13	0
7	N7	26	13	0

Joint Boundary Conditions

	Joint Label	X [k/in]	Y [k/in]	Rotation[k-ft/rad]	Footing
1	N1	Reaction	Reaction		
2	N4	Reaction	Reaction		

Member Primary Data

	Label	I Joint	J Joint	Rotate(deg)	Section/Shape	Type	Design List	Material	Design Rules
1	M1	N1	N6		HR1A	Beam	Wide Flange	A572 Gr.50	Typical
2	M2	N6	N2		HR1A	Beam	Wide Flange	A572 Gr.50	Typical
3	M3	N2	N5		HR1A	Beam	Wide Flange	A572 Gr.50	Typical
4	M4	N5	N3		HR1A	Beam	Wide Flange	A572 Gr.50	Typical
5	M5	N4	N7		HR1A	Beam	Wide Flange	A572 Gr.50	Typical
6	M6	N7	N3		HR1A	Beam	Wide Flange	A572 Gr.50	Typical
7	M7	N6	N7		HR2	Beam	Wide Flange	A572 Gr.50	Typical

Joint Loads and Enforced Displacements (BLC 4 : wind horiz)

	Joint Label	L,D,M	Direction	Magnitude[(k,k-ft), (in,rad), (k*s^2/ft...
1	N2	L	X	.75
2	N3	L	X	.75
3	N6	L	X	.5
4	N7	L	X	.5

Joint Loads and Enforced Displacements (BLC 5 : seismic)

	Joint Label	L,D,M	Direction	Magnitude[(k,k-ft), (in,rad), (k*s^2/ft...
1	N2	L	X	.25
2	N3	L	X	.25
3	N6	L	X	1.51
4	N7	L	X	1.51

Member Distributed Loads (BLC 1 : dl)

	Member Label	Direction	Start Magnitude[k/ft,F]	End Magnitude[k/ft,F]	Start Location[ft,%]	End Location[ft,%]
1	M4	Y	-.1	-.1	0	13.4
2	M3	Y	-.1	-.1	0	13.4
3	M7	Y	-1.2	-1.2	0	26

Member Distributed Loads (BLC 2 : ll wind down)

	Member Label	Direction	Start Magnitude[k/ft,F]	End Magnitude[k/ft,F]	Start Location[ft,%]	End Location[ft,%]
1	M3	Y	-.29	-.29	0	13.4
2	M4	Y	-.29	-.29	0	13.4

Member Distributed Loads (BLC 3 : ll wind up)

	Member Label	Direction	Start Magnitude[k/ft,F]	End Magnitude[k/ft,F]	Start Location[ft,%]	End Location[ft,%]
1	M3	Y	-.145	-.145	0	13.4
2	M4	Y	-.145	-.145	0	13.4

Member Distributed Loads (BLC 6 : ii flr)

	Member Label	Direction	Start Magnitude[k/ft,F]	End Magnitude[k/ft,F]	Start Location[ft,%]	End Location[ft,%]
1	M7	Y	-1.45	-1.45	0	26

Basic Load Cases

	BLC Description	Category	X Gravity	Y Gravity	Joint	Point	Distributed
1	dl	None		-1			3
2	ll wind down	None					2
3	ll wind up	None					2
4	wind horiz	None			4		
5	seismic	None			4		
6	ii flr	None					1

Load Combinations

	Description	Solve	PD...	SR...	BLC	Factor	BLC	Factor	BLC	Factor	BLC	Factor	BLC	Factor	BLC	Factor	BLC	Factor	BLC	Factor
1	dl+wind	Yes	Y		1	1	4	.6												
2	dl+seismic	Yes	Y		1	1	5	.7												
3	dl+wind up	Yes	Y		1	1	3	1	4	.45										
4	dl+ll+wind	Yes	Y		1	1	2	.75	4	.45	6	.75								
5	dl+ rf ll+ flrll	Yes	Y		1	1	2	.75	6	.75										
6	dl+flr ll	Yes	Y		1	1	6	1												
7	dl + seismic ...	Yes	Y		1	1	5	.525	6	.75										

Joint Reactions

	LC	Joint Label	X [k]	Y [k]	MZ [k-ft]
1	1	N1	-.918	18.53	0
2	1	N4	-.582	21.339	0
3	1	Totals:	-1.5	39.869	
4	1	COG (ft):	X: 13	Y: 14.605	
5	2	N1	-1.406	18.288	0
6	2	N4	-1.058	21.581	0
7	2	Totals:	-2.464	39.869	
8	2	COG (ft):	X: 13	Y: 14.605	
9	3	N1	-.873	20.786	0
10	3	N4	-.252	22.937	0
11	3	Totals:	-1.125	43.722	
12	3	COG (ft):	X: 13	Y: 15.818	
13	4	N1	-.949	35.754	0
14	4	N4	-.176	38.17	0
15	4	Totals:	-1.125	73.924	
16	4	COG (ft):	X: 13	Y: 15.068	
17	5	N1	-.378	36.962	0
18	5	N4	.378	36.962	0
19	5	Totals:	0	73.924	
20	5	COG (ft):	X: 13	Y: 15.068	
21	6	N1	-.156	38.784	0
22	6	N4	.156	38.784	0
23	6	Totals:	0	77.569	
24	6	COG (ft):	X: 13	Y: 13.825	
25	7	N1	-1.093	32.686	0
26	7	N4	-.755	35.458	0
27	7	Totals:	-1.848	68.144	
28	7	COG (ft):	X: 13	Y: 13.939	

Joint Deflections

	LC	Joint Label	X [in]	Y [in]	Rotation [rad]
1	1	N1	0	0	-5.476e-3
2	1	N2	1.262	-.007	-1.533e-3

Joint Deflections (Continued)

	LC	Joint Label	X [in]	Y [in]	Rotation [rad]
3	1	N3	1.286	-.009	-9.09e-4
4	1	N4	0	0	-5.357e-3
5	1	N5	1.274	-.065	5.513e-4
6	1	N6	.79	-.006	-4.162e-3
7	1	N7	.79	-.007	-4.429e-3
8	2	N1	0	0	-7.378e-3
9	2	N2	1.636	-.006	-1.743e-3
10	2	N3	1.66	-.009	-1.119e-3
11	2	N4	0	0	-7.26e-3
12	2	N5	1.649	-.065	6.461e-4
13	2	N6	1.054	-.006	-5.404e-3
14	2	N7	1.055	-.007	-5.671e-3
15	3	N1	0	0	-4.262e-3
16	3	N2	.952	-.008	-1.542e-3
17	3	N3	.998	-.01	-3.273e-4
18	3	N4	0	0	-4.032e-3
19	3	N5	.975	-.12	4.22e-4
20	3	N6	.604	-.007	-3.029e-3
21	3	N7	.605	-.008	-3.549e-3
22	4	N1	0	0	-4.906e-3
23	4	N2	1.084	-.014	-1.805e-3
24	4	N3	1.141	-.015	-2.948e-4
25	4	N4	0	0	-4.619e-3
26	4	N5	1.112	-.152	4.741e-4
27	4	N6	.693	-.012	-3.425e-3
28	4	N7	.694	-.013	-4.072e-3
29	5	N1	0	0	-1.433e-4
30	5	N2	-.028	-.015	-7.551e-4
31	5	N3	.028	-.015	7.551e-4
32	5	N4	0	0	1.433e-4
33	5	N5	0	-.152	0
34	5	N6	0	-.013	3.234e-4
35	5	N7	0	-.013	-3.234e-4
36	6	N1	0	0	-5.915e-5
37	6	N2	-.012	-.014	-3.118e-4
38	6	N3	.012	-.014	3.118e-4
39	6	N4	0	0	5.915e-5
40	6	N5	0	-.071	0
41	6	N6	0	-.013	1.335e-4
42	6	N7	0	-.013	-1.335e-4
43	7	N1	0	0	-6.265e-3
44	7	N2	1.383	-.012	-1.517e-3
45	7	N3	1.406	-.014	-8.925e-4
46	7	N4	0	0	-6.146e-3
47	7	N5	1.395	-.069	5.439e-4
48	7	N6	.893	-.011	-4.551e-3
49	7	N7	.894	-.012	-4.818e-3

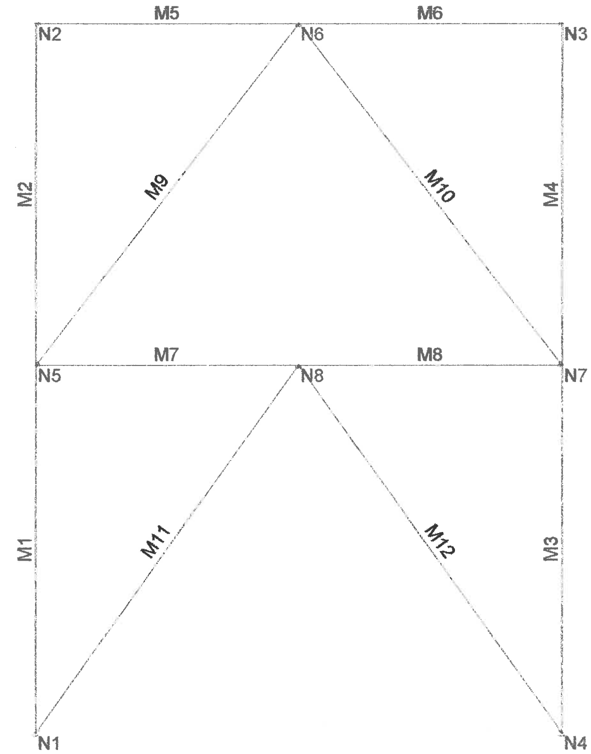
Member AISC 13th(360-05): ASD Steel Code Checks

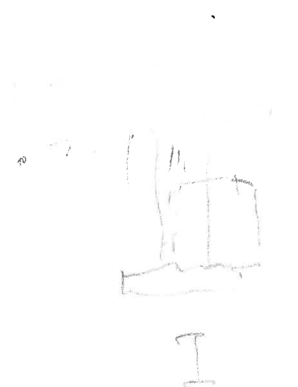
	LC	Member	Shape	UC Max	Loc[ft]	Shear UC	Loc[ft]	Pnc/om [k]	Pnt/om [k]	Mn/om [k-ft]	Cb	Eqn
1	1	M1	W12x53	.097	13	.013	0	349.575	467.066	194.361	1.667	H1-1b
2	1	M2	W12x53	.077	0	.002	0	333.761	467.066	185.689	1.06	H1-1b
3	1	M3	W12x53	.066	3.184	.018	13.288	345.071	467.066	194.128	1.092	H1-1b
4	1	M4	W12x53	.129	13.288	.039	13.288	345.071	467.066	194.361	2.333	H1-1b
5	1	M5	W12x53	.080	13	.009	0	349.575	467.066	194.361	1.667	H1-1b
6	1	M6	W12x53	.132	14	.013	0	333.761	467.066	194.361	1.318	H1-1b

Member AISC 13th(360-05): ASD Steel Code Checks (Continued)

	LC	Member	Shape	UC Max	Loc[ft]	Shear UC	Loc[ft]	Pnc/om [k]	Pnt/om [k]	Mn/om [k-ft]	Cb	Eqn
7	1	M7	W16x67	.460	13	.128	26	183.746	586.826	232.786	1.136	H1-1b
8	2	M1	W12x53	.132	13	.019	0	349.575	467.066	194.361	1.667	H1-1b
9	2	M2	W12x53	.109	0	.005	0	333.761	467.066	194.361	1.125	H1-1b
10	2	M3	W12x53	.079	1.661	.021	13.288	345.071	467.066	194.361	1.138	H1-1b
11	2	M4	W12x53	.145	13.288	.042	13.288	345.071	467.066	194.361	2.251	H1-1b
12	2	M5	W12x53	.116	13	.015	0	349.575	467.066	194.361	1.667	H1-1b
13	2	M6	W12x53	.149	14	.009	0	333.761	467.066	194.361	1.189	H1-1b
14	2	M7	W16x67	.460	13	.128	26	183.746	586.826	232.786	1.136	H1-1b
15	3	M1	W12x53	.096	13	.012	0	349.575	467.066	194.361	1.667	H1-1b
16	3	M2	W12x53	.072	0	.010	0	333.761	467.066	194.361	1.544	H1-1b
17	3	M3	W12x53	.069	8.858	.031	0	345.071	467.066	194.361	1.115	H1-1b
18	3	M4	W12x53	.139	13.288	.056	13.288	345.071	467.066	194.361	2.586	H1-1b
19	3	M5	W12x53	.058	13	.005	0	349.575	467.066	194.361	1.667	H1-1b
20	3	M6	W12x53	.144	14	.018	0	333.761	467.066	194.361	1.477	H1-1b
21	3	M7	W16x67	.461	13	.128	26	183.746	586.826	232.786	1.136	H1-1b
22	4	M1	W12x53	.130	13	.014	0	349.575	467.066	194.361	1.667	H1-1b
23	4	M2	W12x53	.087	0	.013	0	333.761	467.066	194.361	1.65	H1-1b
24	4	M3	W12x53	.082	9.135	.040	0	345.071	467.066	194.361	1.14	H1-1b
25	4	M4	W12x53	.164	13.288	.068	13.288	345.071	467.066	194.361	2.62	H1-1b
26	4	M5	W12x53	.083	13	.005	0	349.575	467.066	194.361	1.667	H1-1b
27	4	M6	W12x53	.170	14	.022	0	333.761	467.066	194.361	1.484	H1-1b
28	4	M7	W16x67	.856	13	.238	26	183.746	586.826	232.786	1.136	H1-1b
29	5	M1	W12x53	.077	13	.005	0	349.575	467.066	194.361	1.667	H1-1b
30	5	M2	W12x53	.087	14	.017	0	333.761	467.066	194.361	2.115	H1-1b
31	5	M3	W12x53	.083	0	.054	0	345.071	467.066	194.361	1.807	H1-1b
32	5	M4	W12x53	.083	13.288	.054	13.288	345.071	467.066	194.361	1.807	H1-1b
33	5	M5	W12x53	.077	13	.005	0	349.575	467.066	194.361	1.667	H1-1b
34	5	M6	W12x53	.087	14	.017	0	333.761	467.066	194.361	2.115	H1-1b
35	5	M7	W16x67	.856	13	.238	26	183.746	586.826	232.786	1.136	H1-1b
36	6	M1	W12x53	.065	13	.002	0	349.575	467.066	194.361	1.667	H1-1b
37	6	M2	W12x53	.036	14	.007	0	333.761	467.066	194.361	2.115	H1-1b
38	6	M3	W12x53	.034	0	.022	0	345.071	467.066	194.361	1.807	H1-1b
39	6	M4	W12x53	.034	13.288	.022	13.288	345.071	467.066	194.361	1.807	H1-1b
40	6	M5	W12x53	.065	13	.002	0	349.575	467.066	194.361	1.667	H1-1b
41	6	M6	W12x53	.036	14	.007	0	333.761	467.066	194.361	2.115	H1-1b
42	6	M7	W16x67	.987	13	.274	0	183.746	586.826	232.786	1.136	H1-1b
43	7	M1	W12x53	.139	13	.017	0	349.575	467.066	194.361	1.667	H1-1b
44	7	M2	W12x53	.095	0	.005	0	333.761	467.066	194.361	1.166	H1-1b
45	7	M3	W12x53	.065	3.322	.018	13.288	345.071	467.066	193.565	1.089	H1-1b
46	7	M4	W12x53	.127	13.288	.039	13.288	345.071	467.066	194.361	2.336	H1-1b
47	7	M5	W12x53	.122	13	.013	0	349.575	467.066	194.361	1.667	H1-1b
48	7	M6	W12x53	.131	14	.009	0	333.761	467.066	194.361	1.206	H1-1b
49	7	M7	W16x67	.855	13	.238	26	183.746	586.826	232.786	1.136	H1-1b

App A-2





e2	twrb Br. Frame	SK - 2
kd	topock ~~electrical panel canopy~~	Apr 29, 2014 at 10:06 AM
ww-peg-2174-043062		topoc[redacted]c.bracefr.r2d

Hot Rolled Steel Properties

	Label	E [ksi]	G [ksi]	Nu	Therm (\1E5 F)	Density[k/ft^3]	Yield[ksi]
1	A36 Gr.36	29000	11154	.3	.65	.49	36
2	A572 Gr.50	29000	11154	.3	.65	.49	50
3	A992	29000	11154	.3	.65	.49	50
4	A500 Gr.42	29000	11154	.3	.65	.49	42
5	A500 Gr.46	29000	11154	.3	.65	.49	46

Joint Coordinates and Temperatures

	Label	X [ft]	Y [ft]	Temp [F]
1	N1	0	0	0
2	N2	0	27.	0
3	N3	15	27.	0
4	N4	15	0	0
5	N5	0	14.	0
6	N6	7.5	27.	0
7	N7	15	14.	0
8	N8	7.5	14.	0

Joint Boundary Conditions

	Joint Label	X [k/in]	Y [k/in]	Rotation[k-ft/rad]	Footing
1	N1	Reaction	Reaction		
2	N4	Reaction	Reaction		

Member Primary Data

	Label	I Joint	J Joint	Rotate(deg)	Section/Shape	Type	Design List	Material	Design Rules
1	M1	N1	N5	90	HR1a	Column	Wide Flange	A572 Gr.50	Typical
2	M2	N5	N2	90	HR1a	Column	Wide Flange	A572 Gr.50	Typical
3	M3	N4	N7	90	HR1a	Column	Wide Flange	A572 Gr.50	Typical
4	M4	N7	N3	90	HR1a	Column	Wide Flange	A572 Gr.50	Typical
5	M5	N2	N6		HR3	Beam	Wide Flange	A572 Gr.50	Typical
6	M6	N6	N3		HR3	Beam	Wide Flange	A572 Gr.50	Typical
7	M7	N5	N8		HR3	Beam	Wide Flange	A572 Gr.50	Typical
8	M8	N8	N7		HR3	Beam	Wide Flange	A572 Gr.50	Typical
9	M9	N5	N6		HR2	Beam	Wide Flange	A572 Gr.50	Typical
10	M10	N7	N6		HR2	Beam	Wide Flange	A572 Gr.50	Typical
11	M11	N1	N8		HR2	Beam	Wide Flange	A572 Gr.50	Typical
12	M12	N4	N8		HR2	Beam	Wide Flange	A572 Gr.50	Typical

Joint Loads and Enforced Displacements (BLC 4 : wind horiz)

	Joint Label	L,D,M	Direction	Magnitude[(k,k-ft), (in,rad), (k*s^2/ft...
1	N2	L	X	1.2
2	N3	L	X	1.2
3	N5	L	X	.8
4	N7	L	X	.8

Joint Loads and Enforced Displacements (BLC 5 : seismic)

	Joint Label	L,D,M	Direction	Magnitude[(k,k-ft), (in,rad), (k*s^2/ft...
1	N3	L	X	.43
2	N2	L	X	.43
3	N5	L	X	2.58
4	N7	L	X	2.58

Joint Reactions (By Combination)

	LC	Joint Label	X [k]	Y [k]	MZ [k-ft]
1	1	N1	.322	1.761	0
2	1	N4	-2.722	8.739	0
3	1	Totals:	-2.4	10.5	
4	1	COG (ft):	X: 7.5	Y: 15.486	
5	2	N1	-.586	.794	0
6	2	N4	-3.628	9.706	0
7	2	Totals:	-4.214	10.5	
8	2	COG (ft):	X: 7.5	Y: 15.486	
9	3	N1	.619	2.161	0
10	3	N4	-2.419	7.394	0
11	3	Totals:	-1.8	9.555	
12	3	COG (ft):	X: 7.5	Y: 14.347	
13	4	N1	1.957	7.414	0
14	4	N4	-3.757	12.648	0
15	4	Totals:	-1.8	20.063	
16	4	COG (ft):	X: 7.5	Y: 15.689	
17	5	N1	2.857	10.031	0
18	5	N4	-2.857	10.031	0
19	5	Totals:	0	20.063	
20	5	COG (ft):	X: 7.5	Y: 15.689	
21	6	N1	3.298	10.687	0
22	6	N4	-3.298	10.688	0
23	6	Totals:	0	21.375	
24	6	COG (ft):	X: 7.5	Y: 14.73	
25	7	N1	1.273	5.986	0
26	7	N4	-4.434	12.671	0
27	7	Totals:	-3.161	18.656	
28	7	COG (ft):	X: 7.5	Y: 14.836	

Joint Deflections (By Combination)

	LC	Joint Label	X [in]	Y [in]	Rotation [rad]
1	1	N1	0	0	-4.147e-5
2	1	N2	.011	0	-2.623e-5
3	1	N3	.011	-.002	-2.484e-5
4	1	N4	0	0	-4.283e-5
5	1	N5	.007	0	-3.357e-5
6	1	N6	.011	-.002	-6.45e-6
7	1	N7	.007	-.002	-3.35e-5
8	1	N8	.006	-.004	-6.45e-6
9	2	N1	0	0	-8.279e-5
10	2	N2	.013	0	8.344e-7
11	2	N3	.013	-.001	2.225e-6
12	2	N4	0	0	-8.415e-5
13	2	N5	.011	0	-3.943e-5
14	2	N6	.013	-.002	-2.758e-6
15	2	N7	.012	-.001	-3.936e-5
16	2	N8	.011	-.004	-2.758e-6
17	3	N1	0	0	-3.147e-5
18	3	N2	.008	0	-1.93e-5
19	3	N3	.008	-.001	-1.9e-5
20	3	N4	0	0	-3.176e-5
21	3	N5	.005	0	-2.516e-5
22	3	N6	.008	-.001	-4.838e-6
23	3	N7	.005	-.001	-2.514e-5
24	3	N8	.005	-.004	-4.838e-6

Joint Deflections (By Combination) (Continued)

	LC	Joint Label	X [in]	Y [in]	Rotation [rad]
25	4	N1	0	0	-3.014e-5
26	4	N2	.008	-.002	-2.066e-5
27	4	N3	.008	-.003	-1.764e-5
28	4	N4	0	0	-3.309e-5
29	4	N5	.005	-.002	-2.523e-5
30	4	N6	.008	-.003	-4.838e-6
31	4	N7	.005	-.003	-2.508e-5
32	4	N8	.005	-.008	-4.838e-6
33	5	N1	0	0	1.474e-6
34	5	N2	0	-.002	-1.51e-6
35	5	N3	0	-.002	1.51e-6
36	5	N4	0	0	-1.474e-6
37	5	N5	0	-.002	-7.339e-8
38	5	N6	0	-.003	0
39	5	N7	0	-.002	7.339e-8
40	5	N8	0	-.008	0
41	6	N1	0	0	6.786e-7
42	6	N2	0	-.002	-6.953e-7
43	6	N3	0	-.002	6.953e-7
44	6	N4	0	0	-6.786e-7
45	6	N5	0	-.002	-3.379e-8
46	6	N6	0	-.003	0
47	6	N7	0	-.002	3.379e-8
48	6	N8	0	-.009	0
49	7	N1	0	0	-6.193e-5
50	7	N2	.01	-.002	4.533e-7
51	7	N3	.01	-.002	1.844e-6
52	7	N4	0	0	-6.329e-5
53	7	N5	.009	-.002	-2.959e-5
54	7	N6	.01	-.002	-2.069e-6
55	7	N7	.009	-.002	-2.952e-5
56	7	N8	.008	-.008	-2.069e-6

Member Distributed Loads (BLC 1 : dl)

	Member Label	Direction	Start Magnitude[k/ft,F]	End Magnitude[k/ft,F]	Start Location[ft,%]	End Location[ft,%]
1	M5	Y	-.08	-.08	0	7.5
2	M6	Y	-.08	-.08	0	7.5
3	M7	Y	-.62	-.62	0	7.5
4	M8	Y	-.62	-.62	0	7.5

Member Distributed Loads (BLC 2 : ll wind down)

	Member Label	Direction	Start Magnitude[k/ft,F]	End Magnitude[k/ft,F]	Start Location[ft,%]	End Location[ft,%]
1	M5	Y	-.125	-.125	0	7.5
2	M6	Y	-.125	-.125	0	7.5

Member Distributed Loads (BLC 3 : ll wind up)

	Member Label	Direction	Start Magnitude[k/ft,F]	End Magnitude[k/ft,F]	Start Location[ft,%]	End Location[ft,%]
1	M5	Y	.063	.063	0	7.5
2	M6	Y	.063	.063	0	7.5

Member Distributed Loads (BLC 6 : flr ll)

	Member Label	Direction	Start Magnitude[k/ft,F]	End Magnitude[k/ft,F]	Start Location[ft,%]	End Location[ft,%]
1	M7	Y	-.725	-.725	0	7.5
2	M8	Y	-.725	-.725	0	7.5

Basic Load Cases

	BLC Description	Category	X Gravity	Y Gravity	Joint	Point	Distributed
1	dl	None					4
2	ll wind down	None					2
3	ll wind up	None					2
4	wind horiz	None			4		
5	seismic	None			4		
6	flr ll	None					2

Load Combinations

	Description	Solve	PD...	SR...	BLC	Factor	BLC	Factor	BLC	Factor	BLC	Factor	BLC	Factor	BLC	Factor	BLC	Factor	BLC	Factor
1	dl+wind	Yes	Y		1	1	4	.6												
2	dl+seismic	Yes	Y		1	1	5	.7												
3	dl+wind up	Yes	Y		1	1	3	1	4	.45										
4	dl+ll+wind	Yes	Y		1	1	2	.75	4	.45	6	.75								
5	dl+ rf+flr ll	Yes	Y		1	1	2	.75	6	.75										
6	dl + flr ll	Yes	Y		1	1	6	1												
7	dl+seis+flr ll	Yes	Y		1	1	5	.525	6	.75										

Member AISC 13th(360-05): ASD Steel Code Checks (By Combination)

	LC	Member	Shape	UC Max	Loc[ft]	Shear UC	Loc[ft]	Pnc/om [k]	Pnt/om [k]	Mn/om [k-ft]	Cb	Eqn
1	1	M1	W12x53	.002	14	.000	0	333.761	467.066	72.605	1	H1-1b
2	1	M2	W12x53	.001	0	.000	0	349.575	467.066	72.605	1	H1-1b
3	1	M3	W12x53	.006	14	.000	0	333.761	467.066	72.605	1	H1-1b
4	1	M4	W12x53	.001	0	.000	0	349.575	467.066	72.605	1	H1-1b
5	1	M5	W12x30	.006	7.5	.006	7.5	200.717	263.174	107.535	1.709	H1-1b
6	1	M6	W12x30	.006	0	.006	0	200.717	263.174	107.535	1.709	H1-1b
7	1	M7	W12x30	.038	7.5	.044	7.5	200.717	263.174	107.535	1.764	H1-1b
8	1	M8	W12x30	.039	0	.044	0	200.717	263.174	107.535	1.764	H1-1b
9	1	M9	LL4x4x6x0	.003	0	.000	0	40.038	171.257	12.018	1	H1-1b
10	1	M10	LL4x4x6x0	.023	0	.000	0	40.038	171.257	12.018	1	H1-1b

Member AISC 13th(360-05): ASD Steel Code Checks (By Combination) (Continued)

	LC	Member	Shape	UC Max	Loc[ft]	Shear UC	Loc[ft]	Pnc/om [k]	Pnt/om [k]	Mn/om [k-ft]	Cb	Eqn
11	1	M11	LL4x4x6x0	.010	0	.000	0	35.752	171.257	12.018	1	H1-1b
12	1	M12	LL4x4x6x0	.081	0	.000	0	35.752	171.257	12.018	1	H1-1b
13	2	M1	W12x53	.004	14	.000	0	333.761	467.066	72.605	1	H1-1b
14	2	M2	W12x53	.002	0	.000	0	349.575	467.066	72.605	1	H1-1b
15	2	M3	W12x53	.006	14	.000	0	333.761	467.066	72.605	1	H1-1b
16	2	M4	W12x53	.002	0	.000	0	349.575	467.066	72.605	1	H1-1b
17	2	M5	W12x30	.005	7.5	.006	7.5	200.717	263.174	107.535	1.709	H1-1b
18	2	M6	W12x30	.005	0	.006	0	200.717	263.174	107.535	1.709	H1-1b
19	2	M7	W12x30	.041	7.5	.044	7.5	200.717	263.174	107.535	1.764	H1-1b
20	2	M8	W12x30	.040	0	.044	0	200.717	263.174	107.535	1.764	H1-1b
21	2	M9	LL4x4x6x0	.001	0	.000	0	40.038	171.257	12.018	1	H1-1b
22	2	M10	LL4x4x6x0	.013	0	.000	0	40.038	171.257	12.018	1	H1-1b
23	2	M11	LL4x4x6x0	.004	0	.000	0	35.752	171.257	12.018	1	H1-1b
24	2	M12	LL4x4x6x0	.215	0	.000	0	35.752	171.257	12.018	1	H1-1a
25	3	M1	W12x53	.002	14	.000	0	333.761	467.066	72.605	1	H1-1b
26	3	M2	W12x53	.000	0	.000	0	349.575	467.066	72.605	1	H1-1b
27	3	M3	W12x53	.005	14	.000	0	333.761	467.066	72.605	1	H1-1b
28	3	M4	W12x53	.000	0	.000	0	349.575	467.066	72.605	1	H1-1b
29	3	M5	W12x30	.002	7.5	.001	7.5	200.717	263.174	107.535	1.709	H1-1b
30	3	M6	W12x30	.002	0	.001	0	200.717	263.174	107.535	1.709	H1-1b
31	3	M7	W12x30	.038	7.5	.044	7.5	200.717	263.174	107.535	1.743	H1-1b
32	3	M8	W12x30	.037	0	.044	0	200.717	263.174	107.535	1.743	H1-1b
33	3	M9	LL4x4x6x0	.003	0	.000	0	40.038	171.257	12.018	1	H1-1b
34	3	M10	LL4x4x6x0	.015	0	.000	0	40.038	171.257	12.018	1	H1-1b
35	3	M11	LL4x4x6x0	.018	0	.000	0	35.752	171.257	12.018	1	H1-1b
36	3	M12	LL4x4x6x0	.072	0	.000	0	35.752	171.257	12.018	1	H1-1b
37	4	M1	W12x53	.006	14	.000	0	333.761	467.066	72.605	1	H1-1b
38	4	M2	W12x53	.001	0	.000	0	349.575	467.066	72.605	1	H1-1b
39	4	M3	W12x53	.009	14	.000	0	333.761	467.066	72.605	1	H1-1b
40	4	M4	W12x53	.001	0	.000	0	349.575	467.066	72.605	1	H1-1b
41	4	M5	W12x30	.011	7.5	.012	7.5	200.717	263.174	107.535	1.709	H1-1b
42	4	M6	W12x30	.011	0	.012	0	200.717	263.174	107.535	1.709	H1-1b
43	4	M7	W12x30	.069	7.5	.083	7.5	200.717	263.174	107.535	1.768	H1-1b
44	4	M8	W12x30	.070	0	.083	0	200.717	263.174	107.535	1.768	H1-1b
45	4	M9	LL4x4x6x0	.000	0	.000	0	40.038	171.257	12.018	1	H1-1b
46	4	M10	LL4x4x6x0	.025	0	.000	0	40.038	171.257	12.018	1	H1-1b
47	4	M11	LL4x4x6x0	.058	0	.000	0	35.752	171.257	12.018	1	H1-1b
48	4	M12	LL4x4x6x0	.222	0	.000	0	35.752	171.257	12.018	1	H1-1a
49	5	M1	W12x53	.007	14	.000	0	333.761	467.066	72.605	1	H1-1b
50	5	M2	W12x53	.001	0	.000	0	349.575	467.066	72.605	1	H1-1b
51	5	M3	W12x53	.007	14	.000	0	333.761	467.066	72.605	1	H1-1b
52	5	M4	W12x53	.001	0	.000	0	349.575	467.066	72.605	1	H1-1b
53	5	M5	W12x30	.010	7.5	.012	7.5	200.717	263.174	107.535	1.709	H1-1b
54	5	M6	W12x30	.010	0	.012	0	200.717	263.174	107.535	1.709	H1-1b
55	5	M7	W12x30	.068	7.5	.083	7.5	200.717	263.174	107.535	1.768	H1-1b
56	5	M8	W12x30	.068	0	.083	0	200.717	263.174	107.535	1.768	H1-1b
57	5	M9	LL4x4x6x0	.011	0	.000	0	40.038	171.257	12.018	1	H1-1b
58	5	M10	LL4x4x6x0	.011	0	.000	0	40.038	171.257	12.018	1	H1-1b
59	5	M11	LL4x4x6x0	.085	0	.000	0	35.752	171.257	12.018	1	H1-1b
60	5	M12	LL4x4x6x0	.085	0	.000	0	35.752	171.257	12.018	1	H1-1b
61	6	M1	W12x53	.007	14	.000	0	333.761	467.066	72.605	1	H1-1b
62	6	M2	W12x53	.000	0	.000	0	349.575	467.066	72.605	1	H1-1b
63	6	M3	W12x53	.007	14	.000	0	333.761	467.066	72.605	1	H1-1b
64	6	M4	W12x53	.000	0	.000	0	349.575	467.066	72.605	1	H1-1b
65	6	M5	W12x30	.005	7.5	.006	7.5	200.717	263.174	107.535	1.709	H1-1b
66	6	M6	W12x30	.005	0	.006	0	200.717	263.174	107.535	1.709	H1-1b
67	6	M7	W12x30	.078	7.5	.096	7.5	200.717	263.174	107.535	1.749	H1-1b

Member AISC 13th(360-05): ASD Steel Code Checks (By Combination) (Continued)

	LC	Member	Shape	UC Max	Loc[ft]	Shear UC	Loc[ft]	Pnc/om [k]	Pnt/om [k]	Mn/om [k-ft]	Cb	Eqn
68	6	M8	W12x30	.078	0	.096	0	200.717	263.174	107.535	1.749	H1-1b
69	6	M9	LL4x4x6x0	.005	0	.000	0	40.038	171.257	12.018	1	H1-1b
70	6	M10	LL4x4x6x0	.005	0	.000	0	40.038	171.257	12.018	1	H1-1b
71	6	M11	LL4x4x6x0	.098	0	.000	0	35.752	171.257	12.018	1	H1-1b
72	6	M12	LL4x4x6x0	.098	0	.000	0	35.752	171.257	12.018	1	H1-1b
73	7	M1	W12x53	.006	14	.000	0	333.761	467.066	72.605	1	H1-1b
74	7	M2	W12x53	.001	0	.000	0	349.575	467.066	72.605	1	H1-1b
75	7	M3	W12x53	.008	14	.000	0	333.761	467.066	72.605	1	H1-1b
76	7	M4	W12x53	.001	0	.000	0	349.575	467.066	72.605	1	H1-1b
77	7	M5	W12x30	.005	7.5	.006	7.5	200.717	263.174	107.535	1.709	H1-1b
78	7	M6	W12x30	.005	0	.006	0	200.717	263.174	107.535	1.709	H1-1b
79	7	M7	W12x30	.071	7.5	.083	7.5	200.717	263.174	107.535	1.751	H1-1b
80	7	M8	W12x30	.071	0	.083	0	200.717	263.174	107.535	1.751	H1-1b
81	7	M9	LL4x4x6x0	.000	0	.000	0	40.038	171.257	12.018	1	H1-1b
82	7	M10	LL4x4x6x0	.011	0	.000	0	40.038	171.257	12.018	1	H1-1b
83	7	M11	LL4x4x6x0	.038	0	.000	0	35.752	171.257	12.018	1	H1-1b
84	7	M12	LL4x4x6x0	.262	0	.000	0	35.752	171.257	12.018	1	H1-1a

App - A-3

Vinod Badani

From: Alfred.Voegels@CH2M.com
Sent: Tuesday, April 08, 2014 11:51 AM
To: John.Porcella@CH2M.com; vinod.badani@e2.com
Cc: Nathan.Betts@CH2M.com; Doug.Sunseri@CH2M.com; Rob.VanderArk@ch2m.com
Subject: RE: TOPOCK-Fresh Water Pre-Injection treatment

Hi Vinod, when could we expect updated structural sketches? No rush, just planning workload. Thanks.

From: Porcella, John/BAO
Sent: 4/8/2014 11:24 AM
To: vinod.badani@e2.com
Cc: Betts, Nathan/LAS; Sunseri, Doug/SEA; Voegels, Alfred/PDX
Subject: RE: TOPOCK-Fresh Water Pre-Injection treatment

Hi Vinod –

1. Treatment vessels - I estimate for
- 8' dia x 12.5 ' side shell ~ 17' overall vessel height,
- supported on 30" concrete pier supports,
- 22.5 feet overall height floor to top of head.

All dimensions scaled from Doug's drawings, about 45,000 pounds fully loaded (water, media, internals).

2. Filter skids - see attachments
   - "SPECIFICATION HUR 8x170FL-1.pdf" for single unit weight.
   - FP817-D-6-P.pdf is plan drawing for 2 filter skid package. Filters mounted on steel skid frame. One skid each pre-filter and post filter.

2. The chemical storage area – not final, but pretty close as shown on "ChemStorage Layout". It looks like we have allocated more space than we really need. Marty PDF'd the cad files the hypochlorite tablet vendor provided in case you want to look at that ("Binder2.pdf").

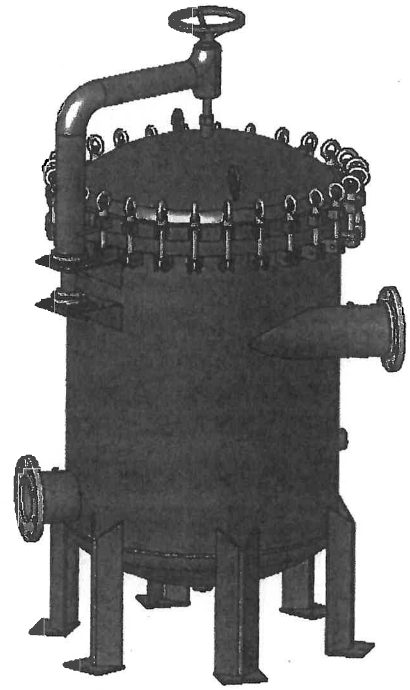
Feel free to call to discuss.

Thanks.

From: Vinod Badani [mailto:vinod.badani@e2.com]
Sent: Monday, April 07, 2014 12:14 PM
To: Porcella, John/BAO
Cc: Betts, Nathan/LAS
Subject: TOPOCK-Fresh Water Pre-Injection treatment

John:
Can you[provide me with weight of Treatment Vessels?
I know it is 8-feet in diameter with 10 feet side wall (16-feet overall height. Mounted 18-inches to 2 feet above floor.
Also need total weights for Filter skids.
Any progress on Chemical storage Building? I need you to verify size to make it sure this will house all equipment+ need information for containment requirements.

PRODUCT SPECIFICATION
Harmsco® Model #: HUR 8X170FL



Description: Tangential Entry, Up-Flow Cartridge Filter Housing with; Swing Bolt Closure, Davit Cover Lift, and Flanged Connections.

Details:

1. Stainless steel construction, all wetted metallic components are ASTM A-240.
2. Swing bolt style housing closure. Swing bolts are ASTM A-193 B8.
3. NSF Certified using Genuine Harmsco® Hurricane® replacement filter cartridges.*
4. Tangential inlet and the integral inner-can, create a centrifugal flow that induces pre-filtration by heavy particulate separation.
5. Patented "Up-Flow" design that;
   a. Self purges housing of air.
   b. Eliminates by-pass contamination during servicing.
   c. Improves efficiency by creating an even flow distribution across filtering media.
6. Strong, durable construction.
7. Utilizes eight (8) Genuine Harmsco® Hurricane® HC/170 filter cartridges, available in many micron ratings. *
   Note: Harmsco® Hurricane® HC/170 filter cartridges available include: Activated Carbon, High Temperature, SureSafe™, Poly-Mesh, Poly-Pleat™ & more. **
8. Inlet & Outlet are NPS 6 Flanges ANSI/ASME B16.5 Class 150
9. Drains (Qty 2) are 1-1/2" Female NPT (FPT) Couplings, Class 1000
10. Vent is ½" Female NPT (FPT) Coupling, Class 1000
11. Gauge Ports (Qty 2) are ¼" Female NPT (FPT) Couplings, Class 1000
12. Closure Gasket is EPDM 70 Durometer O-ring.
13. Electro-polish finish.
14. Pressure Rating - 150 P.S.I.G.
15. Temperature Rating – Up to 140°F
    Note: Higher temperatures are possible, check cartridge specifications. **
16. Flow Rate – 1,200 GPM Maximum. See Pressure Drop vs. Flow Rate Curve, page 2.
17. One person can perform maintenance.

Requirements:

Floor Load: Dry weight = 1,600 lbs.
Volume = 232 US gallons x 8.337 lbs./US gallon (water) = 1,935 lbs.
Total weight = 1,600 + 1,935 = 3,535 lbs. (housing + water)
Floor contact area = 1.164 ft².
Floor Load = 3,535 lbs. divided by 1.164 ft² = **3,100 pounds per square foot** (approx.)
Note: Piping shall conform to all applicable codes and be independently supported. If floor strength is suspect, use appropriate measures to adequately distribute load.

Floor Space: 14 ft² (does not include Cover/Davit swing position), See Installation Diagram, page 3.
Service Height: 104-1/2", See Installation Diagram, page 3.
Bonding: Housing shall be bonded in accordance with all applicable codes. A grounding lug is provided.

Recommended Spare Parts:
Closure Gasket O-ring: PN 368-E
Set of 8 Harmsco® Hurricane® HC/170 replacement cartridges

* The use of any filter cartridges other than Genuine Harmsco® Hurricane® filter cartridges in this filter housing voids certifications by NSF International.
** Contact a Harmsco® sales representative for Harmsco® Hurricane® HC/170 filter cartridge specifications.

This product is manufactured under one or more of the following patents: U.S. NO. 4,187,179; 3,720,322; CANADA NO. 977,693; GT. BRIT. NO. 1,372,014; W. GERMANY NO. 2,261,817; FRANCE NO. 7,246,864; EUROPEAN NO. 0,191,844, Other patents pending.
Notice: The information contained in this publication is considered accurate, and is intended to be used as a guide. This information is subject to change without notification. Contact Harmsco® Filtration Products for the latest, most up to date, specifications. Harmsco® Filtration Products does not assume any liability for the accuracy and completeness of the data in this publication. Temperature ratings, flow rates and chemical resistance can be affected by a number of unknown factors. End users should perform their own tests to determine suitability for each application.

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Revised: 3-4-09

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Economical Solutions to Liquid Filtration Challenges

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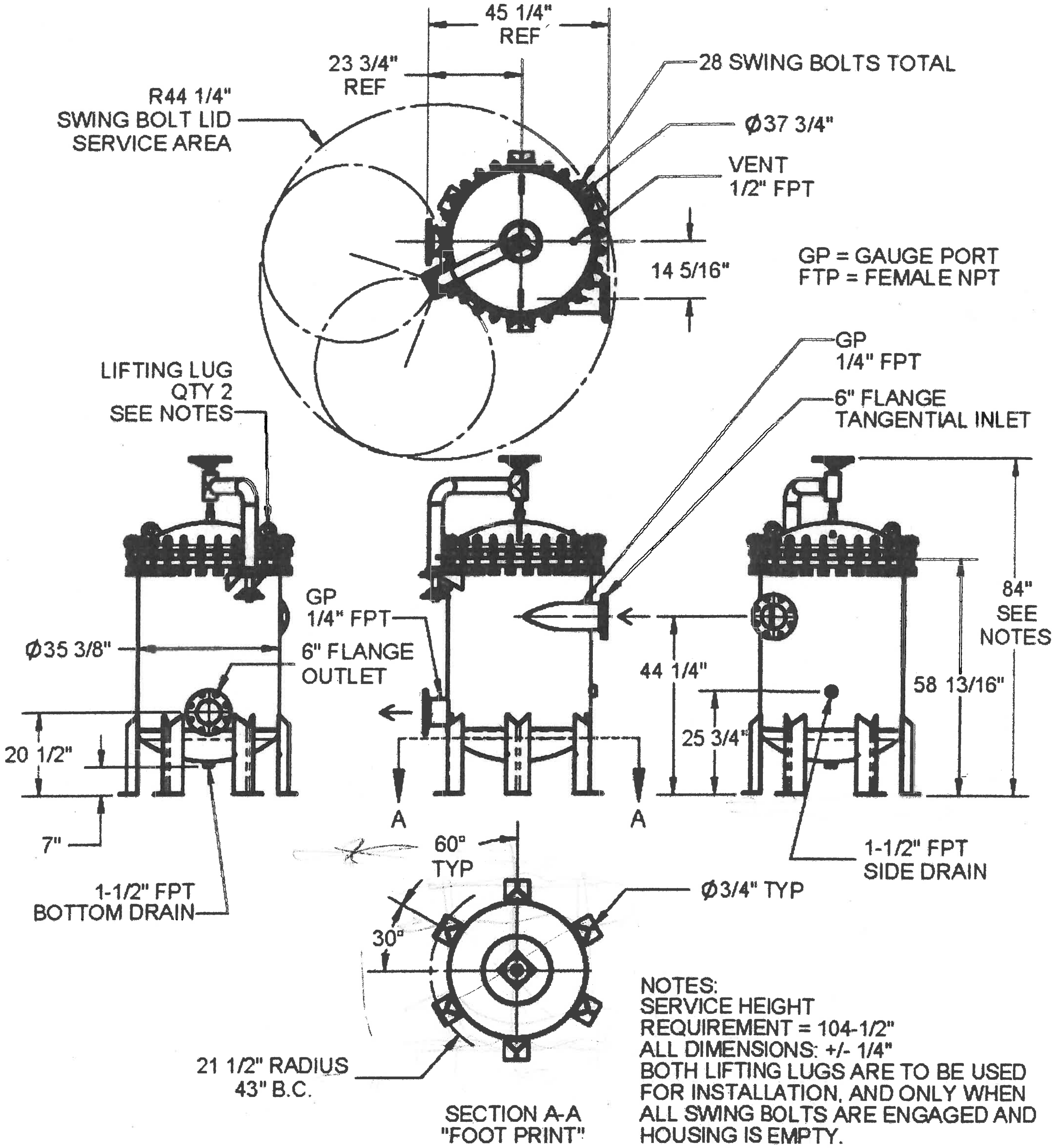
800-327-3248
561-848-9628

Harmsco® Filtration Products
Installation Diagram
Hurricane® 8 X 170 Swing Bolt Housing



NOTES:
SERVICE HEIGHT REQUIREMENT = 104-1/2"
ALL DIMENSIONS: +/- 1/4"
BOTH LIFTING LUGS ARE TO BE USED FOR INSTALLATION, AND ONLY WHEN ALL SWING BOLTS ARE ENGAGED AND HOUSING IS EMPTY.

MODEL #: HUR 8X170FL

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File Name: SPECIFICATION HUR 8X170FL (pg. 3 of 3)

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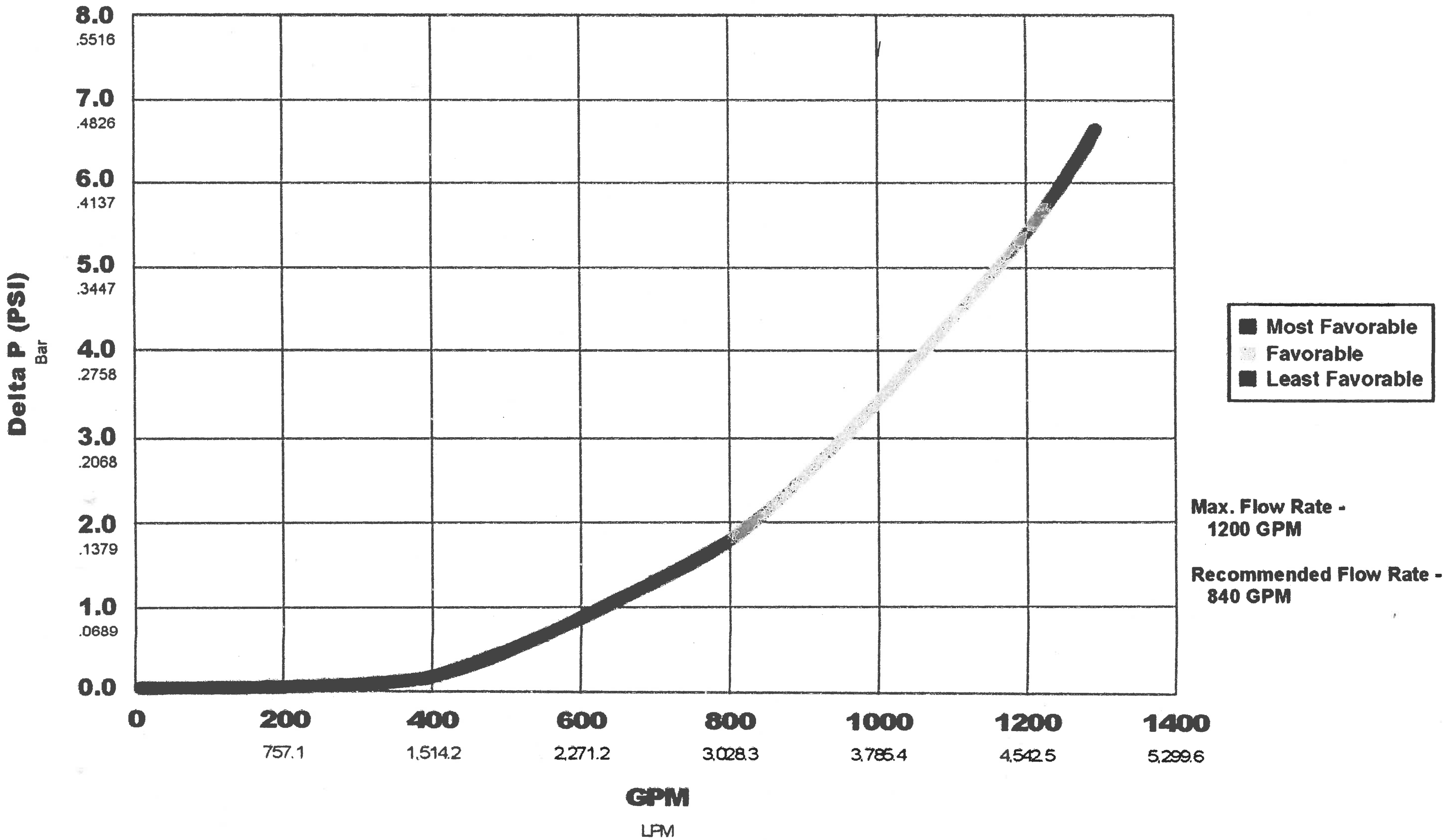
Pressure Drop vs. Flow Rate Curve

Harmsco® HUR 8X170FL
Hurricane® HC/170-20 Cartridges
Qty 8; with clean water.



Max. Flow Rate - 1200 GPM

Recommended Flow Rate - 840 GPM

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Attach. - A

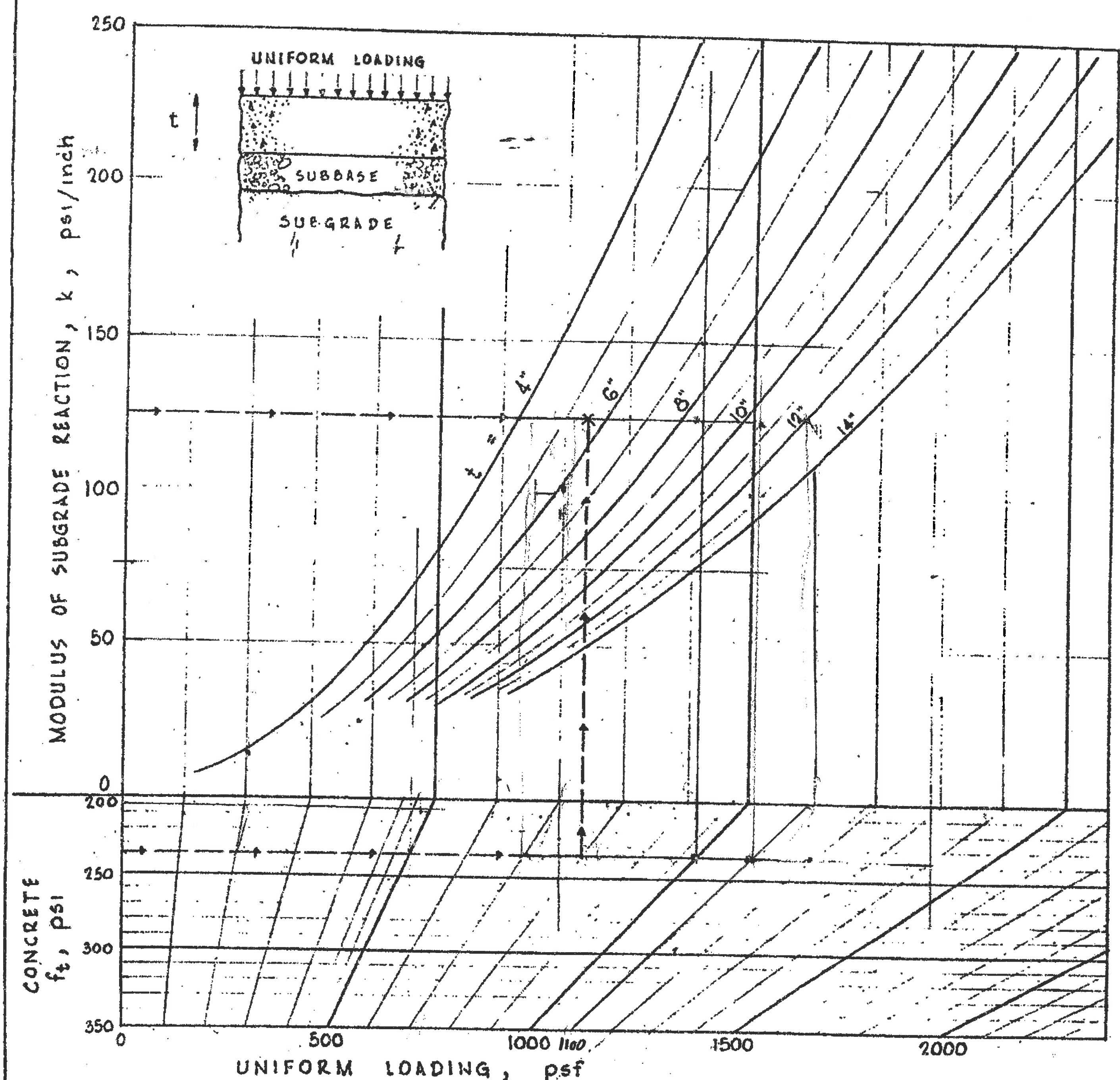
SLABS-ON-GRADE - THICKNESS FOR UNIFORM LOADING

Concrete f'_c psi	Modulus of Rupture (ACI 9.5.2.2) $f_r = 7.5\sqrt{f'_c}$ psi	Allowable Flexural Tensile Strength $f_t = f_r/2$ psi
3000	411	206
4000	474	237

EXAMPLE

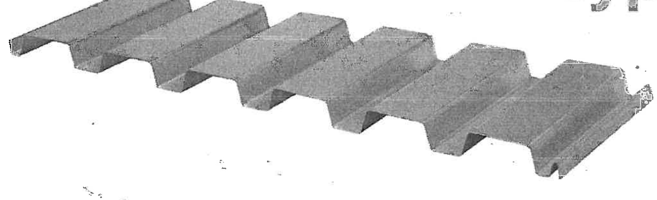
Given: f'_c = 4000 psi ▸ Use f_t = 237 psi
Uniform Loading = 800 psf
Subgrade k = 125 psi/inch

From Chart, read t = 5½" ▸ **Use t = 6"**



ATTACH. 'B'

Type PLB™-36 or HSB®-36



1½" Deep Roof Deck
Primer Painted or Galvanized

LOADS

Allowable Uniform Loads (psf)

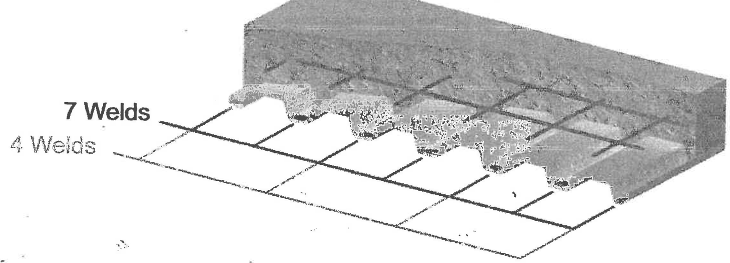
SPAN	GAGE		4'-0"	5'-0"	5'-6"	6'-0"	6'-6"	7'-0"	7'-6"	8'-0"	8'-6"	9'-0"	9'-6"	10'-0"	10'-6"	11'-0"	11'-6"	12'-0"
SINGLE	22	Stress	185	118	98	82	70	60	53	46	41	37	33	30				
		L/240	185	95	71	55	43	34	28	23	19	16	14	12				
	20	Stress	223	149	123	104	88	76	66	58	52	46	41	37	34	31	28	26
		L/240	229	117	88	68	53	43	35	29	24	20	17	15	13	11	10	8
	18	Stress	300	204	168	141	120	104	90	80	70	63	56	51	46	42	38	35
		L/240	♦♦♦	160	120	93	73	58	47	39	33	27	23	20	17	15	13	12
	16	Stress	300	259	214	180	153	132	115	101	89	80	72	65	59	53	49	45
		L/240	♦♦♦	200	150	116	91	73	59	49	41	34	29	25	22	19	16	14
DOUBLE	22	Stress	194	124	103	86	73	63	55	49	43	38	34	31				
		L/240	♦♦♦	♦♦♦	♦♦♦	♦♦♦	♦♦♦	♦♦♦	♦♦♦	♦♦♦	♦♦♦	♦♦♦	♦♦♦	30				
	20	Stress	244	156	129	108	92	80	69	61	54	48	43	39	35	32	30	27
		L/240	♦♦♦	♦♦♦	♦♦♦	♦♦♦	♦♦♦	♦♦♦	♦♦♦	♦♦♦	♦♦♦	♦♦♦	43	37	32	27	24	21
	18	Stress	300	212	175	147	125	108	94	83	73	65	59	53	48	44	40	37
		L/240	♦♦♦	♦♦♦	♦♦♦	♦♦♦	♦♦♦	♦♦♦	♦♦♦	♦♦♦	♦♦♦	♦♦♦	56	48	42	36	32	28
	16	Stress	300	262	217	182	155	134	117	103	91	81	73	66	60	54	50	46
		L/240	♦♦♦	♦♦♦	♦♦♦	♦♦♦	♦♦♦	♦♦♦	♦♦♦	♦♦♦	♦♦♦	♦♦♦	70	60	52	45	40	35
TRIPLE	22	Stress	243	155	128	108	92	79	69	61	54	48	43	39				
		L/240	♦♦♦	♦♦♦	♦♦♦	♦♦♦	86	69	56	46	39	33	28	24				
	20	Stress	300	195	161	136	116	100	87	76	68	60	54	49	44	40	37	34
		L/240	♦♦♦	♦♦♦	♦♦♦	132	104	83	68	56	47	39	33	29	25	21	19	17
	18	Stress	300	265	219	184	157	135	118	103	92	82	73	66	60	55	50	46
		L/240	♦♦♦	♦♦♦	♦♦♦	175	138	110	90	74	62	52	44	38	33	28	25	22
	16	Stress	300	300	271	228	194	167	146	128	113	101	91	82	74	68	62	57
		L/240	♦♦♦	♦♦♦	♦♦♦	218	172	137	112	92	77	65	55	47	41	35	31	27

Notes:
1. Stress = Uniform load which produces maximum allowable stress in deck.
2. L/240 = Uniform load which produces L/240 deflection in deck.
3. Self-weight of the deck should be included when determining dead load.
4. The symbol ♦♦♦ indicates allowable uniform load based on deflection exceeds allowable uniform load based on stress.

Attach. 'C'

PLB™ or B FORMLOK™

- 6 in. TOTAL SLAB DEPTH
- Normal Weight Concrete (145 pcf)
  60.8 psf
- Galvanized or Phosphatized/Painted
- 2 Hour Fire Rating



B 6" NW

Deck Weight and Section Properties

Gage	Weight (psf) Galv G60	Weight (psf) Phos/ Painted	I_d for Deflection Single Span (in.⁴/ft)	I_d for Deflection Multiple Spans (in.⁴/ft)	Moment $+S_{eff}$ (in.³/ft)	Moment $-S_{eff}$ (in.³/ft)	End Bearing 2"	End Bearing 3"	End Bearing 4"	Interior Bearing 3"	Interior Bearing 4"
22	1.9	1.8	0.177	0.192	0.176	0.188	935	1076	1163	1559	1671
20	2.3	2.2	0.219	0.231	0.230	0.237	1301	1492	1609	2190	2340
18	2.9	2.8	0.302	0.306	0.314	0.331	2181	2484	2667	3714	3950
16	3.5	3.4	0.381	0.381	0.399	0.410	3265	3699	3955	5607	5938

(Allowable Reactions per ft of Width (lb) apply to the End Bearing and Interior Bearing columns.)

Allowable Superimposed Loads (psf)

Gage	Spans	Max. UCS[1]	6'-0"	6'-6"	7'-0"	7'-6"	8'-0"	8'-6"	9'-0"	9'-6"	10'-0"	10'-6"	11'-0"
22	1	5'-4"	400	369	320	279	244	215	191	169	151	134	120
	2	6'-2"	400	369	320	279	244	215	191	169	151	134	120
	3	6'-3"	400	369	320	279	244	215	191	169	151	134	120
20	1	6'-3"	400	389	337	295	259	228	202	180	160	143	128
	2	7'-4"	400	400	395	295	259	228	202	180	160	143	128
	3	7'-5"	400	400	395	295	259	228	202	180	160	143	128
18	1	7'-3"	400	400	400	321	282	250	222	197	177	158	142
	2	8'-8"	400	400	400	379	340	308	222	197	177	158	142
	3	8'-11"	400	400	400	379	340	308	222	197	177	158	142
16	1	7'-10"	400	400	400	376	279	246	219	195	174	156	140
	2	9'-7"	400	400	400	376	337	305	277	253	174	156	140
	3	9'-8"	400	400	400	376	337	305	277	253	174	156	140

[1] Max. UCS = Maximum Unshored Clear Span (ft-in.)

Shoring required in shaded areas to right of heavy line.

Allowable Diaphragm Shear Values, q (plf) and Flexibility Factors, F (in./lb x 10^6)

Gage	Welds	6'-0"	6'-6"	7'-0"	7'-6"	8'-0"	8'-6"	9'-0"	9'-6"	10'-0"	10'-6"	11'-0"
22	q4	3021	2983	2950	2921	2896	2874	2855	2837	2822	2807	2794
	F4	0.27	0.28	0.28	0.28	0.28	0.29	0.29	0.29	0.29	0.29	0.29
	q7	3230	3176	3129	3089	3053	3022	2995	2970	2947	2927	2909
	F7	0.26	0.26	0.26	0.27	0.27	0.27	0.28	0.28	0.28	0.28	0.28
20	q4	3088	3042	3003	2969	2939	2912	2889	2868	2849	2832	2817
	F4	0.24	0.25	0.25	0.25	0.26	0.26	0.26	0.26	0.26	0.27	0.27
	q7	3340	3275	3219	3170	3128	3090	3057	3027	3000	2976	2954
	F7	0.23	0.23	0.23	0.24	0.24	0.24	0.25	0.25	0.25	0.25	0.25
18	q4	3241	3180	3128	3082	3042	3007	2976	2948	2923	2900	2880
	F4	0.20	0.21	0.21	0.21	0.21	0.22	0.22	0.22	0.22	0.22	0.23
	q7	3577	3490	3415	3350	3294	3244	3199	3160	3124	3092	3062
	F7	0.18	0.19	0.19	0.19	0.20	0.20	0.20	0.21	0.21	0.21	0.21
16	q4	3410	3334	3268	3211	3161	3117	3078	3043	3012	2983	2957
	F4	0.17	0.17	0.18	0.18	0.18	0.19	0.19	0.19	0.19	0.20	0.20
	q7	3829	3721	3627	3546	3476	3413	3358	3308	3263	3223	3186
	F7	0.15	0.16	0.16	0.16	0.17	0.17	0.17	0.18	0.18	0.18	0.18

APPENDIX A - CALCULATION COVER SHEET

CALCULATION ID NUMBER	TA05
REVISION NUMBER	
JOB NUMBER	WW-PGE- 2174

TITLE	Topock Chemical Storage Area Building

Page No.	Item
1	General
2	Roof Design & Braced Frame
3	Seismic Loads / Wind Loads on Frame
4	Foundation
5 to 8	Moment Frame
ATTACH'T	A & B

	initial	date
PREPARED	KD	5/30/14
TITLE		
REVIEWED		
TITLE		

10/14/15

REVISION NOTES	

E2 Consulting Engineers, Inc. 1900 Powell Street, Suite 250 Emeryville, CA 94608	Designed By:	KD	Date: 5/15/14
	Checked By:		Date:
	Reviewed By:		Date:
Project No. WW-PGE-2174	Calc. No. TA05		Sheet No. 1
Project Description: Topock Chemical Storage Area Bldg.			

Reference: DWGS S-13-11 TO S-13-13

General References

1. CBC 2010
2. ASCE 7-10
3. ACI 318-11

Seismic Data

$S_s = .23$ $S_{ms} = 1.6 \times .23 = .368$

$S_1 = .12$ $S_{m1} = F_v S_1 = 2.318 \times .12 = .28$

$S_{DS} = .267$ $S_{D1} = .187$

Soil Bearing press. = 4000 PSF

Conc. Data

$f'_c = 5.0$ ksi $F_y = 60$ ksi

E2 Consulting Engineers, Inc. 1900 Powell Street, Suite 250 Emeryville, CA 94608	Designed By:	KD	Date: 5/14/14
	Checked By:		Date:
	Reviewed By:		Date:
Project No.	UW-PGE-2174		Sheet No. 2
Project Description:	Topock Chemical Storage Area Bldg.		

Reference:

Roof Loads on Mom. Frame

B-1 ($l = 14'$) purlin

$w_{TL} = (.01 \times 3.5 + .02 \times 3.5) = .035 + .07 = .105^{k/'}$ USE $.12^{k/'}$

$R = .12 \times 7 = .84^{k}$ $M = \frac{.12 \times 14^2}{8} = 2.94^{1k}$

W 8x10 $M_R = 21^{1k}$ (50 ksi)

$\Delta_{TL} = \frac{5}{384} \times \frac{.12 \times 14^4}{29000 \times 30.8} \times 1728 = .116'' = \frac{l}{1448} < \frac{l}{240}$ ok

B-2 ($l = 16'$) Girder @ Mom. Frame

$w_{TL} = (.01 + .02) \times 14 = .14 + .28 = .42^{k/'}$ USE $.45^{k/'}$

$R = .45 \times 8 = 3.6^{k}$ $M = \frac{.45 \times 16^2}{8} = 14.4^{1k}$

W 10x22 $M_R = 64^{1k}$ $I = 118 \text{ in}^4$ (See Computer Printout)

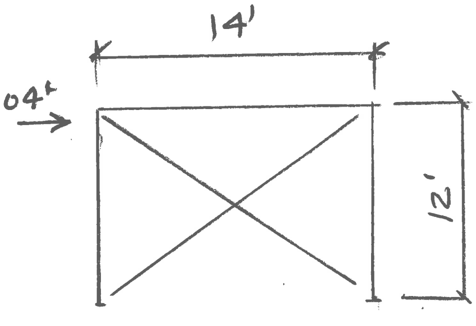
Roof Deck See Attach. B — $w_{TL} = 10 + 20 = 30$ PSF $1\frac{1}{2}''$ deck, 18GA by Verco @ = 4'

Allow. load = 300 PSF < 30 PSF ok

Braced Frame

Max. $P_w = 1.04^{k}$ $P_{seis.} = .51^{k}$

X Br. $l = \sqrt{12^2 + 14^2} = 18.43'$ USE 18'



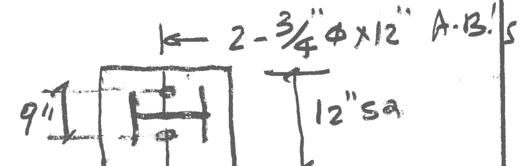
Try ⌐⌐ 4x4x1/4 $r = 1.25$

$\frac{Kl}{r} = \frac{18 \times 12}{1.25} = 172.8 < 200$

Cap. Ten. $= 3.88 \times .6 \times 46 = 107^{k}$

Cap. Comp. $= 19^{k}$ USE ⌐⌐ 4x4x1/4

Base pl. (12"x12"x5/8")



$f_p = \frac{4 + 1}{12 \times 12} = .035$ ksi. $t = 2 \times 3.7 \sqrt{\frac{.035}{36}} = .23''$

USE 12"x5/8"x1'-0" PL. w/ 2-3/4"Φ x12" A.B.'s (uplift = .33^{k}) ok by insp.

E2 Consulting Engineers, Inc. 1900 Powell Street, Suite 250 Emeryville, CA 94608	Designed By:	KD	Date: 5/14/14
	Checked By:		Date:
	Reviewed By:		Date:
Project No.	WW-PGE-2174		Sheet No. 3
Project Description:	Topock Chemical Storage Area Bldg.		

Reference:

Seismic Loads

Using Equivalent Lateral procedure

$V = C_s W$ $I = 1.25$ $R = 3.5$ (OMF)
$R = 3.25$ (Braced Frame)

$W = (.01 \times 32 \times 16 + .015 \times 6 \times 28 \times 2) = 10.2^k$

Mom. Fr. $T = C_t h_n^x = .028(14)^{.8} = .231$ sec. $C_{s_{max}} = \frac{.5 S_{D1}}{T(R/I)}$

$C_s = \frac{S_{DS}}{(R/I)} = \frac{.247}{(3.5/1.25)} = \frac{.247}{2.8} = .088$ $= \frac{.5 \times .187}{.231 \times 2.8} = .145$

USE .10

Br. Fr. $T = .02(12)^{.75} = .129$ sec.

$C_{s_{max}} = \frac{.5 \times .187}{.129 \times 2.6} = .278$ $C_s = \frac{.247}{2.6} = .095$ USE .10

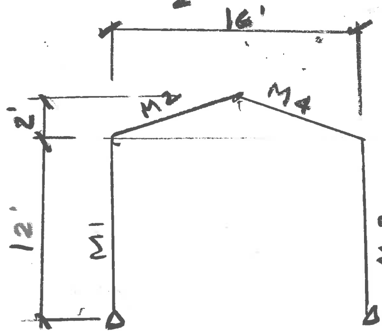
$V = .1 \times 10.2 = 1.02^k$

USE $.51^k$ for Mom. Frame & Braced Frame

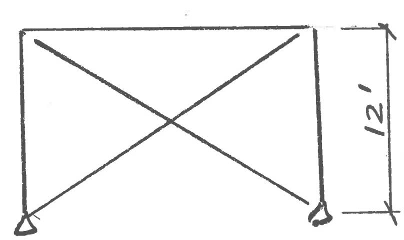
Wind Loads

Mom. Fr. $V = .02\left(\frac{14}{2}\right)(14) = 1.96^k > .51^k$ Wind Governs

Br. Fr. $V = .02 \times \left(\frac{13}{2}\right)\left(\frac{16}{2}\right) = 1.04^k > .51^k$ Wind Governs



Mom. Fr.



Braced Fr.

Note: See pages 5 to 8 for computerized Mom. fr. design. (Risa-2d)

E2 Consulting Engineers, Inc. 1900 Powell Street, Suite 250 Emeryville, CA 94608	Designed By:	KD	Date: 5/15/14
	Checked By:		Date:
	Reviewed By:		Date:
Project No. WW-PGE-2174			Sheet No. 4
Project Description:	Topock Chemical Storage Area Bldg		

Reference:

Foundation

Column Footings (Try 3'-0" SQ. Ftg.)

Max P = 5 (Roof) + 1 (Siding+misc) + .15 × 2 × 3^2 = 8.7^k USE 9^k

$A_{Ftg} = \frac{9.0}{4} = 2.25$ $b_r = 1.5'$

USE 2'-6" SQ. Ftg. × 1'-6" TK w/ 3-#5 Bars Ea. Way & #5 Dowels @ 24" into Ftg.

$p = \frac{9}{2.5 \times 2.5} = 1.44^{KSF}$ ok

Slab on Grade (12" TK slab)

DL slab = 150^{PSF}

LL slab = 125

375 PSF

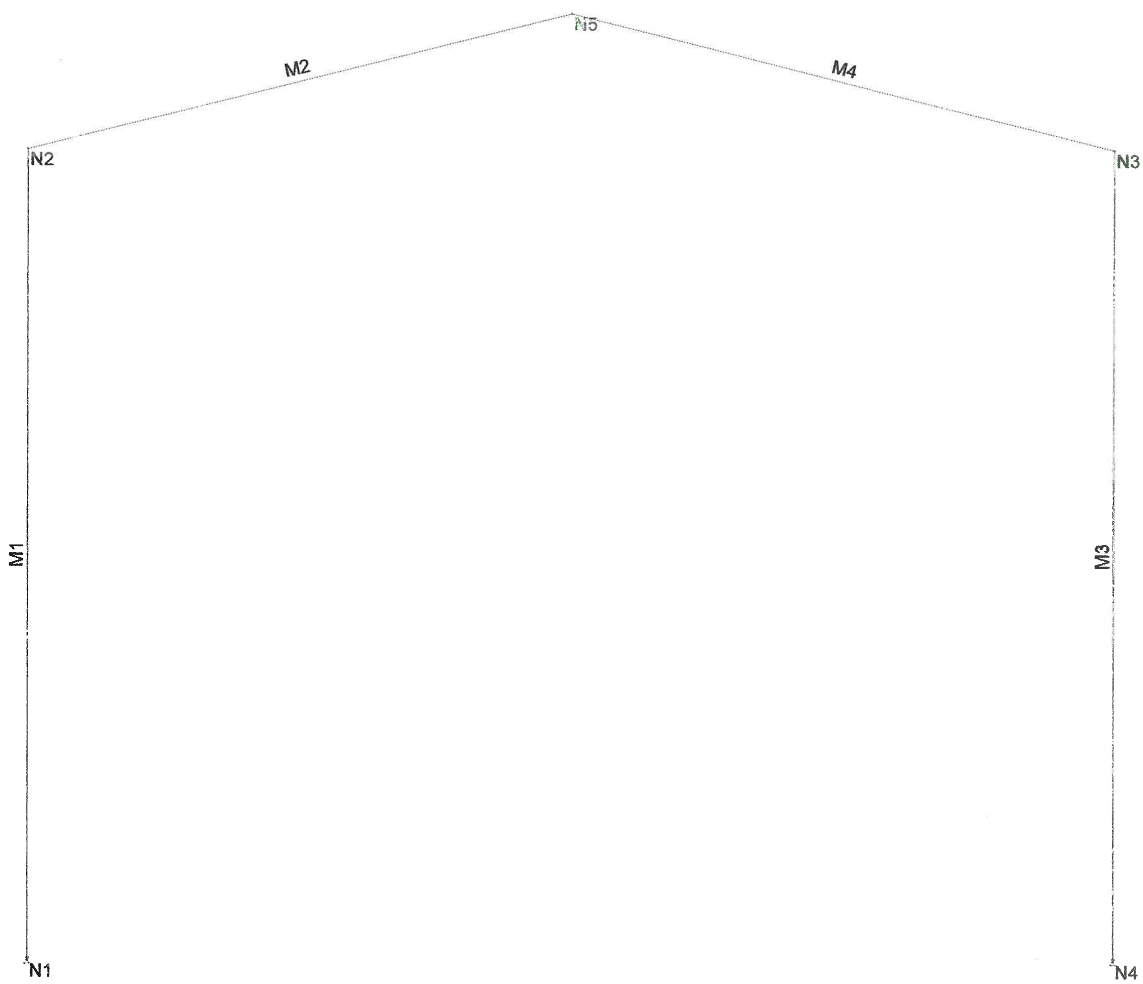
12" slab w/ #5 @ 12" Ea. Way @ BOT.

$f_c' = 4^{ksi}$
$f_y = 60^{ksi}$

Min. A_s = .002 × 12 × 12 = .288 in² A_{sa} = .31 in² ok

Allow. load for 12" slab = 1100^{PSF} > 375^{PSF} ok

See attachment - A



Results for LC 1, dl+wind

e2	topock chemical storage moment frame	SK - 1
kd		May 14, 2014 at 5:22 PM
ww-peg-2174-043062		topoccsmf.ewdir.r2d

Hot Rolled Steel Properties

	Label	E [ksi]	G [ksi]	Nu	Therm (\1E5 F)	Density[k/ft^3]	Yield[ksi]
1	A36 Gr.36	29000	11154	.3	.65	.49	36
2	A572 Gr.50	29000	11154	.3	.65	.49	50
3	A992	29000	11154	.3	.65	.49	50
4	A500 Gr.42	29000	11154	.3	.65	.49	42
5	A500 Gr.46	29000	11154	.3	.65	.49	46

Hot Rolled Steel Section Sets

	Label	Shape	Type	Design List	Material	Design Rules	A [in2]	I (90,270) [i...	I (0,180) [in4]
1	HR1A	W10x22	Column	Wide Flange	A572 Gr.50	Typical	6.49	11.4	118
2	HR2	W10x22	Beam	Wide Flange	A572 Gr.50	Typical	6.49	11.4	118

Joint Coordinates and Temperatures

	Label	X [ft]	Y [ft]	Temp [F]
1	N1	0	0	0
2	N2	0	12	0
3	N3	16	12	0
4	N4	16	0	0
5	N5	8	14	0

Joint Boundary Conditions

	Joint Label	X [k/in]	Y [k/in]	Rotation[k-ft/rad]	Footing
1	N1	Reaction	Reaction		
2	N4	Reaction	Reaction		

Member Primary Data

	Label	I Joint	J Joint	Rotate(deg)	Section/Shape	Type	Design List	Material	Design Rules
1	M1	N1	N2		HR1A	Column	Wide Flange	A572 Gr.50	Typical
2	M2	N2	N5		HR2	Beam	Wide Flange	A572 Gr.50	Typical
3	M3	N3	N4		HR1A	Column	Wide Flange	A572 Gr.50	Typical
4	M4	N3	N5		HR2	Beam	Wide Flange	A572 Gr.50	Typical

Joint Loads and Enforced Displacements (BLC 4 : wind horiz)

	Joint Label	L,D,M	Direction	Magnitude[(k,k-ft), (in,rad), (k*s^2/ft...
1	N2	L	X	-.98
2	N3	L	X	-.98

Joint Loads and Enforced Displacements (BLC 5 : seismic)

	Joint Label	L,D,M	Direction	Magnitude[(k,k-ft), (in,rad), (k*s^2/ft...
1	N2	L	X	-.26
2	N3	L	X	-.26

Member Distributed Loads (BLC 1 : dl)

	Member Label	Direction	Start Magnitude[k/ft,F]	End Magnitude[k/ft,F]	Start Location[ft,%]	End Location[ft,%]
1	M2	Y	-.14	-.14	0	8.246
2	M4	Y	-.14	-.14	0	8.246

Member Distributed Loads (BLC 2 : ll wind down)

	Member Label	Direction	Start Magnitude[k/ft,F]	End Magnitude[k/ft,F]	Start Location[ft,%]	End Location[ft,%]
1	M2	Y	-.28	-.28	0	8.246
2	M4	Y	-.28	-.28	0	8.246

Member Distributed Loads (BLC 3 : ll wind up)

	Member Label	Direction	Start Magnitude[k/ft,F]	End Magnitude[k/ft,F]	Start Location[ft,%]	End Location[ft,%]
1	M2	Y	-.14	-.14	0	8.246
2	M4	Y	-.14	-.14	0	8.246

Basic Load Cases

	BLC Description	Category	X Gravity	Y Gravity	Joint	Point	Distributed
1	dl	None					2
2	ll wind down	None					2
3	ll wind up	None					2
4	wind horiz	None			2		
5	seismic	None			2		

Load Combinations

	Description	Solve	PD...	SR...	BLC	Factor	BLC	Factor	BLC	Factor	BLC	Factor	BLC	Factor	BLC	Factor	BLC	Factor	BLC	Factor
1	dl+wind	Yes	Y		1	1	4	1												
2	dl+seismic	Yes	Y		1	1	5	1												
3	dl+wind up	Yes	Y		1	1	3	1	4	.75										
4	dl+ll+wind	Yes	Y		1	1	2	.75	4	.75										
5	dl+ll	Yes	Y		1	1	2	1												

Joint Reactions (By Combination)

	LC	Joint Label	X [k]	Y [k]	MZ [k-ft]
1	1	N1	1.14	2.636	0
2	1	N4	.82	-.328	0
3	1	Totals:	1.96	2.309	
4	1	COG (ft):	X: 8	Y: 13	
5	2	N1	.429	1.548	0
6	2	N4	.091	.761	0
7	2	Totals:	.52	2.309	
8	2	COG (ft):	X: 8	Y: 13	
9	3	N1	1.069	3.43	0
10	3	N4	.401	1.188	0
11	3	Totals:	1.47	4.618	
12	3	COG (ft):	X: 8	Y: 13	
13	4	N1	1.154	4.011	0
14	4	N4	.316	1.761	0
15	4	Totals:	1.47	5.772	
16	4	COG (ft):	X: 8	Y: 13	
17	5	N1	.51	3.463	0
18	5	N4	-.51	3.463	0
19	5	Totals:	0	6.927	
20	5	COG (ft):	X: 8	Y: 13	

Joint Deflections (By Combination)

	LC	Joint Label	X [in]	Y [in]	Rotation [rad]
1	1	N1	0	0	0
2	1	N2	-.631	-.003	1.409e-3

Joint Deflections (By Combination) (Continued)

	LC	Joint Label	X [in]	Y [in]	Rotation [rad]
3	1	N3	-.614	0	2.165e-3
4	1	N4	0	0	0
5	1	N5	-.623	-.036	-7.849e-4
6	2	N1	0	0	0
7	2	N2	-.174	-.001	9.728e-5
8	2	N3	-.156	0	8.508e-4
9	2	N4	0	0	0
10	2	N5	-.165	-.036	-2.082e-4
11	3	N1	0	0	0
12	3	N2	-.488	-.003	5.97e-4
13	3	N3	-.453	-.001	2.105e-3
14	3	N4	0	0	0
15	3	N5	-.471	-.072	-5.936e-4
16	4	N1	0	0	0
17	4	N2	-.494	-.004	4.142e-4
18	4	N3	-.451	-.002	2.3e-3
19	4	N4	0	0	0
20	4	N5	-.473	-.09	-5.961e-4
21	5	N1	0	0	0
22	5	N2	-.026	-.003	-1.131e-3
23	5	N3	.026	-.003	1.131e-3
24	5	N4	0	0	0
25	5	N5	0	-.108	0

Member AISC 13th(360-05): ASD Steel Code Checks (By Combination)

	LC	Member	Shape	UC Max	Loc[ft]	Shear UC	Loc[ft]	Pnc/om [k]	Pnt/om [k]	Mn/om [k-ft]	Cb	Eqn
1	1	M1	W10x22	.230	12	.024	0	81.967	194.311	64.87	1.667	H1-1b
2	1	M2	W10x22	.217	0	.051	0	129.265	194.311	64.87	2.089	H1-1b
3	1	M3	W10x22	.152	0	.017	0	81.967	194.311	64.87	1.667	H1-1b
4	1	M4	W10x22	.152	0	.030	8.246	129.265	194.311	64.87	1.296	H1-1b
5	2	M1	W10x22	.089	12	.009	0	81.967	194.311	64.87	1.667	H1-1b
6	2	M2	W10x22	.082	0	.030	0	129.265	194.311	64.87	2.554	H1-1b
7	2	M3	W10x22	.022	0	.002	0	81.967	194.311	64.87	1.667	H1-1b
8	2	M4	W10x22	.050	5.068	.014	0	129.265	194.311	59.317	1.072	H1-1b
9	3	M1	W10x22	.222	12	.022	0	81.967	194.311	64.87	1.667	H1-1b
10	3	M2	W10x22	.206	0	.066	0	129.265	194.311	64.87	2.441	H1-1b
11	3	M3	W10x22	.082	0	.008	0	81.967	194.311	64.87	1.667	H1-1b
12	3	M4	W10x22	.123	3.865	.024	8.246	129.265	194.311	57.648	1.042	H1-1b
13	4	M1	W10x22	.242	12	.024	0	81.967	194.311	64.87	1.667	H1-1b
14	4	M2	W10x22	.223	0	.077	0	129.265	194.311	64.87	2.508	H1-1b
15	4	M3	W10x22	.071	0	.007	0	81.967	194.311	64.87	1.667	H1-1b
16	4	M4	W10x22	.134	4.638	.033	0	129.265	194.311	58.345	1.054	H1-1b
17	5	M1	W10x22	.116	12	.010	0	81.967	194.311	64.87	1.667	H1-1b
18	5	M2	W10x22	.106	7.903	.066	0	129.265	194.311	64.87	1.647	H1-1b
19	5	M3	W10x22	.116	0	.010	0	81.967	194.311	64.87	1.667	H1-1b
20	5	M4	W10x22	.106	7.903	.066	0	129.265	194.311	64.87	1.647	H1-1b

ATTACH- 'A'

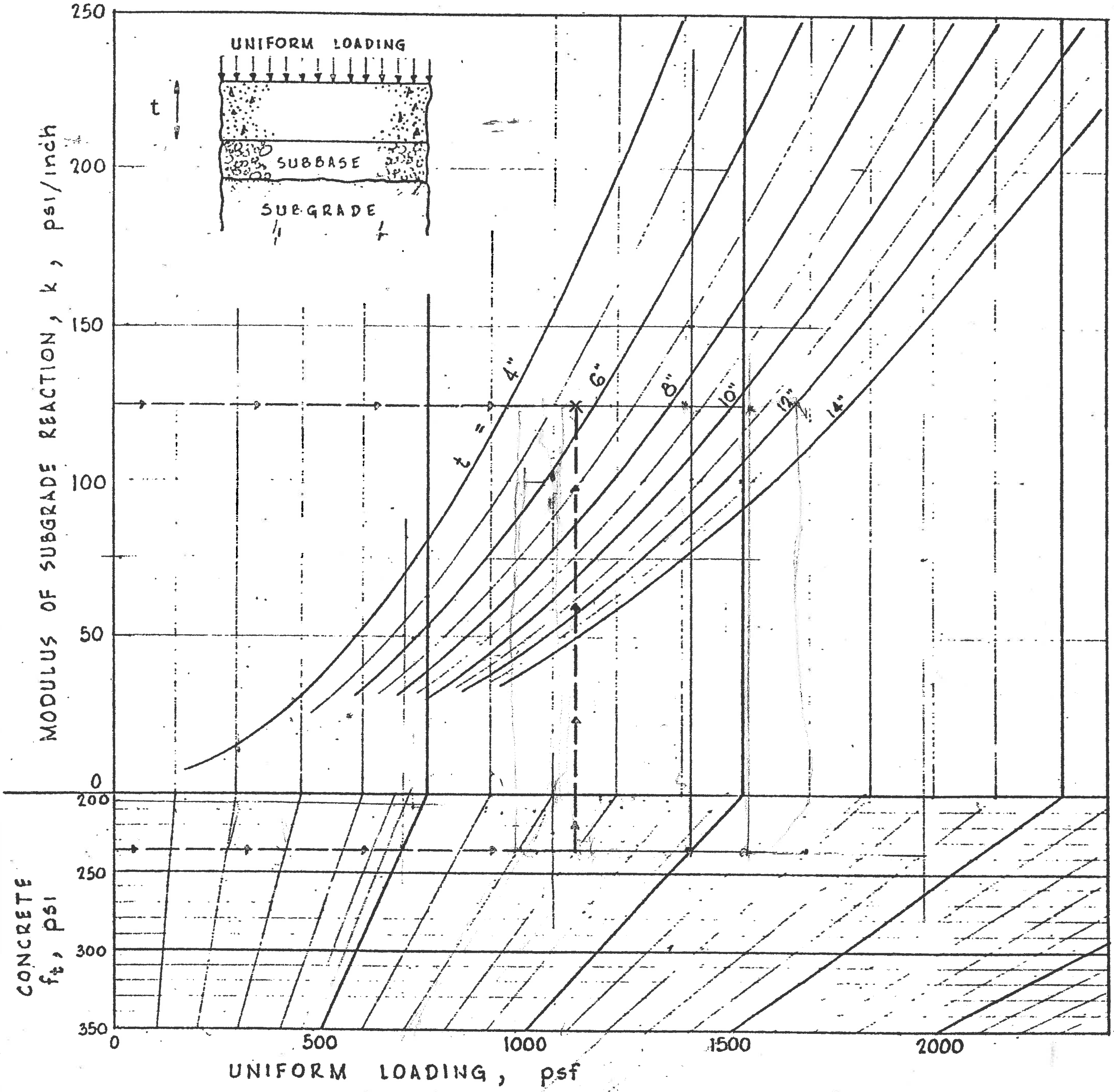
SLABS-ON-GRADE - THICKNESS FOR UNIFORM LOADING

Concrete f'_c psi	Modulus of Rupture (ACI 9.5.2.2) $f_r = 7.5\sqrt{f'_c}$ psi	Allowable Flexural Tensile Strength $f_t = f_r/2$ psi
3000	411	206
4000	474	237

EXAMPLE

Given: f'_c = 4000 psi ▸ Use f_t = 237 psi
Uniform Loading = 800 psf
Subgrade k = 125 psi/inch

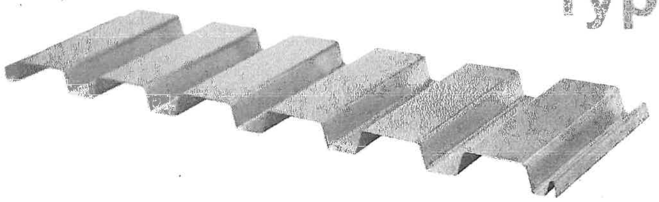
From Chart, read t = 5½" ——▸ **Use t = 6"**



ATTACH-'B'

Type PLB™-36 or HSB®-36

1½" Deep Roof Deck
Primer Painted or Galvanized



VERTICAL LOADS

lowable Uniform Loads (psf)

AN	GAGE		4'-0"	5'-0"	5'-6"	6'-0"	6'-6"	7'-0"	7'-6"	8'-0"	8'-6"	9'-0"	9'-6"	10'-0"	10'-6"	11'-0"	11'-6"	12'-0"
SINGLE	22	Stress	185	118	98	82	70	60	53	46	41	37	33	30				
		L/240	185	95	71	55	43	34	28	23	19	16	14	12				
	20	Stress	223	149	123	104	88	76	66	58	52	46	41	37	34	31	28	26
		L/240	229	117	88	68	53	43	35	29	24	20	17	15	13	11	10	8
	18	Stress	300	204	168	141	120	104	90	80	70	63	56	51	46	42	38	35
		L/240	◆◆◆	160	120	93	73	58	47	39	33	27	23	20	17	15	13	12
	16	Stress	300	259	214	180	153	132	115	101	89	80	72	65	59	53	49	45
		L/240	◆◆◆	200	150	116	91	73	59	49	41	34	29	25	22	19	16	14
DOUBLE	22	Stress	194	124	103	86	73	63	55	49	43	38	34	31				
		L/240	◆◆◆	◆◆◆	◆◆◆	◆◆◆	◆◆◆	◆◆◆	◆◆◆	◆◆◆	◆◆◆	◆◆◆	◆◆◆	30				
	20	Stress	244	156	129	108	92	80	69	61	54	48	43	39	35	32	30	27
		L/240	◆◆◆	◆◆◆	◆◆◆	◆◆◆	◆◆◆	◆◆◆	◆◆◆	◆◆◆	◆◆◆	◆◆◆	43	37	32	27	24	21
	18	Stress	300	212	175	147	125	108	94	83	73	65	59	53	48	44	40	37
		L/240	◆◆◆	◆◆◆	◆◆◆	◆◆◆	◆◆◆	◆◆◆	◆◆◆	◆◆◆	◆◆◆	◆◆◆	56	48	42	36	32	28
	16	Stress	300	262	217	182	155	134	117	103	91	81	73	66	60	54	50	46
		L/240	◆◆◆	◆◆◆	◆◆◆	◆◆◆	◆◆◆	◆◆◆	◆◆◆	◆◆◆	◆◆◆	◆◆◆	70	60	52	45	40	35
TRIPLE	22	Stress	243	155	128	108	92	79	69	61	54	48	43	39				
		L/240	◆◆◆	◆◆◆	◆◆◆	◆◆◆	86	69	56	46	39	33	28	24				
	20	Stress	300	195	161	136	116	100	87	76	68	60	54	49	44	40	37	34
		L/240	◆◆◆	◆◆◆	◆◆◆	132	104	83	68	56	47	39	33	29	25	21	19	17
	18	Stress	300	265	219	184	157	135	118	103	92	82	73	66	60	55	50	46
		L/240	◆◆◆	◆◆◆	◆◆◆	175	138	110	90	74	62	52	44	38	33	28	25	22
	16	Stress	300	300	271	228	194	167	146	128	113	101	91	82	74	68	62	57
		L/240	◆◆◆	◆◆◆	◆◆◆	218	172	137	112	92	77	65	55	47	41	35	31	27

(Column group heading over the spans: SPAN (ft-in.))

ıtes:
Stress = Uniform load which produces maximum allowable stress in deck.
L/240 = Uniform load which produces L/240 deflection in deck.
Self-weight of the deck should be included when determining dead load.
The symbol ◆◆◆ indicates allowable uniform load based on deflection exceeds allowable uniform load based on stress.

APPENDIX A - CALCULATION COVER SHEET

CALCULATION ID NUMBER	TC02, TC03, TC04
REVISION NUMBER	
JOB NUMBER	WW-PAE-2174

TITLE	Tanks outside 12'Φ x 17' Steel, 10'Φ x 21' FRP, 10'Φ x 18' CRP / Adjacent to chemical Storage Area

DWGS S-13-14 TO S-13-15, S-02-03, S-02-04 (12'Φ Steel)

	Pg. No.	CONTENT
TC02	1	General Data & Wind Loads For 12'Φ x 17' Steel Tank
	2 To 5	12'Φ Tank Design, Impulsive & Convective Forces, Sloshing ht.
	6 To 8	Annular Ring & Ring Wall Fdn. Design.
TC03	9	General Data, Wind loads for Fiberglass FRP & CRP Tanks
	10 To 11	10'Φ x 21' FRP Tank Impulsive & Convective Forces, Sloshing ht.
TC04	12 To 13	10'Φ x 21' FRP Tank Ring wall Fdn.
	14	10'Φ x 18' CRP Tank Impulsive & convective Forces
	15	CRP Tank Anchor Bolts & Pedestals
	16	CRP Tank Base pl. & Fdn Design.
	A-1, A-2	Attachments.

	initial	date
PREPARED	KD	4/15/14
TITLE		
REVIEWED		
TITLE		

REVISION NOTES	

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	Checked By:		Date:
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Project No. WW-PGE-2174			Sheet No.
Project Description: Topock 12'd x 17' Steel Tank			

Reference:

Design References

1. AWAA Standard D-100-11
2. IBC 2009 / CBC 2010
3. ACI 318-11
4. Nuclear Reactors & Earthquakes (TID 7024) Chap-6

Design Data

Concrete $f'_c = 5^{ksi}$ $f_y = 60^{ksi}$ - Anchor Bolts - A-307

Tank Data

Height = 13 + 1 + 3 = 17' Height of water = 13'

Dia. of tank = 12' = D

Sec. 3.7 Min t for Shell = $\frac{2.6 h_p D G}{SE} = \frac{2.6 \times 14 \times 12 \times 1}{15000 \times .86} = .05''$ USE $\frac{3}{16}''$ (Table 16)

(.85 ?/t)

Seismic Data

Site Class - D

Seismic Coefficents (See structural Dwg. S-00-01)

$S_S = .23$ $F_a = 1.6$ $S_{MS} = F_a \times S_S = 1.6 \times .23 = .368$ Say .37

$S_1 = .12$ $F_v = 2.318$ $S_{M1} = F_v \times S_1 = 2.318 \times .12 = .279$ Say .28

$S_{DS} = .37 \times .667 = .247$ $S_{D1} = .28 \times .667 = .187$

Soil Data (No Soil Report)

Allow. Soil Press. = 1 x 1.2 = 1200 PSF

Wind Data. Code AWAA D-100-11 (Sect. 3.1.4) Exposure-C

Assume G = Gust Factor = 1.0 Wind Vel. = 100 mph

$q_z = .00256\, k_z I V^2 = .00256 \times 1.09 \times 1.15 \times 100^2 = 32$ PSF

$P_w = q_z G C_f = 32 \times 1 \times .6 = 19.2$ PSF > $30 \times .6 = 18$ PSF

USE $P_w = 20$ PSF

Total $P_w = 20 \times 12 \times 17.5 = 4200^{\#} = 4.20^k$

$V_{max} = 4.32^k$ $M_{max} = 4.20 \times 8.75 = 36.75^{'k}$

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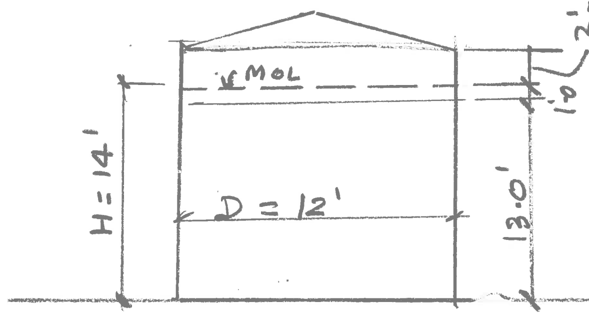
Project No. WW-PGE-2174			Sheet No. 2
Project Description: Topock 12'Φ×17' Tank			

Reference:

Design of Tank for Seismic Loads



Impulsive Components

Eq. 13-18

$A_i = \dfrac{S_{ai} I_E}{1.4 \times R_I}$ $I_E = 1.25$ (Table 24) $R_I = 3.0$ (Table 28)

$= \dfrac{.247 \times 1.25}{1.4 \times 3.0} = .074$ For $T_i \leq T_s$ $S_{ai} = S_{DS}$

$T_i = C_t h_n^x = .02 \times 17^{.75} = .167 < .757$

$A_{i\,min} = \dfrac{.36 S_1 I_E}{R_I}$ $T_S = \dfrac{S_{D1}}{S_{DS}} = \dfrac{.187}{.247} = .757$ $T_L = 12$ sec.

$= \dfrac{.36 \times .12 \times 1.25}{3.0} = .018$ USE $A_i = .074$ g

Eq. 13-20

$V_i = A_i (W_s + W_r + W_f + W_i)$ $M_i = A_i (W_s X_s + W_r \times H_t + W_i X_i)$

W_T = wt of contents = $49 H D^2 = 49 \times 14 \times 12^2 \times 10^{-3} = 98.8^k$

$\dfrac{D}{H} = \dfrac{12}{14} = .86 \angle 3.33$ $\dfrac{W_1}{W_T} = .82$ $\dfrac{W_2}{W_T} = .2$

$\dfrac{X_1}{H} = .42$ $\dfrac{X_2}{H} = .78$

Ref.-1

$X_1 = .42 \times 14 = 5.88'$
$X_2 = .78 \times 14 = 10.92'$ } From charts Figures A.5 & A.6 (pg. 194)

$W_i = W_T \times .82 = 98.8 \times .82 = 81.02^k$ $W_2 = 98.8 \times .2 = 19.76^k$

W_r = wt. of Roof = $\dfrac{\pi}{4} (12)^2 \times .01 = 1.13^k$

W_s = wt. of shell = $\dfrac{\pi}{4} (12.03125^2 - 12.0^2) \times 17 \times .49 = 4.91^k$ say 5^k

Total wt. = $W_t = W_1 + W_r + W_s = 81.02 + 1.13 + 5 = 87.15^k$ USE 88^k

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Project No. WW-PGE-2174			Sheet No. 3
Project Description: Topock 12'φ×17' Tank			

Reference:

12' Φ Water Tank contd.

Total Wt. = 88^k = Wt

Note: Floor wt. not included since it is at ground level.

V_i = Shear due to impulsive forces
= A_i (Wt) = .074 × 88 = 6.51^k

M_i = Moment due to impulsive forces
= .074 ($W_s X_s + W_p H_t + W_i X_i$)
= .074 (5.0 × 8.5 + 1.13 × 17.25 + 81.02 × 5.88)
= .074 (42.50 + 19.49 + 476.40) = .074 × 488.13 = 36.14^{1k}

X_{imf} & M_{imf} Not used since Tank is on Ring Fdn.
(Eq. 13-33) (Eq. 13-32)

Convective Forces (Sloshing Effects)

Eq. 13-18 $A_c = \frac{S_{ac} I_E}{1.4 R_I}$ I_E = 1.25 R_I = 1.5
(See calc. below)
$S_{ac} = \frac{K S_{D1}}{T}$ = .14 < S_{DS} = .247 (Eq. 13-12) $T_c < T_L$

Eq. 13-22 $T_c = 2\pi \sqrt{\frac{D}{3.68\, g \tanh\left(\frac{3.68 H}{D}\right)}} = 2\pi \sqrt{\frac{12}{3.68 \times 32.2 \times .999627}}$ = 2.0 sec.

$\tanh\left(\frac{3.68 \times 14}{12}\right) = \tanh(4.293) = .999627$

$S_{ac} = \frac{1.5 \times .187}{T_c} = \frac{1.5 \times .187}{2.0} = .14025$

$A_c = \frac{.14025 \times 1.25}{1.4 \times 1.50} = .0835$

Eq. 13-30 $X_c = \left[1 - \frac{\cosh\left[\frac{3.67H}{D}\right] - 1}{\frac{3.67H}{D} \sinh\left[\frac{3.67H}{D}\right]}\right] H$

H = 14 D = 12 $\frac{H}{D}$ = 1.167
cosh(4.282) = 36.1994
sinh(4.282) = 36.1856

$= \left[1 - \frac{\cosh(4.282) - 1}{4.282 \sinh(4.282)}\right] 14$

$= \left[1 - \frac{36.1994 - 1}{4.282 \times 36.1856}\right] \times 14$

= 10.81'

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Project No.	WW-DGE-2174
Project Description:	Topock 12"Φ x 17' Tank

Reference:

Sloshing Wave Height

Eq. 13-52 $d = .5 D A_f$

$A_f = \frac{k S_{D1} I_E}{T_c}$ $T_c = 2.0$ sec.

$S_{D1} = .187$ $I_E = 1.25$ (Seis. Group II) $k = 1.50$

$A_f = \frac{1.5 \times .187 \times 1.25}{2.0} = .1753$ OR $A_f = \frac{1.5 \times .187 \times 1.5}{2.0} = .21$ (Seismic Gr. III)

d (Group II) $= .5 \times 12 \times .1753 = 1.052' < 3.0'$ ok

d (Group III) $= .5 \times 12 \times .2104 = 1.262' < 3.0'$ ok

Since we have assumed Group II for seismic calc's according to table-29, there is no requirement for freeboard. Hence the tank height can be reduced to 15' OR 16' (H+2')

Anchor Bolts

$V_{max} = V_f = 6.64^k$ (pg. 4) $M_{max} = M_s = 40^k$ (pg. 4)

$V_A = \tan 30 (W_s + W_r + W_i)(1 - .4 A_v)$ $A_v = .4 S_{DS} = .14 \times .247 = .035$

$= .577 (29.67 + 1.13 + 81.02)(1 - .4 \times .035)$

$= 63.7^k > 6.64^k$ Min. Anchor Bolts to be @ 6'-0" o/c

Uplift

$P_s = \left[\frac{4 M_s}{D A_c} - W'\right] \times \frac{1}{N} + \frac{.035 \times W'}{N}$ $N_{(min.)} = \frac{\pi D}{6} = 7$ A.B.'s USE 8 A.B.'s

$= \left[\frac{4 \times 40.1}{12} - 6.13\right] \times \frac{1}{8} + \frac{.035 \times 6.13}{8}$ $W' = W_r + W_s = 5 + 1.13 = 6.13^k$

$= .905 + .027 = .932^k$

USE 8-1"Φ A.B.'s Cap. = 1" x 1'-6" (Emb.) A.B. = 12.1^k (conc.) $> .932^k$

Conc $f_c' = 4^{ksi}$

T cap. of steel A.B. = $.5 \times 58 \times 1.06 = 17.57^k$

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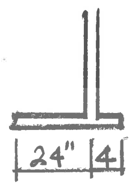
Project No. WW-PAE-2174

Project Description: Topock 12'Φ x 17' Tank

Reference:

Annular Ring



$W_L = 7.9 t_b \sqrt{F_y G} < 1.28\ HDG$

$W_L = 7.9 \times .1875 \times \sqrt{36000 \times 14 \times 1} = 1051.6\ ^{\#}/_{'}$

$1.28\ HDG = 1.28 \times 14 \times 12 \times 1 = 215\ ^{\#}/_{'}$

Reqd. $L = .216 \times .1875 \sqrt{\frac{36000}{14 \times 1}} = 2.053'$

$> .035 D = .035 \times 12 = .42'$

USE 2'-4"

For $J < .785$

Eq. 13-39 $\sigma_c = \left[w_t (1 + .4 A_v) + \frac{1.273\ M_s}{D^2} \right] \times \frac{1}{12\ t_s}$

$w_t = \frac{W_s}{\pi D} + w_{rs}$

$= \left[w_t (1 + .4 \times .035) + \frac{1.273 \times 40.1 \times 10^3}{12^2} \right] \times \frac{1}{12 \times .1875}$

$= \frac{5000}{\pi \times 12} + \frac{1120}{\pi \times 12}$

$= 162.6\ ^{\#}/_{'}$

$= 230.53$ PSI Small ok

Eq. 13-38 Value of $J = \frac{M_s}{D^2 [w_t (1 - .4 A_v) + w_L]}$

$= \frac{40.0 \times 10^3}{12^2 [162.6 (1 - .4 \times .035) + 1051.6]}$

$= .23 < .785$ Eq. 13-39 is ok to use

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Project No.	WW-PGE-2174		Sheet No. 7
Project Description:	Topock 12' Φ x17' Tank		

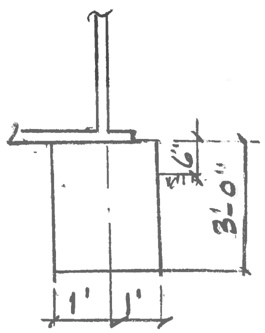
Reference:

Ring Wall Foundation

Try 2'-0" wide x 3'-0" deep foundation

Ring wall outside Dia = d = $2\left(\frac{12}{2}+1\right) = 14'$

Ring wall Inside Dia. = $d_1 = 2\left(\frac{12}{2}-1\right) = 10'$



Try Footing Width = 2'-0"

Footing Depth = 3'-0"

$$A = \frac{\pi}{4}\left[14^2 - 10^2\right] = 122.5 \text{ ft}^2$$

$$S = \frac{\pi}{32}\left[\frac{14^4 - 10^4}{14}\right] = 199.4 \text{ ft}^3$$

Total Weight = $W = w_1' + w_2' + w_3'$

$w_1' = W_r + W_s = 1.13 + 5 = 6.13^k$

$w_2' = W_L \pi D = .215 \times \pi \times 12 = 8.11^k$

w_3' = Wt. of Ftg = $.15\left[A \times 3\right] = .15\left[122.5 \times 3\right] = 55.12^k$

$\Sigma W = 6.13 + 8.11 + 55.12 = 69.37^k$

$q_1 = \frac{69.37}{122.5} = .566$ KSF

M_d = OTM @ Base of Ftg. = $M_s + V_f \times 3 = 40.0 + 6.64 \times 3 = 60.0^{1K}$

$q_2 = \frac{60.0}{199.4} = .301$ KSF

DL + Seis. $q_1 + q_2 = .566 + .301 = .867$ KSF < 1.2 KSF

DL + LL ok by insp.

USE 2'-0" wide x 3'-0" deep Ftg. (Ring Fdn.)

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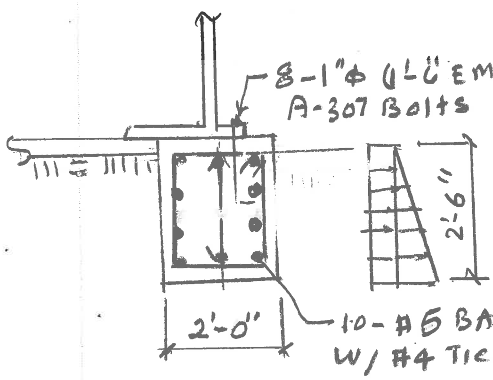
Project No. WW-PGE-2174			Sheet No. 8
Project Description: Topock 12' Φ x 17' Tank			

Reference:

Ring Wall Foundation (contd.)

Hoop Tension



Soil Active Press = P_a

$P_a = k_a w h'$ $\quad h' = 2.5'$

$= .5 \times 120 \times 2.5$ $\quad k_a = .50$

$= 150 \#/'$ $\quad w = 120$ PSF/'

Surcharge

$P_s = w_H \times H \times .5$ $\quad w_H = 62.4$ PSF/'

$= 62.4 \times 14 \times .50$ $\quad H = 14'$

$= 436.8 \#/'$

Hoop Tension $T_H = w_p h' R$

$w_p = \left[\frac{P_a}{2} + P_s \right] = \frac{150}{2} + 436.8 = 511.8 \#/'$ Say $512 \#/'$

$T_H = 512 \times 2.5 \times \frac{12}{2} = 7680^{\#} = 7.68^k$

$T_{HU} = 1.7 \times 7.68 = 13.056^k$ Say 13.1^k

$A_{sy} = \frac{13.1}{.9 \times 60} = .243 \text{ in}^2$ Min. $A_s = .002 \times 36 \times 24 = 1.73 \text{ in}^2$

10 - #5 BARS OK. $A_{sa} = 10 \times .31 = 3.10 \text{ in}^2 > 1.73 \text{ in}^2$

USE 2'-0" W x 3'-6" Tk Ftg. w/ 10-#5 BARS

Shear Reinf. Try #4 @ 12" o/c (3-legs)

$A_v = \frac{50 b_w S}{f_y} = \frac{50 \times 24 \times 36}{60000} = .36 \text{ in}^2 < .2 \times 3 = .6 \times \frac{12}{18} = .4 \text{ in}^2$ ok

#4 Stirrups @ 18" o/c ok

USE 10-#6 Bars w/ #4 stirrups @ 12"

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		Sheet No. 9	

Project No. WW-PGE-2174

Project Description: Topock 10'φ x 21' Fiberglass Tank

Reference:

Design References

1. AWAA Standard D-100-11
2. IBC 2009 / CBC 2010
3. ACI 318-11
4. Nuclear Reactors & Earthquakes (TID 7024) Chap-6

Design Data

Concrete $f'_c = 5^{KSI}$ $f_y = 60^{KSI}$ - Anchor Bolts - A-307

Tank Data

FRP Tank: Height $H_t = 17+1+3 = 21'$ Height of Water $= 17'$

Capacity of Tank = 10000 gallons (See pg 2 for required Ht.)

CRP Tank: Height $H_t = 15+1+2 = 18'$

Capacity of Tank = 10000 gallons (see pg. 6)

See Attachments A-1 & A-2 For Dimensions etc.

Seismic Data

Site Class - D

Seismic Coefficients (See structural Dwg. S-00-01)

$S_s = .23$ $F_a = 1.6$ $S_{ms} = F_a \times S_s = 1.6 \times .23 = .368$ Say .37

$S_1 = .12$ $F_v = 2.318$ $S_{m1} = F_v \times S_1 = 2.318 \times .12 = .279$ Say .28

$S_{DS} = .37 \times .667 = .247$ $S_{D1} = .28 \times .667 = .187$

Soil Data (No Soil Report)

Allow. Soil Press. = 4.0 KSF

Wind Data. Code AWAA D-100-11 (Sect. 3.1.4) Exposure C

Assume G = Gust Factor = 1.0 Wind Vel. = 100 mph

$q_z = .00256\, K_z\, I\, V^2 = .00256 \times 1.09 \times 1.15 \times 100^2 = 32^{PSF}$

$P_w = q_z G C_f = 32 \times 1 \times .6 = 19.2^{PSF} > 30 \times .6 = 18^{PSF}$

USE $P_w = 20^{PSF}$.

Total $P_w = 20 \times 10 \times 21.0 = 4200^{\#} = 4.20^k$

$V_{max} = 4.20^k$ $M_{max} = 4.20 \times 10.50 = 44.1^{'k}$

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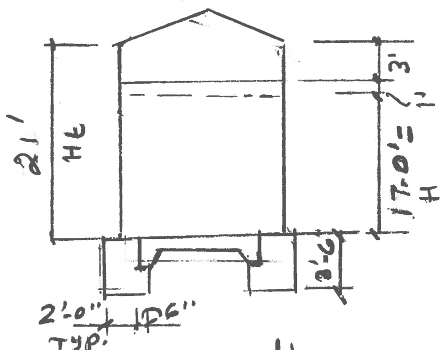
Project No. WW-PGE-2174			Sheet No. 10
Project Description:	Topock 10'Φ x 21' Fiberglass Tank (FRP Tank)		

Reference:

10'Φ x 19'-0" (water level), Fibreglass Tank



Cap. of Tank = 10000 gallons.

Ht. of water = H, $\frac{\pi}{4} \times 10^2 \times H = .1336 \times 10000 \quad H = 17'$

1'-0" Freeboard

3'-0" Assumed sloshing

See pg. 9 for Tank Seismic & wind data

Impulsive Forces (Reference-1)

Eq. 13-18 $A_i = \frac{S_{ai} I_E}{1.4 R_I} = \frac{.247 \times 1.25}{1.4 \times 3.0} = .074$

$T_1 \leq T_S \quad S_{ai} = S_{DS} \quad T_1 = C_t h_n^x = .02 \times 21^{.75} = .196 < T_S \quad T_S = \frac{S_{D1}}{S_{DS}} = \frac{.187}{.247} = .757$

$A_{i_{min}} = \frac{.36 S_1 I_E}{R_I} = \frac{.36 \times .12 \times 1.25}{3.0} = .018 \quad$ USE $A_i = .074\,g$

Eq. 13-20 $V_i = A_i (W_s + W_r + W_f + W_i)$, $M_i = A_i (W_s X_s + W_r H_t + W_i X_i)$

W_T = wt. of Contents $= 49HD^2 = 49 \times 17 \times 10^2 \times 10^{-3} = 83.3^k$

Eq. 13-29 $\frac{D}{H} = \frac{10}{21} = .476 < 3.33 \quad X_i = \left[.5 - .094 \frac{D}{H}\right] H = [.5 - .094 \times .476]\, 21 = 9.56'$

Eq. 13-25 $W_i = \left[1 - 0.218 \frac{D}{H}\right] W_T = [1 - .218 \times .476] \times 83.3 = .896 \times 83.3 = 74.65^k$

W_s = wt. of shell $= 3^k \quad W_r$ = wt. of Roof $= 1^k$

Total Weight $= W_t = W_i + W_r + W_s = 74.65 + 4 = 78.65$ USE 79^k

$V_1 = A_i (W_t) = .074 \times 79 = 5.85^k$

$M_i = .074 (W_s X_s + W_r H_t + W_i X_i) = .074 (3 \times 21 \times .5 + 1 \times 21.5 + 75 \times 9.56)$
$= .074 (31.5 + 21.5 + 717) = 57^{'k}$

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Project No.	WW-PGE-2174		Sheet No. 11
Project Description:	Topock 10'Φ x 21' Fiberglass Tank		

Reference:

Convective Forces (sloshing)

Eq. 13-18 $A_c = \frac{S_{ac} I_E}{1.4 R_I}$ $S_{ac} = \frac{k S_{D1}}{T} = \frac{1.5 \times .187}{T} = \frac{.2805}{1.825} = .1537 < S_{DS} = .247$

Eq. 13-22 $T_c = 2\pi \sqrt{\frac{D}{3.68 g \tanh\left(\frac{3.68 H}{D}\right)}} = 2\pi \sqrt{\frac{10}{3.68 \times 32.2 \times \tanh(6.256)}} = 1.825$ sec.

$\tanh \times \left(\frac{3.68 \times 17}{10}\right) = \tanh(6.256) = .99999$

$A_c = \frac{.1537 \times 1.25}{1.4 \times 1.5} = .0915$

$X_c = \left[1 - \frac{\cosh\left(3.67 \frac{H}{D}\right) - 1}{\frac{3.67 H}{D} \sinh\left[3.67 \frac{H}{D}\right]}\right] H$

$= \left[1 - \frac{\cosh(6.239) - 1}{6.239 \sin(6.239)}\right] \times 17 = \left[1 - \frac{256.1739 - 1}{6.239 \times 256.1739}\right] \times 17 = 14.286'$

256.17

$X_c = 14.286'$

Sloshing Wave Ht.

$d = .5 D A_f$ $A_f = \frac{k S_{D1} I_E}{T_c} = \frac{1.5 \times .187 \times 1.25}{1.825} = .1921$

(Group II)

$= .5 \times 10 \times .1921$ $A_f = .1921$

$= .96'$

Uplift on Tank

$P_s = \left[\frac{4 M_s}{D A_c} - W'\right] \times \frac{1}{N} + \frac{.035 \times W'}{N}$ $N = \frac{\pi D}{6} = 6$

$= \left[\frac{4 \times 57}{10} - 4\right] \times \frac{1}{6} + \frac{.035 \times 4}{6} = 3.16^k$

1"Φ x 1'-6 (Emb.) A.B.'S @ 6'-0" o/c Cap. = $12.1^k > 3.16^k$

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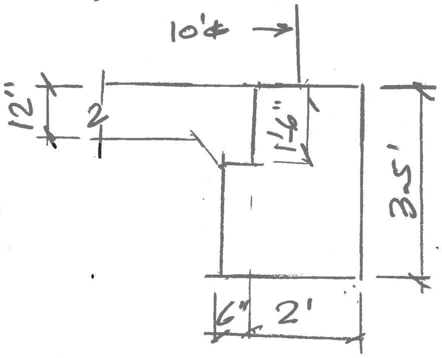
Project No. WW-PHE-2174			Sheet No. 12
Project Description: Topock 10' ϕ × 21' Fiberglass Tank			

Reference:

Ring Wall Foundation w/ Ledge for slab under the Tank
(See pg-10 for sketch)

Ring wall outside Dia = 12'   Ring wall Inside dia. = 8'



Try Footing Width = 2'-6"
Footing Depth = 3'-2"

$$A = \frac{\pi}{4}\left[12^2 - 8^2\right] = 62.83\ ft^2$$

$$S = \frac{\pi}{32}\left[\frac{12^4 - 8^4}{12}\right] = 136.14\ ft^3$$

Total weight $W_t = 79^k$

$w_1' = w_r + w_s = 1 + 3 = 4^k$

$w_2' = w_L \pi D = 1.28 \times 17 \times 10 \times 10^{-3} \times \pi \times 10 = 6.84^k$

$w_3' =$ wt. of Ftg. $= .15 \times 62.83 \times 3.5 = 33^k$

$\Sigma W = 4 + 6.8 + 33 = 45.8^k$ Say 46^k

$$q_1 = \frac{46}{62.83} = .73\ ksf$$

$M_d =$ OTM @ Base of Ftg. $= M_s + V_f \times 3.5 = 57 + .0915 \times 79 \times 3.5 = 57 + 7.23 \times 3.5 = 82.3^k$

$$q_2 = \frac{82.3}{136.14} = .605$$

$p_{(DL+Seis.)} = .73 + .605 = 1.335\ ksf < 4\ ksf$

$$p_{(DL+LL)} = \frac{79}{62.83} = 1.26\ ksf < 4\ ksf$$

$$p_{(DL+LL+wind)} = \frac{79}{62.83} + \frac{44.1}{136.14} = 1.58\ ksf < 4\ ksf$$

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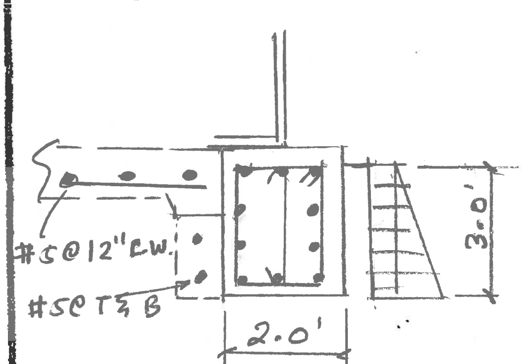
Project No.	WW-PGE-2174
Project Description:	Topock 10' ϕ × 21' Fiberglass Tank

Reference:

Ring Wall Fdn- Contd.

Hoop Tension



Soil Active Press = P_a

$P_a = k_a w h'$ = $h' = 3.0'$
$= .5 \times 120 \times 3$ $K_a = .50$
$= 180$ #/' $w = 120$ PSF/'

Surcharge

$P_s = w_H \times H \times .5$ $w_H = 62.4$ PSF/'
$= 62.4 \times 17 \times .50$ $H = 17'$
$= 530.4$ #/'

Hoop Tension $T_H = w_p h' R$

$w_p = \left[\frac{P_a}{2} + P_s \right] = \frac{180}{2} + 530.4 = 620.4$

$T_H = 620.4 \times 3.0 \times \frac{10}{2} = 9306^{\#} = 9.306^k$

$T_{Hu} = 1.7 \times 9.306 = 15.82^k$

$A_{sr} = \frac{15.82}{.9 \times 60} = .293 \text{ in}^2$ Min. $A_s = .002 \times 42 \times 24 = 2.02 \text{ in}^2$

USE 10 - #6 bars $A_{sa} = 10 \times .44 = 4.4 \text{ in}^2 > 2.02$

Shear Reinf. Try #4 @ 12"

$A_v = \frac{50 b_w s}{f_y} = \frac{50 \times 42 \times 12}{60000} = .42 \text{ in}^2 < .2 \times 3 = .6 \text{ in}^2$

USE 10-#6 Bars w/ #4 Stirrups @ 12" o/c

Conc. Slab on Grade

Min. Reinf. = $.002 \times 12 \times 12 = .288 \text{ in}^2$

USE #5 @ 12" Ea. Way

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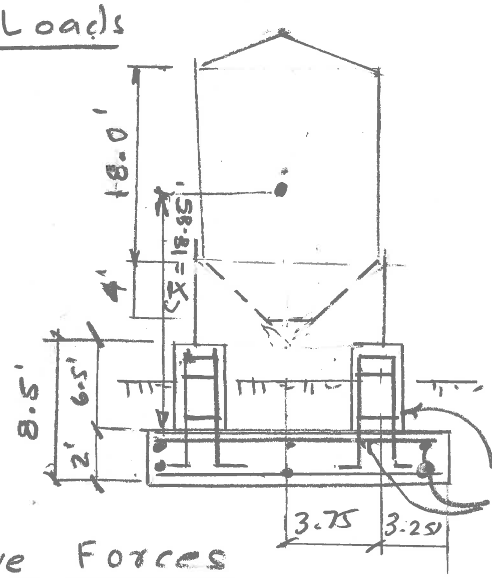
Project No. WW-PG&E - 2174			Sheet No. 14
Project Description: Topock 10"Φ CRP Tank (Fiberglass Tank)			

Reference:

Seismic Loads



Cap. of Tank = 10000 Gallons

$\left(\frac{\pi}{4} \times 10^2 \times H + \frac{\pi}{4} \times 10^2 \times \frac{5}{2}\right) = .1336 \times 10000$

Solving for H

$78.54H + 196.0 = 1336$ H = 14.5'
USE 15'

C.G. (Mom. @ Top of FTG.)

$73.5 \times (7.5 + 5 + 6.5) + 12.23 \times (3.67 + 6.5)$
$= 85.73 \times \bar{x}$
$\bar{x} = 18.85'$

30"×30" PEDSTAL w/ 8-#8 BARS w/ #4 Ties @ 12" o/c (TYP.)

#5 @ 12"

Impulsive Forces

$A_i = \frac{S_{ai} I_E}{1.4 R_I}$ $I_E = 1.25$ $R_I = 3.0$

For $T < T_s$ $S_{ai} = S_{DS}$

$T_1 = C_t h_n^x$

$= \frac{.247 \times 1.25}{1.4 \times 3.0}$

$= .074$

$V_i = A_i (W_s + W_r + W_i)$

$W_1 = 49 H D^2 = 49 \times 15.0 \times 10^2 + 196 \times 62.4$ (cylindrical, conical)
$= 73500 + 12230 = 85730^{\#}$

$= .074(5 + 85.73)$ $W_s + W_r = 3 + 2 = 5^k$

$= 6.71^k$

Convective Forces (See sect. 13.2.9.1 for elevated tanks)

Eq. 13-18

$A_c = \frac{S_{ac} I_E}{1.4 R_I}$ $S_{ac} = \frac{1.5 \times .187}{T_c} = .154$

$T_c = 2\pi \sqrt{\frac{D}{3.68\, g \tanh\left(\frac{3.68 H}{D}\right)}}$

$= 2\pi \sqrt{\frac{10}{3.68 \times 32.2 \tanh(5.52)}}$

$= 1.823$

$= \frac{.154 \times 1.25}{1.4 \times 1.5} = .0915$

$V = .0915 \times 91 = 8.327^k$

$M = (85.73 \times 18.85 + 3 \times 20.5 + 1 \times 30 + 1 \times 10.17) \times .0915 = 157.2^{1k}$

Design OTM M_o @ FTG. $= 1.5 \times 157.2 + 1.5 \times 8.3 \times 2 = 260.7^{1k}$

Resisting Mom. $= M_R$ @ FTG. $= 85.73 \times (3.75 + 3.25) = 643^{1k}$

$F.S. = \frac{643.0}{260.7} = 2.46$ OK

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Project No.	WW-PGE-2174		Sheet No. 15
Project Description:	Topock 10'Φ CRP Tank		

Reference:

Anchor Bolts & Pedestals

Bolts

Check uplift w/ Tank empty + wind

$P_W = 20$ PSF $P_W = .02 \times 10 \times 18 + .02 \times 10 \times 4 = 3.6 + .8 = 4.4^k$

$M_W = 3.6 \times 21 + .8 \times 12.17 = 75.6 + 9.74 = 85.34^{1k}$
(OTM)

$P_{DL} = 5^k$ $M_R = 5 \times (3.75 + 3.25) = 35.00^{1k}$

$P_u = \frac{85.34 \times 1.5 - 35.0}{7.5 \times 2} = 6.2^k$ $V/\text{PED.} = \frac{4.4}{4} = 1.1^k$

(@ Bolt w/ 2 PED.'s)

$P_u = (85.34 \times 1.5 - 35)/(7.5/.707) = 8.77^k$

(@ Bolt w/ single Ped. acting)

1"Φ A.B. $T_{All} = 10.9^k$ $V_{All} = 5.7^k$

$\frac{T}{T_{All}} + \frac{V}{V_{All}} = \frac{8.77}{10.9} + \frac{2.2}{5.7} = 1.19 < 1.33$ USE $1\frac{1}{4}$"Φ × 16" (EMB.) A-307 Bolts

$M/\text{ped.} = 1.1 \times 6.5 \times 1.7 + 85.34 \times .5 \times 1.7 = 84.69^{1k}$

$f_p = \frac{P}{A} + \frac{M}{S}$ $P_{DL} = 5 + .15 \times 2.5^2 \times 6.5 = 11.09^k$

$M = 84.69^{1k}$ $S = \frac{1}{6} \times 14 \times 14^2 = 457.33$

$= \frac{11.09}{14 \times 14} + \frac{84.69}{457.33}$

$= .242$ kSF

Dowels in Pedestal

Ten $T = \frac{84.69 \times 12}{4 \times 24} = 14.12^k$ $T_A = .9 \times 60 \times .79 = 42.66^k$/Dowel

USE 2'-6" SQ. Pedestal w/ 12 - #7 BARS OR 8 - #8 BARS

Comp. in Pedestal (DL + LL + Seismic OR Tank full + Seismic)

$M_S = 157.2^{1k}$ (See pg. 14) $P_s/\text{PED.} = \frac{157.2}{7.5 \times 2} + \frac{86}{4} = 10.48 + 21.5 = 32^k$
(OTM @ Top of Ped.)

$M/\text{PED} = \frac{8.33 \times 6.5}{4} = 13.54^{1k}$

Conc. Col.
$f_c = 5$ ksi
$f_y = 60$ ksi
$\gamma = .75$

$P_u = [1.4 \times 10.5 + 1.4(.15 \times 2.5^2 \times 6.5) + 1.7 \times 21.5]$
$= 59.8^k$

$M_u = 1.7 \times 13.54 = 23.02^{1k}$ $\rho = \frac{A_s}{bd} = \frac{8 \times .79}{30 \times 27.5} = .008$ $\frac{P_u}{A_g} = 2.69$ for $\frac{e}{h} = \frac{23 \times 12}{25 \times 60} = .2$

$P_u = 2.06 \times 30 \times 30 = 1854^k > 60^k$

USE 30" × 30" PEDSTAL w/ 12 #7 BARS & #4 Ties @ 12" o/c

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Project No. WW-PEG-2174			Sheet No. 16
Project Description: Topock 16'Φ CRP Tank			

Reference:

Base Plate (DL+LL+ Seismic or Tank Full + Seismic)

P/PED. = 32^k (pg. 15) Try 12"×12" × 1" TK PL

$S_{pl.} = \frac{1}{6} \times 1'' \times 1.0^2 = .1666 \; in^3$

$p = \frac{32}{12\times12} = .222^{ksi}$ $M_{pl.} = \frac{.222\times6^2}{2} = 4^{''k}$

$f_b = \frac{4}{.1666} = 24^{ksi} < 27^{ksi}$

USE Base pl. 12" × 1" × 1'-0"

Footing Reinf.

Total $P = 86^k$ (pg. 14) $+ 4(.15\times2.5^2\times6.5) + .15\times14^2\times2.0 = 169.2^k$

$M_o = 157.2 + 8.33\times2 = 173.86^{'k}$

(@ Base Ftg.)

$\frac{P}{A} + \frac{M}{S} = \frac{169.2}{14\times14} + \frac{173.86}{\frac{1}{6}\times14\times14^2} = .86 + .38 = 1.24^{ksf} < 4^{ksf}$ ok

M_u @ Face of pedstal $= 1.6\times1.24\times\frac{2^2}{2} = 2.90^{'k}$ M_u (bet'n Ped's) $= \frac{1.24\times1.6\times7.5^2}{10} = 11.16^{'k}$

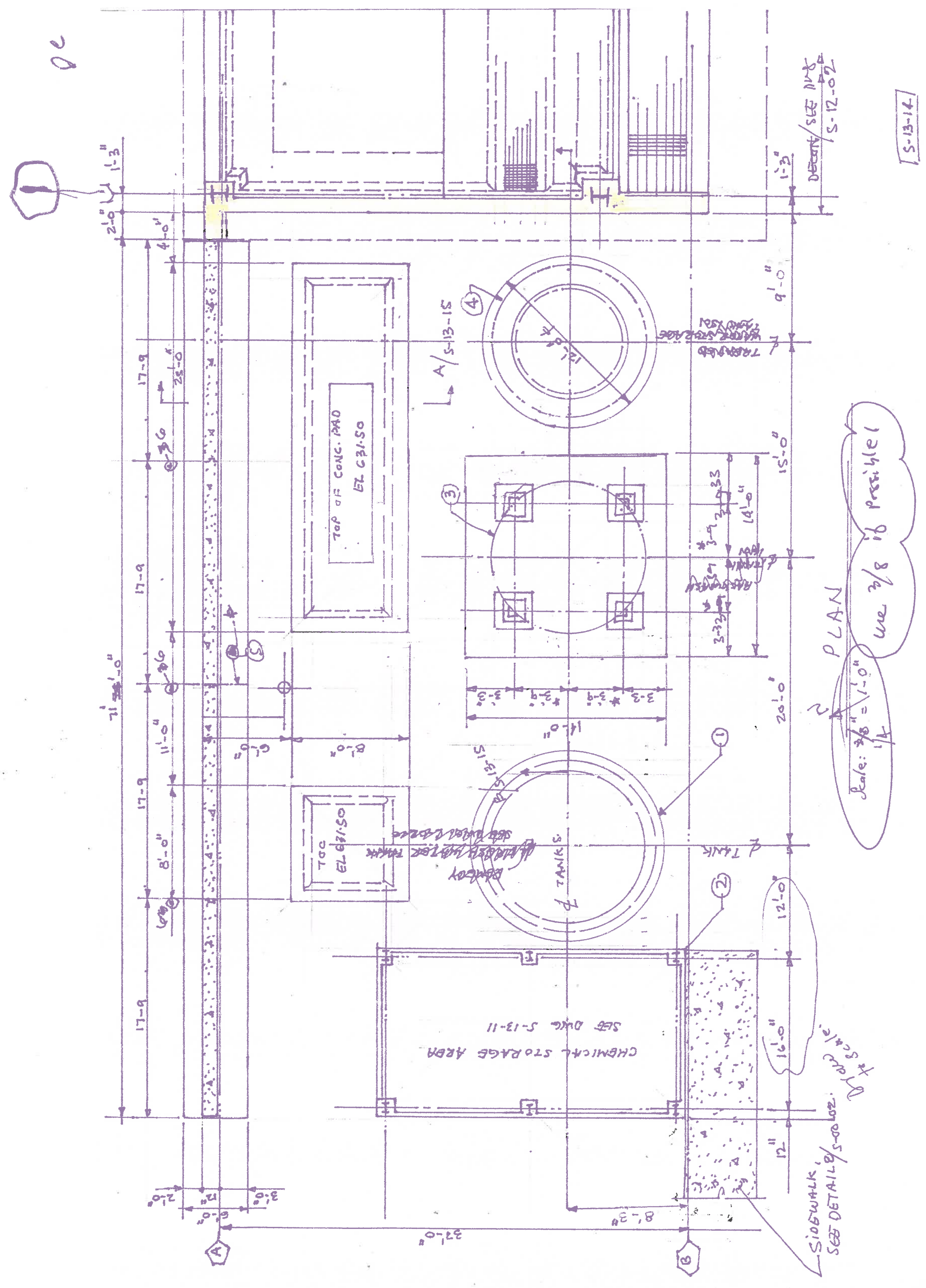
$d = 24 - 3.5 = 21.5''$ $b = 12''$ Try #5 @ 12"

$\phi M_n = .9\times.31\times\frac{60}{12}\left(d - \frac{a}{2}\right)$ $a = \frac{.31\times60}{.85\times5\times12} = .365$

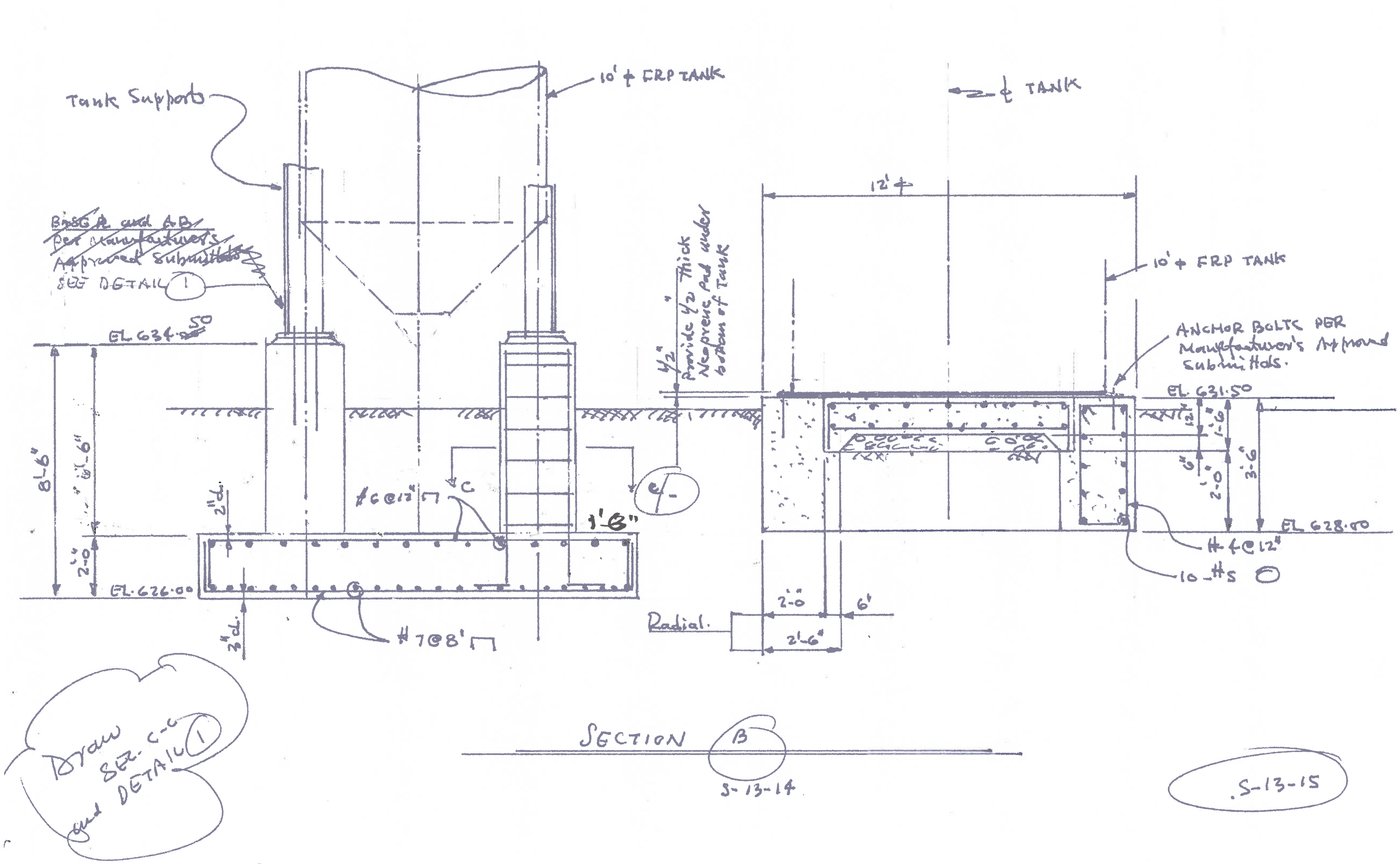
$= .9\times.31\times5\left(21.5 - \frac{.365}{2}\right) = 29.73^{'k} > 11.16^{'k}$

V_u ok by insp.

USE 14'×14' SQ. × 2'-0" TK FTG. w/ #5 @ 12" @ T & B



PLAN
Scale: 3/8" = 1'-0"
use 3/8 if possible
TOP OF CONC. PAD
EL 631.50
TOC
EL 631.50
CHEMICAL STORAGE AREA
SEE DWG S-13-11
SIDEWALK, SEE DETAIL S-00-02
S-13-14
A/S-13-15
TANKS
TANK
37'-0"


Tank Supports
10' ¢ FRP TANK
¢ TANK
12' ¢
10' ¢ FRP TANK
BASE PL and AB Per Manufacturer's Approved Submittals
SEE DETAIL 1
EL 634.50
1/2"
Provide 1/2 Thick Neoprene Pad under bottom of Tank
ANCHOR BOLTS PER Manufacturer's Approved Submittals.
EL 631.50
EL 628.50
8'-6"
6'-6"
2'-0"
2" cl.
3" cl.
EL 626.00
#6@12"
C
1'-6"
#7@8'
Radial.
2'-0"
6'
2'-6"
3'-6"
#4@12"
10-#5
SECTION B
S-13-14
S-13-15
Draw SEC. C-C and DETAIL 1

TAB NO.4

a. CONDITIONING WATER TANK (40,000 GALLONS)
b. REATAINING WALL

APPENDIX A - CALCULATION COVER SHEET

CALCULATION ID NUMBER	TC01
REVISION NUMBER	
JOB NUMBER	WW-PEB-2174-043002

TITLE	Topock Groundwater Remediation Project Steel Water Tank

Page No.	CONTENT	DWGS
		5-14-01 TO 5-14-09
1	Referances And Data	
2 TO 5	Impulsive And Convective Forces	
6	Sloshing Height, wind loads	
7	Annular Ring & Anchor Bolts	
8, 9	Foundation	
10	Attachments	

	initial	date
PREPARED		
TITLE		
REVIEWED		
TITLE		

REVISION NOTES	

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	Revised By:	Date:
Project No. WW-PEG-2174-435062-01.02.02		Sheet No. 1

Project Description: Topock Groundwater Remediation Project, Ref.'s & Data

Design References

1. AWWA Standard D-100-11 (Rev. of ANSI/AWAA D100-05)
2. IBC 2009 / CBC 2010
3. ACI 318-11
4. Nuclear Reactors & Earthquakes (TID 7024) chap.-6

Design Data

Concrete $f_c' = 4.0^{ksi}$ $f_y = 60^{ksi}$

Anchor Bolts. A-307

Tank Data

Total Height = 16' Height of water = H = 12.5'

Dia. of Tank = 25' = D

Min t for shell $= \frac{2.6\, h_p D G}{SE} = \frac{2.6 \times 12.5 \times 25 \times 1}{15000 \times .66} = .05''$ Use .25" (Table 15)

Seismic Data (See attachment-1)

Site Class - D (Assumed w/o any Soil Info.)

Seismic coefficients based on general area in needles, CA.

$S_s = .23$ | $S_s = .434$ $S_1 = .135$ $F_a = 1.4$ $F_v = 2.3$

$S_1 = .12$ | $S_{MS} = F_a \times S_s = 1.4 \times .434$ (.23) $= .608$ (.322) .368 S_{M1}

$F_a = 1.6$ | $S_{M1} = F_v \times S_1 = 2.3 \times .135 = .311$ .279

$F_v = 2.318$ | $S_{DS} = .667 \times .608$ (.322) $= .406$ (.214) $S_{D1} = .667 \times .311 = .207$

Soil Data (NO Soil Report)

Allow. Soil press. $= 1 \times 1.2 = 1200^{PSF}$

Wind Data - Code AWWA D100-11

Assume: G = Gust factor = 1.0 V = wind vel. = 100 m/hr.

$p_W = q_z G C_f = 32 \times 1.0 \times .6 = 19.2^{PSF} > 30 C_f$ | $q_z = .00256\, K_z I V^2 = .00256 \times 1.09 \times 1.15 \times 100^2 = 32^{PSF}$

However use $25\,PSF = P_W$

Total wind $P_W = 25 \times 25 \times 16 = 10000^{\#} = 10^k$

$V_{max} = 10^k$ $M_{max} = 10 \times 8 = 80^{1k}$ (overturning)

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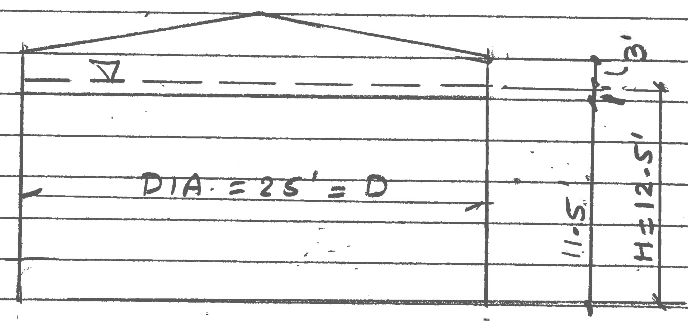
Project No. WW-PEG-2174-43052		Sheet No. 2

Project Description: Topock Groundwater Remediation Proj.

Design of 25' Dia Water Tank (Ref. #1 pg. 1)



Impulsive Components

$A_i = \dfrac{S_{ai}\, I_E}{1.4 \times R_I} = \dfrac{.406 \times 1.25}{1.40 \times 3.0} = .121\ g$

Table 24 (Group II)

$I_E = 1.25$ $\quad R_I = 3.0$ (Table-28) (Impulsive)

$S_{ai} = S_{DS}$ (For $T_i \le T_s$) $\quad R_I = 1.5$ (convective)

$T_i = C_t h_n^{x} = .02 \times 16^{.75} = .16$ sec. $\le$ ~~.51~~ .96 Sec.

$T_L = 12$ sec. $\quad T_S = \dfrac{S_{D1}}{S_{DS}} = \dfrac{.207}{.406} =$ ~~.51 sec.~~ .96

Min. $A_i = \dfrac{.36\, S_1 \times I_E}{R_i} = \dfrac{.36 \times .311 \times 1.25}{3.0} = .047$ USE $A_i = .121\ G$

Eq. 13-20 $\quad V_i = A_i\,(W_s + W_r + W_f + W_i)$

$M_i = A_i\,(W_s X_s + W_r \times H_t + W_i x_i)$

Weights

W_T = wt. of contents $= 49\,HD^2 = 49 \times 12.5 \times 25^2 \times 10^{-3} = 382.8^k$

$\dfrac{D}{H} = \dfrac{25}{12.5} = 2 < 3.33$ $\quad \dfrac{W_1}{W_T} = .55$ $\quad \dfrac{X_1}{H} = .35$

$\dfrac{W_2}{W_T} = .43$ $\quad \dfrac{X_2}{H} = .62$

$X_1 = .35H = .35 \times 12.5 = 4.38'$

$W_1 = .55 \times W_T = .55 \times 382.8 = 210.5^k$ (Effective Weight)

$X_2 = .62H = .62 \times 12.5 = 7.75'$

$W_2 = .43\,W_T = .43 \times 382.8 = 164.6^k$

$W_r = \dfrac{\pi}{4}(25)^2 \times .01 = 4.91^k$ = wt. of Roof

$W_s = \dfrac{\pi}{4}(25.042^2 - 25^2) \times 16 \times .49 = 12.84^k$ = wt. of shell

Total wt. $W = W_1 + W_r + W_s = 210.5 + 4.91 + 12.84 = 228.25^k$ Say 229^k

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Project Description Topock Groundwater Remediation press.

(25' Dia. Water Tank contd.)

Total $W = 229^k$

Note: Floor weight not included since it is at ground level.

Shear V_i (due to impulsive forces)

Eq. 13-20 $= A_i (W_i + W_r + W_s) = .121 \times 229 = 27.7^k$

partial Eq. 13-23 Moment M_i (due to impulsive forces

$= A_i (W_s \times X_s + W_r \times H_t + W_i \times X_i)$

$= .121 (12.84 \times 8 + 4.91 \times 16 + 210.5 \times 4.38)$

$= .121 (102.72 + 78.56 + 922) = 133.5^{'k}$

Adjust & Calculate effective impulsive weight to include varying bot. press. if supported on pile fdn. (Sect. A-135.3)

Eq. 13-29 $X_i = .375 H = .375 \times 12.5 = 4.69'$

$X_{imf} = .375 \left[1 + 1.333 \left\{ \frac{.866 \frac{D}{H}}{\tanh(.866 \times \frac{D}{H})} - 1 \right\} \right] H$

$= .375 \left[1 + 1.333 \left\{ \frac{.866 \times 2}{\tanh(1.732)} - 1 \right\} \right] 12.5$ ($\tanh(1.732) = .939$)

$= .375 [26.572] = 9.96'$

Partial Eq. 13-32 Moment $M_{imf} = .121 (102.72 + 78.56 + 210.5 \times 9.96)$

$= 264.77^{'k}$

→ To be used if supported on pile fdn. or MAT FDN. See sect. A.13.5.3

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Project Description Topock Groundwater Remediation Proj-		

(25' DIA. TANK CONTD.)

Convective Forces (Sloshing Effect)

$A_c = \frac{S_{ac} I_E}{1.4 R_i}$ $I_E = 1.25$ $R_I = 1.5$

$S_{ac} = \frac{K S_{D1}}{T_c} < S_{DS}$ (Eq. 13-12) $T_c \leq T_L$

First mode of sloshing effect given by

$$T_c = 2\pi \sqrt{\frac{D}{3.68 g \tanh\left(\frac{3.68 H}{D}\right)}}$$

$$\tanh\left(\frac{3.68 \times 12.5}{25}\right) = \tanh(1.84) = .9508$$

$$T_c = 2\pi \sqrt{\frac{25}{3.68 \times 32.2 \times .9508}} = 2.96 \text{ sec.} < 12 \text{ sec.}$$

Eq. 13-12 $S_{ac} = \frac{1.5 \times .207}{2.96} = .1049$

$$A_c = \frac{.1049 \times 1.25}{1.4 \times 1.5} = .0625$$

Eq. 13-30 $x_c = \left[1 - \frac{\cosh\left[\frac{3.67H}{D}\right] - 1}{\frac{3.67H}{D} \sinh\left[\frac{3.67H}{D}\right]}\right] H$

Substitue $H = 12.5$, $D = 25$

$$= \left[1 - \frac{\cosh(1.835) - 1}{1.835 \sinh(1.835)}\right] 12.5$$

$$= \left[1 - \frac{3.2124 - 1}{1.835 \times 3.0528}\right] \times 12.5 = 7.5634'$$

$$W_c = .230 \frac{D}{H} \tanh\left[\frac{3.67 \times H}{D}\right] W_T$$

$H = 12.5$ $D = 25$

$W_T = 49 GHD^2 = 382.8^k$

$$= .230 \times 2 \tanh[1.835] \times 382.8$$

$$= .230 \times 2 \times .9503 \times 382.8 = 167.34^k$$

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Project Description Topock Groundwater Remediation Project.		

Eq. 13-35 Height from bot. of shell to the c.G. of effective convective weight W_c adjusted for varying bot. press.

$$= X_{cmf} = \left[1 - \frac{\cosh\left[\frac{3.67H}{D}\right] - 1.937}{\frac{3.67H}{D}\sinh\left[\frac{3.67H}{D}\right]}\right] H \qquad H = 12.5 \quad D = 25$$

$$= \left[1 - \frac{\cosh(1.835) - 1.937}{1.835\sinh(1.835)}\right] 12.5$$

$$= \left[1 - \frac{3.2124 - 1.937}{1.835 \times 3.0528}\right] \times 12.5 = 9.654'$$

Eq. 13-32 $M_{cmf} = \sqrt{A_i(w_s x_s + W_r H_t + W_i x_{imf})^2 + [A_c W_c X_{cmf}]^2}$

Moment due to convective (sloshing)

$= A_c W_c X_{cmf}$ $\qquad A_c = .0625$ (pg. 4)

$= .0625 \times 167.34 \times 9.654$ $\qquad X_{cmf} = 9.654'$

$= 100.97$ $\qquad W_c = 167.34$ (pg. 4)

$M_{cmf} = \sqrt{(264.77)^2 + (100.97)^2}$

$= 283.37^{1K}$

Moment to be used if supported on pile or Mat Fdn.

(Sect. 13.5.3.2.2)

Eq. 13-23 $M_s = \sqrt{[A_i(w_s x_s + w_r H_t + w_i x_i)]^2 + [A_c w_c x_c]^2}$

$= \sqrt{(133.5)^2 + (.0625 \times 167.34 \times 7.5634)^2}$

$= \sqrt{17822.25 + 6257.4} = 155.18^{1K}$

USE 160^{1K}

M_s is Design overturning moment @ bot. of shell (w/o bot varying press effect) for Ring Fdn.

Eq. 13-31 V_f = Design shear @ top of Ring Fdn

$= \sqrt{[A_i(w_s + w_r + w_f + w_i)]^2 + (A_c w_c)^2}$

$= \sqrt{[.121(229)]^2 + [.0625 \times 167.34]^2} = 29.62^k$ USE 30^k

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Project Description Topock Groundwater Remediation Project

Uplift Check

Eq. 13-36 J - Overturning Ratio

$$= \frac{M_s}{D^2[w_t(1-.4A_v)+w_L]}$$

Sect. 13.5.4.3

$A_V = 1.4 S_{DS} = .14 \times .406 = .057$

$M_s = 160^{1k}$

$D = 25'$

Eq. 13-42 $w_t = \frac{W_s}{\pi D} + w_{rs}$

$= \frac{12840}{\pi D} + 100$

$= 163.5 + 100 = 263.5^{\#/}$

$W_s = 12.84$

$w_{rs} = \frac{5}{\pi D} = .064^{k/} = 64^{\#/}$ say $100^{\#/}$

Eq 13-37 $w_L = 7.9 t_b \sqrt{F_y HG} \leq 1.28 HDG$

$1.28 HDG = 1.28 \times 12.5 \times 25 \times 1 = 400^{\#/}$

Eq. 13.38 Required Annulus width $= L = .216 t_b \sqrt{\frac{F_y}{HG}} \leq .035 D$

$= .216 \times .25 \sqrt{\frac{36000}{12.5 \times 1}}$

$= 2.9'$ say $3'$

$.035 \times 25 = .875'$

$$J = \frac{160 \times 10^3}{25^2[263.5(1-.40 \times .057)+400]} = .389 < .785$$

Sloshing Wave Height

Eq. 13-52

$d = .5 D A_f$

A_f when $T_c < 4 = \frac{K S_{D1} I_E}{T_c}$

$T_c = 2.96$ sec (pg. 4)

$S_{D1} = .207$ $I_E = 1.25$ $K = 1.5$

$$A_f = \frac{1.5 \times .207 \times 1.25}{2.96} = .1311$$

$d = .5 \times 25 \times .1311 = 1.64' < 3'$ ok

Wind loads (See pg. 1)

Max $M_W = P_W \times 16 \times .5 = 10 \times 8 = 80^{1k} < 160^{1k}$ (Seismic)

Seismic Loads govern the design of the Tank

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Project No. WW-PEB-2174-43062		Sheet No. 8
Project Description: Topock Groundwater Remediation Proj.		

Ring Wall Foundation

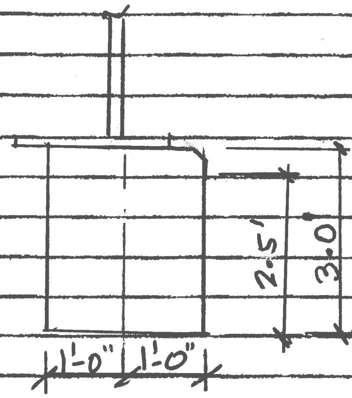
Try 2'-0" wide x 3'-0" deep foundation

Ring wall outside dia = d = 2 (25/2 + 1) = 27'

Ring wall Inside dia. = d_1 = 2 (12.5 − 1) = 23'

width = 2.0'

Depth = 3.0'



$$A = \frac{\pi}{4}\left[27^2 - 23^2\right] = 157.08\ ft^2$$

$$S = \frac{\pi}{32}\left[\frac{27^4 - 23^4}{27}\right] = 914.84\ ft^3$$

Calculate W

$W_1' = W_r + W_s = 5 + 13 = 18^k$

$W_2' = W_L \times \pi \times D = .4 \times \pi \times 25 = 31.42^k$

W_3' = Weight of Ftg

$= .15 \left\{ \frac{\pi}{4}\left[27^2 - 23^2\right] \right\} 3.0 = 70.7^k$

$\Sigma W = 18 + 31.42 + 70.7 = 120.11^k$ USE 125^k

Assume wt. of water is supported by slab or Ground

$q_1 = \frac{125}{157.08} = .796^{KSF}$

$M_{OTM} = 160^{1k}$ $M_d = 160 + 30 \times 3.0 = 250^{1k}$

$q_2 = \frac{250}{914.84} = .273^{KSF}$

DL+Seis. $q_1 + q_2 = .796 + .274 = 1.07^{KSF} < 1.2^{KSF} \times 1.33$ OK

Assume LL $= .016 \times \frac{\pi}{4} \times 25^2 = 7.85^k$ $q_3 = \frac{7.85}{157.08} = .05^{KSF}$

DL+LL $q_1 + q_3 = .796 + .05 = .846^{KSF} < 1.2^{KSF}$ OK

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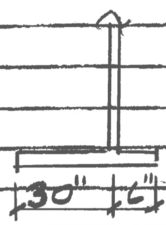
Project Description Topock Groundwater Remediation Project

Annular Ring



Eq. 13-37 $W_L = 7.9\, t_b \sqrt{F_y H G} < 1.28\, HDG$

$W_L = 7.9 \times .25 \sqrt{36000 \times 12.5 \times 1} = 1325\ \#/$

$1.28\, HDG = 1.28 \times 15 \times 1.00$ (1.25) $= 400\ \#/$ (480)

Require L (Annulus width)

Eq. 13-38 $= .216 \times .25 \sqrt{\dfrac{36000}{12.5 \times 1}} = 2.9'\ > .035 \times 25 = .875'$

USE 3'-0"

For J < .785

Eq. 13-39 $\sigma_c = \left[W_t (1 + .4 A_v) + \dfrac{1.273\, M_s}{D^2} \right] \dfrac{1}{12 t_s}$

$= \left[263.5 (1 + .4 \times .057) + \dfrac{1.273 \times 160 \times 10^3}{(25)^2} \right] \times \dfrac{1}{12 \times .25}$

$= \left[595.4 \right] \times \dfrac{1}{12 \times .25} = 198.5$ PSI Small ok

Anchor Bolts

AWWA-D-100-11 $V_{max} = V_f = 30^k$ (pg. 5)

$M_{max} = M_s = 160'^k$

$V_A = \tan 30\, (W_s + W_r + W_1)(1 - .4 A_v)$

$= .577\, (229)(1 - .4 \times .057) = .577 \times 229 \times .977$

$= 129.1^k >> 30^k$

Min. Anchor Bolts to be provided

Min. SPA. = 6'

$\pi D = \pi \times 25 = 78.5'$

No. of Anchor Bolts $= \dfrac{78.5}{6} = 13$ USE 14 - 1"φ × 18" A-307 A-B.'s

Eq. 3-42 $P_s = \dfrac{4 M_s}{N D_{ac}} - \dfrac{W'}{N} = \left[\dfrac{4 \times 160}{25} - .057 \times 18 \times 9 \right] \times \dfrac{1}{14}$ (Design uplift) ($W_r + W_s$)

$= 1.76^k$ ok

Sect. 3.3.3-2 Ten. Cap. of 1" × 1'-6" (Emb.) A.B. $= .5 \times 58 \times .606 = 17.57^k$

Cap. of Cone. $= 12.1^k$ for Emb. = 18"   Root Tensile Area for ¾"φ = .334

Sect. 3.8.5 Min. Dia. = 1" Allowance .25" for corrosion USE Root Area

Ten. Cap. $= .5 \times 58 \times .334 = 9.7^k > 1.76^k$ ok

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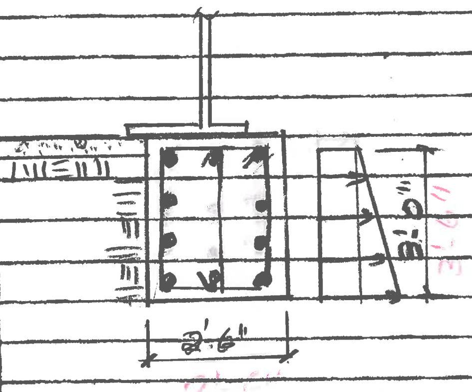
Project Description Topock Groundwater Remediation Proj.

Ring Wall Foundation (contd.)

Hoop Tension



Soil Active Press

$= P_a = K_a w h'$ $\quad h' = 3.0'' \quad K_a = .50 \quad w = 120^{PSF/1}$

$= .5 \times 120 \times 3.0$

$= 255$ #/1

Surcharge

$P_s = w_H \times H \times .5$ $\quad w_H = 62.4^{PSF/1} \quad H = 12.5$

$= 62.4 \times 12.5 \times .5$

$= 390$ #/1

Hoop Ten. $T_H = w_p h' R$

$w_p = \left[\frac{P_a}{2} + P_s\right] = \frac{255}{2} + 390 = 518$ #/1

Av.

$T_H = 518 \times 3.0 \times \frac{25}{2} = 19425^{\#} = 19.43^k$

$T_{H_u} = 1.7 \times 19.43 = 33.03^k$

$A_{s_r} = \frac{33.03}{.9 \times 60} = .61^{in^2}$

$Min.\ A_s = .002 \times 36 \times 36 = 2.59^{in^2}$

USE 10 - #6 Bars $\quad A_{s_a} = 10 \times .44 = 4.40^{in^2} > 2.59^{in^2}$

USE 2'-6" W x 3'-0" TK Ftg. w/ 10 - #6 Bars w/ #4 Stirrups @ 18" o/c or #5 stirrups @ 24" o/c

Shear Reinf.

$A_v = \frac{50 b_w S}{f_y} = \frac{50 \times (36) \times 18}{60000} = .54^{in^2} < .2 \times 3 = .6^{in^2}$

Alternate #5 stirrups @ 24" o/c

$A_v = \frac{50 \times 36 \times 24}{60000} = .72\ in^2 < .31 \times 3 = .93^{in^2}$

Attachment - 1

USGS.gov
NSHMP HazardApp.Jar

Conterminous 48 States
2003 NEHRP Seismic Design Provisions
Zip Code = 92363 (Needles, CA) *
Spectral Response Accelerations Ss and S1
Ss and S1 = Mapped Spectral Acceleration Values
Data are based on a 0.05 deg grid spacing

* This Data Was Preliminary and it is Conservative.

Period (sec)	Centroid Sa (g)	
0.2	0.225	(Ss)
1.0	0.135	(S1)

Period (sec)	Maximum Sa (g)	
0.2	0.434	(Ss)
1.0	0.205	(S1)

Period (sec)	Minimum Sa (g)	
0.2	0.204	(Ss)
1.0	0.131	(S1)

Conterminous 48 States
2003 NEHRP Seismic Design Provisions
Zip Code = 86436 (Topock, AZ)
Spectral Response Accelerations Ss and S1
Ss and S1 = Mapped Spectral Acceleration Values
Data are based on a 0.05 deg grid spacing

Period (sec)	Centroid Sa (g)	
0.2	0.221	(Ss)
1.0	0.131	(S1)

Period (sec)	Maximum Sa (g)	
0.2	0.230	(Ss)
1.0	0.134	(S1)

Period (sec)	Minimum Sa (g)	
.2	.204	(Ss)
1.0	.131	(S1)

APPENDIX A - CALCULATION COVER SHEET

CALCULATION ID NUMBER	
REVISION NUMBER	
JOB NUMBER	

TITLE	Topock Ground Water Remedation Remedy Bldg Tankage area Retaining Walls

CONTENT STRUCTURAL DESIGN CALCULATIONS

Page 1 – Relat Project Dwgs, applied codes & Design Data
2 – Retaining Wall A, B, C Layouts
3 – Retaining Wall A Design
4 – Retaining Wall B Design
5 & 6 – Retaining Wall C Design

	initial	date
PREPARED	KJ	6/13/14
TITLE		
REVIEWED		
TITLE		

REVISION NOTES	

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Emeryville, CA 94608

Designed By:	KJ	Date:	6/13/14
Checked By:		Date:	
Reviewed By:		Date:	

Project No.: WWWPGE2174

Project Description: Topock Ground water Remedation
Remedy Building Tankage Area Retaining Wall

Reference:

Related Project Dwgs

S-12-01 – Foundation Plan
S-12-02 – First Floor Plan
S-12-10 – Sections & Details
S-00-01,2,3 – General Structural Details

Applied Codes

ASCE – 7-10 Non Building structures
IBC – 2009 / CBC 2010 as amended by San Bernandino County
ACI 318-11 – Concrete for $f'_c = 5.0$ ksi & $F_y = 60$ ksi

Seismic Data

USGS for ASCE 7-10 site coordinates
Site Class D

Soil Data

Back fill 0.11 k/cubft
Bearing pressure assumed min 4.0 ksf.
No soil report available
In absence of dynamic soil report followed
AISC 7-10 requirement for Non-Building 15.6.1
Earth retaining structure with equation 11.8-1

$$PGA_M = F_{PGA} \times PGA = 1.2 \times 0.3 = 0.36$$

- PGA_M: Peak ground acceleration
- F_{PGA}: site coeficient – Select 1.2 for site D
- PGA: Table 22-7 – Select %g = 30

Use 1.36 for soil lateral pressure coeficient

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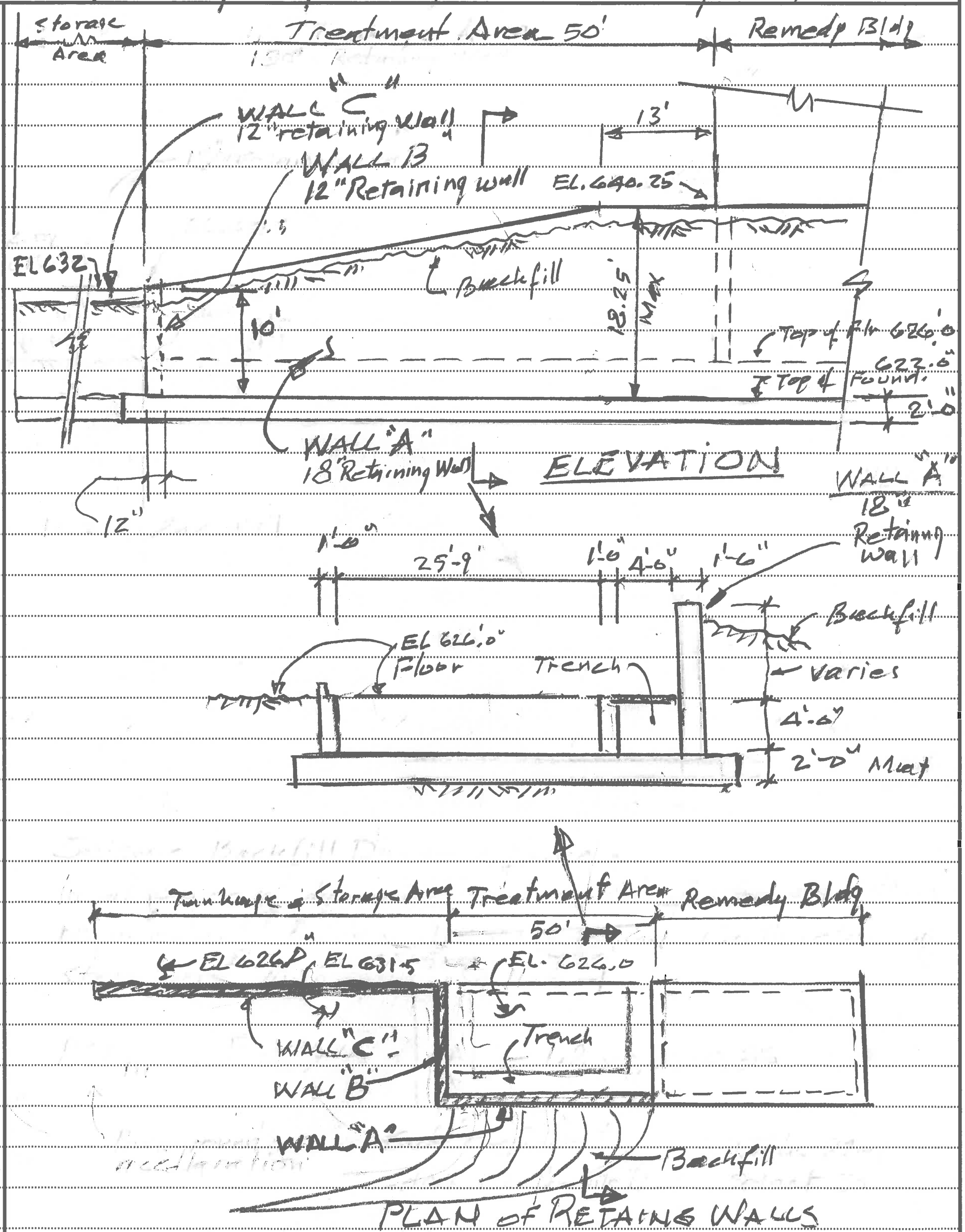
Project No.	PGE 2174		Sheet No. 2 of 6
Project Description:	Topock Ground Water Remediation Remedy Bldg Tankage Area Retaining Wall		

Reference:



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Project No.	WWWW PGE 2174		Sheet No. 3 of 6
Project Description:	Topock Ground Water Remediation Remedy Bldg Tankage Area Retaining Wall		

Reference:

WALL "A" 18" Retaining wall

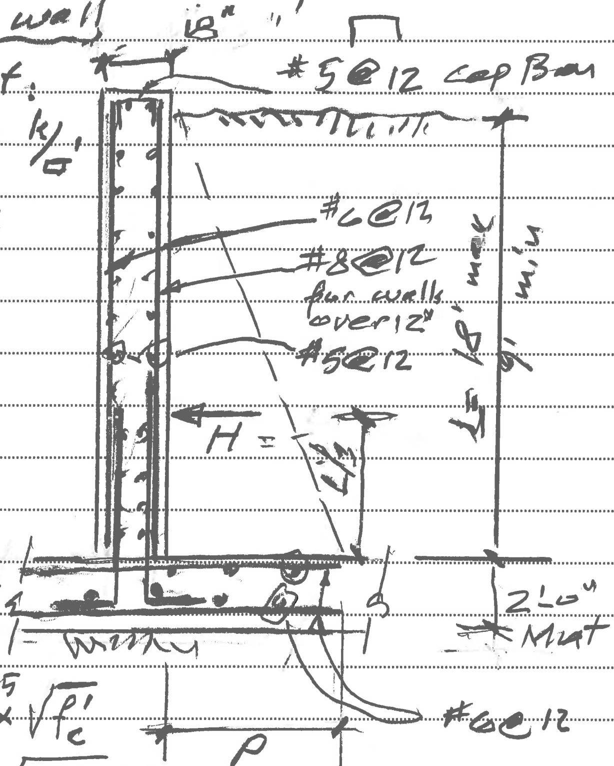
Design for 18' max wall height.

$P = 18 \times 0.11 \times 0.33 = 0.653$ k/□'

Seis. ght2

$H = 0.653 \times \frac{18}{2} \times 1.36 = 8.0^k$

$M_{Base} = 8.0 \times \frac{18}{3} = 48.0'^k$



check deflection:

$\Delta = \frac{WL^3}{15EI}$ $W = 8.0^k$ $L = 18 \times 12$ in

$I = \frac{(18)^4}{12} = 8748$ in^4

$= 0.14"$ ok

$E = 0.033 \times 150^{1.5} \times \sqrt{f'_c}$

$= 0.033 \times 150^{1.5} \times \sqrt{5000}$

$= 4287$ ksi

Reinf. per ACI flexural Diagrams for $M = 48.0'^k$ Max $d = 18" - 2" = 16" \rightarrow A_s = 0.7$ □"

Vert #8 @ 12 = 0.79□" > 0.7□" OF

" #6 @ 12 = 0.44 > 0.35□" IF

Horiz #5 @ 12 = 0.35 > 0.30 Horiz EF

At 9' high $M = 48 \times \frac{1}{2} \times \frac{1}{2} \times \frac{1}{2} = 6'^k$

Vert. #6@12 EF & Horiz #5@12 EF ok by comparison

Overall - #6@12 Vert #5@12 Horiz EF Except #8@12 Vert OF for wall more than 12' high.

For 20" Mat use #6@12 E.W. / T&B more than min Flex Reinf.

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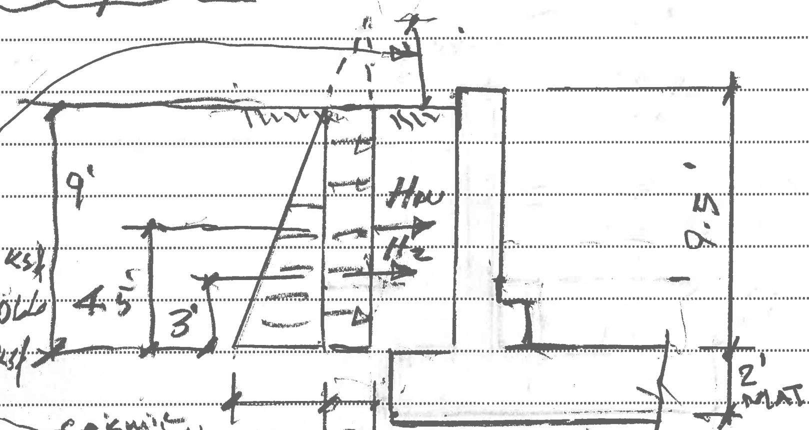
Project No.	WWW PGE 2174		Sheet No. 4 of 6
Project Description:	TOPOCK GROUND WATER REMEDATION SWITCHGEAR ENCLOSURE STRUCTURES		

Reference:

WALL B – 12" Retaining Wall

Wall subject to tank foundation Surcharge

Equiv = 2' Soil



$P_w = 2 \times 0.1 \times 0.33 = 0.066$ ksf

$P_s = 9 \times 0.1 \times 0.33 = 0.3$ ksf

$H_w = 0.066 \times 9 \times 1.36 = 0.8^k$ — seismic coef. sht 1

$H_s = 0.3 \times 9/2 \times 1.36 = 1.8^k$ — Assume as cantilever wall and disregard thickened Bottom

$M_s = 0.8 \times 4.5' = 3.6^{'k}$

$M_w = 1.8 \times 3 = 5.4$

13.5

$M = 13.5'^k$
$d = 12" - 2" = 10"$
$f'_c = 5$ ksi
$f_y = 60$ ksi

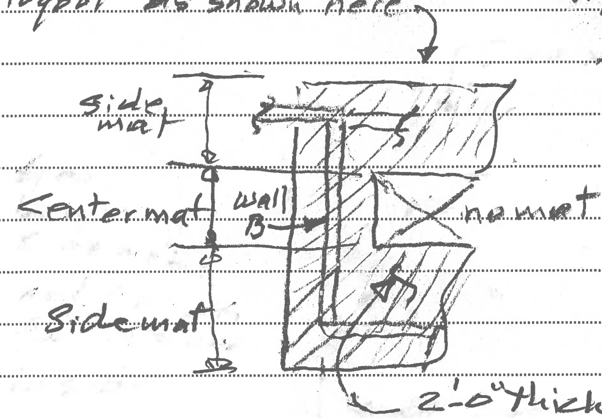
∴ Use Vert #6 @ 8 or #8 @ 12

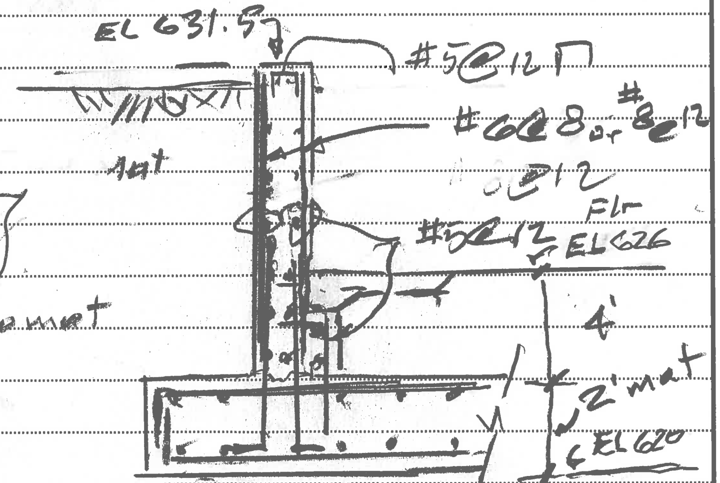
Use Horiz #5 @ 12

Ref. to ACI slab flexural Diagram

Note:

Wall "B" not subject overturning or sliding due to thick mat layout plan layout as shown here





Base shear on Center mat transfers to side mat and no overturning occurs

E2 Consulting Engineers, Inc. 1900 Powell Street, Suite 250 Emeryville, CA 94608	Designed By:	KJ	Date: 6/13/14
	Checked By:		Date:
	Reviewed By:		Date:
Project No.	WWW PGE 2174		Sheet No. 5 of 6
Project Description:	TOPOCK GROUND WATER REMEDATION SWITCHGEAR ENCLOSURE STRUCTURES		

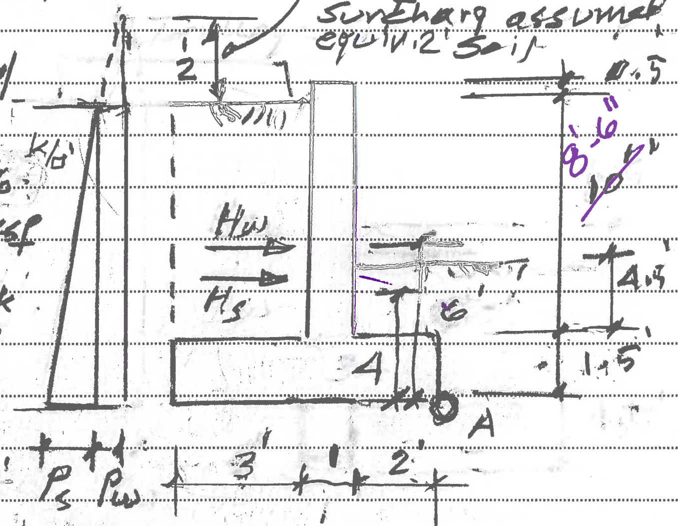
Reference:

$K_a = 1/3$

$\gamma_{soil} = 120^{\#}$

WALL C – 12" Retaining Wall (Raised)

Wt of Tank surcharg assumed equiv. 2' soil



Assume for Tank found equivalent 2' soil

$P_w = 0.1 \times 0.33 \times 2 = 0.066$

$P_s = 0.1 \times 0.33 \times 11.5 = 0.38 ksf$

seis. coef sht 1

$H_w = 0.066 \times 11.5 \times 1.36 = 1.0^k$

$H_s = 0.38 \times \frac{11.5}{2} \times 1.36 = 3.0^k$

$M_{stem} = 1.0 \times 4.5 + 3.0 \times 2.5$
$= 4.5 + 7.5 = 11.5^{'k}$

$M_{OT} = (1.0 \times 6.0) + (3 \times 4) = 18.0^{'k}$

$M_r = (12' \times 4' \times 0.1) \times 4.5 + (9.0 \times 1 \times 0.15)\, 2.5 + (6 \times 1.5 \times 0.15)\, 3' + (2 \times 4.5 \times 0.1)$
$= (4.8 \times 4.5) + (1.35 \times 2.5) + (1.35 \times 3) + (0.9 \times 1) = 30.0^{'k}$

$R = 4.8 + 1.35 + 1.35 + 0.9 = 8.4^k$

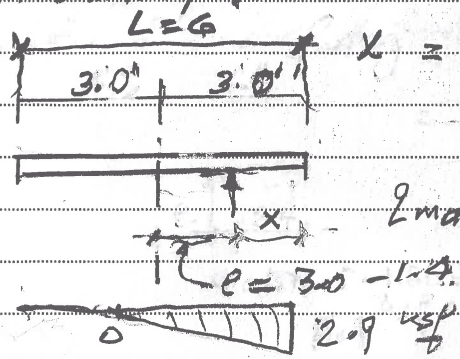
$SF_{OT} = \frac{M_r}{M_{OT}} = \frac{30.0}{18.0} = 1.7 > 1.5$ ok

Passive soil resistance $= w\frac{h^2}{2} = 0.1 \times \frac{6^2}{2} \times 3 = 5.4$ (kp)

$SF_{sliding} = \frac{\text{Resisting Force}}{\text{Base Shear}} = \frac{5.4 + 8.4 \times 0.3}{1.0 + 3.0}$ (soil friction)
$= 2 \geq 2$ ok

Soil bearing

$x = \frac{M_r - M_{OT}}{R} = \frac{30.0 - 18.0}{8.4} = 1.43$



$q_{max} = \frac{4R}{3B(L - 2e)} = \frac{4 \times 8.4}{3 \times 1(7' - 3.14)} = 2.9^{ksf} < 4 \times 1.33$ ok

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	Checked By:		Date:
	Reviewed By:		Date:
Project No.	WWW PGE 2174		Sheet No. 6 of 6
Project Description:	TOPOCK GROUND WATER REMEDATION SWITCHGEAR ENCLOSURE STRUCTURES		

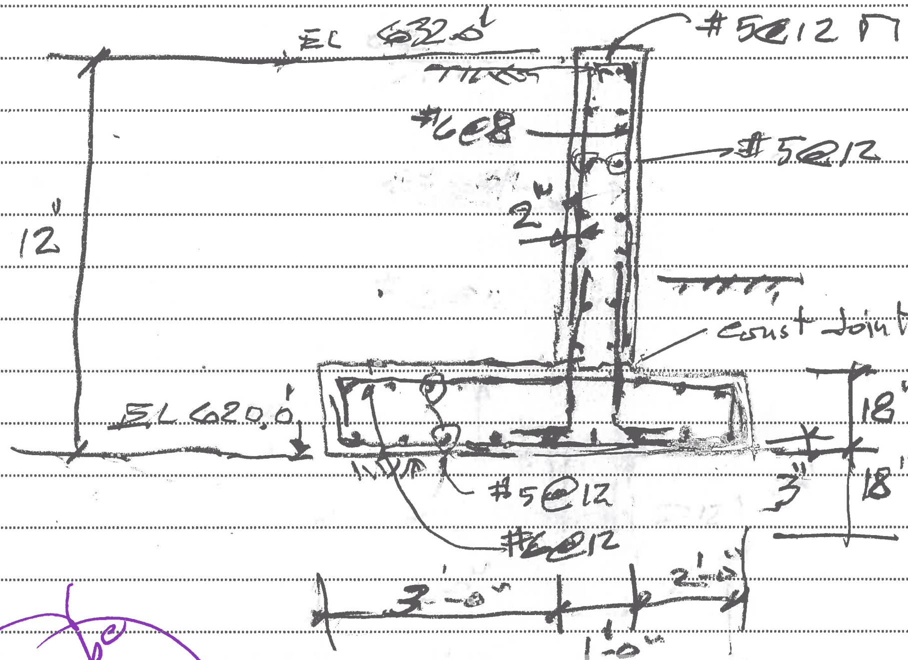
Reference:

Reinforcing Wall C

11.5'k max stem base moment for d = 12-2 = 10"

2.9x2' = 5.8'k max footing moment for d = 18-3 = 15"

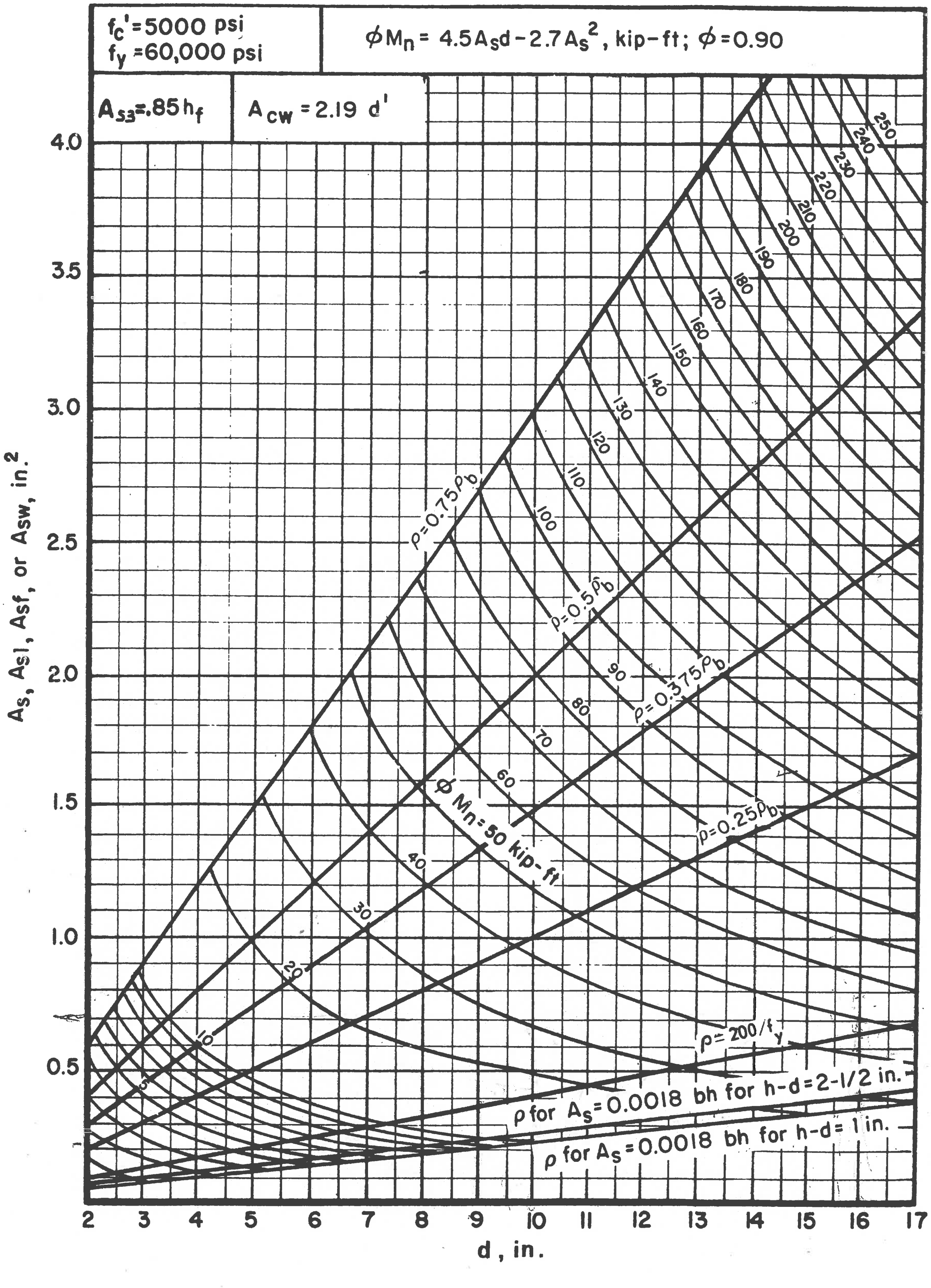
Ref ACI flexural diagrams place reinf as shown



Calculations needs to be Revised. for 10' Height.

FLEXURE 8.8.1—Design moment strength ϕM_n for slab sections 12 in. wide

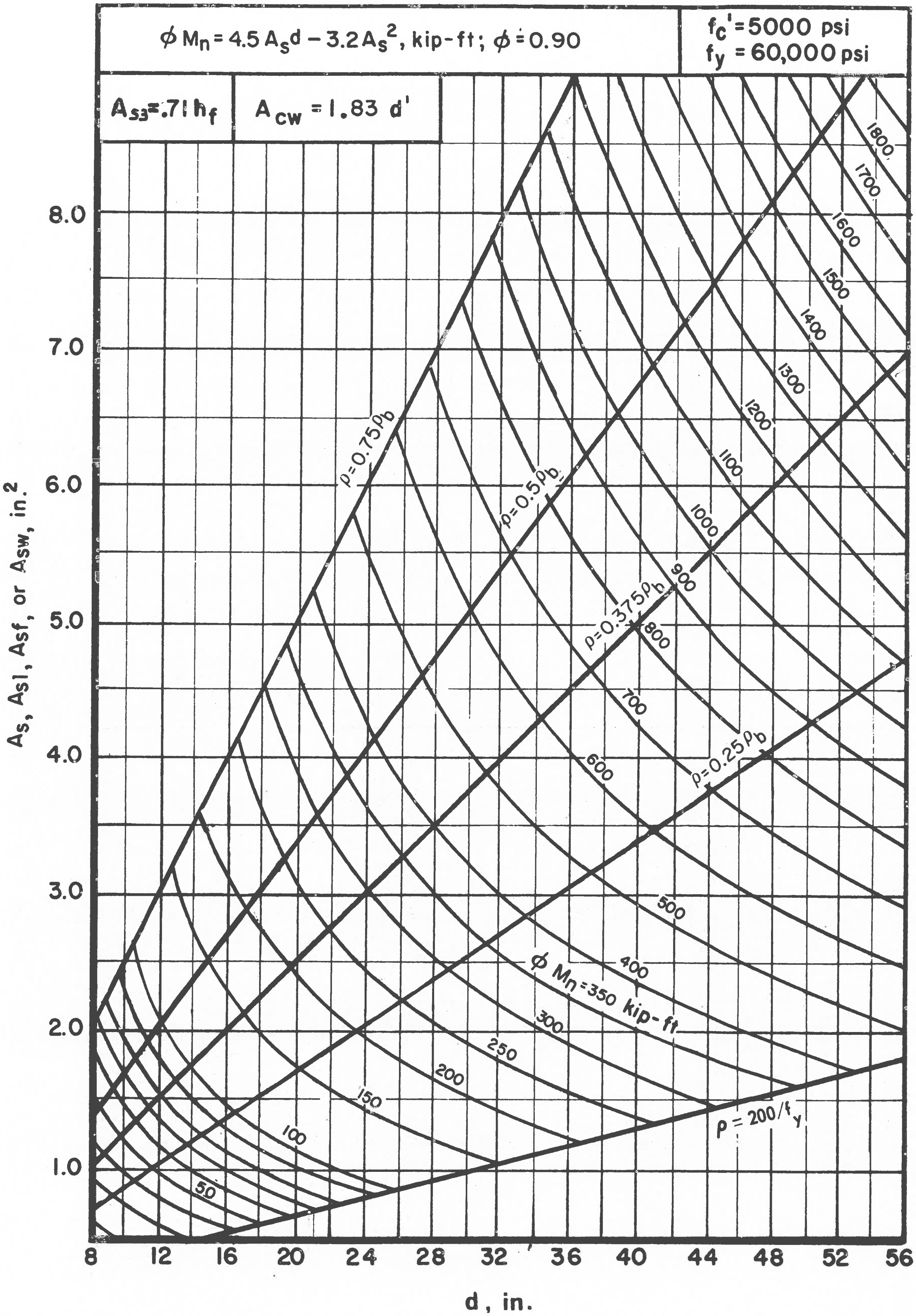
Reference: ACI 318-89 Sections 7.12, 8.4.1, 8.4.3, 9.3.2, 10.2, 10.3.1–10.3.3, 10.5.1, and 10.5.3 and ACI 318R-89 Sections 10.3.1 and 10.3.2



For use of this Design Aid, see Flexure Examples 4-6 and 15.

FLEXURE 8.8.2–Design moment strength ϕM_n for beam sections 10 in. wide

Reference: ACI 318-89 Sections 7.12, 8.4.1, 8.4.3, 9.3.2, 10.2, 10.3.1–10.3.3, 10.5.1, and 10.5.3 and ACI 318R-89 Sections 10.3.1 and 10.3.2



For use of this Design Aid, see Flexure Examples 1, 2, 7, 10, and 14.

APPENDIX A - CALCULATION COVER SHEET

CALCULATION ID NUMBER	ALL
REVISION NUMBER	
JOB NUMBER	WW-PEB-2174

TITLE	Topock Project Master Calc-Index

Calc. No.	Title	Dwg. Nos.
TB01 To TB02	Topock pipe Bridges, Line 'A' & Line 'I' →	S-07-01 To S-07-
TA01 To TA05	Topock Buildings & Influent Tank Farm plus Water Conditioned Tank Farm →	S-12-01 To S-12-20 S-13-01 To S-13-15 S-11-01 To S-11-05 S-14-10 To S-14-13
TC01 To TC07	Topock Ground water Remediation Tanks, Pads & Canopies →	S-14-01 To S-14-09 S-12-22 To S-12-25

	initial	date
PREPARED	KD	7/28/14
TITLE		
REVIEWED		
TITLE		

REVISION NOTES	

E2 Consulting Engineers, Inc. 1900 Powell Street, Suite 250 Emeryville, CA 94608	Designed By:	KJ	Date: 4/9/14
	Checked By:		Date:
	Reviewed By:		Date:
Project No.			Sheet No. 1
Project Description:	Fresh Wate Pre-Injection Treatment System - Structural calculations Topock, Needles, CA		

Reference:

Contents:

Sht No	Description
1	Structural Calculation sheet Nos Design codes, Structural Data & References
2	Roof Loading, Structure Type & Design Approach
3	Interior and Exterior Framing
4	Longitudinal Framing, Treatment Vessel Data
5	Foundation Plan & Column Loading
6	Single Footing Design
7	Mat Foundation Design
8	Treatment Vessel support piers
Design Aids	Steel Beam, cols, Bracing & Conc Tables
Vendor Info	Vessels & Metal decks

Structural Design Data:

$F_y = 60^{ksi}$, $f'_c = 5.0$ ksi, soil bearing $= 4^{ksi}$, soil friction factor $= 0.3$

USGS site Data for Seismic

Applied Codes:

ASCE 7-10, IBC 2009/CBC 2010 as amended by San Bernardino County

AISC 13th edition, ACI 2011

Date: 4/8/14
By: KJ
Sht-2

Fresh Water Pre-Injection Treatment System

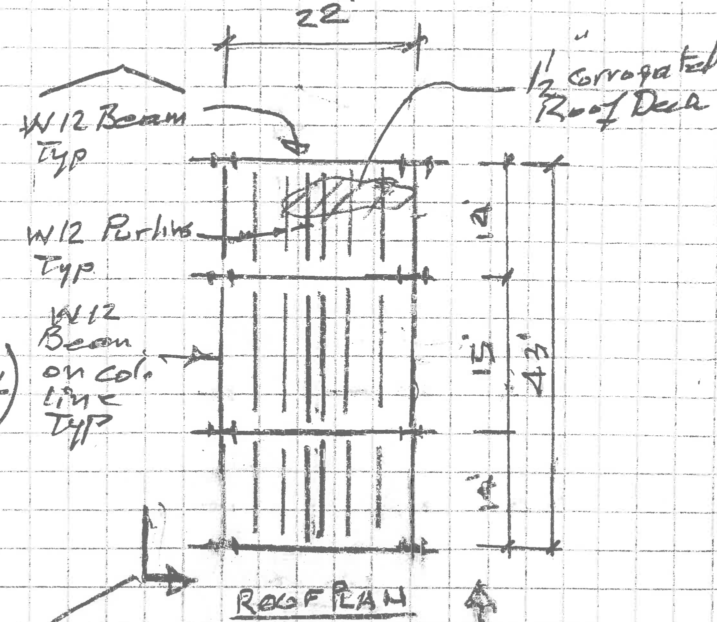
60% Structural design for Foundation

Roof Loading

wt $1\frac{1}{2}$" with Ribs @ 6" | 30 #/□' DL
Piping & Electrical
W12 Beams

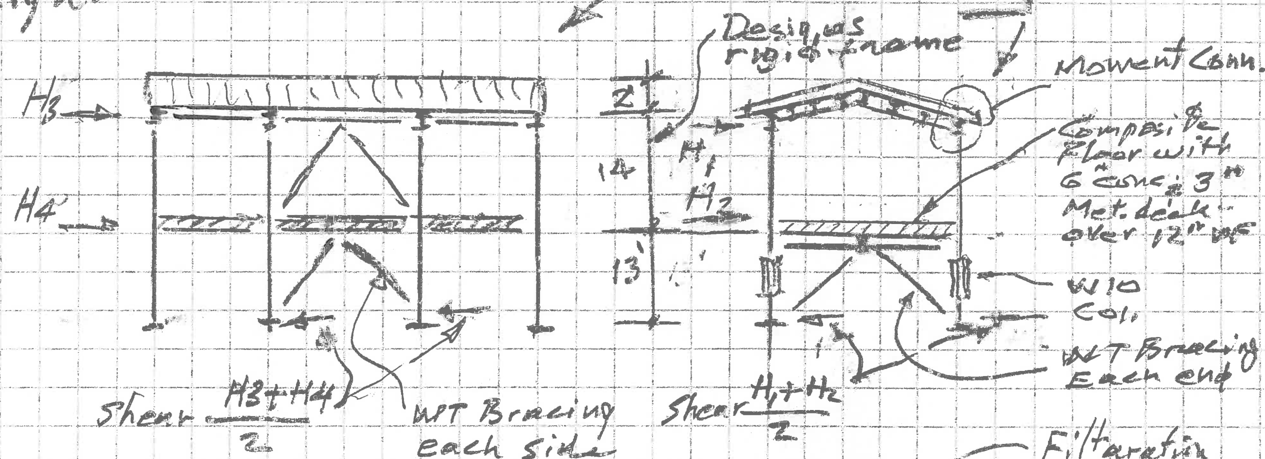
Equivalent Snow or Wind 30 #/□'

Filteration Vessel wt = 4 Kip (Consider As DL)
with attachments
each (4 Required)



Structure Type

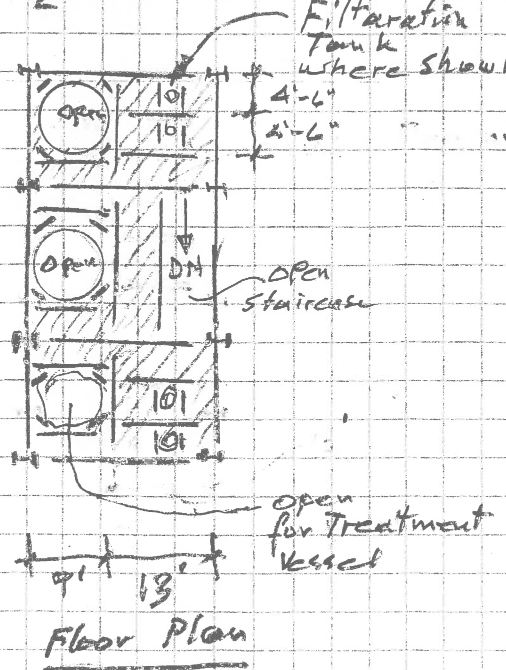
Open all around, by inspection
Seismic governs against wind
for design.



Design approach

Seismic application and distrebution
as shown above, Governs wind

Applied H = DL + ½ LL conservatively
with 0.3 Seismic coefficient
and increase allowab stresses by 1.33



Date 4/9/14
By KJ
sht 3

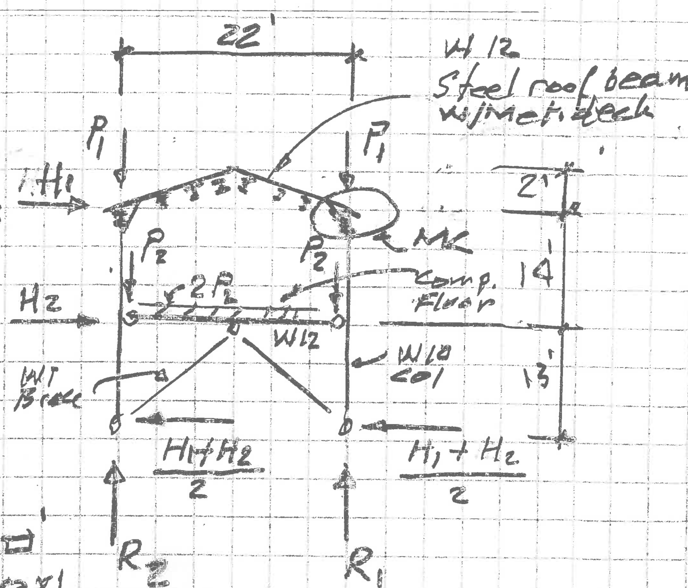
22' Interior Frame

$P_1 = \left(30 + \frac{30}{2}\right) \times \left(\frac{22}{2} \times 14.5\right) = 7.2^k$ ← $\frac{(15+14)}{2}$ ← See Plan

50% LL for Seismic calc.

H_1 = Seismic = $2P_1 \times 0.3 = 2 \times 7.2 \times 0.3 = 4.3^k$

Max M_{col} & Beam $= \frac{4.3}{2} \times 14' = 30.1'^k$
Conservatively



Ref. USS steel beam/col diagram and AISC beam diagram (Attached)

Select W10×39 col & W12×39

$P_2 = \left[(75 + 10 + 15)\left(\frac{22}{2} \times 14.5 - 100\right) + 4000 \times 1\right]$
(75 = DL, 6" conc; 10 = Met roof, piping, Elect.; 15 = LL; 100 = opening; 4000×1 = Filteration Tank + Piping conservatively)

$= 6^k + 4^k = 10^k$

H_2 = Seismic $= 2P \times 0.3 = 20 \times 0.3 = 6^k$

Interior Beams:

Ref AISC Beam capacity tables

Select

4'-6" Beam Supporting ½ Filt Tank ≈ 2^k – W8×15

13'-0" & 14'-6" Beams Supporting Full Load Tank 4^k & Floor DL+LL – W10×22

14' & 15' Col. line beams – W12×19

$R_1 = P_1 + P_2 + \frac{(H_1+H_2)\times 13}{22} = 17.2^k + 6.0^k = 23.2^k$ ← Seismic

$R_2 = 17.2 - 6 = 11.2^k$

$\frac{H_1+H_2}{2} = \frac{4.3+6}{2} = 5.2$

22' End Frames

Use Same Size frame as above interior frame adequate on conservative side

Seismic shear $= (H_1 + H_2) \times \frac{7}{14.5} = 5.2 \times 0.48 = 2.5^k$

Vert. Load $= (P_1 + P_2) \times \frac{7}{14.5} = 23.2 \times 0.48 = 11.2^k$

K Bracing

Per attach WT6×13.5 capacity for $13' \times 1.41 = 18.3' = 26.35^k > 5.2 \times 1.41^k$

Date 4/9/14
By KJ
Sht 4

Long Direction Frame

$H_3 = \left[H_1 \times \frac{43'}{14.5}\right] \times \frac{1}{2} = 6.5^k$

$H_4 = \left[H_2 \times \frac{43}{14.5}\right] \times \frac{1}{2} = 9.0^k$

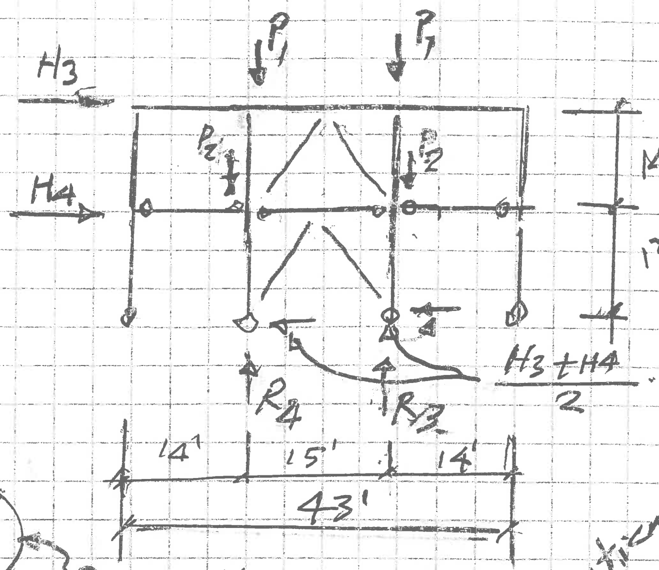
$\frac{H_3 + H_4}{2} = \frac{6.5+9}{2} = 7.8^k$

$R_3 = \frac{6.5 \times 27 + 9 \times 13}{15} + 17.2$

$= 17.2 \pm 19.5 = 36.7^k$

$R_4 = 17.2 - (19.5 - 17.2) = 14.9^k$) Reversable

K Bracing out 6x13.5 adequate per previous sht



Treatment Vessel loading

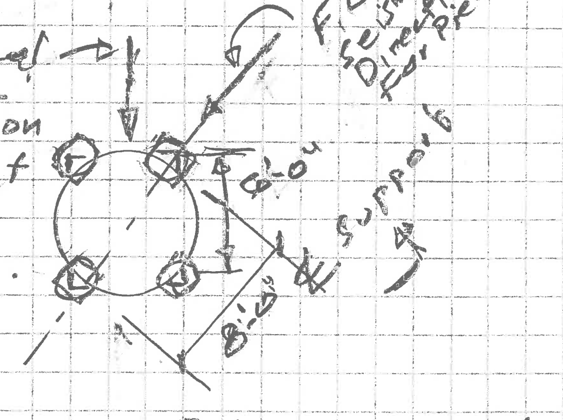
$H_5 = 48 \times 0.3 = 14.4^k$

$R_4 = \frac{48}{4} \pm \frac{14.4 \times 10.5}{8}$

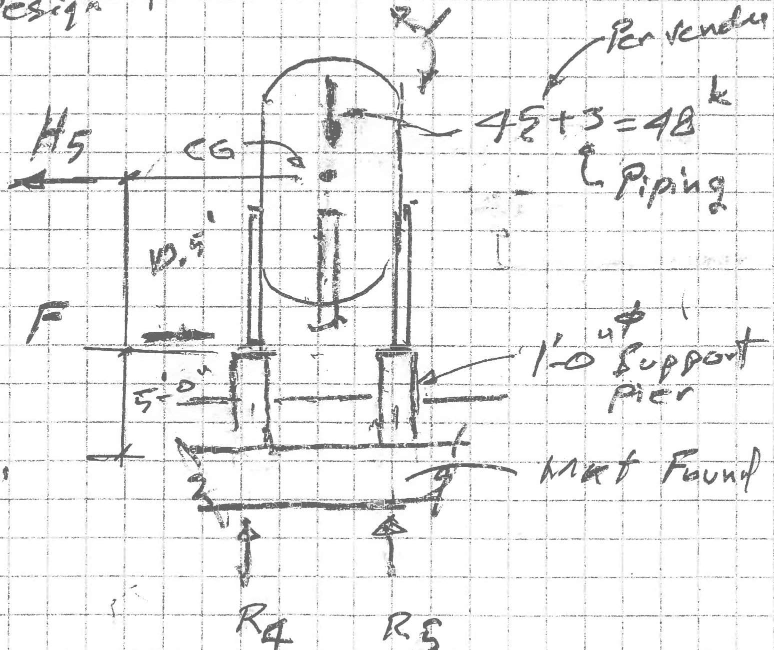
$= 12 \pm 19. = 31^k \downarrow$ or $7^k \uparrow$

R_5 = Same as R_4

— For Pier Design



All piers are subject of 31^k comp. or 7^k tension and $F = \frac{14.4}{4} = 3.6^k$ shear



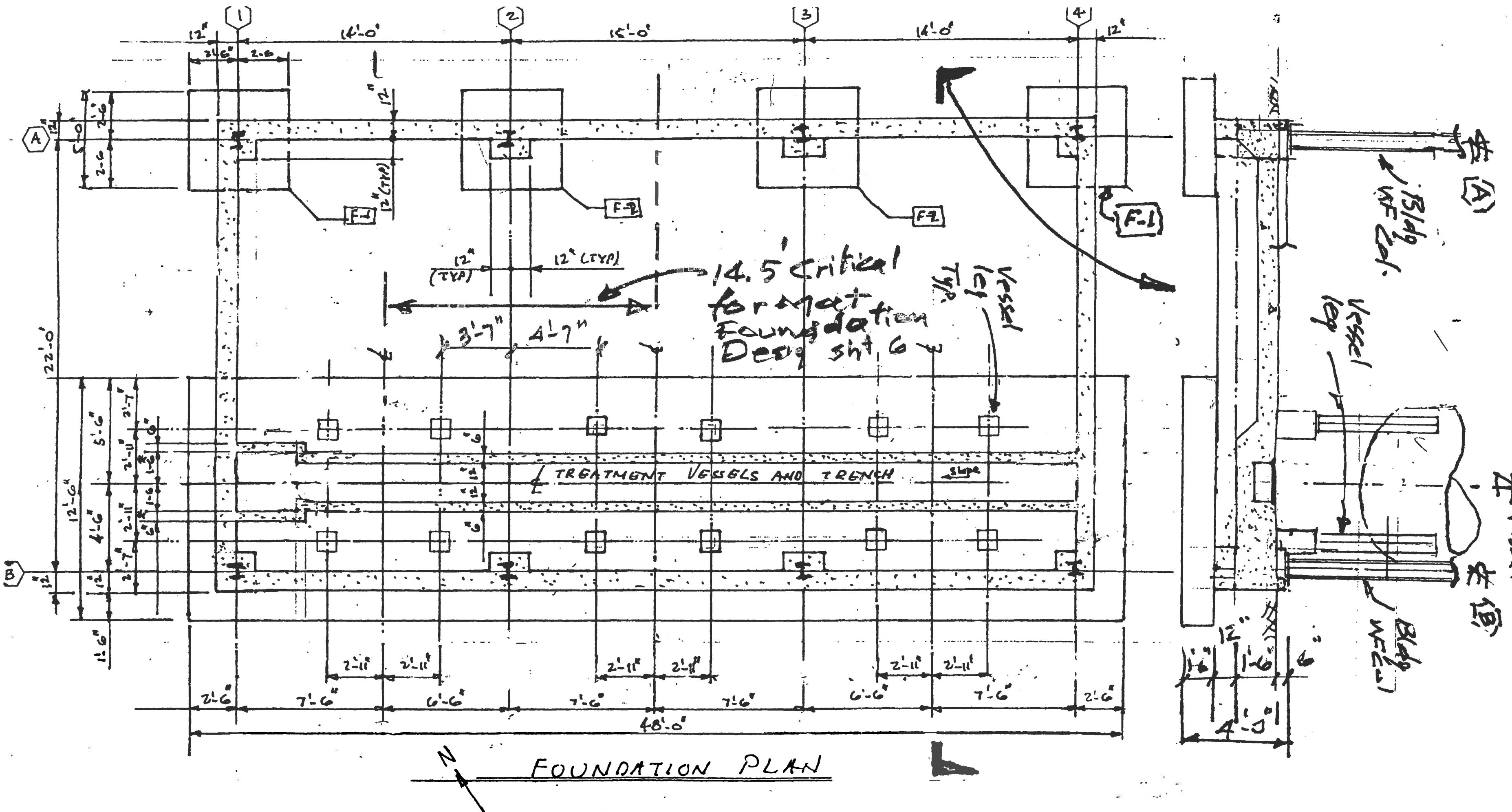
For Mat Design

Each Pier

$\frac{48}{4} \pm \frac{14.4 \times 10.5}{6 \times 2} = 12 \pm 12.7^k$

$R = 24.7^k \downarrow \quad 0.7 \uparrow$

Date 4/9/14
By KJ
sht 5



Column Loading on Foundation

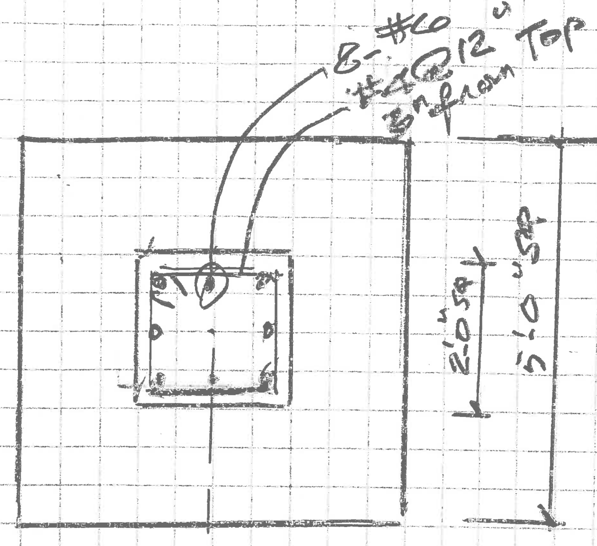
Column	DL + ½ LL + Vert. seismic N/S	DL + ½ LL + Vert. seismic E/W	Seismic Shear N/S	Seismic Shear E/W	Remarks
A2, B2, A3, A3	23.7 k	36.7 k	5.2 k	7.8 k	See Calc
A1, B1, A4, B4	11.2 k	11.2 k	2.5 k	0	See Calc.
Each of leg of 4 leg of Treatment Vessel	12.7 k		3.6 k		For Mat Design
	31 k ↓ & 7 k ↑		3.6 k		For Pier Design

Date 4/9/14
By [illegible]
Sht 6

Footing at A2, B2, A3, B3

Critical for E/W Seismic
Tot Weigh on Bott. Footing

Col. load w/Seismic	36.7	(sht 5)
Footing 5x5x1.5x0.15	5.6	
Pier 2x2x2.5x0.15	1.5	
Grad beam 2x2'x10'x0.15	6.0	
Soil on top of Ftg (25-4)x1x0.11	3.2	
Tot.	53.0^k	



$$p = \frac{Tot.wt}{Area} \pm \frac{M}{\frac{bd^2}{6}} = \frac{53}{5\times5} \pm \frac{7.8\times4}{\frac{5^3}{6}}$$

$= 2.1 \pm 1.5 = 3.6,\ 0.6 < 1.33\times4$ ksi ok

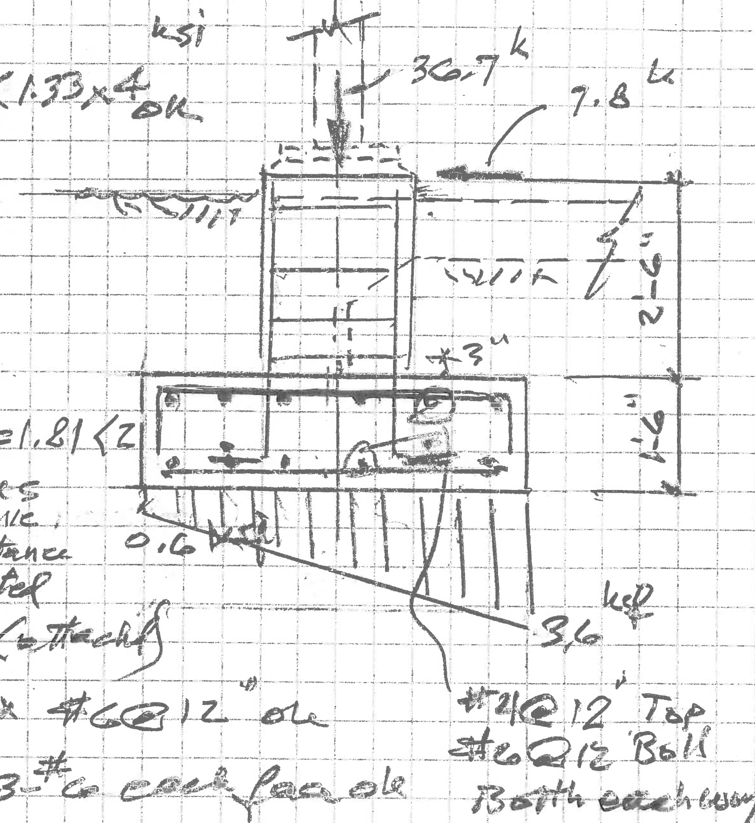
Stability

$$SFOT = \frac{RM}{OTM} = \frac{(53-6)2.5}{7.8\times4}$$

$= 3.7 > 2$ ok

$$SF\ Sliding = \frac{(53-6)\times0.3}{7.8} = \frac{14.1}{7.8} = 1.81 < 2$$

ok as passive resistance neglected



Reinf.

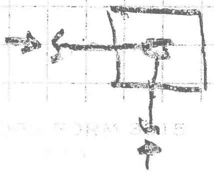
For Footing refer to ACI slab (attached)
for $d = 18" - 3\frac{1}{2} = 15\frac{1}{2}"$ Min Flex #6@12" oc

For Pier $d = 24 - 3\frac{1}{2} = 20\frac{1}{2}"$ 3-#6 each face oc

Footing A1, A2, A4, B4

Use same size footing ok by inspection

Other Seismic Force Direction

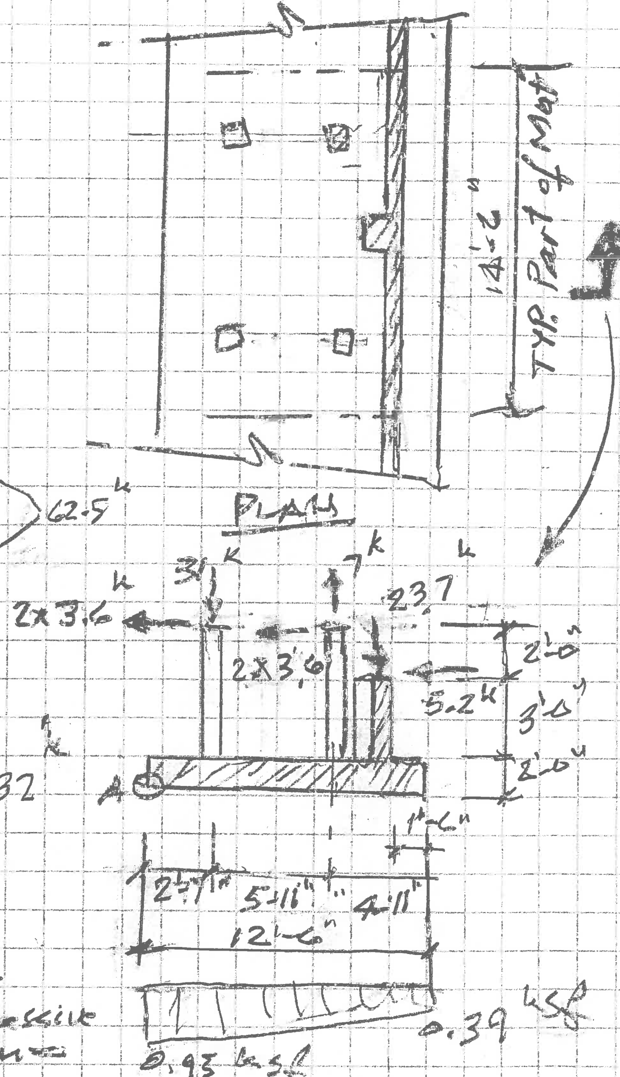


✓ Not critical as it distribute to other footings

Date: 4/9/14
By KJ
Sht 7

FOUNDATION MAT

Ref. to foundation plan loading sht 5
design of mat critical for N/S Seismic.
Force application as shown here.



Tot. vertical load:

Structure Col.	23.7^k
Vessel Col. (Nonseismic)	31.0
2' Conc. mat $12.5\times2\times14.5\times0.15$	54.4
1'-0" thick wall $3\times1\times14.5\times0.15$	6.5
Conc. slab top of mat $1.5\times14.5\times0.15$	3.3
Soil on top of Mat $14.5\times1\times0.11$	1.6
	120.5^k

(54.4 + 6.5 + 3.3 + 1.6 = 62.5^k)

Stability

$$SFOTM = \frac{RM}{OTM} \text{ @ A}$$

$$RM = 62.5\times\frac{12.5}{2} + 31\times2.6 + 23.7\times11.0 = 732^k$$

$$OTM = 4\times3.6\times7 + 5.2\times5 = 101.6^k$$

$$SFOT = \frac{732}{101.6} > 2 \text{ ok}$$

$$SF\ sliding = \frac{120.5\times0.3}{4\times3.6+5.2} = 1.84 < 2$$

ok as passive soil resistance neglected.

$$P = \frac{Tot\ load}{Area} \pm \frac{OTM}{14.5\times\frac{12.5^2}{6}}$$

$$= \frac{120.5}{12.5\times14.5} \pm \frac{101.6}{377.7} = 0.66 \pm 0.27 = \begin{matrix} 0.93 \text{ max} \\ 0.39 \text{ min} \end{matrix} < 4^{ksf} \text{ ok}$$

Reinf. per ACI Table
Use min flex reinf. for $d = 24 - 3\frac{1}{2} = 20\frac{1}{2}''$ Mat #6 @ T/B EW
$d = 12 - 2\frac{1}{2} = 9\frac{1}{2}''$ wall #6 @ 12" EF

For structure pier see sht 6
For Vessel Piers, see sht 8

Date 4/9/14
By RJ
sht 8

Treatment vessel pier

Try 18" sq pier w/12-#6 vert

Use Empirical method

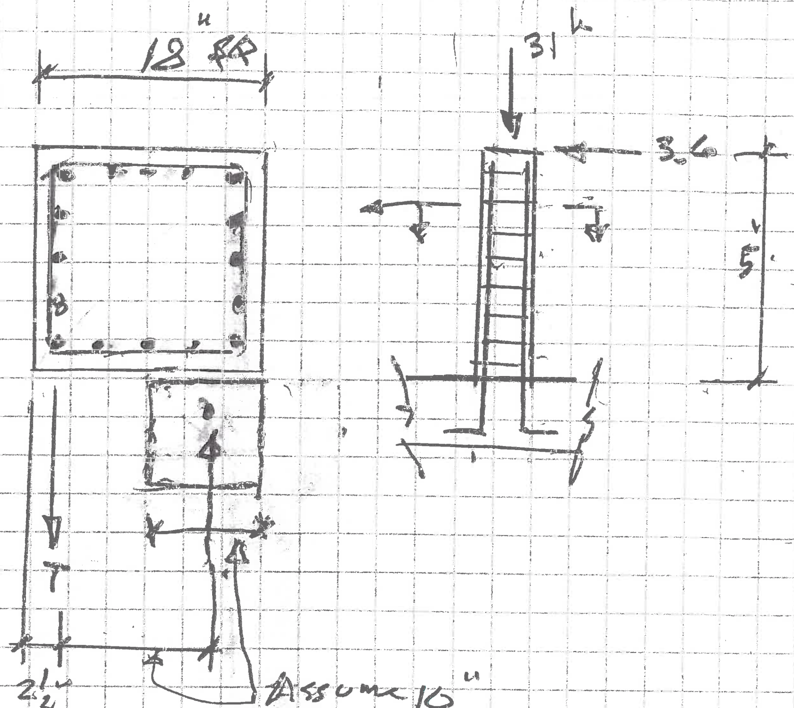
$M_{max} = 3.6^k \times 5' = 18'^k$

$T = C = \frac{18}{10/12} = 21.6^k$

$f_s = \frac{21.6}{5 \times 0.44} = 9.8^{k/\square''} < 36^{ksi}$ ok

$f_c = \frac{21.6}{10 \times 18} + \frac{31}{18 \times 18}$

$= 0.12 + 0.1 = 0.22^{ksi} < 4^{ksi}$ ok



Check Deflection

$\Delta = \frac{PL^3}{3EI} = \frac{3.6^k \times (5 \times 12)^3}{3 \times 3600 \times 35000}$

$= 0.12''$ ok

$E = 57000\sqrt{f'_c}^{psi} = 57000\sqrt{4000}^{psi} = 3600^{ksi}$

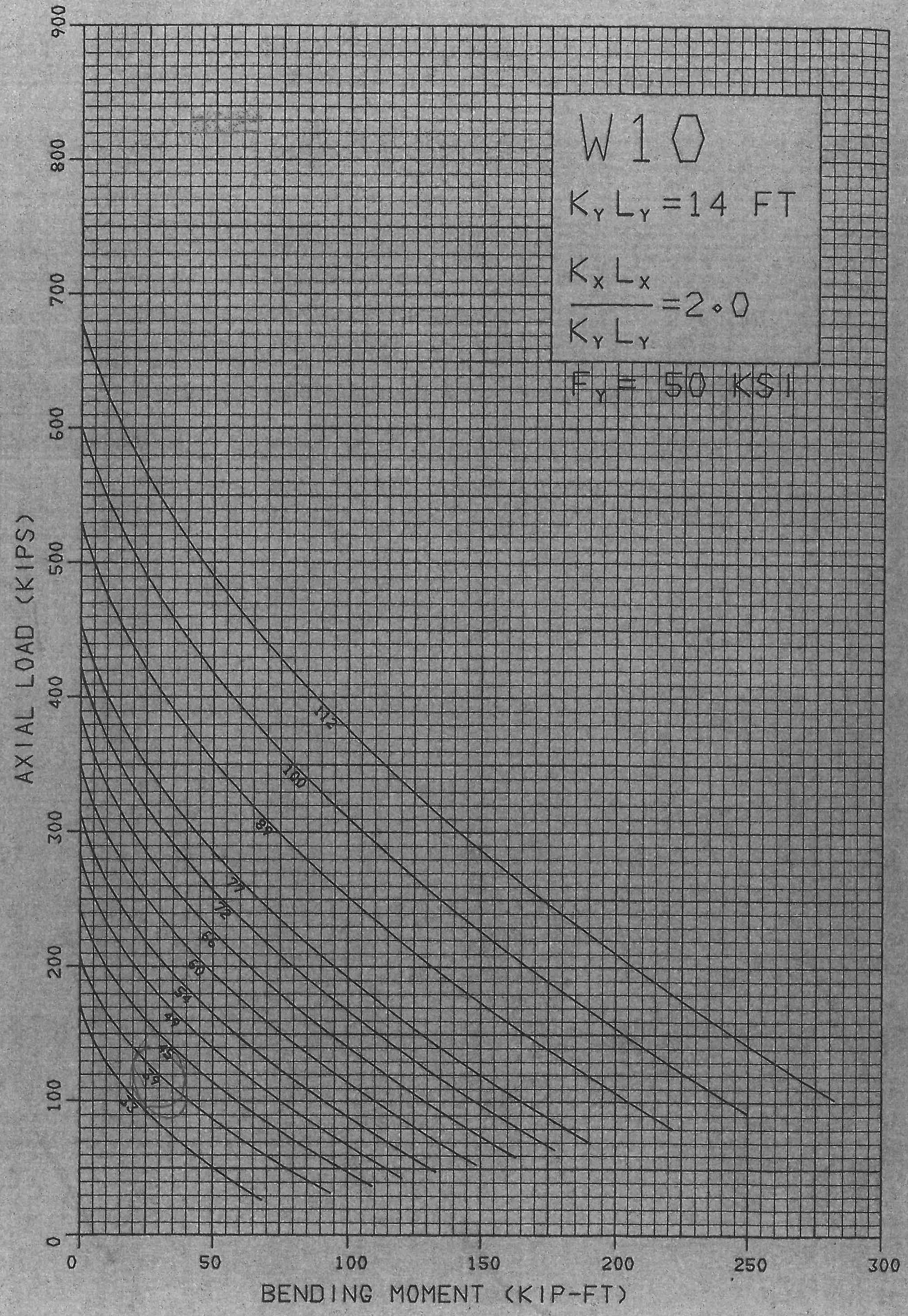
$I = \frac{d^4}{3} = 35000$

If Seismic direction ☐ ↙ $\Delta = 0.48''$ if high use 24"☐ or use 18"⌀

Δ for ~~48~~ 24" sq = 0.48/4 = 0.12"

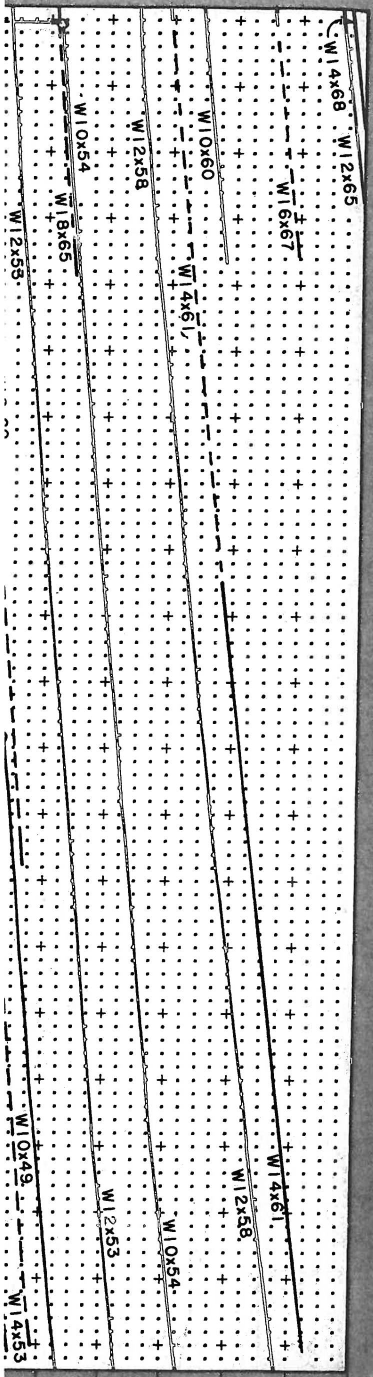
Δ for ~~48~~ 24" ⌀ ≈ 0.48/2 = 0.24"

In all cases T & C will be adequate

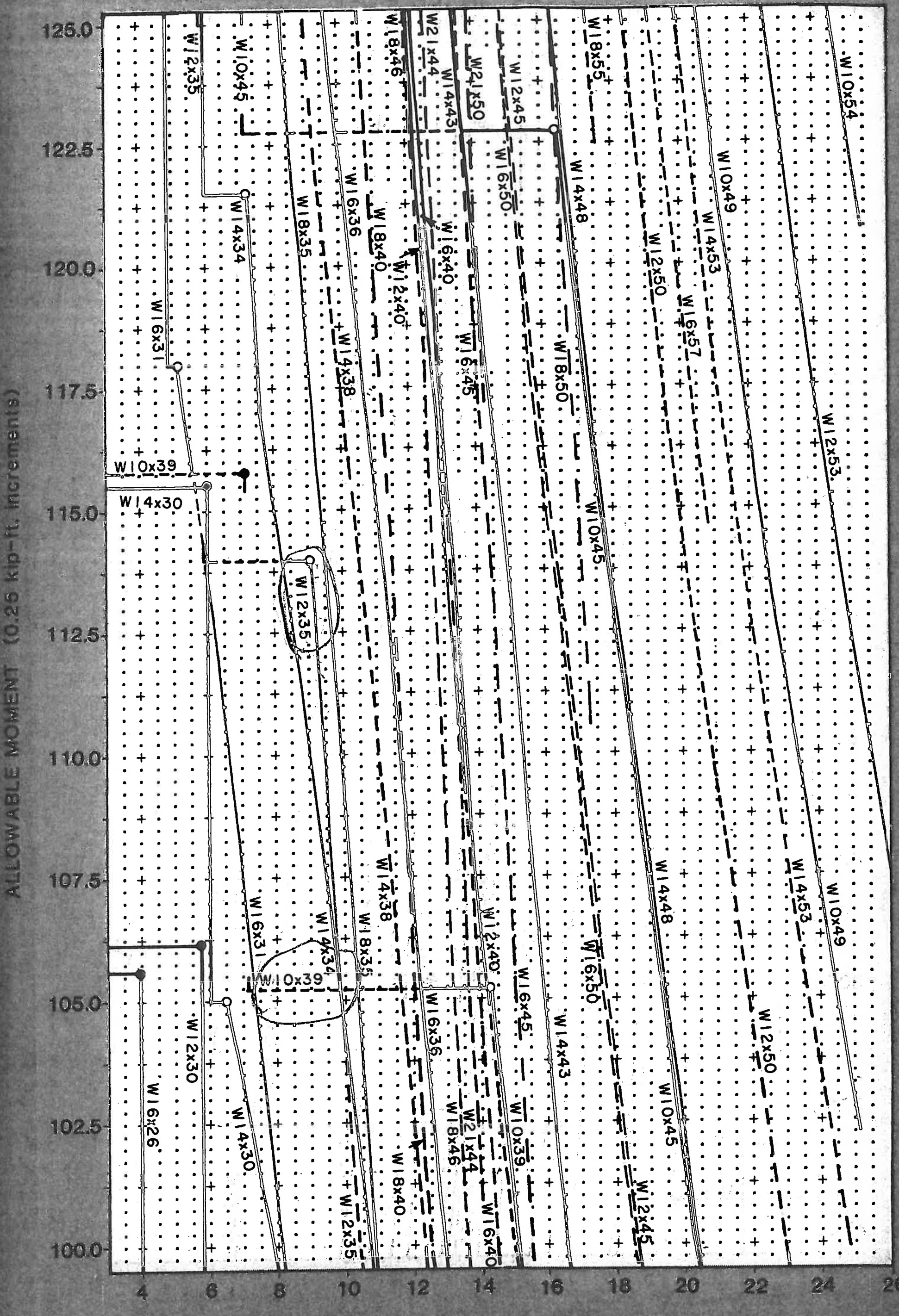


W10
$K_Y L_Y$ = 14 FT
$\frac{K_X L_X}{K_Y L_Y}$ = 2.0
F_Y = 50 KSI
AXIAL LOAD (KIPS)
BENDING MOMENT (KIP-FT)
0
100
200
300
400
500
600
700
800
900
0
50
100
150
200
250
300
112
100
88
77
72
66
60
54
49
45
39
33

...MS (C_b=1, F_y=50 ksi)



ALLOWABLE MOMENTS IN BEAMS (C_b=1, F_y=50 ksi)



Compression Capacity Table

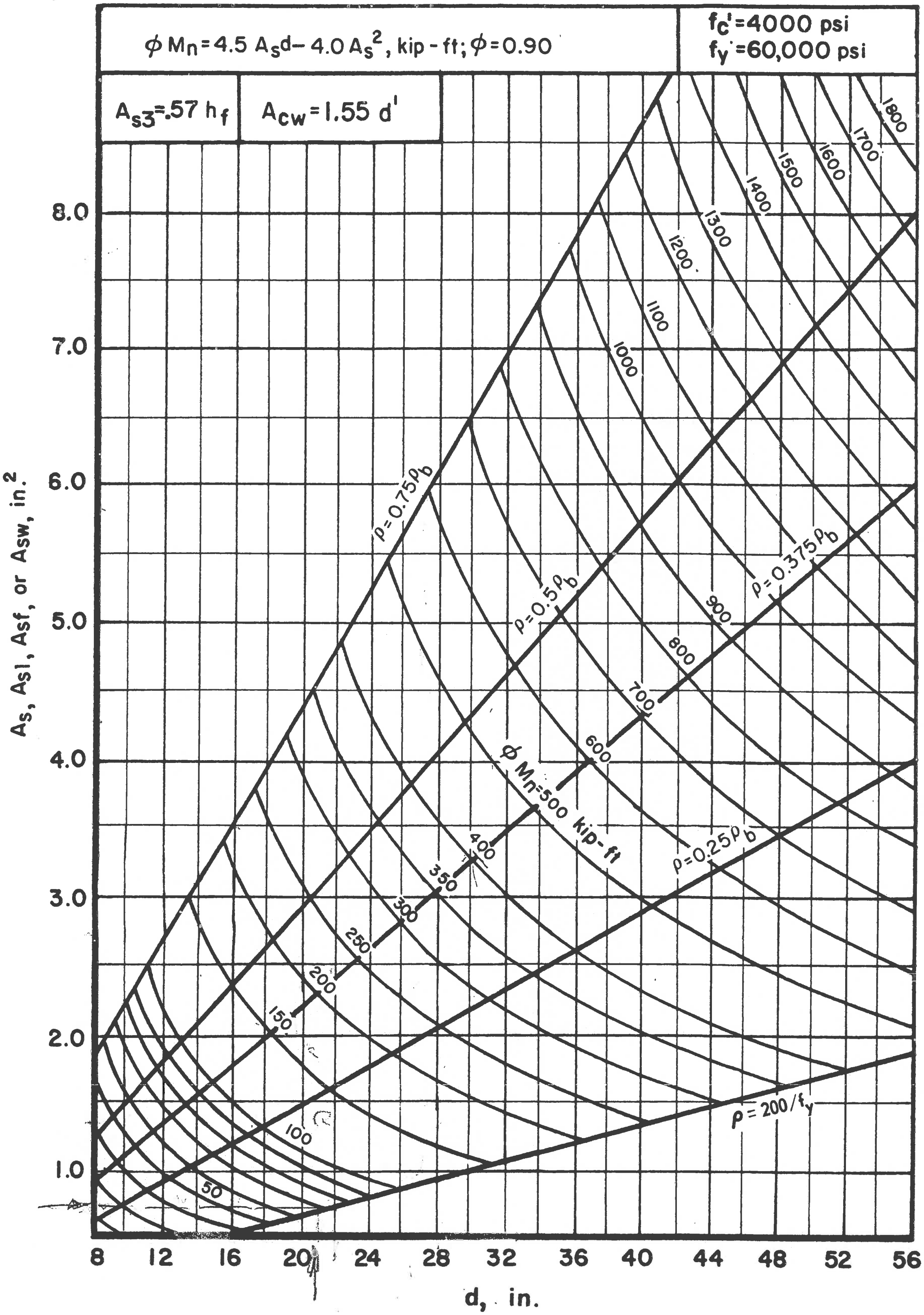
LOADS IN KIPS

MEMBER SIZE WT 6X13.5 FY = 36

		CONCENTRIC LOAD (e = 0)		FLANGE LOAD (e = y)		STEM LOAD (e = t_w)	
L(ft)	L/R min.	MAIN	BRACE	MAIN	BRACE	MAIN	BRACE
5	39.47	64.05	64.05	45.17	45.17	49.78	49.78
6	47.37	62.19	62.19	43.68	43.68	48.00	48.00
7	55.26	60.17	60.17	42.07	42.07	46.04	46.04
8	63.16	58.03	58.03	40.33	40.33	43.94	43.94
9	71.05	55.74	55.74	38.51	38.51	41.71	41.71
10	78.95	53.33	53.33	36.61	36.61	39.38	39.38
11	86.84	50.79	50.79	34.65	34.65	36.99	36.99
12	94.74	48.12	48.12	32.66	32.66	34.55	34.55
13	102.63	45.32	45.32	30.66	30.66	32.12	32.12
14	110.53	42.40	42.40	28.35	28.35	29.73	29.73
15	118.42	39.33	39.33	25.49	25.49	27.41	27.41
16	126.32	36.13	37.31	22.88	23.22	25.17	25.50
17	134.21	32.79	35.30	20.49	21.16	23.02	23.69
18	142.11	29.36	33.01	18.31	19.24	20.97	21.91
19	150.00	26.35	31.00	16.43	17.57	19.16	20.31
20	157.89	23.78	29.34	14.83	16.14	17.56	18.88
21	165.79	21.57	27.97	13.45	14.89	16.16	17.59
22	173.68	19.65	26.86	12.26	13.80	14.92	16.42
23	181.58	17.98	25.98	11.21	12.84	13.81	15.35
24	189.47	16.51	25.30	10.30	11.99	12.82	14.38
25	197.37	15.22	24.82	9.49	11.23	11.94	13.47

FLEXURE 8.6.2–Design moment strength ϕM_n for beam sections 10 in. wide

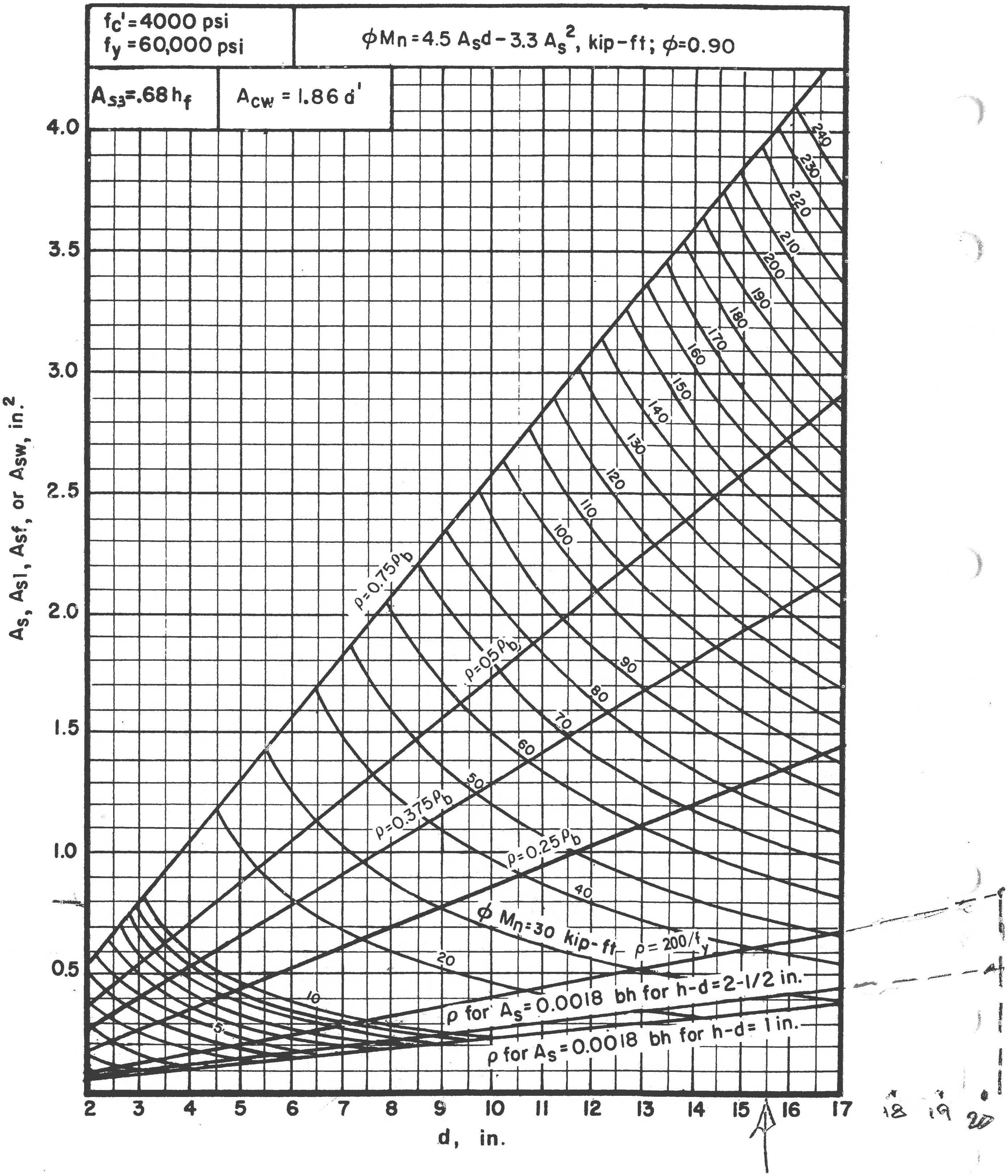
Reference: ACI 318-89 Sections 7.12, 8.4.1, 8.4.3, 9.3.2, 10.2, 10.3.1–10.3.3, 10.5.1, and 10.5.3 and ACI 318R-89 Sections 10.3.1 and 10.3.2



For use of this Design Aid, see Flexure Examples 1, 2, 7, 10, and 14.

FLEXURE 8.6.1–Design moment strength ϕM_n for slab sections 12 in. wide

Reference: ACI 318-89 Sections 7.12, 8.4.1, 8.4.3, 9.3.2, 10.2, 10.3.1–10.3.3, 10.5.1, and 10.5.3 and ACI 318R-89 Sections 10.3.1 and 10.3.2



For use of this Design Aid, see Flexure Examples 1, 2, 4, 5, and 11–15.

Vinod Badani

From: Alfred.Voegels@CH2M.com
Sent: Tuesday, April 08, 2014 11:51 AM
To: John.Porcella@CH2M.com; vinod.badani@e2.com
Cc: Nathan.Betts@CH2M.com; Doug.Sunseri@CH2M.com; Rob.VanderArk@ch2m.com
Subject: RE: TOPOCK-Fresh Water Pre-Injection treatment

Hi Vinod, when could we expect updated structural sketches? No rush, just planning workload. Thanks.

From: Porcella, John/BAO
Sent: 4/8/2014 11:24 AM
To: vinod.badani@e2.com
Cc: Betts, Nathan/LAS; Sunseri, Doug/SEA; Voegels, Alfred/PDX
Subject: RE: TOPOCK-Fresh Water Pre-Injection treatment

Hi Vinod –

1. Treatment vessels - I estimate for

- 8' dia x 12.5 ' side shell ~ 17' overall vessel height,
- supported on 30" concrete pier supports,
- 22.5 feet overall height floor to top of head.

All dimensions scaled from Doug's drawings, about 45,000 pounds fully loaded (water, media, internals).

2. Filter skids - see attachments
   - "SPECIFICATION HUR 8x170FL-1.pdf" for single unit weight.
   - FP817-D-6-P.pdf is plan drawing for 2 filter skid package. Filters mounted on steel skid frame. One skid each pre-filter and post filter.

2. The chemical storage area – not final, but pretty close as shown on "ChemStorage Layout". It looks like we have allocated more space than we really need. Marty PDF'd the cad files the hypochlorite tablet vendor provided in case you want to look at that ("Binder2.pdf").

Feel free to call to discuss.

Thanks.

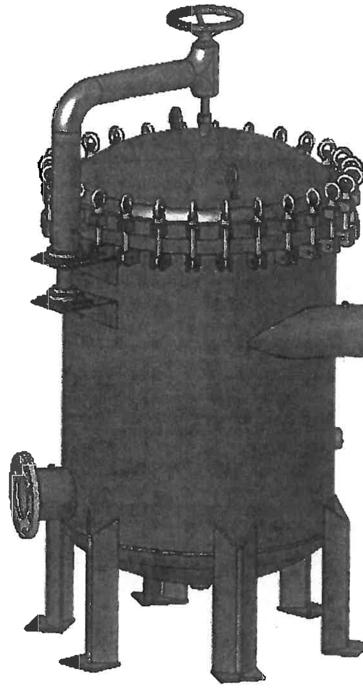
From: Vinod Badani [mailto:vinod.badani@e2.com]
Sent: Monday, April 07, 2014 12:14 PM
To: Porcella, John/BAO
Cc: Betts, Nathan/LAS
Subject: TOPOCK-Fresh Water Pre-Injection treatment

John:
Can you[provide me with weight of Treatment Vessels?
I know it is 8-feet in diameter with 10 feet side wall (16-feet overall height. Mounted 18-inches to 2 feet above floor.
Also need total weights for Filter skids.
Any progress on Chemical storage Building? I need you to verify size to make it sure this will house all equipment+ need information for containment requirements.

Thanks
Vinod

Vinod M. Badani, P.E.
Vice President
E2 Consulting Engineers, Inc.
1900 Powell Street, Suite 250
Emeryville, CA 94608
e-mail: vinod.badani@e2.com
Office: 510-428-4721
Cell-510-754-6560
Fax: 510-355-3611

PRODUCT SPECIFICATION
Harmsco® Model #: HUR 8X170FL



Description: Tangential Entry, Up-Flow Cartridge Filter Housing with; Swing Bolt Closure, Davit Cover Lift, and Flanged Connections.

Details:

1. Stainless steel construction, all wetted metallic components are ASTM A-240.
2. Swing bolt style housing closure. Swing bolts are ASTM A-193 B8.
3. NSF Certified using Genuine Harmsco® Hurricane® replacement filter cartridges.*
4. Tangential inlet and the integral inner-can, create a centrifugal flow that induces pre-filtration by heavy particulate separation.
5. Patented "Up-Flow" design that;
   a. Self purges housing of air.
   b. Eliminates by-pass contamination during servicing.
   c. Improves efficiency by creating an even flow distribution across filtering media.
6. Strong, durable construction.
7. Utilizes eight (8) Genuine Harmsco® Hurricane® HC/170 filter cartridges, available in many micron ratings. *
   Note: Harmsco® Hurricane® HC/170 filter cartridges available include: Activated Carbon, High Temperature, SureSafe™, Poly-Mesh, Poly-Pleat™ & more. **
8. Inlet & Outlet are NPS 6 Flanges ANSI/ASME B16.5 Class 150
9. Drains (Qty 2) are 1-1/2" Female NPT (FPT) Couplings, Class 1000
10. Vent is ½" Female NPT (FPT) Coupling, Class 1000
11. Gauge Ports (Qty 2) are ¼" Female NPT (FPT) Couplings, Class 1000
12. Closure Gasket is EPDM 70 Durometer O-ring.
13. Electro-polish finish.
14. Pressure Rating - 150 P.S.I.G.
15. Temperature Rating – Up to 140°F
    Note: Higher temperatures are possible, check cartridge specifications. **
16. Flow Rate – 1,200 GPM Maximum. See Pressure Drop vs. Flow Rate Curve, page 2.
17. One person can perform maintenance.

Requirements:

Floor Load:
Dry weight = 1,600 lbs.
Volume = 232 US gallons x 8.337 lbs./US gallon (water) = 1,935 lbs.
Total weight = 1,600 + 1,935 = 3,535 lbs. (housing + water)
Floor contact area = 1.164 ft².
Floor Load = 3,535 lbs. divided by 1.164 ft² = **3,100 pounds per square foot** (approx.)
Note: Piping shall conform to all applicable codes and be independently supported.
If floor strength is suspect, use appropriate measures to adequately distribute load.

Floor Space: 14 ft² (does not include Cover/Davit swing position), See Installation Diagram, page 3.
Service Height: 104-1/2", See Installation Diagram, page 3.
Bonding: Housing shall be bonded in accordance with all applicable codes. A grounding lug is provided.

Recommended Spare Parts:
Closure Gasket O-ring: PN 368-E
Set of 8 Harmsco® Hurricane® HC/170 replacement cartridges

* The use of any filter cartridges other than Genuine Harmsco® Hurricane® filter cartridges in this filter housing voids certifications by NSF International.
** Contact a Harmsco® sales representative for Harmsco® Hurricane® HC/170 filter cartridge specifications.

This product is manufactured under one or more of the following patents: U.S. NO. 4,187,179; 3,720,322; CANADA NO. 977,693; GT. BRIT. NO. 1,372,014; W. GERMANY NO. 2,261,817; FRANCE NO. 7,246,864; EUROPEAN NO. 0,191,844, Other patents pending.

Notice: The information contained in this publication is considered accurate, and is intended to be used as a guide. This information is subject to change without notification. Contact Harmsco® Filtration Products for the latest, most up to date, specifications. Harmsco® Filtration Products does not assume any liability for the accuracy and completeness of the data in this publication. Temperature ratings, flow rates and chemical resistance can be affected by a number of unknown factors. End users should perform their own tests to determine suitability for each application.

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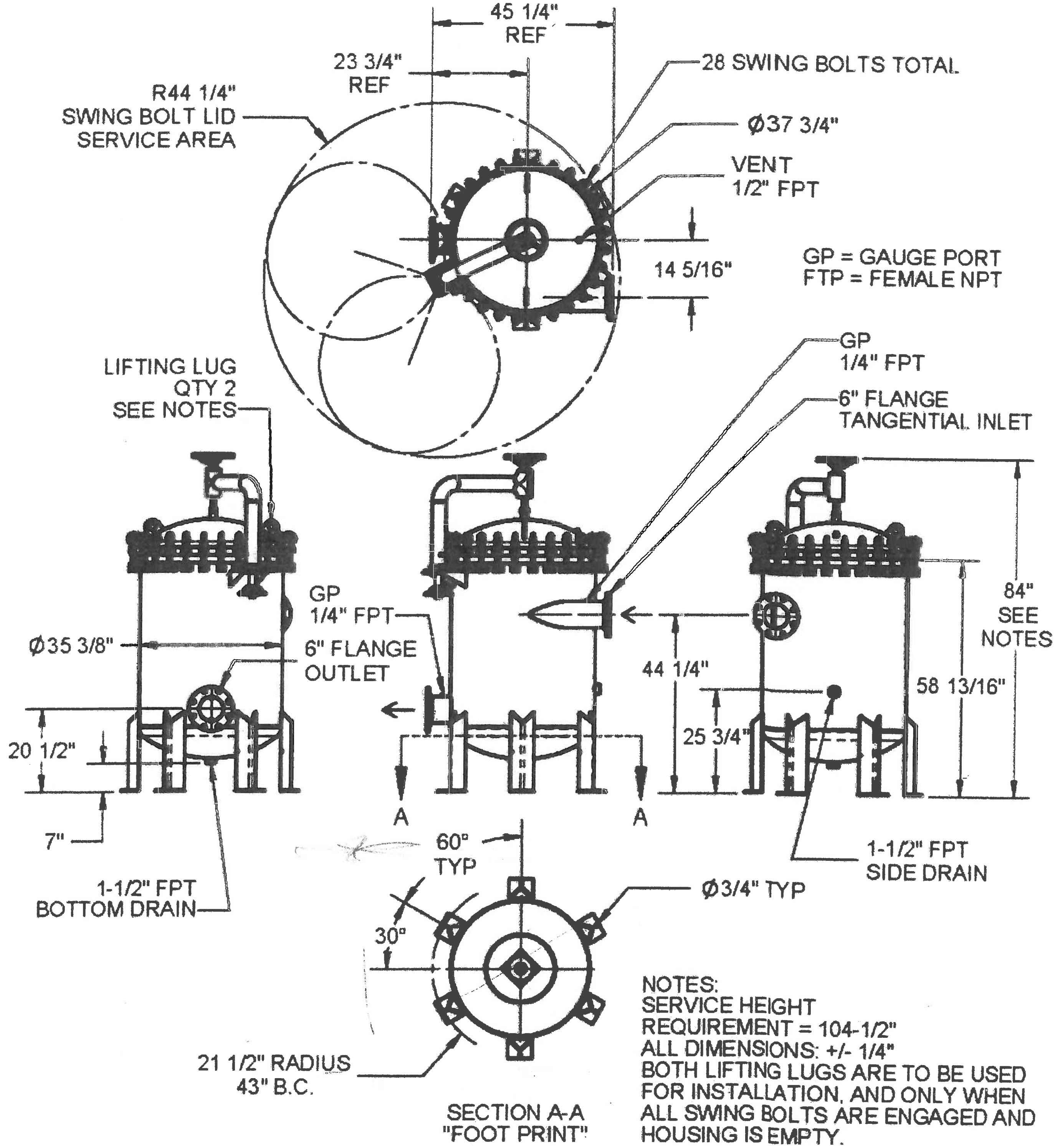
561-848-9628

Harmsco® Filtration Products
Installation Diagram
Hurricane® 8 X 170 Swing Bolt Housing



NOTES:
SERVICE HEIGHT REQUIREMENT = 104-1/2"
ALL DIMENSIONS: +/- 1/4"
BOTH LIFTING LUGS ARE TO BE USED FOR INSTALLATION, AND ONLY WHEN ALL SWING BOLTS ARE ENGAGED AND HOUSING IS EMPTY.

MODEL #: HUR 8X170FL

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Revised: 3-4-09
File Name: SPECIFICATION HUR 8X170FL (pg. 3 of 3)

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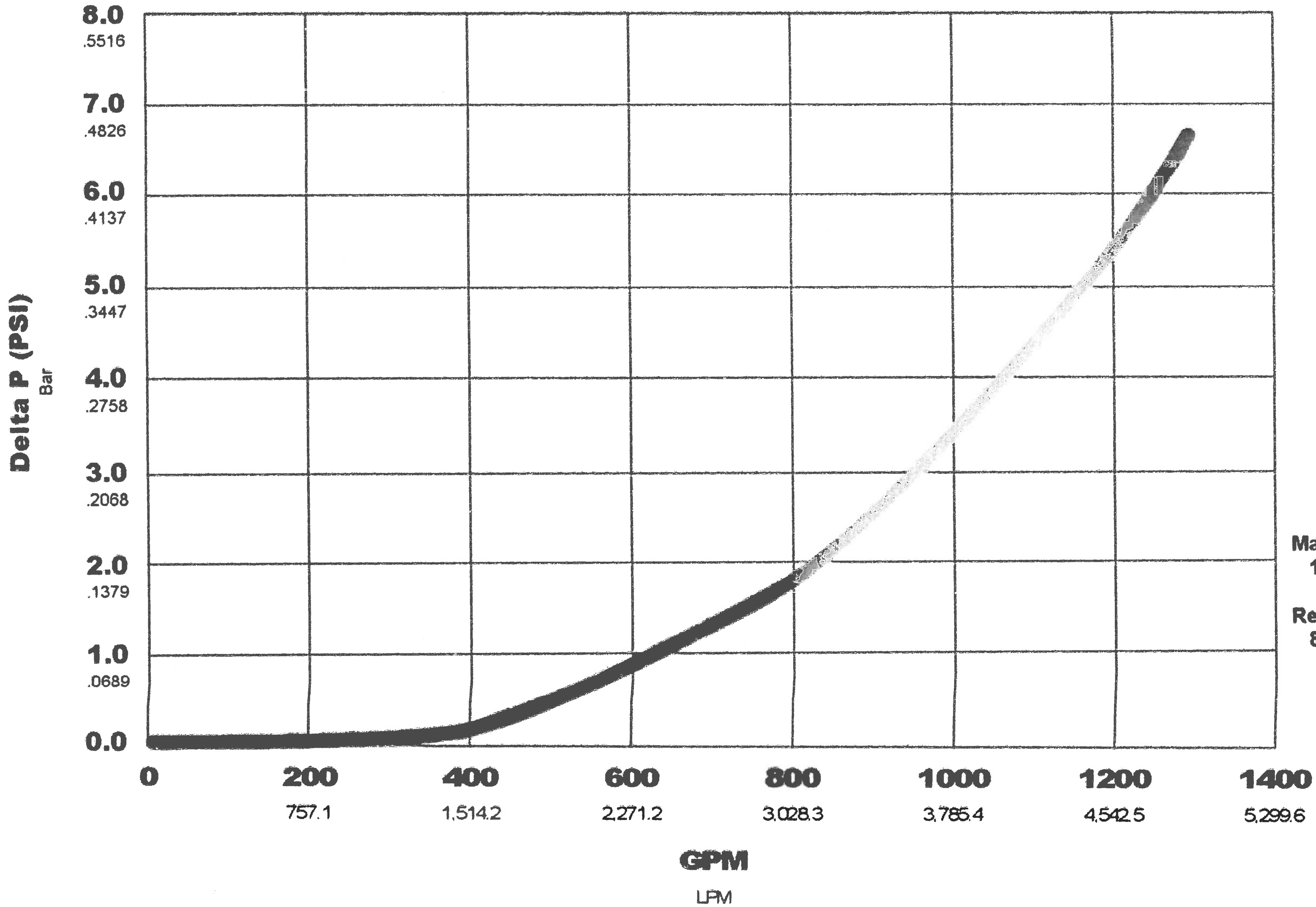
Pressure Drop vs. Flow Rate Curve

Harmsco® HUR 8X170FL
Hurricane® HC/170-20 Cartridges
Qty 8; with clean water.



Max. Flow Rate - 1200 GPM

Recommended Flow Rate - 840 GPM

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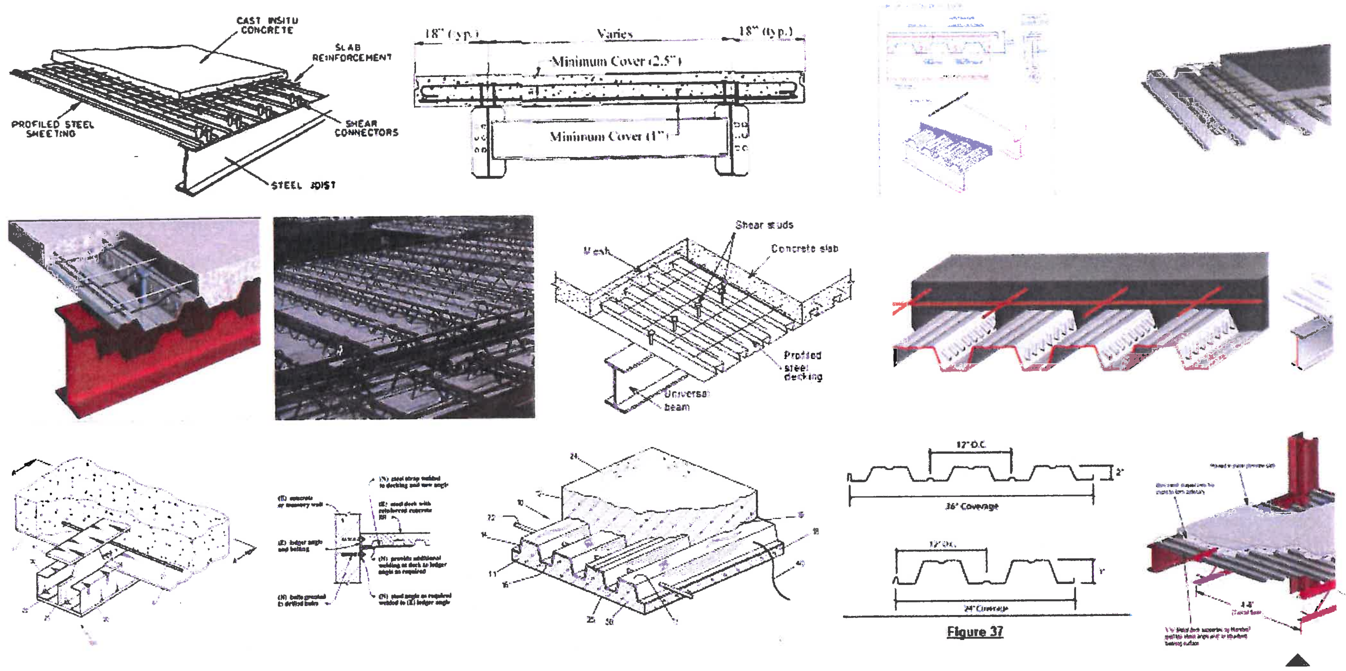

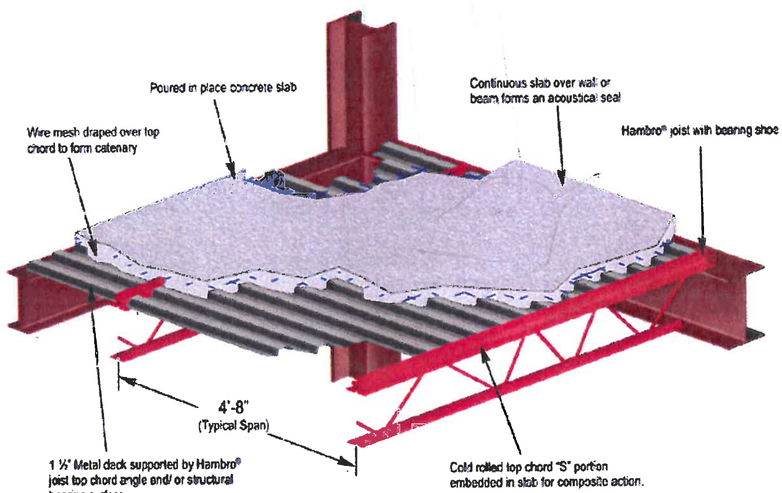

Hambro MD2000 Floor Syste

www.swirnowstructures.com - 650 × 409 - Searc

Hambro MD2000 Floor System combines compo: poured concrete and metal decking

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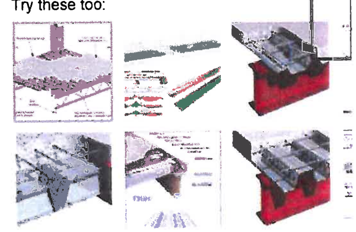

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TAB NO.5

DESIGN CRITERIA

APPENDIX C

Design Criteria

In conformance with requirements from the 1996 Corrective Action Consent Agreement (CACA) (California Department of Toxic Substances Control 1996) and the 2013 Remedial Action/Remedial Design (RD/RA) Consent Decree (U.S. Department of the Interior [DOI] 2013), this appendix describes the design criteria for the groundwater remedy at the Topock Compressor Station (TCS). The design criteria are the technical parameters upon which the design is based, and are based on the translation of the identified applicable or relevant and appropriate requirements (ARARs) and the Environmental Impact Report (EIR; California Department of Toxic Substances Control [DTSC] 2011) mitigation measures (where applicable) into site-specific engineering parameters.

The design criteria are grouped into engineering disciplines (Civil [Section C.2], Structural [Section C.3], Geotechnical [Section C.4], Mechanical [including lighting] [Section C.5], Electrical [Section C.6], Instrumentation and Control [Section C.7], and Architectural [Section C.8]). In addition, this appendix describes PG&E Personnel Requirements (Section C.9) and design criteria for Health and Safety (Section C.10) and Noise (Section C.11). Content of the former Construction Requirements section (Section C.11 in the previous version of this appendix from the 30% design submittal) has been removed and will be merged with the forthcoming Construction/ Remedial Action Work Plan, where construction provisions will be discussed in detail.

This appendix includes five Attachments that contain a large amount of data; these Attachments are presented in PDF format on the CD-ROM version of the 60% Basis of Design Report (enclosed within the report binders).

- Attachment A contains a detailed description of the in situ remediation design basis including carbon substrate selection and discussion of chemical reactions.
- Attachment B provides calculations in the following order:
  - Remedy-produced water pump calculations – recirculation; filter feed; conditioned water transfer
  - Remedy-produced water influent tank eductor sizing
  - Remedy-produced water caustic usage
  - Remedy project structural calculations – Remedy-produced Water Conditioning Building; Conditioned Water Tank; Injection Well and Valve and Meter Vaults; Pipe bridge deflection
  - Freshwater injection/remedy-produced water collection/conditioned remedy water distribution and disposal hydraulic network modeling calculations from EPANET software[1]
  - Hydraulic calculations for National Trails Highway In-situ Remediation Zone (NTH IRZ), Inner Recirculation Loop, and TCS Recirculation Loop wells
  - Structural design calculations for the MW-20 Bench Carbon Amendment Building
- The new Attachment C summarizes information on existing site geology and geotechnical data in support of the groundwater remedy design and to propose areas where supplemental geotechnical investigation is needed to verify design parameters.
- The new Attachment D includes a bulletin on remediation well design and field approach.
- The new Attachment E includes a summary of the hydraulic analysis of the firewater system.

C.1 Codes and Standards

The Groundwater Remedy Project is being designed in accordance with the applicable standards, codes, ordinances and regulations, including but not limited to:

[1] Developed by the U.S. Environmental Protection Agency for hydraulic network modeling and drinking water quality analysis. For details, see http://www.epa.gov/nrmrl/wswrd/dw/epanet.html.

- American Concrete Institute (ACI)
- American National Standards Institute (ANSI)
- American Society for Testing and Materials (ASTM)
- American Water Works Association Standard (AWWA)
- Arizona Department of Transportation Policy for Accommodating Utilities on Highway Rights of Way
- Burlington Northern Santa Fe Railway (BNSF) Utility Accommodation Policy
- California Building Code (2010) as amended by San Bernardino County
- California Fire Code (2010)
- California Mechanical Code (2010)
- California Plumbing Code (2010)
- California Division of Occupational Safety and Health (Cal/OSHA)
- County of San Bernardino 2007 Development Code
- Illuminating Engineering Society of North America (IES) procedures
- International Energy Conservation Code (IECC)
- International Green Building Code
- Institute of Electrical and Electronic Engineers (IEEE)
- Instrument Society of America (ISA)
- Insulated Cable Engineers Association (ICEA)
- Minimum Design Loads for Building and Other Structures (American Society of Civil Engineers [ASCE] 7-10)
- Mohave County Regulations (including Drainage Design Manual for Mohave County)
- Mohave County Floodplain Administrator requirements
- National Electrical Manufacturers Association (NEMA)
- National Electrical Code (NEC)
- National Electrical Safety Code (NESC)
- National Fire Protection Association (NFPA)
- Occupational Safety and Health Administration (OSHA)
- PG&E standards
- San Bernardino Fire Department/Certified Unified Program Agencies (CUPA) requirements
- San Bernardino County Floodplain regulations
- Uniform Fire Code (UFC) (Local Fire Code)
- Underwriters Laboratory (UL)

C.2 Civil

C.2.1 Site Datum

Following completion of recent aerial photogrammetry, the topographic map has been updated to 1-foot topographic contours. The new topographic map, which has been incorporated into the design drawings, is included as Figure 2.4-2 in the Basis of Design Report. The following data were used to establish control for the project and conduct site survey work:

- All coordinates listed are 1983 State Plane Ground Coordinates, Zone 5 (NAD1983, State Plane, California, V, FIPS, 0405). Standard transverse Mercator projection, with projection, with a scale origin point of x=0.0000 y=0.0000, using a grid adjustment factor of 1.000123. These coordinates can be used as ground datum. To convert back to grid coordinates, each coordinate value would be divided by 1.000123.
- The elevations are based on North American Vertical Datum of 1988 (NAVD88) based on NGS data sheets EU1248 and EU0763 in U.S. Survey feet.
- Units = International feet: 1 foot = 0.3048 meter exactly.
- All bearing are grid bearings, distances are ground distances, and coordinates are ground coordinates.

C.2.2 Earthwork

This section describes the design criteria for the movement of soil and rock into forms and structures needed for the project.

- Grading, Paving and Access Roads

  Cut and grading will take place at the site to install new remedy facilities. Access roads may be required to access certain project locations for construction and O&M. Access roads will be designed to the following standards (barring terrain or cultural, biological or natural resource constraints):

  - Maximum grade ≤ 10%
  - One way traffic width = 14 feet
  - Two way traffic width = 20 feet
  - Cut slopes ≤ 1.5:1
  - Fill slopes ≤ 2:1 (H:V)
  - Out slope road (1/4 inch per foot) so that drainage flows perpendicular to road centerline
  - Roadside ditches (V shaped or trapezoidal) with a minimum top width of 2 feet
  - Per San Bernardino County requirements (Chapter 82.13 Section 82.13.080) compaction to 90% minimum

  Pavement replacement will be in accordance with the California Department of Transportation's (Caltrans') *Flexible Pavement Structural Section Design Guide for California Cities and Counties* (latest edition).

- Utility trenches will be excavated to a minimum 3 feet deep and 3 feet wide. Utility trenches may include pipes (freshwater, extracted groundwater, carbon-amended water, remedy-produced water, clean in place (CIP), acid, coagulant, caustic, slurry, waste sump, utility, or spare pipes), as well as electrical and instrumentation conduits. Trench cutoff walls with drain systems may be installed at locations where pipe slopes exceed 8%-10% for long runs (300 to 500 feet) to help divert any potential water flow that may undermine the trench section. These will be added in the design submittal if needed. In areas where utility crossings exist there will be a minimum of 2 feet separation between utilities unless directed otherwise by the utility owner. GPS-based locations of utilities will be recorded as part of the as-built submittals as well as size, material, and horizontal and vertical separation distance from utilities. Construction GPS mapping and surveys of other pipelines will be required as appropriate.

- Pipe and conduit bedding material will be free of rock(s), rubbish, debris, and other objectionable material, and minimum compaction will be 90% to 95% relative density, per American Society for Testing and Materials (ASTM) D-1557 in areas sensitive to settlement. The minimum pipe bedding thickness will be 6 inches and the minimum pipe/conduit backfill zone thickness will be 3 inches. Bedding will be without voids, placed and consolidated to the proper depth in 8-inch maximum lifts. The backfill will be placed to final grade to conform to the elevation of the adjoining surface elevation.

- A survey of aboveground and underground utilities will be conducted within all work areas prior to beginning intrusive site work and construction activities. This survey will include, but will not be limited to, the following activities:

  - Notify Underground Service Alert (USA) or "Dig Alert"
  - Geophysical survey to identify underground features
  - It is Topock Compressor Station policy to minimize operational and safety risks by limiting subsurface intrusion as much as possible, and thus abandoned utilities are typically left in place. Because positive identification of all active and abandoned underground utilities prior to any intrusive activity within the station fence line is impossible, Compressor Station protocol requires all intrusive work be performed by hydrovac or hand excavation methods.

    As described during the October 24, 2011 site visit with the DTSC and the DOI, PG&E policy requires all excavations in the vicinity of existing infrastructure to be hand dug to *a minimum* of 3 feet; in more open areas, hydrovac excavation may also be used. Depending on the location, density of utilities encountered, and available information regarding a specific location, hand excavation or clearing using the hydrovac may be required as deep as 10 feet below ground surface. No power equipment is used until the excavation has been physically cleared for utilities. A station employee observes each excavation effort and determines when it is safe to proceed with more intrusive methods. PG&E does not have a written procedure for this requirement; however, it is policy and is understood and strictly followed by all station personnel.

- Piping installed in utility corridors will be placed above ground or below ground. The preferred installation is below ground for many reasons, including but not limited to the following:

  a) The National Electrical Safety Code (NESC) considers an above-ground, non-overhead, high voltage electrical supply line to be an example of non-Code compliant, therefore, medium and high voltage electrical lines will be place underground. In addition, aboveground low voltage electrical 480 volt power lines carry the risk of causing electrical injuries from contact, and long runs of exposed electrical conduit also present numerous design and O&M challenges.

     i. It is worth noting that along the Route 66 segment in the Upland Area, considerations were also given to the piping alignment (underground) to maintain usable road width in narrow stretches of the road. The California/San Bernardino County Fire Code (Chapter 5) requires 26 feet minimum width for vehicle access. Although variances are allowed if turnarounds are available every 600 feet (County Standard 503.1), additional grading and cut backs would be required to create these turnarounds in several narrow road sections or sections with steep ravine. Note that aboveground structures would also require drainage features which adds to the footprint.

  b) Placement of water lines underground (versus aboveground) will not only avoid increased visual impacts, but will also protect the health, safety, and free movement of humans and animals. Underground piping will also enhance the integrity of the remedy infrastructure (e.g., avoid being hit by vehicular traffic), and minimize remedy footprint and future O&M challenges.

  c) Aboveground piping is inherently vulnerable as members of the public have been known to shoot pipes and large rocks or other debris may strike the pipe during a storm event. In addition, aboveground pipe will need periodic re-coating therefore, would require more maintenance compared to underground piping and as such, create more disturbance to nearby habitats as a result of maintenance activities.

  d) However, in certain cases, aboveground installations will be necessary to protect sensitive resources (e.g., aerial crossings of Bat Cave Wash, crossing of the Colorado River on the Arch Bridge) or to avoid potentially difficult construction conditions in bedrock (e.g., the aboveground piping along Route 66 between the East Ravine and the Arch Bridge).

Belowground utility corridors will be constructed with pre-cast utility trench boxes with lids or buried directly in the soil. The installation option was selected based on the following criteria subject to constraints for the particular route (e.g., width of usable terrain):

- No directly buried water piping will be installed below any other water pipe or conduit.
- Directly buried electrical conduits may be installed beneath other electrical conduits.
- There must be at least 6 inches of clearance between directly buried water piping. The clearance between directly buried water piping may be increased up to 12 inches.
- The minimum spacing between directly buried electrical conduit shall be 3 inches or half the diameter of the conduit, whichever is greater.
- Tracer wire for locating non-metallic pipes or conduit will be installed in the trenches.

- Trenchless construction will be used underneath existing infrastructure such as the I-40 highway and BNSF railway bridges. In such locations, these will be installed using trenchless methods such as auger boring or horizontal directional drilling. The methods will be designed such that they comply with relevant guidelines prepared by the Arizona Department of Transportation (ADOT), Mohave County (for County Road 10 bore), and BNSF listed below (see also Section 5.3.2 of the Basis of Design Report for encroachment permits). Also, the methods will comply with San Bernardino County requirements for trenchless crossings in California.
  - Caltrans Manual for Encroachment Permits on California State Highways, Seventh Edition, January 2002, Section 518, and Table 5.24 - Permit Code TN
  - ADOT Policy for Accommodating Utilities on Highway Rights-of-Way, December 2009
  - BNSF Utility Accommodation Policy, May 2007

  Pipes and conduit will be installed in steel casings when required by BNSF, ADOT, or Mohave County. Casings will extend beyond the length of the crossing a minimum of 10 feet. The need for cathodic protection will be evaluated on a case-by-case basis using site conditions and utility requirements. The casing will have centralizers and end caps 10 feet from the end of the casing. Identified spare pipes and conduits will be installed during construction. Exhibit C.1-1 lists minimum depth of cover for trenchless crossings. In some cases, concerns for pavement or railroad settlement or potential for drill fluid "frac-out" may require a thicker cover. Geotechnical borings may be required by ADOT, BNSF, or Mohave County (see Section C.4). If drilling fluids are used, continuous monitoring for frac-out conditions will be performed to prevent harm to human health and the environment caused by the release of such fluids.

- Any earthwork in areas of sensitive habitat (including floodplain and riparian areas, wetlands, and waters of the US, as well as desert washes and desert riparian) will be subject to the substantive equivalents of Section 404/Section 1600 requirements under mitigation measure BIO-1 (see the Mitigation Monitoring and Reporting Program in the EIR [DTSC 2011]).

EXHIBIT C.1-1
Depth of Cover Design Criteria for Trenchless Crossings
Groundwater Remedy Basis of Design Report/Intermediate (60%) Design
PG&E Topock Compressor Station, Needles, California

Transportation Agencies	Minimum Depth Of Cover
ADOT	• 3 feet minimum • 6 feet minimum for un-sleeved crossings up to 48" diameter • 10 feet minimum for pipelines larger than 48"
BNSF	• 3 feet minimum below flow line of ditch or ground surface • 5-1/2 feet minimum below base of rail, for casing diameters greater than 26" • 10 feet minimum without geotechnical study • 5-1/2 feet if it can be verified by geotechnical study

C.2.3 Storm Drainage

Stormwater will be managed to protect new structures and facilities built as part of the remedy. This section describes the design criteria associated with stormwater drainage.

Impervious surfaces will be sloped to drain. Culverts will be used to drain roadside ditches and protect stream crossings. Roof drainage from buildings will be collected in gutters and drain towards drainage systems. Stormwater captured within secondary containment will be managed at the remedy-produced water conditioning system. All drainage features and structures will be sized to meet San Bernardino County requirements for storm frequency and intensity.

- Rainfall intensity based on period equal to time of concentration for the basin being considered and 25-year recurrence interval.
- Minimum velocity for culverts is 2.0 feet per second. Maximum velocity for culverts is 10.0 feet per second.

During construction, erosion control measures will be implemented in accordance with San Bernardino County requirements and the construction Stormwater Pollution Prevention Plan (SWPPP). The erosion control measures will be tailored to the site to prevent sediment-laden water from leaving the site. The following erosion control measures will be used onsite:

- Site development considerations with construction scheduling
- Maintenance of buffer zones
- Disturbed-soil areas with decomposed granite
- Dust control on disturbed areas and access roads
- Diversion of runoff with earthen dikes, brow ditches, and berms to protect excavations
- Energy dissipaters, riprap channel protection, or outlet protection for discharge pipes, channels, and ditches
- Silt fence at limits of clearing
- Temporary sediment basins to protect existing drainage basins and culverts
- Check dams to control velocity along ditches and long longitudinal grades
- Stabilized construction entrance to all paved surfaces
- Materials management with material delivery, storage, and waste management
- Vehicle and equipment management with construction practices, cleaning, fueling, and maintenance

C.2.4 Site Security

In general, the security for remedial facilities located inside the Compressor Station will be provided for by the Compressor Station security system. Remedial facilities located outside of the Compressor Station will be equipped with security features/systems that are consistent with PG&E's current security standards. Such features, as determined necessary and in compliance with project and landowners' requirements, could include, but are not limited to, fencing to protect the equipment and provide safety for personnel and the public; locks to prevent unauthorized access; security devices and instrumentation; security communication systems; alarms to notify PG&E's security operations; and security cameras. Where appropriate, security features like cameras and card readers are noted on the 60% engineering plans/drawings (see Appendix D of this 60% BOD Report). Examples of security features to be installed at remedy facilities located at the TW Bench, MW-20 Bench, HNWR-1 well site, the North and South Aerial Crossings (crosses Bat Cave Wash) are described below. Additional details on security design criteria will be presented at the 90% design stage, after the remedy infrastructure locations have been confirmed. In compliance with the EIR mitigation measure CUL-1a-6, any additional phone calls and alarms associated with remedial activities will not be routed through PG&E's existing alarm system at the Compressor Station.

Transwestern Bench

- A perimeter fence will be installed with a motorized main gate and a personnel gate. The main gate will have a security card reader and camera to monitor and prevent unauthorized access.
- Perimeter cameras will be installed. Security cameras will also be installed inside select buildings/structures.
- The Central Maintenance Facility will have card readers at entrances.

MW-20 Bench

- Each new gate(s) will have a security card reader and camera.
- Perimeter cameras may be needed, but will be confirmed during the 90% design stage.
- Operational cameras will be installed inside select structures.

HNWR-1 Well Site

- A motorized gate with security card reader and camera will be installed.

North and South Aerial Crossings (Bat cave wash)

- Personnel gates with locks will be installed at each end of the 2 new aerial crossings.

C.2.5 Concrete Vaults

Concrete vaults will be installed to house mechanical and electrical equipment. Vaults will be precast concrete sections. The vaults will vary in depth depending upon use and location, but to the extent possible they will be designed to be shallow enough that entry would not require a confined space entry procedure. Each vault will be equipped with a steel ladder with extension, conforming to California Division of Occupational Safety and Health (Cal/OSHA) standards. Well vaults will be designed for an H-20 loading in traffic areas and the lids will be supplied with spring assists for safe opening. Fall protection removable grating (live load 300 pounds per square foot [psf]) will be provided. For non-traffic areas, standard lids (300 psf) will be supplied. All vault lids will be equipped with security locks or other security devices (e.g., embedded locks or 5-point bolts).

C.2.6 Construction in 100-year Floodplain

The 100-year floodplain is defined in the Flood Insurance Rate Map (FIRM), Panel 5705 of 9400 for San Bernardino County, California and Unincorporated Areas, Revised August 28, 2008, and Panel 5675 of 6700 for Mohave County, Arizona and Unincorporated Areas, Revised November 18, 2009 (Map Number 04015C5675G). The base flood elevation shown on the current FIRM is 464 feet NAVD at River Mile (RM) 234 of the Colorado River. A review of the Mohave County Flood Insurance Study (FIS) shows that this elevation is specific to the California side of the river only, and is different from information found in the newer FIS for Mohave County, AZ.

The effective FIS for San Bernardino County lists a regulatory base flood elevation of 463.90 feet NAVD. This design uses the more conservative elevation of 464 feet NAVD as the base flood elevation for the project on the California side of the Colorado River. The vertical datum for all flood elevations shown on the San Bernardino County FIRM is NAVD88.

The effective FIS for Mohave County lists a regulatory base flood elevation of 465.3 feet NAVD. This is used as the base flood elevation for the project on the Arizona side of the Colorado River. The vertical datum for all flood elevations shown on the Mohave County FIRM is NAVD88.

In this 60% design, certain infrastructure (piping) cannot be located outside of the 100-year floodplain as defined by the above baseline flood elevation. PG&E will work with San Bernardino County and Mohave County Flood Administrator to ensure compliance with the county requirements for construction in the floodplain.

C.3 Structural

This section describes design criteria for physical structures made of concrete and steel.

C.3.1 Concrete

Minimum requirements are listed below for structural concrete:

- Strength of poured-in-place concrete will be a minimum of 5,000 pounds per square inch (psi) at 28 days for all structures. Lower strengths of 3,000 psi will be used for non-critical structural elements as indicated in the specifications. 2,000 psi will be used for concrete fill, pipe and conduit encasement.
- Cement will be clean, fresh, Type II/, low alkali, Portland cement conforming to ASTM C150.
- Aggregate will be non-reactive.
- Cement content for all structures will be a minimum of 7.5 sacks per cubic yard of concrete.
- Slump of concrete will be as low as practicable to produce a dense, well consolidated concrete and not exceed 4" unless otherwise authorized by PG&E Project Engineer.
- Finish of formed surfaces will be smooth and free of fins, honeycomb, and segregation.

- When the surfaces have become sufficiently hardened, they will be kept continually moist for a period of not less than seven days. Curing compound conforming to ASTM C309 may be used in-lieu of wetting surfaces only where approved by the Engineer.
- In conformance with the EIR mitigation measures AES-1d and AES-2e, integral color concrete will be used in place of standard gray concrete.

C.3.2 Reinforcing Steel (Minimum Requirements)

Minimum requirements for reinforcing steel are as follows:

- Reinforcing steel will be deformed, grade 60, conforming to ASTM A615, and be free from coating which will reduce the bond.
- Reinforcing steel will be sized in accordance with the Strength Design Method or Alternate method.
- Reinforcing steel splices will be in accordance with the requirements of ACI 318-11.

C.3.3 Dead Loads

Dead loads will consist of gravity loads induced by all structural elements, equipment, piping, and contained liquids.

C.3.4 Live Loads

Live loads for different structural elements are listed below:

- Roof live loads will be designed for a minimum live load of 20 psf.
- Stairs, walkways, and platforms will be designed for a minimum live load of 100 psf.
- Concrete floor on Grade and Grating will conform to the latest edition (2010) of the California Building Code (CBC), but will be a minimum live load of 500 psf, or Wheel Load of 16 kips.
- Elevated Concrete floor – 200 psf or Fork Lift load – 4 kips.
- Live load on aerial crossings (pipe bridges) will be minimum 500 pounds at alternate panel point of trusses.

C.3.5 Seismic Loads

The design will meet CBC (2010) and as amended by San Bernardino County and/or ASCE 7-10 "Minimum Design Loads for Buildings and Other Structures". Specifically:

- CBC 2010, Site Class D
- S_s = 0.434 (Needles, CA)
- S_1 = 0.135 (Needles, CA)

C.3.6 Wind Loads

The design will meet CBC (2010) and as amended by San Bernardino County and/or ASCE 7-10 "Minimum Design Loads for Buildings and Other Structures". Minimum Wind Load = 20 psf. Detailed structural design criteria are shown in Exhibit C.3-1.

EXHIBIT C.3-1
Structural Design Criteria
Groundwater Remedy Basis of Design Report/Intermediate (60%) Design
PG&E Topock Compressor Station, Needles, California

Category	Criteria
General	
Governing Code	CBC (2010) as amended by San Bernardino County, IBC 2009, ASCE 7-10
Concrete: CODE and SPECIFICATION	ACI 318-11, Building Code Requirements for Reinforced Concrete ACI 350-06, Environmental Engineering Concrete Structures
Concrete Masonry Units: SPECIFICATIONS	CBC (2010)
Structural Steel: SPECIFICATIONS	AISC Allowable Stress Design Specification for Structural Steel Buildings, 13^{th} Edition
Aluminum: SPECIFICATIONS	CBC (2010)
Concrete	
Strength	F'c = 5,000 psi for all structures (pipe bridge foundation and precast concrete containment trench), 3,000 psi for general structural concrete(pump pads, thrust blocks, valve vaults) and 2,000 psi for concrete fill, pipe/conduit encasement.
Reinforcing	ASTM A615, Grade 60, Type S
Prestressing Strand	ASTM A416
Welded Steel Wire Fabric	ASTM A185 or ASTM A497
Design	Strength Design or Alternate Method
Detailing	ACI SP-66(00) Manual of Standard Practice for Detailing Concrete Structures
Color	Integral color concrete in place of standard gray color concrete (EIR mitigation measures AES-1d and AES-2e)
Reinforced Masonry	
Concrete Masonry Units	ASTM C90, Grade N, Type I (Unit Compressive Strength f'm = 1,900 psi at 28 days
Mortar for Unit Masonry	ASTM C270, Type M, Minimum Compressive Strength at 28 days = 2,500 psi.
Reinforcing	ASTM A615, Grade 60, Type S
Cold-Drawn Steel Wire	ASTM A 482
Grout	ASTM C476, Minimum Compressive Strength at 28 days = 3,000 psi.
Structural Steel	
Structural "W" Shapes	ASTM A992 (Fy = 50 ksi)
Structural channels. plates, angles, etc.	ASTM A36 (Fy = 36 ksi)
Structural Tubing	ASTM A500, Grade B (Fy = 46 ksi)
Steel Pipes	ASTM A53, Grade B
Stainless Steel	Alloy Types conforming to ASTM A-167 and ASTM A-276.
Plates and Shapes	Type 316 unless otherwise noted
Bolts, Nuts and Washers	Type 316
Welding	AWS E70 Electrodes
High Strength Bolts	ASTM A325F, Min 3/4" Diameter
Other Bolts	ASTM A307, Grade A

EXHIBIT C.3-1
Structural Design Criteria
Groundwater Remedy Basis of Design Report/Intermediate (60%) Design
PG&E Topock Compressor Station, Needles, California

Category	Criteria
Anchor Bolts	ASTM A36
Chemical Anchor Bolts	SS Type 316, Hilti HVA Adhesive Type or Equal
Expansion Anchors	Hilti SS Quick Bolts, Type 316 or Equal Bolts, Nuts and Washers
Timber	
TBD	CBC (2010)
TBD	National Design Specification for Wood Construction

C.4 Geotechnical

A geotechnical data summary is included in Attachment C of this Appendix. The purpose of this geotechnical summary is to provide information on existing site geology and geotechnical data in support of the groundwater remedy design and to propose areas where supplemental geotechnical investigation is needed to verify design parameters. Coordination with the Soil RFI/RI investigation program was conducted in planning of the supplemental geotechnical investigation to minimize the number of boreholes, thereby minimizing ground disturbance. It is important to note that as PG&E continues to engage in discussions with transportation agencies, counties, and other property owners/land managers to obtain institutional controls, access agreements, and permits, additional geotechnical data may be required to meet specific requirements of agencies and/or property owners/land managers.

The geotechnical design criteria presented in Exhibit C.4-1 are based on existing site-specific geologic information and geotechnical data, to support foundation and trenching designs, as well as trenchless crossings (I-40 and BNSF crossings).

EXHIBIT C.4-1
Geotechnical Design Criteria
Groundwater Remedy Basis of Design Report/Intermediate (60%) Design
PG&E Topock Compressor Station, Needles, California

Parameter	Criteria
Moist soil unit weight	120 pounds per cubic foot (pcf)
Shear strength parameters	<u>Cohesionless Soils</u> Friction angle: from 32 to 35 degrees for compacted fill Friction angle: from 28 to 30 degrees for native soils <u>Cohesive Soils</u> Undrained shear strength: from 800 to 1,000 pounds per square foot (psf)
Controlling earthquake magnitudes	Mean earthquake magnitude is 6.6 Modal earthquake magnitude is 7.9
Peak ground acceleration	For structure design is 0.10 g (design value for Site Class D) For liquefaction assessment is 0.15 g (for Site Class D)
Allowable bearing capacity	4,000 psf
Allowable long-term settlement	1 inch

EXHIBIT C.4-1
Geotechnical Design Criteria
Groundwater Remedy Basis of Design Report/Intermediate (60%) Design
PG&E Topock Compressor Station, Needles, California

Parameter	Criteria
Sliding coefficient of friction	0.45
Lateral soil pressure equivalent fluid unit weight	Active pressure: 45 pcf Pressure at rest : 60 pcf. Passive resistance = 175 pcf
Temporary cut and fill slopes	2 Horizontal:1Vertical
Frost depth	8-10 inches

Additional Geotechnical Criteria

- Soil is corrosive to concrete structures and steel (resistivity > 1,000 ohm-centimeters, sulfate > 2,000 parts per million (ppm) and chloride > 500 ppm).
- Soil profile is classified as Site Class D (stiff soil site), as defined in the CBC (2010).
- Shallow foundations for buildings with support extending a minimum of 2 feet below lowest adjacent grade. Slabs and footings set on a minimum of 6" layer of granular base leveling course.
- Pipe design based on depth of fill, weight of fill, compaction of fill and modulus of soil reaction (E' = 1,000 psi).
- Native onsite materials may be considered for backfill if they have an expansion index (EI) less than 50 and contain less than 8 percent fines, as determined by ASTM D4829 and D422.

C.5 Mechanical

This section describes the design criteria associated with key mechanical elements of the project. Mechanical design will follow the California Mechanical Code (2010) unless noted, and fire requirements per the California Fire Code (2010).

C.5.1 Piping

Based on experience with operation and maintenance of the IM facilities, the groundwater in the floodplain has high levels of total dissolved solids, chlorides, sulfate, and other minerals that have caused significant corrosion to iron-based piping material from mild carbon steel to Type 316 stainless steel. Therefore, piping will be designed and installed in accordance with best practices and past site experience for operation and maintenance, including use of flanged or union joints for serviceability and isolation valves for systems requiring routine maintenance.

In general, piping materials will be compatible with the characteristic of the conveying fluids and will be single-walled unless the pipe is used to convey: (1) groundwater or remedy-produced water that exhibits the hazardous waste characteristic; or (2) concentrated carbon substrate. In these cases, double-walled piping will be used. Double-walled pipe segments conveying either of the fluids described above will include appropriately designed leak detection systems. Low point sumps/traps with level switches and alarms will be the primary method of detecting leaks. Continuous leak detection systems may be used as an alternative to low point switches if switches are deemed impractical or incompatible with the installation. Pipeline segments installed in belowground concrete trenches (e.g., Pipeline A) will be designed with leak detection at low points (level switch with alarm).

In the case of Pipeline H which connects to well IRL-4 located at the bottom of a wash, double walled pipe segments will be used to convey remedy produced water from the wellhead to a valve vault located on the plateau. As access to this well is difficult and via a steep slope, this containment design is to provide for safe operations during well rehabilitation where acids and chemicals are used. In the event of a leak, the secondary containment will drain to a concrete sump located at the wellhead. The concrete sump will be equipment with a level switch and alarm, as well as a sump pump.

Corrosion Control

For corrosion control, above ground and belowground steel pipe will be coated. Any steel pipe near the point where it emerges from the ground will be coated. Air-to-soil transition piping is any steel piping located 18" below ground or 6" above ground. Cathodic protection equipment will be applied as follows: 1) steel piping and structures will be cathodically protected underground; 2) plastic pipe (e.g., HDPE or CPVC or PVC) will be preferentially used when appropriate for corrosion resistance; and 3) steel pipe will be cement mortar-lined to prevent internal corrosion. Piping cathodic protection will conform to National Association of Corrosion Engineers SP0177-2007 Standard Recommended Practice - Mitigation of Alternating Current and Lightning Effects on Metallic Structures and Corrosion Control Systems. Exceptions to coating and cathodic protection requirements are steel casing pipes used for trenchless crossings.

In compliance with the EIR mitigation measures AES-1d and AES-2e, the external coatings used for wells, pipelines, storage tanks, structures, and utilities will consist of muted, earth tone colors that are consistent with the surrounding natural color palette, and matte finishes. Coating materials will be corrosion-resistant to protect the underlying surfaces.

Pressure Loss

For the freshwater and the remedy-produced water piping network, a hydraulic model built using the EPANET water supply program was used to simulate and optimize the piping design. Attachment B of this Appendix contains more details about the hydraulic modeling.

For the design of the in-situ remediation piping system, to ensure adequate distribution, the pressure loss in the branch distribution piping to each of the injection wells (including frictional losses and wellhead pressures from drop pipe frictional losses and pressure drop across the foot valve) will be designed to be 10 times higher than the pressure drop in the distribution header. The CIP loop conveyance piping will be designed to operate at a velocity of 3 to 5 feet per second (fps) and will have cleanouts at least every 400 feet.

C.5.2 Process Equipment

Primary process equipment (substrate dosing pumps, compliance related sensors, safety switches, etc.) will be designed for parallel operation or provide stand-by equipment to provide sufficient redundant capacity.

To the extent practical, all valving, instrumentation, manways, and access ladders for tanks will be located on the northern face (including northeastern face) of the remedial facilities to allow O&M personnel to work on the shady side during O&M activities.

C.5.3 Valves

Valves installed for throttling and flow control will include globe, needle, and diaphragm valves. Isolation valves will include; gate, ball, and butterfly valves. Other valves expected to be included in the remedy system include spring and swing check valves, pressure relief, air relief, variable orifice, foot, and vacuum relief valves. Carbon substrate storage tanks may include additional safety valves, including emergency ventilation and combination pressure/vacuum relief valves in accordance with applicable standards. Valves will meet PG&E and industry standards appropriate to the application and process conditions.

Exhibit C.5-1 lists potential valve types associated with the major equipment. Valves will meet industry standards appropriate to the application and process conditions. More details will be provided in the Intermediate design submittal.

EXHIBIT C.5-1
Potential Valve Type with Associated Device
Groundwater Remedy Basis of Design Report/Intermediate (60%) Design
PG&E Topock Compressor Station, Needles, California

Equipment	Potential Valve Type
Fresh Water Injection Pumps	Pressure reducing, ball, ~~gate~~, swing check
Riverbank Extraction Pumps	Swing check, globe, butterfly, ball
Transwestern Bench Extraction Pumps	Swing check, globe, ball
IRZ Pumps	Swing check, globe, ball, pressure reducing, pressure relief
East Ravine Pumps	Swing check, globe, ball
IRZ Backflush Pumps	Swing check, gate, ball
Freshwater Backflush Pumps	Swing check, butterfly, flow control, ~~multiport gate~~
Carbon Substrate Pumps	Pressure and vacuum relief, solenoid, swing check, motor operate valve, ball
Pipelines	Butterfly, motor-operated valve, combination air release, ball,
Well Maintenance Reagent Pumps	Ball, Swing check, solenoid, multi-port, motor-operated valve
Ethanol Storage and Transfer	Pressure and vacuum relief, swing check, solenoid, ball, emergency vent
Process Pumps (Submersible Sump Pumps, Air-operated Diaphragm Pumps, Metering Pumps, Centrifugal Pumps)	Butterfly, swing check, motor-operated valve, ball, solenoid

C.5.4 Water Storage Tanks

Fixed steel tanks used for storing conditioned remedy-produced water will be designed in accordance with American Water Works Association Standard D-100 (2011). Foundations will be designed in accordance with the structural criteria described in Section C.3 above. Frac tanks used for storing remedy-produced water will be fabricated of welded steel and equipped with axles and wheels to enable them to be moved. Corrosion prevention measures will be applied to all tanks, including internal coatings. Permanent metal tank(s) will also have internal and external cathodic protection except for ethanol tanks mounted on saddle-type supports.

C.5.5 Secondary Containment

Secondary containment systems will be sized and designed in conformance with NFPA standards and California Fire Code (2010). In general, key design criteria are:

- Containment Volume
  - Secondary containment for a single container (tank) will be 110 percent of the primary container. Secondary containment for multiple containers will be 100 percent of the largest container's volume or 10 percent of the aggregate volumes of all containers, whichever is greater. In addition to the aforementioned, secondary containment systems open to rainfall will also be sized to accommodate spillage from the largest single tank at a minimum plus a 24-hr rainfall, as determined by a 25-yr storm. All secondary containment systems open to fire sprinkler discharge will also be sized to accommodate the discharge from all sprinkler heads over the secondary containment system for 20 minutes. Sprinkler system requirements to be determined.

- Containment Construction and Drainage
  - Secondary containment will be constructed using materials capable of containing a spill or leak for at least as long as the period between monitoring inspections. Drainage can be accomplished through the use of one of the following methods:
    - Liquid-tight sloped or recessed floors in indoor locations or similar areas in outdoor locations
    - Liquid-tight floors in indoor locations or similar areas in outdoor locations provided with liquid- tight raised or recessed sills or dikes
    - Sumps and collection systems (e.g., collection sump)
    - Drainage systems leading to an approved location
    - Other approved engineered systems
  - Collection systems will be equipped with a monitoring system to monitor level in containment sumps. Upon detection of fluids in the sump an alarm will be initiated to alert the operators of a potential release.
- Overfill Protection
  - A means of providing overfill protection for primary container will be required. This may be an overfill prevention device and/or an attention getting high level alarm.
- Separation of Materials
  - Materials that in combination may cause a fire or explosion, or the production of a flammable, toxic, or poisonous gas, or the deterioration of a primary or secondary container will be separated in both the primary and secondary containment so as to avoid intermixing.

C.5.5.1 Remedy-produced Water Conditioning Plant and Associated Tank Farm Areas

The Remedy-produced Water Conditioning Plant will contain hazardous materials (caustic, acids, etc.) and the B-side Remedy portion of the plant will process water streams with known or suspected contamination. The conditioned water tank farm area will be equipped with the capability for local neutralization using caustic or acids. Therefore, these areas will be designed with the following secondary containment and monitoring systems:

- Area 1 – The influent storage tank farm area will have secondary containment constructed with concrete, coated with epoxy, and equipped with a collection sump and a sump pump that pumps to either the Influent Storage Tanks or the Compressor Station Clean Water Tank.[2] The destination will be selected manually. A level switch mounted in the sump will issue an alarm when liquids are detected.
- Area 2 – The remedy-produced water conditioning system will have secondary containment constructed with concrete, coated with epoxy, and equipped with a sump and a sump pump that pumps to the Influent Storage Tanks or the TCS Cooling Tower Blowdown line. Sump monitoring will be accomplished via a level switch and alarm.
- Area 3 – The conditioned water tank farm area will have secondary containment constructed with concrete, coated with epoxy, and equipped with a sump and a sump pump that pumps to the Clean Water Tank or the Influent Storage Tanks. Sump monitoring will be accomplished via a level switch and alarm.

C.5.5.2 Truck Loading/Unloading Areas

There will be three truck loading/unloading stations with one at the MW-20 Bench, one at the Transwestern Bench, and one at the Compressor Station. Each truck loading/unloading area will be equipped with a secondary

[2] The Clean Water Tank receives clean water from the Oil/Water Separator and other sources of non-oily wastewater streams such as the cooling tower blowdown. Water from the Clean Water Tank is pumped directly to the TCS evaporation ponds.

containment system constructed of epoxy-coated concrete, transfer pumps, pipes or hoses for connecting to the trucks, and sumps and sump pumps. The sumps will have level switches that will alarm in the event of a spill.

C.5.5.3 Decontamination Pad

Consistent with the EIR mitigation measure CUL-1a-9, the existing decontamination pad at the Transwestern Bench will be reused during remedy implementation. This pad will be repaired and equipped with a collection sump and a sump pump that pumps to the remedy-produced water conditioning plant at the Compressor Station. It will be used to store soil cuttings, water from groundwater sampling, and to clean/store equipment used in well installation, maintenance, and sampling.

C.5.6 Septic and Plumbing System

The bathrooms and showers in the Central Maintenance Facility at the Transwestern Bench will be connected to a new leach field. The work will follow PG&E standards and County codes (adopted California Plumbing Code 2010). Fresh water will be supplied for use in the onsite laboratories and sample preparation areas in the Maintenance Facility, Remedy-produced Water Conditioning Plant building, and the MW-20 bench. Washbasins or sinks in laboratories will be drained to tanks or containers specifically for storing the fluids. The contained fluids will be managed in accordance with applicable permits, and state and federal regulations.

Remedial buildings will include rain water downspouts with spill out fittings to outside splash blocks for surface runoff, potable water emergency eyewash and shower stations, and plant water piping with wash-down hose bibs and connections for flushing of the chemical feed systems. The emergency eyewash and shower stations will be located near the chemical storage/feed areas, unless existing stations are nearby, and will be provided with drains.

C.5.7 Fire Protection Equipment

The Remedy-produced Water Conditioning Plant at the Compressor Station and the Central Maintenance Facility at the Transwestern Bench are unclassified, as described by NFPA 820; hence, only fire hydrants for fire protection are required. No fire and explosion hazard, materials of construction and ventilation requirements are listed in NFPA 820 for these facilities. However, PG&E is evaluating the installation of a sprinkler system for the Maintenance Facility.

Portable fire extinguishers will be mounted in buildings in accordance with PG&E requirements and County Fire codes. Portable fire extinguishers will be ABC multipurpose dry chemical type UL-rated 20A:120B:C.

All electrical equipment will have Underwriters Laboratory approval where applicable. Areas of the electrical installation will be classified in accordance by Class, Division, and Group. Specifically, for the IRZ facilities at the MW-20 Bench and the Transwestern Bench, the following will apply:

- Class I, Division I within a 5-ft radius of the carbon storage tank vents.
- Class I, Division II within a 10-ft radius of the carbon storage tank vents (from vent elevation to ground).
- Class I, Division II from ground surface to 18-inches above grade within a 10-ft radius of the tank footprint.
- Class I, Division II within the carbon amendment building where there are pipes with >10% ethanol.

C.5.8 Heating, Ventilation, and Air Conditioning

The new heating, ventilation, and air conditioning (HVAC) systems in planned remedy facilities are independent of the existing Compressor Station HVAC system. The design criteria for makeup air and temperature control for the laboratory/office and motor control center (MCC) rooms are as follows:

- Office/laboratory: Summer temperature <86 degrees F with no control for humidity. Makeup ventilation rate at 0.15 cubic feet per minute (cfm) per square foot or 15 cfm/person by code requirements.
- MCC Room: Summer temperature <90 degrees F with no control for humidity.

Wall-mounted ductless mini-split heat pumps will serve the rooms. A second, 100 percent capacity redundant unit will be installed for the Office/laboratory space. Wall mounted ductless mini-split heat pumps have two main components: an outdoor compressor/condenser and an indoor air-handling unit. Each unit will be capable of both cooling and heating the space. A conduit that houses the power cable, refrigerant tubing, suction tubing, and a condensate drain links the outdoor and indoor units. The indoor units will be mounted on the upper part of the room wall. Each unit will be sized per the heating and cooling requirements of each room.

For ventilation air in the Office/laboratory space, a 60 cfm exhaust fan will be installed with either inlet door louvers or by undercutting the door to transfer outside air from the filter room.

Outside of the office/lab and MCC room, the first and second floors of the remedy-produced water conditioning system will be naturally ventilated by constructing the building with no walls on three sides of the first floor (north, east and west), a wall on the north side with louvers, and a steel grating on the second floor adjacent to the filters and outside the MCC room and laboratory/office.

C.5.9 Air Pollution Control

Temporary and permanent mobile and fixed equipment emissions will comply with Clean Air Act - USC §§ 7401, et seq. (National Emission Standards for Hazardous Air Pollutants [NESHAP]); 40 Code of Federal Register (CFR) 61; 40 CFR 63 and local air district requirements (e.g., Mojave Desert Air Quality Control District).

C.5.10 Hazardous Materials Storage

The Hazardous Materials Division of the San Bernardino County Fire Department is the Administering Agency and the CUPA for San Bernardino County with responsibility for regulating hazardous materials handlers, hazardous waste generators, underground storage tank facilities, aboveground storage tanks, and stationary sources handling regulated substances. The handling and management of hazardous materials within the remedy facilities (e.g., the remedy-produced water conditioning facility) located within the Compressor Station will be incorporated into the existing Compressor Station Hazardous Materials Business Plan (HMBP). A separate HMBP will cover the handling and management of hazardous materials at remedy facilities located outside of the Compressor Station (e.g., MW-20 Bench, Transwestern Bench). A table of contents for the HMBP is provided in Volume 1 of the O&M Manual; complete plans will be provided at the 90% design stage. PG&E is in discussion with San Bernardino County regarding the HMBP; additional details will be provided at 90% stage.

Chemicals that are anticipated to be used in remedy processes and stored on site are listed below with location (estimated quantities of chemicals will be provided in the 90% design after process parameters have been confirmed):

- Potential chemicals to be used and stored for the Remedy-produced Water Conditioning System at the Compressor Station include the following:
  - 25% sodium hydroxide (caustic)
  - 19% hydrochloric acid
  - A coagulant is under evaluation for aiding in settling solids in the Conditioning System (if determined to be needed in the process, it will be identified during the 90% design)
  - A flocculent addition is under evaluation to aid in the dewatering of the influent tank bottoms prior to pumping to the liquid phase separators (the need for this dewatering aid and flocculent type would have to be tested during operations)
- Potential chemicals to be used and stored for the freshwater pre-injection treatment at the Compressor Station include the following:
  - An oxidizer such as calcium hypochlorite
  - An acid like sulfuric acid for pH adjustment and media regeneration
  - A caustic for pH adjustment and media regeneration

- Potential chemicals to be used and stored at the carbon amendment facilities include the following:
  - Carbon substrate (95% ethanol and 5% isopropyl alcohol) – one 15,000-gallon tank located at the MW-20 Bench and one 3,000-gallon tank located at the Transwestern Bench
  - Acids, caustics, and/or dispersants for use in the Clean-In-Place (CIP) systems at the MW-20 Bench and Transwestern Bench

Potential chemicals to be used in well maintenance include hydrochloric acid, sulfamic acid, sulfuric acid, phosphoric acid, hydroxyacetic acid, acetic acid, citric acid, oxalic acid, ascorbic acid, hydrogen peroxide, sodium hypochlorite, sodium hydroxide, chlorine dioxide, potassium hydroxide, polyphosphate, Aqua Clear™ PFD, Rodine-103/Rodine 213, QC-21, CB4, NuWell 120, NuWell 130, nitrogen, and/or carbon dioxide. These materials will be brought on site during the well maintenance/rehabilitation activities, but will not be permanently stored on site.[3]

C.6 Electrical

In this section, the electrical design criteria and goals are described. Electrical systems and equipment will be designed to meet PG&E standards and the California Electrical Code (2010) unless specifically noted. The new Remedy electrical power distribution system will receive power from a single source; potential sources of power are under evaluation by PG&E. Regardless of its source, electrical power will be distributed to the project loads at the Transwestern Bench, the Remedy-produced Water Conditioning Plant at the Compressor Station, the MW-20 Bench, and three distribution locations for wells.

C.6.1 Safety, Availability, Reliability, and Efficiency

Of paramount importance is the need to minimize electrical hazards to operating personnel, including shock, arc flash, electrical fire, and combustion of explosive atmospheres. This is accomplished by applying electrical equipment within its ratings and in accordance with the electrical, fire, and life safety codes listed herein. Every 480 volt and above disconnect will have provisions for lock-out tag-out. This will provide safe working for equipment that may not be in view of the breaker handle. Where possible, the breaker handles will be in view of the connected load for additional safety.

A backup generator will be available for use by this project. The location of the generator will be determined by the 90% stage.

The power distribution system will include energy management features, such as real-time power and energy monitoring, which can be used in conjunction with process data to optimize process efficiency.

C.6.2 Distribution Voltage Selection

The project's standard distribution systems include the following:

- 12.47 kV, ungrounded delta, 3-phase, 3-wire
- 480Y/277 volts solidly grounded wye, 3-phase, 4-wire
- 240/120 volts solidly grounded wye, 1-phase, 3-wire
- 208/120 volts solidly grounded wye, 3-phase, 4-wire

The distribution voltages used throughout the project will be selected to reduce maximum load flows to levels below standard electrical equipment capacity ratings, to increase the distance that it may be transmitted, to reduce fault duty to levels standard electrical equipment withstand and interrupting ratings, and to minimize the cost of the electrical installation. Exhibit C.6-1 lists the equipment utilization voltages.

[3] For additional details, see the Operations and Maintenance Manual, Volume 1, Section 4, Exhibit 4.2-5.

EXHIBIT C.6-1
Equipment Utilization Voltages
Groundwater Remedy Basis of Design Report/Intermediate (60%) Design
PG&E Topock Compressor Station, Needles, California

Equipment	Volts	Phase
Fluorescent Lighting	120	Single, in office areas
Incandescent Lighting	120	Single
High-Intensity Discharge Lighting	120 or 240	Single
Other lighting	120	Single
Convenience Outlets	120	Single
Motor Control	120	Single
Motors, less than 1/2 horsepower (hp)	120	Single
Motors, 1/2 hp and above	480	Three

C.6.2.1 Voltage Drop

Total voltage drop from the transformer secondary to the point of utilization, including feeder, branch circuit, and transformation, will not exceed:

- Lighting - 3 percent
- Motors - 5 percent
- Receptacles - 5 percent
- Electric Heaters - 5 percent

Voltage dip calculations will be performed for motor starting whenever an individual motor exceeds 20 horsepower or if the motor is the longest or shortest distance from the transformer.

C.6.2.2 Demand Factors

The demand factors listed in Exhibit C.6-2 will be used for sizing power switchboards, MCCs, panelboards, and transformers. Connected load will be used for circuit and equipment sizing in accordance with NEC requirements. A 10 to 20 percent spare capacity will be provided at MCCs and panelboards. In accordance with the NEC, where it is unlikely that two or more coincident loads will be in use simultaneously, only the largest load(s) that will be in operation at one time will be used for calculating the total load of a feeder.

C.6.2.3 Metering

Multifunction digital meters will be provided for the MCC in the Remedy-produced Water Conditioning Plant.

C.6.2.4 Branch Circuits

- Connected load and NEC requirements will be used for sizing branch circuit breakers and conductors.
- A minimum wire size of No. 12 American wire gauge (AWG) copper will be used for lighting and receptacle branch circuits. No. 10 AWG will be used when voltage drop requires a larger conductor on lighting circuits, and when receptacle circuits are longer than 75 feet. Where electronic ballasts are specified for fluorescent or high-intensity discharge lighting, a dedicated neutral will be provided for each lighting circuit. There will be NO common neutral for multiple lighting circuits.
- In general, lighting branch circuit loads will be limited to 1,500 watts. Lighting and receptacle branch circuits will not be combined, and the number of convenience receptacles on any one branch circuit will be limited to five duplex in process areas, and six duplex in office areas.

- The electrical design will include a circuit and raceway schedule providing unique names and termination location information for each power, control, and signal circuit.

EXHIBIT C.6-2
Demand Factors
Groundwater Remedy Basis of Design Report/Intermediate (60%) Design
PG&E Topock Compressor Station, Needles, California

Service	Demand Factor
Lighting	1.0 x Connected Load
Emergency Lighting	1.0 x Connected Load
Air Conditioning Equipment	1.0 x Connected Load
Ventilation Equipment	1.0 x Connected Load
Drainage Pumps and Ejectors	1.0 x Connected Load
Convenience Receptacles	180 VA each [a]
Process Loads	1 x Full Load Amps of loads plus 25% of largest motor

Notes:
a. Apply NEC demand factor of 50% for totals over 10 kW
VA = volt-amperes

C.6.2.5 Panelboards

- Branch circuits or feeders on the drawings will identify the panelboard and device protecting the individual circuit or feeder.
- Each panelboard will be equipped with a minimum of 20 percent spare breakers with spaces, bus work, and terminations to complete the standard size panelboard.
- Panelboard schedules will be prepared indicating circuit identification, protective device trip rating, number of poles, load in volt-amps by phase, rating of main lugs or main circuit breaker, neutral bus size, ground bus size, and the integrated short circuit rating of the panelboard.

C.6.2.6 Uninterruptible Power Supply

Uninterruptible power supply (UPS) will be provided for each control panel. The UPS output will be automatically selected through an automatic bypass relay.

C.6.2.7 Motor Control and Protection

Safety interlocks, such as emergency stop pushbuttons, will be hardwired directly to motor control circuits. Process controls and interlocks will be hardwired from Supervisory Control and Data Acquisition (SCADA) system programmable logic controllers (PLCs) to motor starters. Electrical metering data will be transmitted from intelligent motor overloads and relays to the SCADA system over an Ethernet network. Elementary (ladder-type) control diagrams will be prepared for each motor showing control wiring, pilot devices, auxiliary contacts, and external connections. A single diagram will be used for more than one motor having the same control.

In addition, the following guidelines will be used:

- Adjustable overload relays will be provided for all MCC-mounted and remote mounted constant-speed motor controllers. MCC-type construction will be used.
- MCCs located in the same room with the switchboard that powers them will not have a main circuit breaker. MCCs located in areas remote from the common MCC or switchboard that powers them will have a main circuit breaker.

- MCC enclosures will be NEMA 1 gasketed. Circuit breakers 225 amps and smaller and motor starters NEMA 4 and smaller will be the cubicle type with auto disconnect of control and motor power conductors.
- MCCs will include feeder circuit breakers and motor starters. Motor starters for motors up to 25 hp will be the full-voltage, non-reversing, combination type with a magnetic-only circuit breaker. Motor starters for motors larger than 25 hp will be the solid-state, soft-start, reduced-voltage, combination type with a magnetic-only circuit breaker.
- Motor starters will include an ON/OFF/AUTO or HAND/OFF/REMOTE selector switch, GREEN motor ON light, RED motor OFF light, and AMBER abnormal condition, fault, or alarm lights, as required. Lights will be the LED push-to-test type. These devices will be mounted on the front of the motor starter control center cubical.

C.6.2.8 Equipment Identification

Process and instrumentation diagram (P&ID) tag numbers will be used for motors, instrumentation and control devices, and other process equipment shown on electrical drawings. This same numbering method will be used to create unique tags for major electrical distribution equipment.

C.6.3 Electrical Equipment

This section discusses general guidelines for the selection and configuration of electrical equipment.

C.6.3.1 Distribution System Equipment

Equipment will be selected with adequate momentary and interrupting capacity for the point in the system where it is used. Series-rated criteria will not be used, except for self-contained equipment. Where practical, phase and ground fault protective devices and device settings will be selected that will function selectively to disconnect that portion of the system that is malfunctioning, and with as little disturbance to the rest of the system as possible.

Distribution equipment criteria include the following:

- 15 kV-class metal-clad switchgear will be specified to provide power distribution selection at the front end of the Remedy system.
- The switches will be interlocked, so only one power feed will be allowed to connect to the system at any given time. There will not be any provisions or need for paralleling systems.
- 15 kV-class cable will connect the transformers together through underground conduit.
- Sectionalizing equipment will allow for individual transformers to be isolated and replaced or repaired.
- The transformers will be distribution style, similar to those used for commercial buildings. The secondary voltage will be 480/277 volt.
- 480-volt MCCs with combination motor starters of the motor circuit protector (MCP) type rated for the available fault current.
  - Starters that are NEMA size 2 (25 hp) and larger will be the solid-state, soft-start type or adjustable-speed drives.
  - MCCs will be hardwired to the PLC for motor control.
  - Field-mounted, maintained, emergency stop push buttons will be hardwired directly to the motor starter.
  - MCCs will be sized to accept future loads and either allow for space in the structures, or floor space for future sections.
- 480-volt and 240/120-volt power distribution and lighting panelboards with molded case, bolt-in, circuit breakers with integrated short-circuit rating suitable for the available fault current.

C.6.3.2 Raceway Systems

Separate ductbanks will be used for the following systems:

- 12.47-kV power distribution
- 480-volt power wiring and 120-volt control wiring
- Communications systems, including Ethernet, low-voltage signal for fire alarm, telephone and data systems, and fiber optic cabling

Special consideration will be given to separation of raceways involving low-level process control signal wiring and power system wiring to minimize the possibility of interference. General guidelines for raceway sizing, selection, and installation are as follows:

- Conduit sizing will be based on Type THW insulation.
- The following minimum sizes will be used:
  - 3/4-inch minimum diameter for conduit not in ductbanks used within buildings or connected directly to the equipment or device.
  - 1-inch minimum diameter for conduit in ductbanks for field interconnection of equipment or buildings.
- Raceways will be a combination of concealed and exposed in process areas.
- Raceways will be concealed in walls and ceilings in control rooms, offices, and areas that have finished interiors.
- PVC-coated rigid galvanized steel conduit will be used for the transition from underground direct burial and under-slab PVC conduit and concrete-encased (in-floor slab) PVC and rigid galvanized steel conduit to exposed rigid galvanized steel conduit. The transition section will extend from 1 foot below grade or top of floor slab or the last foot of conduit in the floor slab, to 6 inches out of the floor slab, concrete encasement, or above grade.
- The number of conduit bends will be limited to an equivalent of 270 degrees on long runs without pull boxes.
- PVC-coated rigid galvanized steel conduit and fittings that are resistant to direct sunlight and include an interior urethane coating will be used in exposed corrosive interior and exterior areas. This conduit will also be used for underground direct-burial. Direct buried conduit will have a 3-inch red colored concrete cap.
- PVC Schedule 40 conduit and fittings will be used for under-slab and concrete-encased ductbanks.
- Rigid galvanized steel conduit and fittings will be used when exposed in interior non-corrosive process and non-process areas, pre-cast concrete utility trenches, and in non-corrosive areas outdoors.
- Flexible, nonmetallic, liquid-tight conduit 4 inches or smaller in size will be used for connections to motors, transformers, etc., as required. Fittings will be PVC-coated in wet or corrosive areas. Length of flexible conduit will be limited to 36 inches.
- Underground conduit routes will be identified with nonmetallic warning tape and tracer wire above underground direct-burial conduits.
- Raceways will be tagged with a engraved plastic or nonferrous metal embossed tag attached to the raceway with a stainless steel wiring. Raceway tags as defined in the plans and conduit schedule will be located at each terminus, pullbox, and at minimum intervals of every 50 feet on exposed raceways (in ceiling spaces and surface-mounted).
- Cable trays will be evaluated for use where appropriate.

C.6.3.3 Wire and Cable

- Stranded copper conductors will be used for all except lighting and receptacle wiring. Solid conductors No. 10 AWG and smaller will be used for lighting and receptacle wiring.
- A minimum conductor size of No. 12 AWG will be used for power and lighting branch circuits. Type THHN/THWN-2 insulation will be used for No. 10 AWG and smaller conductors (conduit will be sized for Type THW conductors). Type XHHW-2 insulation will be used for No. 8 AWG and larger conductors (conduit will be sized for THW conductors). Conductor ampacity ratings of 75°C will be used for sizing conductors.
- A minimum conductor size of No. 14 AWG will be used for individual 120-volt control circuits.
- A minimum conductor size of No. 14 AWG will be used for 120-volt control circuits routed in a common conduit with the power conductors to the motor circuit controls. Combining individual motor power and control conductors in a common conduit will be done up to a maximum power conductor size of No. 2 AWG.
- Power and control conductors will be color-coded. Conductors No. 8 AWG and smaller will have colored insulation. Conductors No. 6 AWG and larger will be color-coded with tape at each end and at accessible intermediate points.
- Conductors and control cables will be tagged with a permanent sleeve or nylon marker plate attached with a nylon strap. Conductor tags with an approved tag number will be provided by the Contractor and will be located in accessible locations at each termination.
- Under normal conditions, the maximum wire size will be limited to 500 kcmil. Parallel conductors will be used for circuits requiring greater capacity.
- The 120-volt control circuits will be combined in control cables containing multiple No. 14 AWG stranded copper conductors with type THHN insulation and a common PVC outer jacket.
- A 600-volt multi-circuit control cable will be used where grouping control circuits is practical, and the number of individual wires exceeds six conductors. When selecting control cable size, 25 percent spare (plus or minus 10 percent) conductors will be used.
- Multi-conductor control cable color-coding will be ICEA S-61-402 Appendix K, Method 1, Table K-2.
- Low-voltage analog signal circuits will be routed in 600-volt single twisted shielded pair instrumentation control cables. The cables will consist of No. 16 AWG stranded copper conductors with combination PVC/nylon insulation, drain wire, shield, and PVC outer jacket. Signal circuits may be combined in multi-twisted shielded pair instrumentation control cables with common overall shield. The cables will consist of No. 18 AWG minimum stranded copper conductors, with a combination PVC/nylon insulation, pair and common drain wires, pair and common shields, and PVC outer jacket. Instrumentation control cables will be in accordance with ICEA S-82-552. Low-voltage analog signal circuits will not be routed in the same control cable or conduit with 120-volt control or power circuits.
- Adequate separation of power and instrumentation and control (I&C) wiring will be provided to avoid signal interference.
- Shielded power cables will be used between adjustable-frequency drives and the driven motor.

C.6.3.4 Color Coding

Conductor insulation colors will be as shown in Exhibit C.6-3.

EXHIBIT C.6-3
System Color Coding
Groundwater Remedy Basis of Design Report/Intermediate (60%) Design
PG&E Topock Compressor Station, Needles, California

System	Conductor	Color
All Systems	Ground	Green
208Y/120 Volts	Neutral	White
	Phase A	Black
	Phase B	Red
	Phase C	Blue
240/120 Volts	Neutral	White
	Phase L1	Black
	Phase L2	Red
480Y/277 Volts	Neutral	White
	Phase A	Brown
	Phase B	Orange
	Phase C	Yellow
12.47 kV	Phase A	Phase A
	Phase B	Phase B
	Phase C	Phase C

C.6.3.5 Circuit Identification

Circuit names will be assigned based on the device or equipment at the load end of the circuit. Circuits will be identified at each termination and in accessible manholes and pull boxes. Plastic sleeves for conductor No. 3 AWG or smaller and plastic marker plates for larger conductors will be used. For lighting circuits, the panel and circuit number will be identified for each fixture.

C.6.3.6 Enclosures

NEMA 1 enclosures will be used for equipment in electrical rooms and finished areas, while NEMA 12 enclosures will be used for electrical equipment in dry industrial locations. NEMA 3R enclosures will be used for outside and in wet locations, and NEMA 4X enclosures will be used for corrosive locations. NEMA 4 enclosures will be used for underground and in wet locations.

C.6.3.7 Fiber Optic Cabling

Where used, fiber optic cabling will be installed either in conduit (4-inch-diameter minimum with three 1 ¼-inch inner ducts), or in a cable tray. Routing of the raceway system will provide for large-radius turns to prevent breaking of the fiber optic cable.

C.6.3.8 Convenience Receptacles

General-service duplex receptacles will not be spaced more than 25 feet apart in process areas. Receptacles will be surface-mounted on walls or columns. Weatherproof receptacles will be installed in damp areas or areas subject to washdown.

Outlet-mounted ground-fault circuit-interrupters (GFCIs) will be provided where required by the NEC. Panelboard or feed-through-type devices will not be used.

C.6.3.9 Low Voltage AC Induction Motors

Enclosures for both horizontal and vertical motors 25 hp and smaller will be totally enclosed, fan-cooled (TEFC) severe-duty for indoor and outdoor locations. In wet and/or corrosive locations, chemical industry severe-duty (CISD-TEFC) motors will be used. Motors larger than 25 hp will be open drip-proof, unless TEFC or CISD-TEFC is required for specific conditions (evaluated on a case-by-case basis considering cost and required physical protection). Submerged motors will be totally submersible, air- or oil-sealed. Bearings will be rated for 100,000-hour Anti-Friction Bearings Manufacturers' Association (AFBMA) B-10 life.

Alternating current (AC) induction motors will be the premium efficiency type with the following:

- Motors will have a 1.15 service factor at 50 degrees Celsius ambient, except where inverter-duty rated.
- NEMA design letter to fit the application (usually NEMA design B), and locked rotor kV-amps kVA Code G or lower.
- Motor windings will be copper wire.
- Motors 15 hp and larger located in damp or wet areas will be provided with 115-volt space heaters to prevent moisture condensation.
- TEFC motors will be equipped with weep holes and drain plugs to withdraw condensed moisture.
- Motors operated by variable frequency drives (VFDs) will be specified with special provisions for inverter duty operation.

C.6.4 Electrical Systems Analysis

An analysis of the fault current will be made during the 90% design. Maximum fault current will be analyzed with sufficient accuracy to establish the required interrupting ratings of circuit protective devices specified.

During construction, a final load flow, short circuit, coordination, and arc flash hazard analysis will be performed by the Project Engineer, based on actual equipment purchased, to establish protective device settings that will result in reasonable selectivity of device operation for both three-phase and ground faults, while minimizing the arc flash hazard to workers. The following protective device characteristics will be specified:

- Protective relay model, pickup, and time delay settings
- Circuit breaker model, frame size, trip unit, trip settings, and time delay settings
- Current transformer ratios

Arc flash labels will be placed on the installed electrical equipment.

C.6.5 Grounding System

An integrated grounding system will be installed throughout the new remedial facilities and interconnected with the existing grounding system at the Compressor Station. A lightning protection system will be connected to the facility ground ring as well as to any exposed metallic surfaces.

Grounding electrode ground mats or embedded rods and cables will be designed for a maximum resistance to ground of 25 ohms. Where more than one rod is required, rods will be installed at least 20 feet apart. A minimum of No. 4/0 AWG stranded bare copper cable will be used for interconnecting to ground rods and footing rebar.

A lightning protection system will be designed with air terminals and separate grounding system on buildings or structures used for operations and maintenance and chemical storage, including shade structures. Shade structures, if isolated from electrical equipment, may not be required to have lightning protection.

Equipment Grounding

A separate ground conductor sized in accordance with NEC requirements will be installed in raceways for power feeders and branch circuit raceways for motor control, lighting, and receptacle loads.

Shields of shielded instrumentation cables will be grounded to the ground bus at the power supply for the analog or low-voltage discrete signal circuit. Shielded instrumentation cables will not be grounded at more than one point.

C.6.6 Hazardous and Corrosive Area Definition

Area classification will be shown on the drawings and will be defined at the 90% design stage.

C.6.7 Energy Efficiency and Lighting

Energy efficiency will be a factor in equipment selection. Motors will be specified to be Premium Efficient per latest NEMA MG 1 standard where possible. Lighting equipment and facilities for safe operations will be designed to be energy efficient and comply with California Title 24 and county lighting ordinances. In compliance with EIR mitigation measure CUL-1a-7, to minimize construction and operations-related lighting impacts, the lighting for the remedy will include the following features: (1) shrouding/shielding for portable lights during construction and operational activities; (2) installation of portable lights at the lowest allowable height and in the smallest number feasible to maintain adequate night lighting for safety; and (3) shielding and orientation of lights such that off-site visibility of light sources, glare, and light from construction activities are minimized to the extent feasible. In addition, no additional permanent poles will be installed for lighting.

C.6.7.1 General Lighting Requirements

Since CUL-1a-7 is not meant to replace or subsume any actions required by the County or state or federal entities with regard to lighting required for minimum security and safety purposes, the following specifications will also be met:

- Construction Industry 29 CFR 1926.56 (lighting safety requirements)
- General Industry 29 CFR 1910.120 (HAZWOPER) (lighting safety requirements)
- San Bernardino County Code Title 8 Section § 83.07.040 Glare and Outdoor Lighting - Mountain and Desert Regions
- Mohave County Outdoor Light Control Ordinance 87-1
- Specific requirements from land owners, if feasible and is not in conflicting with the mitigation measures and county codes

The San Bernardino County lighting requirements are divided into two categories: residential and commercial/industrial. Remedy facilities are located both on and outside of PG&E-owned land, as follows:

- PG&E parcel (zoned industrial) – Compressor Station and Transwestern Bench
- Outside of PG&E parcel (zoned recreational) – Federally-owned land (including MW-20 Bench), the Havasu National Wildlife Refuge, and Fort Mojave Indian Tribe-owned land

PG&E will apply industrial requirements on the PG&E parcel and residential requirements outside of the PG&E parcel. The rationale for installing lights outside of the PG&E parcel is as follows:

Well Sites

- Nighttime access is not necessary; therefore no permanent lights will be installed. No new permanent light poles will be installed.
- Portable or truck-mounted lights can be brought in the event that an emergency or unforeseen condition occurs and plugged in locally.

MW-20 Bench

- Similar to the IM-3 Brine Storage Facilities located at the MW-20 bench, nighttime access is not normally required. Exterior lights will be installed but activated manually.
- No new permanent light poles will be installed.

In both Mohave and San Bernardino Counties, the lighting requirements are intended to reduce glare or other light emissions on adjacent properties. Exhibit C.6-4 lists San Bernardino County shielding requirements for different types of fixtures in residential and commercial areas.

EXHIBIT C.6-4
Shielding Requirements For Outdoor Lighting in the Mountain Region and Desert Region
Groundwater Remedy Basis of Design Report/Intermediate (60%) Design
PG&E Topock Compressor Station, Needles, California

Fixture Lamp Type	Residential Area Shielded	Commercial/Industrial Area Shielded
Low pressure sodium	Fully	Fully
High pressure sodium	Prohibited except fully shielded on streets	Fully
Metal halide	Prohibited	Fully
Fluorescent	Fully	Fully
Quartz	Prohibited	Fully
Incandescent > 60 watts	Fully	Fully
Incandescent 60 watts or less	No requirement	No requirement
Glass tubes filled with neon, argon, or krypton	No requirement	No requirement
Mercury vapor	Prohibited	Fully
Halogen	Prohibited	Fully
Searchlights for advertising purposes	Prohibited	Prohibited
Laser source light or similar light intensity light for advertising purposes	Prohibited when projected above the horizontal	Prohibited when projected above the horizontal

Source: San Bernardino County Development Code, Ch. 83.07.040 Table 83-7. Note that LED lights (a low energy form) may be suitable for the Remedy. This technology is not covered in the County Code.

Fixtures prohibited by the County Code will not be used on the project. Fixtures planned for use in the remedy project are listed in Exhibit C.6-5. Fixtures used at the Compressor Station will comply with County requirements and follow PG&E standards for energy efficiency and lighting at operating facilities.

EXHIBIT C.6-5
Planned Fixtures for Remedy and Associated County Requirements For Outdoor Lighting
Groundwater Remedy Basis of Design Report/Intermediate (60%) Design
PG&E Topock Compressor Station, Needles, California

Fixture Lamp Type	Shielding Requirement	Type Used in Remedy Project?
Low pressure sodium	Fully	Indoors/Outdoors
Fluorescent	Fully	Indoors
Incandescent > 60 watts	Fully	Indoors
Incandescent 60 watts or less	No requirement	Indoors
LED	No requirement (not covered in the County Code)	Indoors

Source: San Bernardino County Development Code, Ch. 83.07.040 Table 83-7.

The amount of light or the illumination level is based on having sufficient light to do the expected tasks safely. OSHA sets standards for construction activities as shown on Exhibit C.6-6 below.

EXHIBIT C.6-6
Minimum Illumination Intensities
Groundwater Remedy Basis of Design Report/Intermediate (60%) Design
PG&E Topock Compressor Station, Needles, California

Level (foot-candles)	Area of Operation
5	General construction area lighting.
3	General construction areas, concrete placement, excavation and waste areas, access ways, active storage areas, loading platforms, refueling, and field maintenance areas.
5	Indoors: warehouses, corridors, hallways, and exit ways.
5	Tunnels, shafts, and general underground work areas. (Exception: minimum of 10 foot-candles is required at tunnel and shaft heading during drilling, mucking, and scaling. Bureau of Mines approved cap lights shall be acceptable for use in the tunnel heading.)
10	General construction plant and shops (e.g., batch plants, screening plants, mechanical and electrical equipment rooms, carpenter shops, rigging lofts and active store rooms, mess halls, and indoor toilets and workrooms.)
30	First aid stations, infirmaries, and offices.

Source: Safety Lighting Levels During Construction – OSHA 29 CFR 1926.56(a) Table D-3.

For activities and areas not included under the OSHA standard, the ANSI/IES has established recommended illumination levels under Recommended Practice RP-07-01 (see Exhibit C.6-7 below).

EXHIBIT C.6-7
Recommended Illumination Levels per ANSI/IES RP-07-01
Groundwater Remedy Basis of Design Report/Intermediate (60%) Design
PG&E Topock Compressor Station, Needles, California

Category	Description	Level
A	Public spaces	3 fc (30 lux)
B	Simple orientation for short visits	5 fc (50 lux)
C	Working space where simple visual tasks are performed	10 fc (100 lux)
D	Performance of visual tasks of high contrast and large size	30 fc (300 lux)
E	Performance of visual tasks of high contrast and small size, or tasks of low contrast and large size	50 fc (500 lux)
F	Performance of visual tasks of low contrast and small size	100 fc (1,000 lux)
G	Performance of visual tasks of critical importance	300 – 1,000 fc (3,000 – 10,000 lux)

Notes:
fc=foot-candles
1 fc ≈ 10 lux

C.6.7.2 Lighting Calculations

The recommended illumination level (foot-candles) for each space will be calculated in accordance with IES procedures. The following assumptions will be made, unless specific information is available:

Reflectances for finished rooms:

- Ceilings 80 percent reflectance
- Walls 50 percent reflectance
- Floors 20 percent reflectance

Reflectances for unfinished rooms:

- Ceilings 50 percent reflectance
- Walls 30 percent reflectance
- Floors 10 percent reflectance

Maintenance factor (light loss factor):

- Fluorescent lighting 0.80

C.6.7.3 Emergency Lighting System

- Emergency illumination will be provided in appropriate spaces, as required by code to provide life safety, property, and equipment protection.
- Adequate lighting levels will be provided to maintain safe building egress and critical process plant functions. Emergency lighting will be located near MCCs and any equipment locations that need to be monitored on a continuing basis.
- In large process areas, emergency standby lighting units with a battery pack and two lamps and lighted exit signs with a battery pack will be provided. The battery pack will power the lights for at least 90 minutes.

- In non-process and finished areas, continuous-on lights with emergency ballast and battery pack, and exit signs with a battery pack will be provided. The continuous-on light battery pack will power one fluorescent lamp and the exit sign battery pack will power the exit sign for at least 90 minutes.

C.6.7.4 Explosion-Proof Luminaires

Any room or space listed as a hazardous atmosphere area will have explosion-proof-type luminaires UL listed for installation in the hazardous area classifications, as required by Article 500 of the NEC.

C.6.7.5 Nighttime Construction Lighting

The first step will be to determine whether nighttime construction work is required. Nighttime construction-related activities will be limited to work that cannot be disrupted or suspended until the following day, such as, but not limited to, well drilling and development or decommissioning activities. If nighttime construction is required, the following principles will be applied:

- Identify the active area for construction and the applicable lighting standards. Only areas of active construction may be illuminated.
- Obtain portable lighting (including solar-powered). Lights must include shielding/shrouding (e.g., downward facing fixtures with cutoff shields to reduce light diffusion). No permanent poles will be installed for nighttime lighting.
- Install the minimum lighting feasible to maintain adequate night lighting for safety at the lowest allowable height. Orient the lights such that off-site visibility of light sources, glare, and construction activities is limited.
- Assign a responsible member of the construction crew, such as foreman or crew boss, to extinguish the lighting as soon as the nighttime construction work is completed.

C.6.8 Communications

Fiber optic cable or conventional copper wire will be used for sending signals via cable. Wireless communications devices like radio, satellite, or cellular, may be used as appropriate.

C.6.9 Existing Utilities

All existing utilities will be potholed for actual depth prior to construction following Compressor Station or utility owner methods and requirements, including maintaining a minimum 25-foot right-of-way for the L300 gas pipelines located near occupied buildings. Existing engineering drawings have been reviewed to identify areas of potential conflict, but are for planning purposes only, not solely relied upon. A utility survey was conducted in early 2012 to support the remedy design. See also Section C.2.2, Earthwork.

C.7 Instrumentation and Control

The I&C system for the project will utilize a stand-alone SCADA system and local PLCs. The SCADA system will be located at the Central Maintenance Facility (Transwestern Bench) and will provide monitoring, supervisory control, alarming, and control functions. Historian software will collect, archive and distribute project-wide raw data and provide access to historical data.

In general, emergency shutdown of equipment due to alarm conditions (low discharge flow, high discharge pressure, motor overload, pump seal water failure, high level vault alarms, etc.) will be hardwired and will occur remotely or be executed locally. These alarm conditions will require manual reset at the SCADA or the local digital controller. In conformance with the EIR mitigation measure CUL-1a-6, all additional phone calls and alarms associated with remediation activities or facilities will not be routed through PG&E's existing alarm system utilized at the Compressor Station. The notification system for remediation-related alerts and/or phone calls will not introduce additional noise to the project area, to the maximum extent feasible, provided there is ongoing compliance with applicable safety regulations or standards of the Federal Energy Regulatory Commission, Occupational Safety and Health Administration, and other agencies.

Local PLCs will have operator interface terminals. The operator interface will include sufficient access to modify system set-points, parameters, alarms limits, and indication of associated process variables and instruments. This data will also be available to the SCADA system for full remote control, alarming, trending, archiving, etc.

Each PLC switch will be connected to the Maintenance Building's gigabit capable Ethernet backbone switch. The fiber cable will be run from the Maintenance Building communication panel to remote communication panels and onto each remote PLC. The fiber cable will be multimode or single mode as applicable, consisting of 12 fibers per cable. All fiber cables will be color coded, labeled and terminated at a fiber interconnect panel.

The system has been designed to allow for isolation/removal of components that could fail from operational sequencing, thereby minimizing downtime. Full redundancy of the control system was determined to be unnecessary. System outage in individual area is expected to be repaired and put back into service within two to three days given an appropriate inventory of parts and skilled staff availability.

Power Distribution to Instrument Power Panel

All control power for each area PLC will be supplied by control panel. The control panel shall be fed from the area primary distribution transformer. All I&C power for field devices or panels will be sourced from the control.

Uninterruptible Power Supply

The UPS will be double conversion "true online" and configured with an automatic bypass switch for battery maintenance. The UPS will provide power to the PLC, 24-volt DC power supply, Digital Input/Digital Output (DI&DO) cards, and analyzer power.

Power System Monitoring/Control from SCADA

Power distribution panels, motor control centers, and communications panels will be supplied with digitally networked power metering devices for remote energy monitoring and control. Primary distribution equipment and selected secondary equipment will be supplied with electrically actuated circuit breakers or contactors which will be available for remote position monitoring and alarming as well as remote manual and automatic control via the SCADA system. Automatic sequencing for restarting of equipment after restoration of power will be provided through SCADA.

C.8 Architectural

Building and all infrastructure components will conform to the following:

- Exterior finishes: In conformance with the EIR mitigation measure AES-1d and AES-2e, the color of the wells, pipelines, reagent storage tanks, control structures, and utilities shall consist of muted, earth-tone colors that are consistent with the surrounding natural color palette. Matte finishes shall be used to prevent reflectivity along the view corridor. Integral color concrete should be used in place of standard gray concrete.
- The design, location, and physical appearance and character of new construction at the Topock Compressor Station will be consistent with existing buildings in scale, form, materials, and architectural detail.
- For new construction within the Compressor Station fenceline: In keeping with the Secretary of the Interior's Standards for the Rehabilitation of Historic Buildings, the new construction will be differentiated from existing historic architecture on the property, but will be compatible with the historic materials, features, size, scale and proportion, and massing to protect the integrity of the Topock Compressor Station and its environment.
- Floors: Floors will be reinforced cast-in-place concrete and steel grates where required for water containment. Six-inch housekeeping pads at equipment locations.
- Doors and frames: Heavy-gauge hollow metal doors and frames will be used. Doors from the exterior into the facility and the interior door into the groundwater sampling equipment room will receive a tempered glass window. Hardware to be of heavy gauge and made of stainless steel where practical.

- Overhead sectional doors: A 12-foot wide by 12-foot high heavy-gauge steel overhead sectional door with perforations to allow for air movement. Overhead door to be manually operated.
- Exterior wall assemblies: Exposed concrete and painted concrete masonry unit (CMU) on the lower floor. Insulated metal siding on the upper floor with Kynar finishes to match existing adjacent buildings.
- Interior walls and ceilings: Metal studs with Batt insulation where separating conditioned and non-conditioned spaces. Wall to be built on a concrete curb and receive moisture resistant gypsum board on both sides.
- Windows: Aluminum framed windows with a clear anodized finish. Energy efficient insulated tempered glass with a low-E coating. Extensive use of day lighting through windows.
- Louvers: Aluminum drainable louver with a clear anodized finish.
- Roof: Insulated metal roof with continuous ridge vent and Kynar light colored finishes to match existing adjacent buildings.
- Fire protection: Fire extinguishers as required per building and fire codes including NFPA 10.
- Interior finishes: Epoxy paint over gypsum board and CMU. Clear sealer at concrete. All paint to be off-white to promote a bright space where light can reach areas behind equipment.
  - Cabinetry: Wood cabinets with chemical-resistant countertops and stainless steel pulls.
  - Floors: Smooth texture and finished with a clear surface sealer to increase the durability of the concrete surface and to maintain a clean, dust-free environment.
  - Framing: Steel framing to be finished with an epoxy primer and polyurethane finish coating.
  - Interior walls: Epoxy paint over gypsum board in laboratory room and MCC room, light colored vinyl backed insulation at metal roof, painted concrete at lower floor ceiling to improve light reflectivity.
  - Pedestrian doors: Field finished with polyurethane and epoxy finish coating.

C.9 PG&E Personnel Requirements

PG&E personnel will perform the following activities during construction:

- PG&E personnel, or their designee, will lead TCS-specific safety and biological and cultural sensitivity training for contractors and employees.
- Serve as liaison and primary contact for any agency, tribal, or other third party personnel inspecting and/or monitoring construction and O&M activities.
- Serve as liaison and primary contact for community, stakeholders, agencies, Tribes, members of the press, and others requesting site tours or project-related information.
- Initiate communications with/notifications to agencies, land owners, and others, as required, in the event of emergencies or contingency triggers.
- Attend stand-up tailboard (safety) meetings before the start of work each day to review safety policies and specific hazards likely to be encountered in the day's activities.
- Sign waste manifest forms and compliance documents that require PG&E certification.
- Monitor for compliance with PG&E safety standards and requirements and contract specifications, terms, and conditions.

Additional criteria may be added for the pre-final (90%) design submittal.

C.10 Health and Safety

The project falls under federal Occupational Safety and Health Administration (OSHA) Hazardous Waste Operations and Emergency Response (HAZWOPER) requirements (29 CFR 1910.120) so these procedures must be followed in addition to California and Arizona state requirements.

These requirements will be embodied in project-specific health and safety plan(s) for construction and O&M that will be prepared and submitted to DTSC and DOI for review prior to ground disturbance activities. In addition, health and safety work plans will be prepared or amended by construction, drilling and other service contractors working on the project. Existing health and safety plans will be reviewed and amended, as needed, to suit new project requirements and/or conditions. PG&E personnel similarly work under PG&E's own health and safety requirements. These health and safety plans will describe such things as training, site control, medical surveillance, safety personnel roles and responsibilities, personnel protective equipment, exposure monitoring and air sampling programs, heat and cold stress, and site work rules and procedures.

Project-specific health and safety plans will be provided with the Pre-Final (90%) Design submittals.

C.11 Noise

- A design margin of 3 to 5 A-weighted decibels (dB[A]) will be considered in all noise design criteria.
- In conformance with the EIR mitigation measures NOISE-3 and CUL-1a-10, the operational noise design criteria for the project will be per San Bernardino County Development Code 83.01.080 for acceptable exterior noise standards for place of worship, which is 55 dB(A) Leq daytime (7 a.m.-10 p.m.) and 45 dB(A) Leq nighttime (10 p.m.-7 a.m.) (Leq is the equivalent average hourly noise level) (see page 4.9-24 of the EIR [DTSC 2011]). The noise measurement locations will be at the edge of the Maze closest to the subject facilities and at the short-term ambient noise measurement locations (ST-1, ST-2, and ST-3) in Exhibit 4.9-2 of the certified EIR (DTSC 2011).
- For remedy facilities in Arizona, the operational noise design criteria will be 60 dB daytime and 50 dB nighttime average at closest residences (per current Mohave General Plan, Exhibit V-5, Maximum Noise Levels for Various Land Use).
- For remedy facilities on the Refuge, the operational noise design criteria will be 60 dB.
- For remedy facilities located on the Compressor Station and within PG&E property, the operational noise design criteria will be consistent with the noise environment at the Station, per San Bernardino County Development Code 83.01.080 for industrial land use, 70 dB(A).
- The construction noise criteria will conform to San Bernardino Development Code and Mojave County standards, as well as the EIR mitigation measures NOISE-1, -2, and -3. Per San Bernardino County Code Division 3 Chapter 83.01.080, temporary construction, maintenance, repair, or demolition activities between 7:00 a.m. and 7:00 p.m., except Sundays and federal holidays, are exempt from noise limits.

C.12 References

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Final (100%) Design Submittal for the Final Groundwater Remedy
PG&E Topock Compressor Station
Needles, California

L-300 Pipe Load Calculations

11/18/2015

Prepared for:

Pacific Gas and Electric Company

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ARCADIS Design & Consultancy for natural and built assets

Topock Remediation Design

Load Calculations for L-300 pipe

Background

The boneyard area south of the Topock Compressor Station will be backfilled with soil to create an embankment and access area to the proposed Remedy Produced Water Conditioning Building as shown on TCS Civil Site Plan (Drawing C-10-01 from the 60% design). Up to eight feet of fill will be added on top of the existing L-300 pipe that crosses through this area. The depth of cover over this pipe varies. According to PG & E personnel, there is only one foot of cover on the L-300 pipe (30 inch diameter) in certain areas. An analysis is needed to determine whether the L-300 pipe will be detrimentally affected short term by construction operations or long term by dead loads due to increased cover on top of the pipe.

Analysis

Information on the L-300 pipeline is incomplete. While we know the pipe diameter and material, we don't know the pipe thickness, yield strength or whether the pipe is lined and/or coated. For this reason, pipeline analysis was conducted for a number of different pipe thicknesses and yield strengths. The pipe thicknesses and yield strengths were selected based upon a review of PG & E Document A-34 and matching them to the Maximum Allowable Operating Pressure of 660 psi (from PG & E staff). The selected pipes are:

- API 5L X42 (yield stress 42,000 psi) with thicknesses of 0.406, 0.438 and 0.469
- API 5L X52 (yield stress 52,000 psi) with thicknesses of 0.375, 0.406 and 0.438
- API 5L X60 (yield stress 60,000 psi) with thicknesses of 0.375, 0.406 and 0.438

Each of these pipes has different pressure ratings based on % of maximum yield stress. This is presented in Table 1. PG & E Utility Standard TD-4127S establishes a procedure determining this percentage based on compliance requirements in accordance with 49 CFR § 192.5, "Class Locations". The class location for this area is unknown and the determination of class is outside the scope of this analysis.

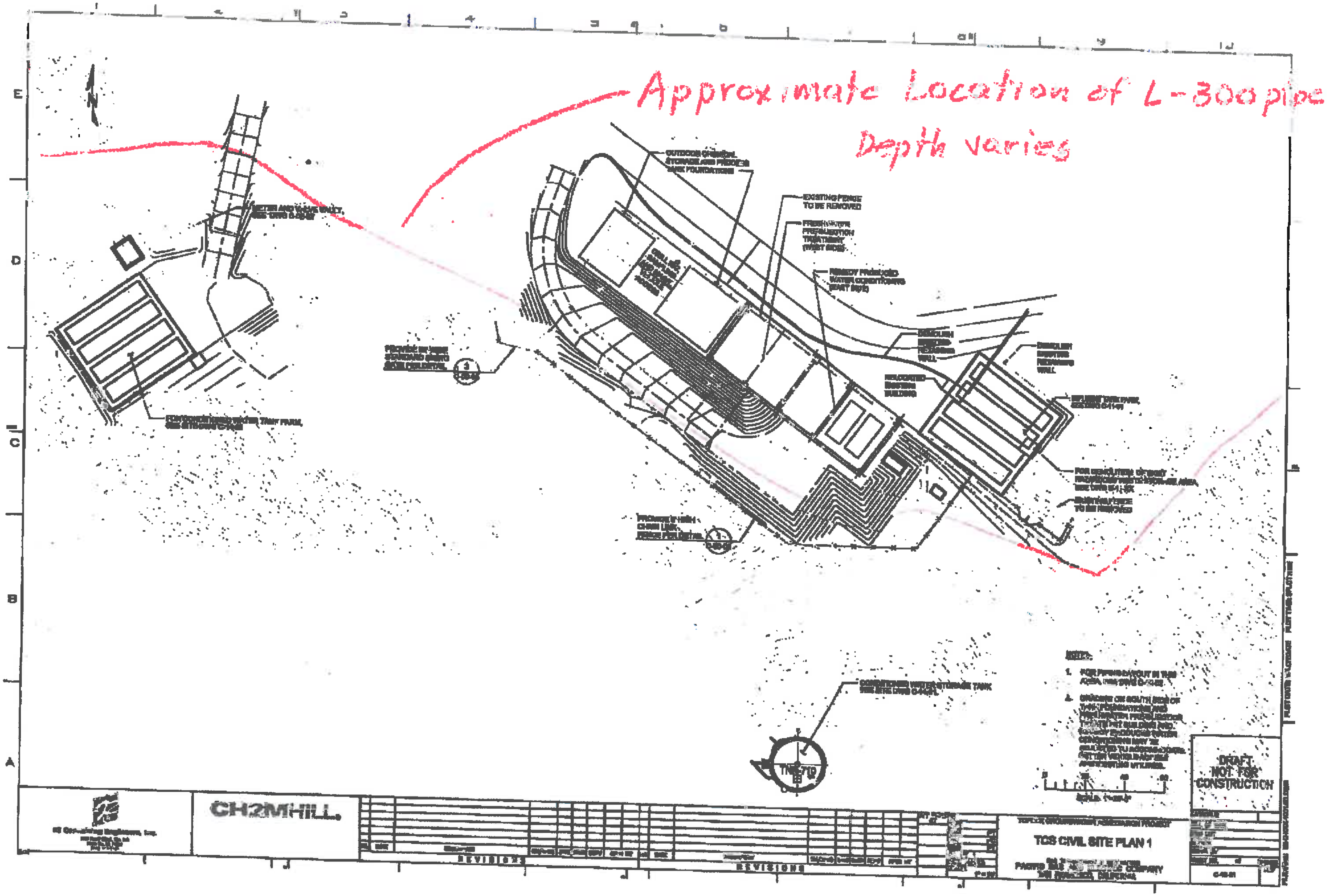
The L-300 pipe was analyzed in accordance with AWWA M-11, Steel Pipe Design Manual. The following data and assumptions were utilized during analysis:

- Minimum cover = 1' (during construction operations)
- Maximum cover = 13' (5' of existing cover plus 8' of backfill placed on top)
- Soil Weight = 120 pcf (from Geotechnical Investigation for Topock AOC 4)
- Soil Classification = SM (from Geotechnical Investigation for Topock AOC 4 boring logs)
- Compaction of existing soil = 85%
- Water table is substantially below the pipe, so buoyancy effects can be neglected
- Deflection Lag Factor = 1.0 (Long term deflections are offset by internal hydrostatic pressure)

BY PT, E2 Consulting Engineers, July 2013

- Steel pipe with linings and coatings that are **not** comprised of mortar
- Steel pipe modulus of elasticity = 30,000,000 psi
- Transverse moment of inertia (per unit length of pipe wall) = $t^3/12$
- Soil reaction modulus (for 13' calculations) = 1,000 psi (from Table 6-1 in AWWA M-11, based on 85% relative compaction, coarse grained soils and 10-15' depth of cover)
- Soil reaction modulus (for 1' calculations) = 600 psi (from Table 6-1 in AWWA M-11, based on 85% relative compaction, coarse grained soils and 2-5' depth of cover)
- Live loads are negligible at 8 feet of cover and greater, so they were not considered in the analysis with 13' of cover
- Live loads are based on large loaders with dual wheels, weighing approximately 127,000 lbs with 42,300 lbs per wheel.

Results from the analysis are presented in Tables 2 through 7. It is recommended that cover on the L-300 pipe be increased to a minimum of 3' prior to construction to protect the pipe during construction activities. The analysis for this condition is contained in Tables 6 and 7.



Approximate Location of L-300 pipe
Depth varies
EXISTING FENCE TO BE REMOVED
NOTES:
DRAFT NOT FOR CONSTRUCTION
CH2MHILL
REVISIONS
TCS CIVIL SITE PLAN 1

Extreme External Loading Conditions

Worst case is 1' minimum cover of pipe subjected to heavy equipment loading during construction

Assume the following:

- Live load from a large loader
- Total weight = 127,000 lbs
- Weight on one set of dual wheels, P = 42,300 lbs
- Tire pattern is 44" x 24"

Calculation:

Tire pattern: 44/12 x 24/12 = 3.66 x 2 = 7.33 sq ft (for dual wheels)

Surface pressure: 42,300 lbs/7.33 sq ft = 5,768 psf

If height of cover = 1', then determine coefficients for modified Boussinesq equation (Table 6-4 in AWWA M-11 – Steel Pipe Design Manual)

A = 3.66/1, B = 2/1

m = A/H = 3.66/1 = 3.66

n = B/H = 2/1 = 2.00

from Table 6-4, Influence coefficient = 0.23833

Then P = 0.23833 x 4 x 5,768 = 5,498 psf

Dead load for 1' of cover = 120 pcf / 1' = 120 psf

Combined dead load and live load

= 5,498 + 120 = 5,618 psf = 468.2 lbs per inch of pipeline length = 39.0 psi

If height of cover = 3', then determine coefficients for modified Boussinesq equation (Table 6-4 in AWWA M-11 – Steel Pipe Design Manual)

A = 3.66/3, B = 2/3

m = A/H = 3.66/3 = 1.22

n = B/H = 2/3 = 0.67

from Table 6-4, Influence coefficient = 0.152

Then P = 0.152 x 4 x 5,768 = 3507 psf

Dead load for 3' of cover = 3*120 pcf / 1' = 360 psf

Combined dead load and live load

= 3,507 + 360 = 3,867 psf = 322.3 lbs per inch of pipeline length = 26.9 psi

Table 1
Steel Pipe Pressure Ratings

API 5L Pipe Grade	Wall Thickness (in)	Pressure % of SMYS Piping							
		Class Location		1	2	3	4		
		100%	90%	72%	60%	50%	40%	30%	20%
X42	0.406	1137	1024	819	683	569	455	342	228
X42	0.438	1227	1104	884	736	614	491	368	246
X42	0.469	1314	1182	946	788	657	526	394	263
X52	0.375	1300	1170	934	780	650	520	390	260
X52	0.406	1408	1267	1014	845	704	563	423	282
X52	0.438	1519	1367	1091	912	760	608	456	304
X60	0.375	1500	1350	1080	900	750	600	450	300
X60	0.406	1624	1462	1170	975	812	650	488	325
X60	0.438	1752	1577	1262	1052	876	701	526	351

Values in Table are from Pacific Gas and Electric Document A-34, Attachment B, Piping Design and Test Requirements
SMYS = Specified Maximum Yield Stress which corresponds to API Pipe Grade (X42 = 42,000 psi yield stress)

Shaded areas indicate the pipe grades, wall thickness and pressure conditions which are rated higher than the maximum allowable operating pressure for the L-300 pipeline

Table 2
Summary of Pipe Deflections for L-300 Pipeline based on 13 feet of cover
(Dead Loads only, Live Loads neglected)

API 5L Pipe Grade	Wall Thickness (in)	Horizontal Deflection, Δx (in)	% Horizontal Deflection	% Horizontal Deflection < 5%
X42	0.406	0.294	0.98%	yes
X42	0.438	0.264	0.88%	yes
X42	0.469	0.237	0.79%	yes
X52	0.375	0.325	1.08%	yes
X52	0.406	0.294	0.98%	yes
X52	0.438	0.264	0.88%	yes
X60	0.375	0.325	1.08%	yes
X60	0.406	0.294	0.98%	yes
X60	0.438	0.264	0.88%	yes

Deflection Lag Factor (D_l) = 1
Bedding Constant (K) = 0.1
Load per unit length (W)= 325 lbs/in
Pipe radius (r) = 15 in
Modulus of Elasticity (E) = 30000000 psi
Moment of Inertia (I) = $t^3/12$ in^3
Modulus of Soil (E') = 1000 psi

Horizontal Deflection from Iowa deflection formula by Marston
% Horizontal Deflection = Δx/pipe dia = Δx/30
Allowable Deflection = 5% of 30 inches = 1.5 inches

Table 3
Summary of Buckling Pressures for L-300 Pipeline with 13 feet of cover

API 5L Pipe Grade	Wall Thickness (in)	Buckling Pressure (psi)	Load (psi)	Load < Buckling Pressure
X42	0.406	199.1	10.8	yes
X42	0.438	223.1	10.8	yes
X42	0.469	247.2	10.8	yes
X52	0.375	176.7	10.8	yes
X52	0.406	199.1	10.8	yes
X52	0.438	223.1	10.8	yes
X60	0.375	176.7	10.8	yes
X60	0.406	199.1	10.8	yes
X60	0.438	223.1	10.8	yes

Factor of Safety (FS) = 2
Pipe Diameter (D) = 30 in
Water Buoyancy Fact. (R_W) = 1.0
Coeff of Elastic Support (B') = 0.79943
Modulus of Elasticity (E) = 30000000 psi
Moment of Inertia (I) = $t^3/12$ in^3
Modulus of Soil (E') = 1000 psi

Table 4
Summary of Pipe Deflections for L-300 Pipeline based on 1 feet of cover
(Dead Loads plus Live Loads)

API 5L Pipe Grade	Wall Thickness (in)	Horizontal Deflection, Δx (in)	% Horizontal Deflection	% Horizontal Deflection < 5%
X42	0.406	1.358	4.53%	yes
X42	0.438	1.184	3.95%	yes
X42	0.469	1.036	3.45%	yes
X52	0.375	1.547	5.16%	no
X52	0.406	1.358	4.53%	yes
X52	0.438	1.184	3.95%	yes
X60	0.375	1.547	5.16%	no
X60	0.406	1.358	4.53%	yes
X60	0.438	1.184	3.95%	yes

Deflection Lag Factor (D_l) = 1
Bedding Constant (K) = 0.1
Load per unit length (W)= 1170.5 lbs/in
Pipe radius (r) = 15 in
Modulus of Elasticity (E) = 30000000 psi
Moment of Inertia (I) = $t^3/12$ in^3
Modulus of Soil (E') = 600 psi

Horizontal Deflection from Iowa deflection formula by Marston
% Horizontal Deflection = Δx/pipe dia = Δx/30
Allowable Deflection = 5% of 30 inches = 1.5 inches

Table 5
Summary of Pipe Deflections for L-300 Pipeline based on 1 feet of cover
(Dead Loads plus Live Loads)

API 5L Pipe Grade	Wall Thickness (in)	Buckling Pressure (psi)	Load (psi)	Load < Buckling Pressure
X42	0.406	83.8	39.0	yes
X42	0.438	93.9	39.0	yes
X42	0.469	104.1	39.0	yes
X52	0.375	74.4	39.0	yes
X52	0.406	83.8	39.0	yes
X52	0.438	93.9	39.0	yes
X60	0.375	74.4	39.0	yes
X60	0.406	83.8	39.0	yes
X60	0.438	93.9	39.0	yes

Factor of Safety (FS) = 2
Pipe Diameter (D) = 30 in
Water Buoyancy Fact. (R_W) = 1.0
Coeff of Elastic Support (B') = 0.23626
Modulus of Elasticity (E) = 30000000 psi
Moment of Inertia (I) = $t^3/12$ in^3
Modulus of Soil (E') = 600 psi

Table 6

Summary of Pipe Deflections for L-300 Pipeline based on 3 feet of cover

(Dead Loads plus Live Loads)

API 5L Pipe Grade	Wall Thickness (in)	Horizontal Deflection, Δx (in)	% Horizontal Deflection	% Horizontal Deflection < 5%
X42	0.406	0.935	3.12%	yes
X42	0.438	0.815	2.72%	yes
X42	0.469	0.713	2.38%	yes
X52	0.375	1.065	3.55%	yes
X52	0.406	0.935	3.12%	yes
X52	0.438	0.815	2.72%	yes
X60	0.375	1.065	3.55%	yes
X60	0.406	0.935	3.12%	yes
X60	0.438	0.815	2.72%	yes
Deflection Lag Factor (D_l) =		1		
Bedding Constant (K) =		0.1		
Load per unit length (W)=		805.6	lbs/in	
Pipe radius (r) =		15	in	
Modulus of Elasticity (E) =		30000000	psi	
Moment of Inertia (I) =		$t^3/12$	in^3	
Modulus of Soil (E') =		600	psi	
Horizontal Deflection from Iowa deflection formula by Marston				
% Horizontal Deflection = Δx/pipe dia = Δx/30				
Allowable Deflection = 5% of 30 inches = 1.5 inches				

Table 7

Summary of Pipe Deflections for L-300 Pipeline based on 3 feet of cover

(Dead Loads plus Live Loads)

API 5L Pipe Grade	Wall Thickness (in)	Buckling Pressure (psi)	Load (psi)	Load < Buckling Pressure
X42	0.406	97.8	26.9	yes
X42	0.438	109.6	26.9	yes
X42	0.469	121.4	26.9	yes
X52	0.375	86.8	26.9	yes
X52	0.406	97.8	26.9	yes
X52	0.438	109.6	26.9	yes
X60	0.375	86.8	26.9	yes
X60	0.406	97.8	26.9	yes
X60	0.438	109.6	26.9	yes
Factor of Safety (FS) =		2		
Pipe Diameter (D) =		30	in	
Water Buoyancy Fact. (R_W) =		1.0		
Coeff of Elastic Support (B') =		0.32140		
Modulus of Elasticity (E) =		30000000	psi	
Moment of Inertia (I) =		$t^3/12$	in^3	
Modulus of Soil (E') =		600	psi	

Final (100%) Design Submittal for the Final Groundwater Remedy
PG&E Topock Compressor Station
Needles, California

Hydraulic Calculations

11/18/2015

Prepared for:

Pacific Gas and Electric Company

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PG&E Topock Groundwater Remediation Project

Hydraulic Analysis of Freshwater Injection System

The piping and pumps for the freshwater injection system on the Topock Remediation project were sized from simulations of a hydraulic network model of the system. The hydraulic model was developed in EPANET, a widely used distribution system tool developed by U.S. EPA. In EPANET, pipe junctions, reservoirs, and tanks are represented as nodes. Pipes, pumps, and valves are represented as links. EPANET tracks flow and head loss through links, pressure and heads at nodes, and can be used to evaluate distribution system configurations.

The freshwater system includes several provisional extraction wells located in Arizona. After crossing the river, the line splits into a single pipe that leads to FW-2. The other pipeline consists of parallel pipes leading north past MW-20 and west to the other freshwater well along with the four IRL wells. The development and results of the hydraulic model follow.

Pipe trenches, piping lengths, and pipe / node elevations were modeled based on the plan and profile sheets for the 90% submittal. A previous version of the freshwater model was developed externally as part of the 90% submittal. This model was reviewed and updated with new considerations (removed TCS injection, HNWR-1A operation only, and use actual inner diameters). Additionally, it was decided to remove the freshwater storage located near the TW bench; the tank provided minimal storage and had little impact on model hydraulics. The overall model plan has been simplified compared to actual trench pathways. However, since well coordinates, pipe lengths, and pipe elevations were used, this does not affect the accuracy of the hydraulic analysis. The system configuration can be seen in the map on the following page.

The extraction wells were modeled as pumps attached to underground reservoirs. The reservoir's head represents the normal operating ground water level, the pump upstream junction represents the pump intake elevation, and the pump downstream junction represents the ground elevation. Injection wells were modeled as a positive demand, and pressure reducing valves (PRVs) were included upstream to limit injection pressures to 10 psi.

The loop was designed based on maximum flow conditions of 900 GPM at the IRL injection wells; this was modeled as 100-200 GPM demands at the IRL and FW injection wells and simulated by operating only HNWR-1A. Nominal flow conditions of 450 GPM were also evaluated for the IRL Loop; this was modeled as 50-200 GPM demand at the injection wells and by running HNWR-1A at 79% speed (simulating a Variable Frequency Drive (VFD) pump).

Simulations were previously performed to size the pipes and pumps of the IRL loop. However because of the model adjustments (especially upon using actual diameters), some pipe sizes needed adjusted so that water would reach all injection wells under maximum conditions. After multiple alternatives, it was decided that the six inch parallel pipes in the uplands would be converted to parallel eight inch lines (except for concrete box trenches where the line would become a single ten inch line). The final configuration is able to transmit maximum and nominal flows and retain adequate pressure for the system. Max flow conditions result in pressure between 12 and 45 psi upstream of the injection PRV's, and nominal flow conditions result in pressure between 27 and 55 psi upstream of the injection PRV's. Results for all links and nodes for the final maximum flow simulation are found on the following pages.

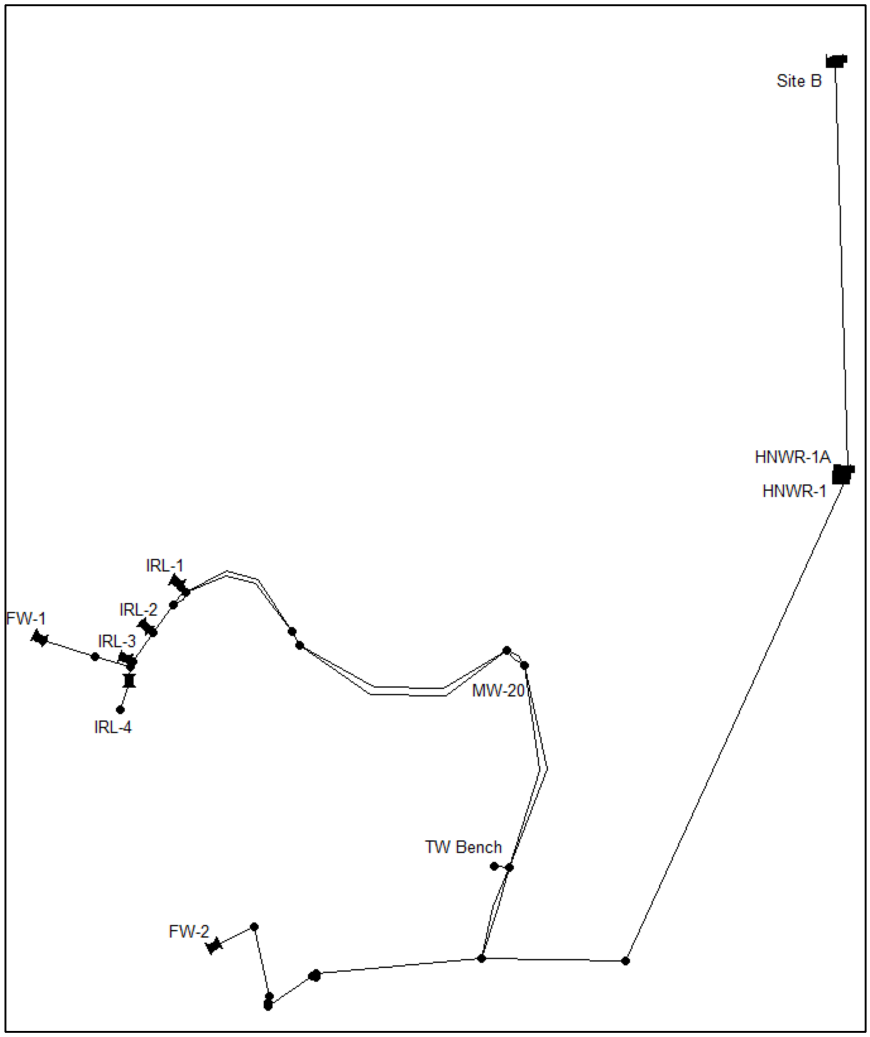

Figure 1 - Proposed IRL Model Configuration

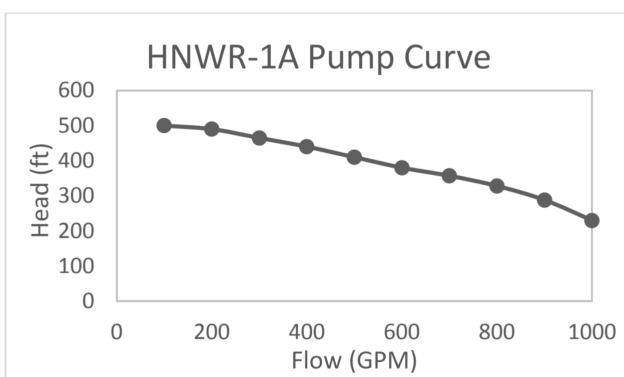

Figure 2 - Modeled pump curve for freshwater extraction pump

Table 1 – Network Model Characteristics

ID	Node1	Node2	Length	Diameter	Roughness	Minor Loss	Status
101	101	102	84	6	130	0	Open
102	102	103	66	6	130	0	Open
103A	103	104	89	6	130	12.75	Open
103B	103	104	32	6	130	0	Closed
104	104	105	22	6	130	0	Open
105	105	106	145	10.3	150	0	Open
106	106	107	50	10.3	150	0	Open
107	107	108	4205	10.3	150	0	Open
108	108	109	2111	10.3	150	0	Open
109	109	400	1847	10.3	150	0.5	Open
110A	109	110	813	6.96	150	0	Open
110B	109	110	813	6.96	150	0	Open
111A	110	111	2608	6.96	150	0	Open
111B	110	111	2608	6.96	150	0	Open
112A	111	112	170	6.96	150	0	Open
112B	111	112	170	6.96	150	0	Open
114A	112	114	1283	6.96	150	0	Open
114B	112	114	1283	6.96	150	0	Open
115B	114	115	170	8.68	130	0	Open
116A	115	116	695	6.96	150	0	Open
116B	115	116	695	6.96	150	0	Open
117A	116	116b	168	6.96	150	0	Open
117B	116	116b	168	6.96	150	0	Open
118A	117	118	159	8.68	150	0	Open
119	118	119	47	5.35	150	0	Open
120	119	120	127	5.35	150	0	Open
121	120	121	881	5.35	150	0	Open
122A	121	121A	13	3	150	0	Open
122B	121B	122	5	3	150	0	Open
123	116	123	73	5.35	150	0	Open
124A	123	123A	13	2	150	0	Open
124B	123B	124	2	3.63	150	0	Open
125	117	125	242	5.35	150	0	Open
126A	125	125A	13	2	150	0	Open
126B	125B	126	5	2	150	0	Open
127	118	127	70	5.35	150	0	Open
128A	127	127A	13	2	150	0	Open
128B	127B	128	5	2	150	0	Open

ID	Node1	Node2	Length	Diameter	Roughness	Minor Loss	Status
129	119	129	178	5.35	150	0	Open
130A	129	129A	9	5.35	150	0	Open
130B	129B	130	15	5.35	150	0	Open
131	130	131	512	5.35	150	0	Open
132	131	132	3	2	150	0	Open
133	110	133	44	2.8	150	0	Open
201	201	202	155	6	130	0	Open
202A	202	203	89	6	130	12.75	Open
202B	202	203	32	6	130	0	Closed
203	203	204	22	6	130	0	Open
204	204	106	3652	10.29	150	0	Open
301	301	302	111	6	130	0	Open
302	302	303	140	12	130	0	Open
303	303	304	41	12	130	0	Open
304	304	107	123	10.29	150	0	Open
400	400	401	53	2.8	150	1	Open
401	401	402	24	2.8	150	0	Open
402	402	403	217	2.8	150	0	Open
403A	403	403A	21	2.8	150	0	Open
403B	403A	404	70	2.8	150	0	Open
404	404	405	700	2.8	150	0	Open
405	405	403B	600	2.8	150	0	Open
117C	116b	117	410	8.68	150	0	Open
P100	100	101	Pump w/ Curve HNWR-1A				Open
P200	200	201	Pump w/ Curve N/A				Closed
P300	300	301	Pump w/ Curve N/A				Closed
V501	403B	406	--	3	Valve: PRV Setting = 10psi		
V504	123A	123B	--	2	Valve: PRV Setting = 10psi		
V505	125A	125B	--	2	Valve: PRV Setting = 10psi		
V506	127A	127B	--	2	Valve: PRV Setting = 10psi		
V507	129A	129B	--	4	Valve: PRV Setting = 10psi		
V508	121A	121B	--	3	Valve: PRV Setting = 10psi		

Table 2 – Network Junction Simulation Results

Node ID	Elevation ft.	Demand GPM	Head ft.	Pressure psi
Junc 101	382	0	692.2	134.41
Junc 102	466	0	686.97	95.74
Junc 103	466	0	682.86	93.96
Junc 104	466	0	656.2	82.42
Junc 105	466	0	654.83	81.82
Junc 106	459	0	654.34	84.64
Junc 107	459	0	654.16	84.56
Junc 108	495	0	639.71	62.7
Junc 109	551	0	632.46	35.3
Junc 110	536	0	628.25	39.97
Junc 111	480	5	614.9	58.45
Junc 112	481	0	614.04	57.65
Junc 114	489	0	607.55	51.37
Junc 115	489	0	606.17	50.77
Junc 116	497	0	602.65	45.78
Junc 117	554	0	599.25	19.61
Junc 118	556	0	598.66	18.49
Junc 119	556	0	597.81	18.12
Junc 120	556	0	597.17	17.84
Junc 121	558	0	592.72	15.04
Junc 121A	558	0	591.62	14.57
Junc 121B	558	0	582.14	10.46
Junc 122	558	200	581.72	10.28
Junc 123	498	0	602.65	45.34
Junc 123A	498	0	602.65	45.34
Junc 123B	498	0	522.14	10.46
Junc 124	498	0	522.14	10.46
Junc 125	551	0	598.02	20.38
Junc 125A	551	0	590.11	16.94
Junc 125B	551	0	575.14	10.46
Junc 126	551	200	572.09	9.14
Junc 127	552	0	598.31	20.07
Junc 127A	552	0	590.39	16.64
Junc 127B	552	0	576.14	10.46
Junc 128	552	200	573.09	9.14
Junc 129	567	0	596.91	12.96
Junc 129A	567	0	596.86	12.94
Junc 129B	567	0	582.28	6.62

Node ID	Elevation ft.	Demand GPM	Head ft.	Pressure psi
Junc 130	567	0	582.2	6.59
Junc 131	557	0	579.62	9.8
Junc 132	557	200	577.79	9.01
Junc 133	537	5	628.24	39.54
Junc 201	382	0	654.34	118
Junc 202	479	0	654.34	75.97
Junc 203	479	0	654.34	75.97
Junc 204	479	0	654.34	75.97
Junc 301	382	0	654.16	117.93
Junc 302	466	0	654.16	81.53
Junc 303	466	0	654.16	81.53
Junc 304	459	0	654.16	84.56
Junc 401	632.5	0	630.19	-1
Junc 402	632	0	629.41	-1.12
Junc 403	607	0	622.3	6.63
Junc 403A	607	0	621.61	6.33
Junc 403B	546	0	576.72	13.31
Junc 404	604	0	619.32	6.64
Junc 405	545	0	596.38	22.26
Junc 406	546	100	569.08	10
Junc 116b	519	0	601.8	35.88
Junc 400	631.5	0	632.35	0.37
Resvr 100	410	-910	410	0
Resvr 200	410	0	410	0
Resvr 300	410	0	410	0

Table 3 – Network Link Simulation Results

Link ID	Flow GPM	Velocity fps	Unit Headloss ft./Kft
Pipe 101	910	10.33	62.28
Pipe 102	910	10.33	62.28
Pipe 103A	910	10.33	299.44
Pipe 103B	0	0	0
Pipe 104	910	10.33	62.28
Pipe 105	910	3.5	3.44
Pipe 106	910	3.5	3.44
Pipe 107	910	3.5	3.44
Pipe 108	910	3.5	3.44
Pipe 109	100	0.39	0.06
Pipe 110A	405	3.42	5.18
Pipe 110B	405	3.42	5.18
Pipe 111A	402.5	3.39	5.12
Pipe 111B	402.5	3.39	5.12
Pipe 112A	400	3.37	5.06
Pipe 112B	400	3.37	5.06
Pipe 114A	400	3.37	5.06
Pipe 114B	400	3.37	5.06
Pipe 115B	800	4.34	8.12
Pipe 116A	400	3.37	5.06
Pipe 116B	400	3.37	5.06
Pipe 117A	400	3.37	5.06
Pipe 117B	400	3.37	5.06
Pipe 118A	600	3.25	3.66
Pipe 119	400	5.71	18.23
Pipe 120	200	2.85	5.05
Pipe 121	200	2.85	5.05
Pipe 122A	200	9.08	84.52
Pipe 122B	200	9.08	84.52
Pipe 123	0	0	0
Pipe 124A	0	0	0
Pipe 124B	0	0	0
Pipe 125	200	2.85	5.05
Pipe 126A	200	20.42	609.1
Pipe 126B	200	20.42	609.11
Pipe 127	200	2.85	5.05
Pipe 128A	200	20.42	609.1

Link ID	Flow GPM	Velocity fps	Unit Headloss ft./Kft
Pipe 128B	200	20.42	609.11
Pipe 129	200	2.85	5.05
Pipe 130A	200	2.85	5.05
Pipe 130B	200	2.85	5.05
Pipe 131	200	2.85	5.05
Pipe 132	200	20.42	609.09
Pipe 133	5	0.26	0.13
Pipe 201	0	0	0
Pipe 202A	0	0	0
Pipe 202B	0	0	0
Pipe 203	0	0	0
Pipe 204	0	0	0
Pipe 301	0	0	0
Pipe 302	0	0	0
Pipe 303	0	0	0
Pipe 304	0	0	0
Pipe 400	100	5.21	40.72
Pipe 401	100	5.21	32.77
Pipe 402	100	5.21	32.76
Pipe 403A	100	5.21	32.76
Pipe 403B	100	5.21	32.76
Pipe 404	100	5.21	32.76
Pipe 405	100	5.21	32.76
Pipe 117C	800	4.34	6.23
Pump P100	910	0	-282.2
Pump P200	0	0	0
Pump P300	0	0	0
Valve V501	100	4.54	7.65
Valve V504	0	0	80.51
Valve V505	200	20.42	14.97
Valve V506	200	20.42	14.25
Valve V507	200	5.11	14.59
Valve V508	200	9.08	9.48

Final (100%) Design Submittal for the Final Groundwater Remedy
PG&E Topock Compressor Station
Needles, California

Hydraulic Calculations

11/18/2015

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PG&E Topock Groundwater Remediation Project

Hydraulic Analysis of Inner Recirculation Loop

The piping and pumps for the Inner Recirculation Loop (IRL) system on the Topock Remediation project were sized from simulations of a hydraulic network model of the system. The hydraulic model was developed in EPANET, a widely used distribution system tool developed by U.S. EPA. In EPANET, pipe junctions, reservoirs, and tanks are represented as nodes. Pipes, pumps, and valves are represented as links. EPANET tracks flow and head loss through links, pressure and heads at nodes, and can be used to evaluate distribution system configurations.

The IRL system includes a continuous loop around the river bank extraction wells, which then connects to the treatment facility at MW-20. Afterwards, piping leads west through the uplands to the four IRL injection wells. The development and results of the hydraulic model follow.

Pipe trenches, piping lengths, and pipe / node elevations were modeled based on the plan and profile sheets for the 90% submittal. The model plan has been simplified compared to actual trench pathways. However since well coordinates, pipe lengths, and pipe elevations were used, this does not affect the accuracy of the hydraulic analysis. The system configuration can be seen in the map on the following page.

The extraction wells were modeled as pumps attached to underground reservoirs. The reservoir's head represents the normal operating ground water level, the pump upstream junction represents the pump intake elevation, and the pump downstream junction represents the ground elevation. For the riverbank extraction wells, actual ground water operating levels were approximated by using expected static water levels and design flow rates for each well. Injection wells were modeled as a positive demand, and pressure reducing valves (PRV) were included upstream to limit injection pressures to 10 psi.

All pipes were assumed to have a Hazen-Williams C factor of 150. Since the pipes used for this recirculation loop are small, actual pipe diameters were used during modeling. For the planned HDPE DR-11 pipes, actual diameters are 5.35" for 6" pipes and 6.96" for 8" pipes.

The loop was designed based on maximum flow conditions of 500 GPM at the IRL injection wells; this was modeled as 125 GPM demand at each injection well and simulated by operating only RB2, RB3, and RB4 extraction wells. Nominal flow conditions of 150 GPM were also evaluated for the IRL Loop; this was modeled as 25-66 GPM demand at the injection wells and by shutting off the RB2 extraction well. Speed parameters were used at the extraction wells when necessary to adjust desired flows and simulate Variable Frequency Drive (VFD) pumps.

Multiple simulations were performed to size the pipes and pumps of the IRL loop. It was discovered that while max flow conditions showed adequate results, nominal conditions showed pressures that were upwards of 160 psi. It was therefore decided to size the riverbank pumps smaller so that pressures would not be so high in nominal conditions, and include a booster pump at the treatment facility for max conditions. Using this configuration, pipe diameters were kept at their previously designed sizes (between 6 and 8 inches). The final configuration is able to transmit maximum and nominal flows and retain adequate pressure for the system. Max flow conditions result in pressure between 16 and 50 psi upstream of the injection PRV's, and nominal flow conditions result in pressure between 75 and 100 psi upstream of the injection PRV's. Results for all links and nodes for the final maximum flow simulation are found on the following pages.

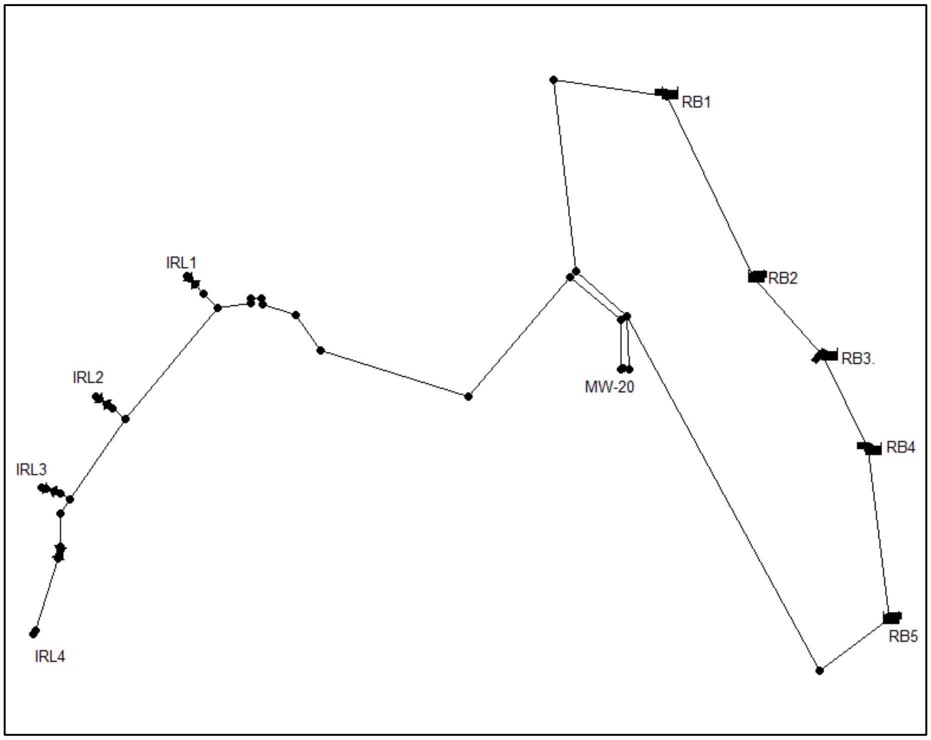

Figure 1 - Proposed IRL Model Configuration

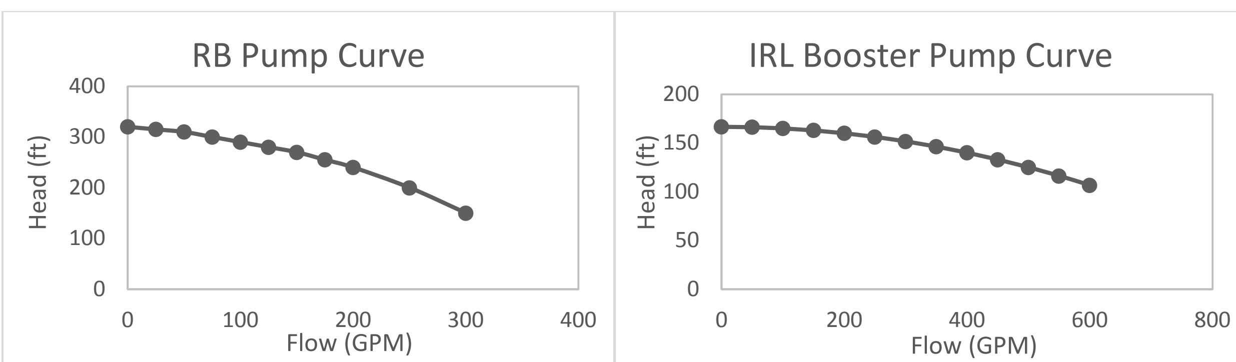

Figure 2 - Modeled Pump Curves for extraction pumps and booster

Table 1 – Network Model Characteristics

ID	Node1	Node2	Length	Diameter	Roughness	Minor Loss	Status
A4-A5	116	117	578	5.35	150	0	Open
A3	117	118	159	5.35	150	0	Open
119	118	119	47	5.35	150	0	Open
123	116	123	73	5.35	150	0	Open
124A	123	123A	13	2	150	0	Open
124B	123B	IRL1	2	2	150	0	Open
125	117	125	242	5.35	150	0	Open
126A	125	125A	13	2	150	0	Open
126B	125B	IRL2	5	2	150	0	Open
127	118	127	70	5.35	150	0	Open
128A	127	127A	13	2	150	0	Open
128B	127B	IRL3	5	2	150	0	Open
129	119	129	178	5.35	150	0	Open
130A	129	129A	9	2	150	0	Open
130B	129B	130	15	2	150	0	Open
131	130	131	512	5.35	150	0	Open
132	131	IRL4	3	2	150	0	Open
G1	RB1	1	378	5.35	150	0	Open
G2	RB1	RB2	569	5.35	150	0	Open
G3	RB2	RB3	318	5.35	150	0	Open
G4	RB3	RB4	292	5.35	150	0	Open
G5	RB4	RB5	478	5.35	150	0	Open
G6	RB5	2	286	5.35	150	0	Open
C3	1	3	811	5.35	150	0	Open
C4	3	4	153	5.35	150	0	Open
C5	4	2	898	5.35	150	0	Open
C6	4	5	325	5.35	150	0	Open
MW20	5	16	10	5.35	150	0	Open
C6b	6	7	325	6.96	150	0	Open
C4b	7	8	153	6.96	150	0	Open
A6-1	8	9	851	5.35	150	0	Open
A6-2	9	10	882	5.35	150	0	Open
A7	10	11	170	5.35	150	0	Open
A6-3	11	12	227	5.35	150	0	Open
A8a	12	13	10	5.35	150	0	Open
A8	13	14	194	5.35	150	0	Open
A8b	14	15	10	5.35	150	0	Open

ID	Node1	Node2	Length	Diameter	Roughness	Minor Loss	Status
A6-4	15	116	290	5.35	150	0	Open
8	WELL1	RB1b	1	12	150	0	Open
9	WELL2	RB2b	1	12	150	0	Open
10	WELL3	RB3b	1	12	150	0	Open
11	WELL4	RB4b	1	12	150	0	Open
12	WELL5	RB5b	1	12	150	0	Open
6	RB1a	RB1	367	2	150	0	Open
7	RB2a	RB2	253	2	150	0	Open
13	RB3a	RB3	216	2	150	0	Open
14	RB4a	RB4	193	2	150	0	Open
15	RB5a	RB5	87	2	150	0	Open
1	RB1b	RB1a	Pump w/ Curve 230S200-5				Closed
2	RB2b	RB2a	Pump w/ Curve 230S200-5				Open
3	RB3b	RB3a	Pump w/ Curve 230S200-5				Open
4	RB4b	RB4a	Pump w/ Curve 230S200-5				Open
5	RB5b	RB5a	Pump w/ Curve 230S200-5				Closed
Booster	16	6	Pump w/ Curve (166.67-0.0001667(Q)^2)				Open
V504	123A	123B	--	2	Valve: PRV Setting = 10psi		
V505	125A	125B	--	2	Valve: PRV Setting = 10psi		
V506	127A	127B	--	2	Valve: PRV Setting = 10psi		
V507	129A	129B	--	2	Valve: PRV Setting = 10psi		

Table 2 – Network Junction Simulation Results

Node ID	Elevation ft.	Demand GPM	Head ft.	Pressure psi
Junc 116	497	0	615.43	51.32
Junc 117	554	0	606.08	22.57
Junc 118	556	0	604.87	21.18
Junc 119	556	0	604.77	21.13
Junc 123	498	0	615.28	50.82
Junc 123A	498	0	611.96	49.38
Junc 123B	498	0	521.08	10
Junc IRL1	498	125	520.57	9.78
Junc 125	551	0	605.57	23.65
Junc 125A	551	0	602.26	22.21
Junc 125B	551	0	574.08	10
Junc IRL2	551	125	572.8	9.45
Junc 127	552	0	604.72	22.84
Junc 127A	552	0	601.41	21.41
Junc 127B	552	0	575.08	10
Junc IRL3	552	125	573.8	9.45
Junc 129	567	0	604.39	16.2
Junc 129A	567	0	602.1	15.21
Junc 129B	567	0	590.08	10
Junc 130	567	0	586.25	8.34
Junc 131	557	0	585.17	12.21
Junc IRL4	557	125	584.4	11.87
Junc RB1	472	0	585.45	49.16
Junc RB2	478	0	589.49	48.31
Junc RB3	466	0	589.78	53.63
Junc RB4	464	0	589.46	54.36
Junc RB5	462	0	585.56	53.54
Junc 1	472	0	582.76	47.99
Junc 2	458	0	583.23	54.26
Junc 3	479	0	576.98	42.46
Junc 4	478	0	575.89	42.42
Junc 5	495	0	566.94	31.17
Junc 6	495	0	691.66	85.21
Junc 7	478	0	689.18	91.5
Junc 8	479	0	688.01	90.56
Junc 9	560	0	664.56	45.31
Junc 10	490	0	640.26	65.11
Junc 11	483	0	635.57	66.11

Node ID	Elevation ft.	Demand GPM	Head ft.	Pressure psi
Junc 12	479	0	629.32	65.13
Junc 13	488	0	629.04	61.11
Junc 14	488	0	623.7	58.8
Junc 15	467	0	623.42	67.78
Junc RB1b	105	0	470	158.15
Junc RB2b	225	0	430.8	89.17
Junc RB3b	250	0	422.5	74.74
Junc RB4b	271	0	421.8	65.34
Junc RB5b	375	0	455	34.66
Junc RB1a	105	0	585.45	208.18
Junc RB2a	478	0	693.67	93.45
Junc RB3a	250	0	682.92	187.58
Junc RB4a	271	0	678.51	176.58
Junc RB5a	375	0	585.56	91.24
Junc 16	495	0	566.66	31.05
Resvr WELL1	470	0	470	0
Resvr WELL2	430.8	-161.89	430.8	0
Resvr WELL3	422.5	-165.97	422.5	0
Resvr WELL4	421.8	-172.15	421.8	0
Resvr WELL5	455	0	455	0

Table 3 – Network Link Simulation Results

Link ID	Flow GPM	Velocity fps	Unit Headloss ft./Kft
Pipe A4-A5	375	5.35	16.17
Pipe A3	250	3.57	7.63
Pipe 119	125	1.78	2.11
Pipe 123	125	1.78	2.11
Pipe 124A	125	12.77	255.07
Pipe 124B	125	12.77	255.07
Pipe 125	125	1.78	2.11
Pipe 126A	125	12.77	255.07
Pipe 126B	125	12.77	255.07
Pipe 127	125	1.78	2.11
Pipe 128A	125	12.77	255.07
Pipe 128B	125	12.77	255.07
Pipe 129	125	1.78	2.11
Pipe 130A	125	12.77	255.07
Pipe 130B	125	12.77	255.07
Pipe 131	125	1.78	2.11
Pipe 132	125	12.77	255.07
Pipe G1	240.73	3.44	7.12
Pipe G2	-240.73	3.44	7.12
Pipe G3	-78.85	1.13	0.9
Pipe G4	87.12	1.24	1.08
Pipe G5	259.27	3.7	8.16
Pipe G6	259.27	3.7	8.17
Pipe C3	240.73	3.44	7.12
Pipe C4	240.73	3.44	7.12
Pipe C5	-259.27	3.7	8.16
Pipe C6	500	7.14	27.55
Pipe MW20	500	7.14	27.55
Pipe C6b	500	4.22	7.65
Pipe C4b	500	4.22	7.65
Pipe A6-1	500	7.14	27.55
Pipe A6-2	500	7.14	27.55
Pipe A7	500	7.14	27.55
Pipe A6-3	500	7.14	27.55
Pipe A8a	500	7.14	27.56
Pipe A8	500	7.14	27.55
Pipe A8b	500	7.14	27.56

Link ID	Flow GPM	Velocity fps	Unit Headloss ft./Kft
Pipe A6-4	500	7.14	27.55
Pipe 8	0	0	0
Pipe 9	161.89	0.46	0.06
Pipe 10	165.97	0.47	0.06
Pipe 11	172.15	0.49	0.06
Pipe 12	0	0	0
Pipe 6	0	0	0
Pipe 7	161.89	16.53	411.75
Pipe 13	165.97	16.95	431.19
Pipe 14	172.15	17.58	461.39
Pipe 15	0	0	0
Pump 1	0	0	0
Pump 2	161.89	0	-262.87
Pump 3	165.97	0	-260.42
Pump 4	172.15	0	-256.71
Pump 5	0	0	0
Pump Booster	500	0	-125
Valve V504	125	12.77	90.88
Valve V505	125	12.77	28.18
Valve V506	125	12.77	26.33
Valve V507	125	12.77	12.02

PG&E Topock Groundwater Remediation Project

Hydraulic Analysis of IRZ Loop

The piping and pumps for the IRZ Loop system on the Topock Remediation project were sized from simulations of a hydraulic network model of the system. The hydraulic model was developed in EPANET, a widely used distribution system tool developed by U.S. EPA. In EPANET, pipe junctions, reservoirs, and tanks are represented as nodes. Pipes, pumps, and valves are represented as links. EPANET tracks flow and head loss through links, pressure and heads at nodes, and can be used to evaluate distribution system configurations.

The IRZ system includes a northern extraction line that joins with another extraction well near MW-20. After treatment, the line splits into three: one northern injection line and two southern injection lines. The development and results of the hydraulic model follow.

Pipe trenches, piping lengths, and pipe / node elevations were modeled based on the plan and profile sheets for the 90% submittal. The model plan has been simplified compared to actual trench pathways. However since well coordinates, pipe lengths, and pipe elevations were used, this does not affect the accuracy of the hydraulic analysis. The system configuration can be seen in the map on the following page.

The extraction wells were modeled as pumps attached to underground reservoirs. The reservoir's head represents the normal operating ground water level, the pump upstream junction represents the pump intake elevation, and the pump downstream junction represents the ground elevation. The extraction wells IRZ-1, IRZ-5, and IRZ-9 are dual screen so two pumps were included at each location corresponding to the different screen depths. For all IRZ extraction wells, actual ground water operating levels were approximated by using expected static water levels and design flow rates for each well (including the combined dual screen flow were applicable). Injection wells were modeled as a positive demands. The northern injection line includes dual screen well clusters (made up of two wells with two screens each); positive demands were included for each well separately (combining dual screen totals where applicable).

All pipes were assumed to have a Hazen-Williams C factor of 150. Since the pipes used for this recirculation loop are small, actual pipe diameters were used during modeling. For the planned HDPE DR-11 pipes, actual diameters are 3.53 for 4" and 5.35" for 6" pipes.

The loop was designed based on maximum flow conditions of 400 GPM at the IRZ wells; only certain extraction and injection wells were operating to achieve these flows (see Tables 2 and 3). Nominal flow conditions of 300 GPM were also evaluated for the IRZ Loop; this was modeled as nominal demands at each injection well and by running all extraction wells and applying speed parameters to adjust to desired flows (simulating Variable Frequency Drive (VFD) pumps).

Simulations were performed to size the pipes and pumps of the IRZ loop. With original extraction pumps, pressures for both maximum and nominal flow conditions were too high (upwards of 100 psi throughout the system). Therefore, the IRZ-1, IRZ-5, and IRZ-9 pumps were lowered in size to provide lower head at the given design flows. Using this configuration, pipe diameters were kept at their previous sizes (between 4 and 6 inches). The final configuration is able to transmit maximum and nominal flows and retain adequate pressure for the system. Max flow conditions result in pressure between 19 and 32 psi upstream of the injection wells, and nominal flow conditions result in pressure between 40 and 52 psi upstream of the injection wells. Results for all links and nodes for the final maximum flow simulation are found on the following pages.

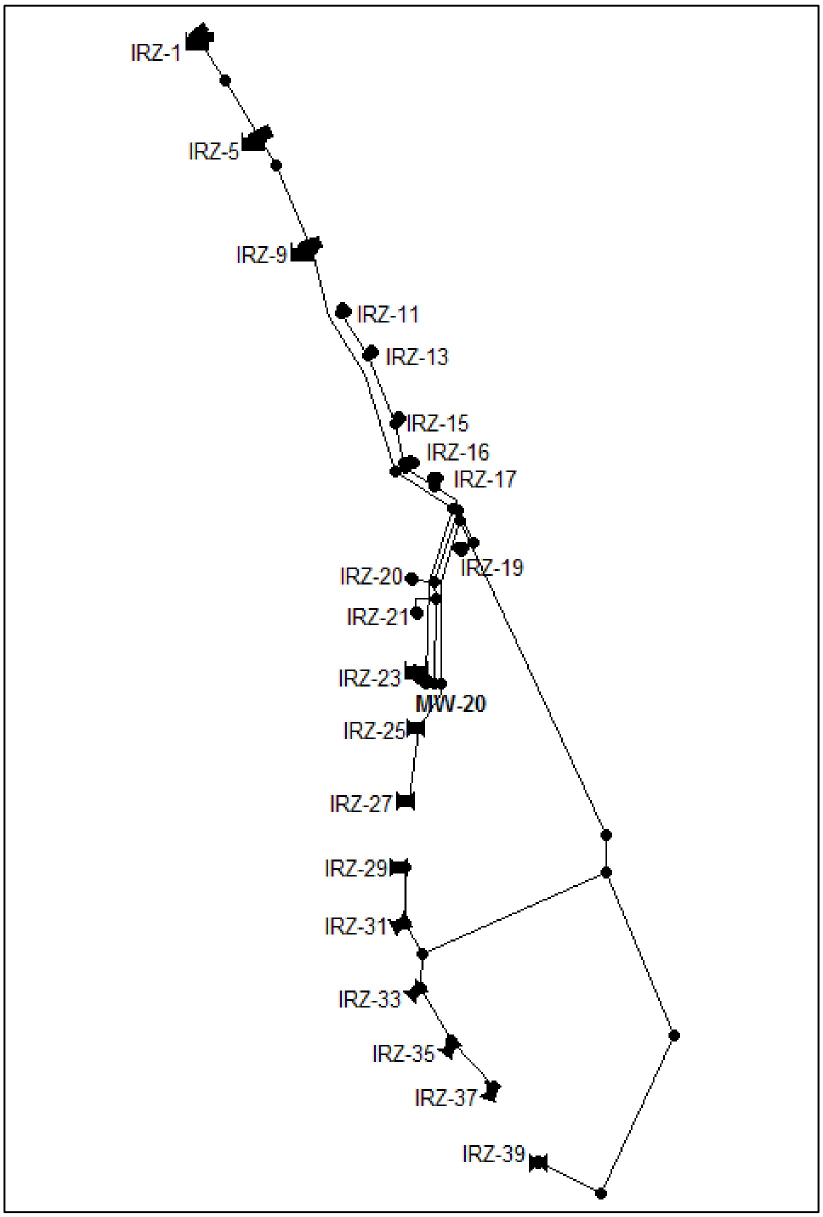

Figure 1 - Proposed IRZ Model Configuration

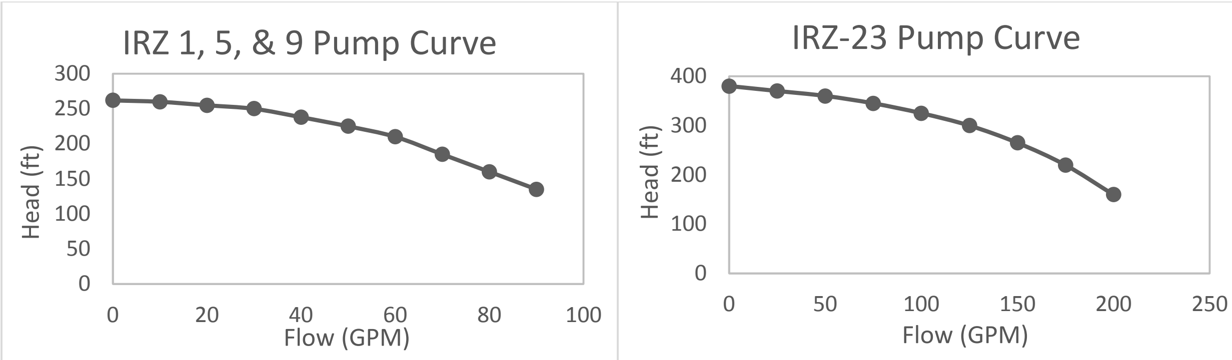

Figure 2 - Modeled Pump Curves for extraction pumps

Table 1 – Network Model Characteristics

ID	Node1	Node2	Length	Diameter	Roughness	Minor Loss	Status
C17	1	IRZ-39	147	3.63	150	0	Open
C9	2	1	250	3.63	150	0	Open
C8	3	2	647	3.63	150	0	Open
C14	3	4	450	3.63	150	0	Open
C16a	4	IRZ-33	75	3.63	150	0	Open
C15a	4	IRZ-31	55	3.63	150	0	Open
MW-20a	MW-20inlet	MW-20outlet1	8	5.35	150	0	Open
C6	MW-20outlet	7	525	5.35	150	0	Open
C5	7	5	895	5.35	150	0	Open
C7	5	3	158	5.35	150	0	Open
8	IRZ-23	MW-20inlet	35	3.63	150	0	Open
C15b	IRZ-31	IRZ-29	138	3.63	150	0	Open
C16b	IRZ-33	IRZ-35	170	3.63	150	0	Open
C16c	IRZ-35	IRZ-37	135	3.63	150	0	Open
C13a	MW-20outlet	IRZ-25	90	5.35	150	0	Open
C13b	IRZ-25	IRZ-27	149	5.35	150	0	Open
C2a	8	IRZ-5	253	5.35	150	0	Open
C2b	IRZ-5	6	19	5.35	150	0	Open
C1	IRZ-1	8	39	5.35	150	0	Open
C3b	IRZ-9	14	510	5.35	150	0	Open
C6-2	9	MW-20inlet	525	5.35	150	0	Open
C6-3a	MW-20outlet1	11	245	5.35	150	0	Open
MW-20b	MW-20outlet1	MW-20outlet	2	5.35	150	0	Open
C3a	6	IRZ-9	301	5.35	150	0	Open

ID	Node1	Node2	Length	Diameter	Roughness	Minor Loss	Status
C6-3b	11	12	62	5.35	150	0	Open
C6-3c	12	10	218	5.35	150	0	Open
2	11	IRZ-21	90	3.63	150	0	Open
3	12	IRZ-20	45	3.63	150	0	Open
C5-1a	10	13	140	5.35	150	0	Open
5	13	IRZ-19	25	5.35	150	0	Open
C4-2a	10	IRZ-17	25	5.35	150	0	Open
C4-2b	IRZ-17	IRZ-16	77	5.35	150	0	Open
C3-2c	15	IRZ-15	61	5.35	150	0	Open
C3-2d	IRZ-15	IRZ-13	137	5.35	150	0	Open
C3-2e	IRZ-13	IRZ-11	162	5.35	150	0	Open
C4	14	9	153	5.35	150	0	Open
C4-2c	IRZ-16	15	51	5.35	150	0	Open
1	1A	IRZ-1	177	1.9	150	0	Open
4	1B	IRZ-1	177	1.9	150	0	Open
7	IRZ1	1C	1	120	150	0	Open
12	IRZ5	5D	1	120	150	0	Open
13	5A	IRZ-5	203	1.9	150	0	Open
14	5B	IRZ-5	358	1.9	150	0	Open
18	IRZ9	9D	1	120	150	0	Open
19	9A	IRZ-9	180	1.9	150	0	Open
20	9B	IRZ-9	310	1.9	150	0	Open
23	IRZ23	23B	1	120	150	0	Open
24	23A	IRZ-23	153	1.9	150	0	Open
6	1D	IRZ1	1	120	150	0	Open
9	5C	IRZ5	1	120	150	0	Open
10	9C	IRZ9	1	120	150	0	Open
11	IRZ-11	IRZ11a	175	1.9	150	0	Open
15	IRZ-11	IRZ11b	175	1.9	150	0	Open
16	IRZ-13	IRZ13a	175	1.9	150	0	Open
17	IRZ-13	IRZ13b	175	1.9	150	0	Open
21	IRZ-15	IRZ15a	175	1.9	150	0	Open
22	IRZ-15	IRZ15b	175	1.9	150	0	Open
26	IRZ-16	IRZ16a	175	1.9	150	0	Open
27	IRZ-16	IRZ16b	175	1.9	150	0	Open
28	IRZ-17	IRZ17a	175	1.9	150	0	Open
29	IRZ-17	IRZ17b	175	1.9	150	0	Open
30	IRZ-19	IRZ19a	175	1.9	150	0	Open
31	IRZ-19	IRZ19b	175	1.9	150	0	Open
32	IRZ-20	IRZ20a	175	1.9	150	0	Open

ID	Node1	Node2	Length	Diameter	Roughness	Minor Loss	Status
33	IRZ-20	IRZ20b	175	1.9	150	0	Open
34	IRZ-21	IRZ21a	175	1.9	150	0	Open
35	IRZ-21	IRZ21b	175	1.9	150	0	Open
36	IRZ-25	27	150	1.9	150	0	Open
38	IRZ-27	29	150	1.9	150	0	Open
40	IRZ-29	30	150	1.9	150	0	Open
41	IRZ-31	32	150	1.9	150	0	Open
42	IRZ-33	34	150	1.9	150	0	Open
43	IRZ-35	36	64	1.9	150	0	Open
44	IRZ-37	38	64	1.9	150	0	Open
50	IRZ-39	39	64	1.9	150	0	Open
1-UPPER	1C	1A	Pump w/ Curve 75S50-8				Open
1-LOWER	1D	1B	Pump w/ Curve 75S50-9				Open
5-UPPER	5C	5A	Pump w/ Curve 75S50-10				Open
5-LOWER	5D	5B	Pump w/ Curve 75S50-11				Closed
9-UPPER	9C	9A	Pump w/ Curve 75S50-12				Closed
9-LOWER	9D	9B	Pump w/ Curve 75S50-13				Closed
25	23B	23A	Pump w/ Curve 150S150-7				Open
37	27	IRZ25	--	2	Valve: Open		
39	29	IRZ27	--	2	Valve: Open		
45	38	IRZ37	--	2	Valve: Open		
46	36	IRZ35	--	2	Valve: Open		
47	34	IRZ33	--	2	Valve: Open		
48	32	IRZ31	--	2	Valve: Open		
49	30	IRZ29	--	2	Valve: Open		
51	39	IRZ39	--	2	Valve: Open		

Table 2 – Network Junction Simulation Results

Node ID	Elevation ft.	Demand GPM	Head ft.	Pressure psi
Junc IRZ-1	481	0	569.48	38.34
Junc IRZ-5	473	0	568.6	41.42
Junc IRZ-9	478	0	566.49	38.34
Junc IRZ-23	500	0	559.5	25.78
Junc IRZ-11	482	0	553.71	31.07
Junc IRZ-13	481	0	553.86	31.57
Junc IRZ-15	481	0	554.31	31.77
Junc IRZ-16	479	0	554.69	32.8
Junc IRZ-17	479	0	554.95	32.91
Junc IRZ-19	477	0	554.96	33.78
Junc IRZ-20	499	0	556.25	24.81
Junc IRZ-21	499	0	556.45	24.89
Junc IRZ-25	500	0	558.48	25.34
Junc IRZ-27	501	0	558.44	24.89
Junc IRZ-29	500	0	550.74	21.99
Junc IRZ-31	501	0	550.88	21.61
Junc IRZ-33	502	0	550.85	21.17
Junc IRZ-35	503	0	550.73	20.68
Junc IRZ-37	506	0	550.72	19.38
Junc IRZ-39	481	0	555.74	32.38
Junc 1	484	0	555.74	31.09
Junc 2	458	0	555.75	42.35
Junc 3	459	0	555.77	41.93
Junc 4	501	0	551.05	21.69
Junc 5	460	0	556.05	41.62
Junc MW-20inlet	495	0	558.65	27.58
Junc MW-20outlet1	495	0	558.5	27.52
Junc 7	480	0	557.59	33.62
Junc 8	480	0	569.36	38.72
Junc 9	480	0	562.11	35.58
Junc 10	480	0	555.03	32.51
Junc MW-20outlet	495	0	558.5	27.51
Junc 6	473	0	568.47	41.37
Junc 11	496	0	556.6	26.26
Junc 12	495	0	556.25	26.54
Junc 13	477	0	554.97	33.78
Junc 14	480	0	563.12	36.02
Junc 15	480	0	554.52	32.29

Node ID	Elevation ft.	Demand GPM	Head ft.	Pressure psi
Junc 1A	304	0	592.45	124.98
Junc 1B	101	0	592.45	212.94
Junc 1C	304	0	422	51.13
Junc 1D	101	0	422	139.09
Junc 5A	270	0	597.33	141.83
Junc 5B	115	0	568.6	196.54
Junc 5C	270	0	436	71.93
Junc 5D	115	0	436	139.09
Junc 9A	298	0	566.49	116.34
Junc 9B	168	0	566.49	172.66
Junc 9C	298	0	454	67.59
Junc 9D	168	0	454	123.92
Junc 23B	347	0	416	29.9
Junc 23A	347	0	646.99	129.98
Junc IRZ11a	482	40	546.76	28.06
Junc IRZ11b	482	40	546.76	28.06
Junc IRZ13a	481	40	546.91	28.56
Junc IRZ13b	481	40	546.91	28.56
Junc IRZ15a	481	0	554.31	31.77
Junc IRZ15b	481	0	554.31	31.77
Junc IRZ16a	479	0	554.69	32.8
Junc IRZ16b	479	0	554.69	32.8
Junc IRZ17a	479	0	554.95	32.91
Junc IRZ17b	479	0	554.95	32.91
Junc IRZ19b	477	26	551.83	32.42
Junc IRZ19a	477	26	551.83	32.42
Junc IRZ20a	499	0	556.25	24.81
Junc IRZ20b	499	0	556.25	24.81
Junc IRZ21a	499	20	554.53	24.06
Junc IRZ21b	499	20	554.53	24.06
Junc 27	500	0	558.48	25.34
Junc IRZ25	500	0	558.48	25.34
Junc 29	501	0	553.55	22.77
Junc IRZ27	501	36	553.55	22.77
Junc 30	500	0	547.25	20.47
Junc IRZ29	500	30	547.25	20.47
Junc 32	501	0	548.2	20.45
Junc IRZ31	501	26	548.2	20.45
Junc 34	502	0	548.17	20.01

Node ID	Elevation ft.	Demand GPM	Head ft.	Pressure psi
Junc IRZ33	502	26	548.17	20.01
Junc 36	503	0	550.32	20.5
Junc IRZ35	503	15	550.32	20.5
Junc 38	506	0	550.52	19.29
Junc IRZ37	506	10	550.52	19.29
Junc 39	481	0	555.68	32.36
Junc IRZ39	481	5	555.68	32.36
Resvr IRZ1	422	-151.64	422	0
Resvr IRZ5	436	-79.47	436	0
Resvr IRZ9	454	0	454	0
Resvr IRZ23	416	-168.9	416	0

Table 3 – Network Link Simulation Results

Link ID	Flow GPM	Velocity fps	Unit Headloss ft./Kft
Pipe C17	5	0.16	0.04
Pipe C9	5	0.16	0.04
Pipe C8	5	0.16	0.04
Pipe C14	107	3.32	10.49
Pipe C16a	51	1.58	2.66
Pipe C15a	56	1.74	3.16
Pipe MW-20a	400.01	5.71	18.23
Pipe C6	112	1.6	1.73
Pipe C5	112	1.6	1.73
Pipe C7	112	1.6	1.73
Pipe 8	168.9	5.24	24.42
Pipe C15b	30	0.93	0.99
Pipe C16b	25	0.78	0.71
Pipe C16c	10	0.31	0.13
Pipe C13a	36	0.51	0.21
Pipe C13b	36	0.51	0.21
Pipe C2a	151.64	2.16	3.02
Pipe C2b	231.11	3.3	6.6
Pipe C1	151.64	2.16	3.02
Pipe C3b	231.11	3.3	6.6
Pipe C6-2	231.11	3.3	6.6
Pipe C6-3a	252	3.6	7.75
Pipe MW-20b	148	2.11	2.9
Pipe C3a	231.11	3.3	6.6
Pipe C6-3b	212	3.03	5.62
Pipe C6-3c	212	3.03	5.62
Pipe 2	40	1.24	1.69
Pipe 3	0	0	0
Pipe C5-1a	52	0.74	0.42
Pipe 5	52	0.74	0.42
Pipe C4-2a	160	2.28	3.34
Pipe C4-2b	160	2.28	3.34
Pipe C3-2c	160	2.28	3.34
Pipe C3-2d	160	2.28	3.34
Pipe C3-2e	80	1.14	0.92
Pipe C4	231.11	3.3	6.6
Pipe C4-2c	160	2.28	3.34

Link ID	Flow GPM	Velocity fps	Unit Headloss ft./Kft
Pipe 1	75.82	8.58	129.74
Pipe 4	75.82	8.58	129.74
Pipe 7	75.82	0	0
Pipe 12	0	0	0
Pipe 13	79.47	8.99	141.53
Pipe 14	0	0	0
Pipe 18	0	0	0
Pipe 19	0	0	0
Pipe 20	0	0	0
Pipe 23	168.9	0	0
Pipe 24	168.9	19.11	571.8
Pipe 6	-75.82	0	0
Pipe 9	-79.47	0	0
Pipe 10	0	0	0
Pipe 11	40	4.53	39.69
Pipe 15	40	4.53	39.69
Pipe 16	40	4.53	39.69
Pipe 17	40	4.53	39.69
Pipe 21	0	0	0
Pipe 22	0	0	0
Pipe 26	0	0	0
Pipe 27	0	0	0
Pipe 28	0	0	0
Pipe 29	0	0	0
Pipe 30	26	2.94	17.87
Pipe 31	26	2.94	17.87
Pipe 32	0	0	0
Pipe 33	0	0	0
Pipe 34	20	2.26	11
Pipe 35	20	2.26	11
Pipe 36	0	0	0
Pipe 38	36	4.07	32.66
Pipe 40	30	3.39	23.3
Pipe 41	26	2.94	17.87
Pipe 42	26	2.94	17.87
Pipe 43	15	1.7	6.45
Pipe 44	10	1.13	3.05
Pipe 50	5	0.57	0.84
Pump 1-UPPER	75.82	0	-170.45

Link ID	Flow GPM	Velocity fps	Unit Headloss ft./Kft
Pump 1-LOWER	75.82	0	-170.45
Pump 5-UPPER	79.47	0	-161.33
Pump 5-LOWER	0	0	0
Pump 9-UPPER	0	0	0
Pump 9-LOWER	0	0	0
Pump 25	168.9	0	-230.99
Valve 37	0	0	0
Valve 39	36	3.68	0
Valve 45	10	1.02	0
Valve 46	15	1.53	0
Valve 47	26	2.66	0
Valve 48	26	2.66	0
Valve 49	30	3.06	0
Valve 51	5	0.51	0

PG&E Topock Groundwater Remediation Project

Hydraulic Analysis of TCS Recirculation Loop

The piping for the TCS recirculation loop system on the Topock Remediation project was sized from simulations of a hydraulic network model of the system. The hydraulic model was developed in EPANET, a widely used distribution system tool developed by U.S. EPA. In EPANET, pipe junctions, reservoirs, and tanks are represented as nodes. Pipes, pumps, and valves are represented as links. EPANET tracks flow and head loss through links, pressure and heads at nodes, and can be used to evaluate distribution system configurations.

As part of the final design of the TCS recirculation loop, a new piping route was developed to remove the need for a separate treatment facility. Instead the loop has been extended to the primary carbon amendment building. The development of the hydraulic model and proposed design follows.

Pipe trenches, piping lengths, and pipe / node elevations were modeled based on the plan and profile sheets for the 90% submittal. The model plan has been simplified compared to actual trench pathways. However since well coordinates, pipe lengths, and pipe elevations were used, this does not affect the accuracy of the hydraulic analysis. The system configuration can be seen in the map on the following page.

The extraction wells were modeled as pumps attached to underground reservoirs. The reservoir's head represents the normal operating ground water level, the pump upstream junction represents the pump intake elevation, and the pump downstream junction represents the ground elevation. For TWB-1 & 2 and ER-6, the pump intake was modeled as 100 feet below ground surface and a worst case operating water surface elevation of 100 feet below ground surface was assumed. For ER-1, 2, 3, & 4, the pump intake was modeled as 140 feet below ground surface and a worst case operating water surface elevation of 140 feet below ground surface was assumed. The TWB and ER well pumps were modeled with pump curves from the pumps that were selected during the previous TCS loop design.

All pipes were assumed to have a Hazen-Williams C factor of 150. Since the pipes used for this recirculation loop are very small, actual pipe diameters were used during modeling. For the planned HDPE DR-11 pipes, actual diameters are 1.9" for 2" pipes, 2.8" for 3" pipes, and 3.6" for 4" pipes.

The loop was design and sized based on maximum flow conditions of 80 GPM at the TCS injection wells; this was modeled as a 40 GPM demand at each well. Each injection well also has a PRV placed upstream to keep pressures less than 10psi. A negative demand of 30 GPM was also added at the carbon amendment facility to represent the additive supplemental flow branch. Minor losses from valves and bends were added for the extraction well vaults, carbon amendment building, and injection well vaults, however their impact on model results was minimal (<1 psi pressure drop).

Multiple simulations were performed to size the pipes of the TCS loop. Initial diameters of 2" for the extraction line and 3" for the injection line resulted in major simulation errors. Iterations were also run where diameters were increased by 1", a simulation where a booster pump was added at the treatment facility, and a simulation with both of these adjustments. While these alternatives resulted in valid results, the increased diameter and option to use the booster pump as needed was chosen. This configuration is able to transmit maximum flow, retain adequate pressure for the system, and also has pressures close to the desired 10 psi at the injection wells. Results for all links and nodes for the final simulation are found on the following pages.

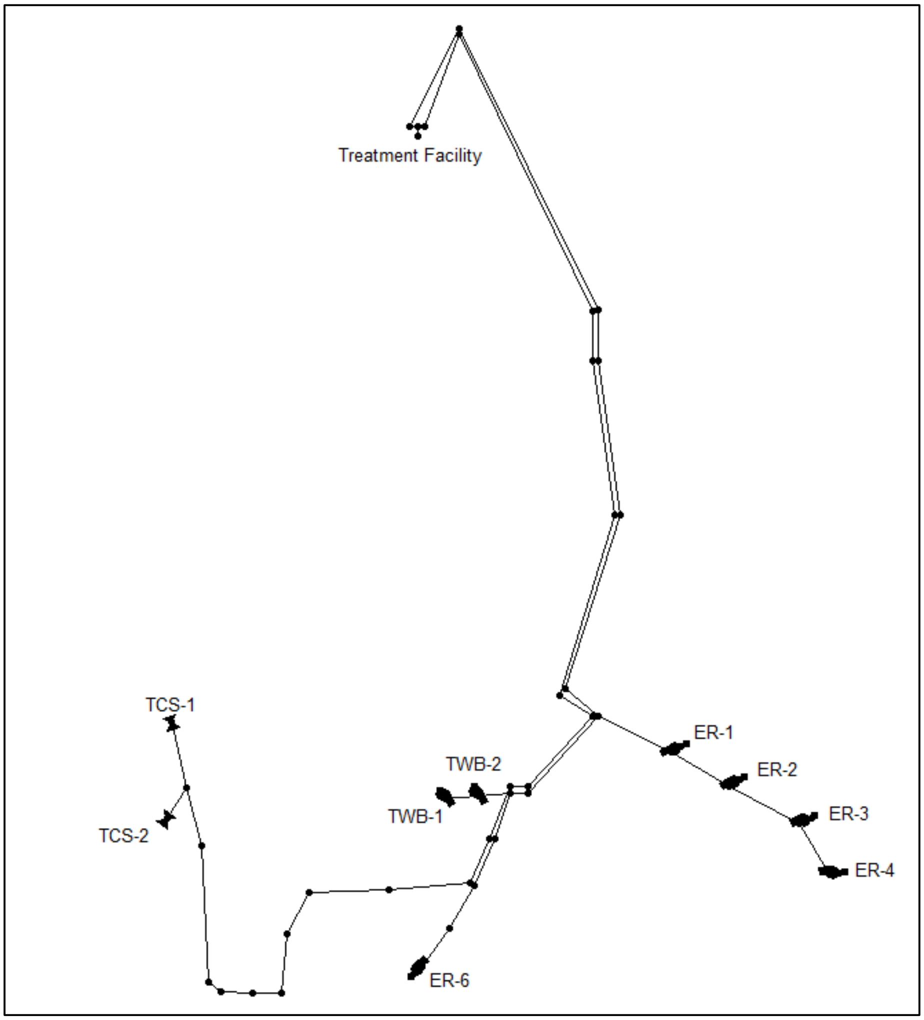

Figure 1 - Proposed TCS Recirculating Loop Model Configuration

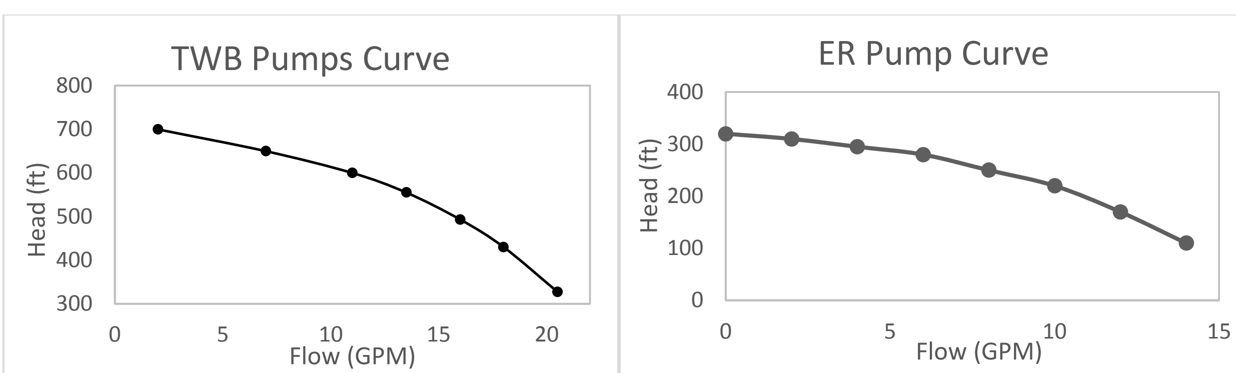

Figure 2 - Modeled Pump Curves for Extraction Wells

Table 1 – Network Model Characteristics

ID	Node1	Node2	Length	Diameter	Roughness	Minor Loss	Status
C11a	ER-4	ER-3	160	2.8	150	0	Open
C11b	ER-3	ER-2	225	2.8	150	0	Open
C11c	ER-2	ER-1	200	2.8	150	0	Open
E1a	TWB-1	TWB-2	222	2.8	150	0	Open
C18a	ER-6	1	465	2.8	150	0	Open
E1b	TWB-2	9	222	2.8	150	0	Open
F4	7	8	110	2.8	150	0	Open
F3	8	9	100	2.8	150	0	Open
F2	9	10	40	2.8	150	0	Open
F1	10	11	400	2.8	150	0	Open
C11d	ER-1	11	253	2.8	150	0	Open
F1-2	14	12	400	3.6	150	0	Open
F2-2	12	13	40	3.6	150	0	Open
F3-2	13	15	100	3.6	150	0	Open
F4-2	15	16	110	3.6	150	0	Open
F-5	16	17	242	3.6	150	0	Open
F-6	17	18	318	3.6	150	0	Open
F-7	18	25	207	3.6	150	0	Open
F-8	25	24	325	3.6	150	0	Open
M1	24	23	48	3.6	150	0	Open
M2	23	22	160	3.6	150	0	Open
M3	22	21	70	3.6	150	0	Open
M4	21	20	497	3.6	150	0	Open
M5	20	19	113	3.6	150	0	Open
M6	19	T1	215	2.8	150	6.6	Open
N1	19	T2	138	2.8	150	6.6	Open
C6	32	27	325	2.8	150	0	Open
C10	11	28	105	2.8	150	0	Open
C9	28	29	188	2.8	150	0	Open
C8	29	30	652	2.8	150	0	Open
C7	30	31	150	2.8	150	0	Open
C5	31	32	898	2.8	150	0	Open
C1	27	37	10	2.8	150	0	Open
C3	38	37	10	3.6	150	0	Open
C6-2	41	36	325	3.6	150	0	Open
C5-2	36	35	898	3.6	150	0	Open
C7-2	35	34	150	3.6	150	0	Open

ID	Node1	Node2	Length	Diameter	Roughness	Minor Loss	Status
C8-2	34	33	652	3.6	150	0	Open
C9-2	33	26	188	3.6	150	0	Open
C10-2	26	14	105	3.6	150	0	Open
C18b	1	7	180	2.8	150	0	Open
T1	TWB-1res	2	1	2.8	150	0	Open
T2	TWB-2res	3	1	2.8	150	0	Open
E4	ER-4res	39	1	2.8	150	0	Open
E3	ER-3res	6	1	2.8	150	0	Open
E2	ER-2res	5	1	2.8	150	0	Open
E1	ER-1res	4	1	2.8	150	0	Open
E6	ER-6res	40	1	2.8	150	0	Open
C2	37	41	10	2.8	150	6.4	Open
Vault1	42	TWB-1	100	1.25	150	15	Open
Vault2	43	TWB-2	100	1.25	150	15	Open
2	44	ER-6	100	1.25	150	15	Open
3	45	ER-4	140	1.25	150	15	Open
4	46	ER-3	140	1.25	150	15	Open
5	47	ER-2	140	1.25	150	15	Open
6	48	ER-1	140	1.25	150	15	Open
TWB-1	2	42	Pump w/ Curve 16S30-24				Open
ER-1	4	48	Pump w/ Curve 10Redi-Flo3-220				Open
ER-2	5	47	Pump w/ Curve 10Redi-Flo3-220				Open
ER-3	6	46	Pump w/ Curve 10Redi-Flo3-220				Open
ER-4	39	45	Pump w/ Curve 10Redi-Flo3-220				Open
ER-6	40	44	Pump w/ Curve 10Redi-Flo3-220				Open
TWB-2	3	43	Pump w/ Curve 16S30-24				Open
Booster	37	41	Pump w/ Curve (100-0.003907(Q^2))				Open
TCS2_PRV	T2	TCS-2	--	2.8	Valve: PRV Setting = 10psi		
TCS1_PRV	T1	TCS-1	--	2.8	Valve: PRV Setting = 10psi		

Table 2 – Network Junction Simulation Results

Node ID	Elevation ft.	Demand GPM	Head ft.	Pressure psi
Junc TCS-1	619	40	628.46	4.1
Junc TCS-2	584	40	607.08	10
Junc TWB-1	534	0	689.36	67.32
Junc TWB-2	534	0	689.04	67.18
Junc ER-1	503	0	684.85	78.8
Junc ER-2	508	0	684.89	76.65
Junc ER-3	518	0	684.92	72.33
Junc ER-4	519	0	684.93	71.9
Junc ER-6	550	0	688.09	59.83
Junc 7	556	0	687.94	57.17
Junc 8	538	0	687.92	64.96
Junc 9	534	0	687.9	66.68
Junc 10	534	0	687.61	66.56
Junc 11	492	0	684.8	83.54
Junc 12	534	0	644.41	47.84
Junc 13	534	0	644.15	47.73
Junc 14	492	0	646.96	67.14
Junc 15	538	0	643.52	45.72
Junc 16	556	0	642.82	37.62
Junc 17	592	0	641.27	21.35
Junc 18	612	0	639.25	11.81
Junc 19	622	0	630.2	3.55
Junc 20	618	0	630.92	5.6
Junc 21	621	0	634.09	5.67
Junc 22	624	0	634.53	4.56
Junc 23	625	0	635.55	4.57
Junc 24	625	0	635.86	4.7
Junc 25	616	0	637.93	9.5
Junc 26	484	0	647.63	70.9
Junc 27	495	0	663.76	73.12
Junc 28	484	0	683.85	86.59
Junc 29	457	0	682.14	97.55
Junc 30	458	0	676.22	94.56
Junc 31	469	0	674.86	89.2
Junc 32	478	0	666.71	81.77
Junc 33	457	0	648.82	83.12
Junc 34	458	0	652.98	84.48
Junc 35	469	0	653.93	80.13

Node ID	Elevation ft.	Demand GPM	Head ft.	Pressure psi
Junc 36	478	0	659.66	78.71
Junc 37	495	0	663.67	73.08
Junc 38	495	-30	663.68	73.09
Junc 1	522	0	687.98	71.92
Junc 2	436	0	436	0
Junc 3	436	0	436	0
Junc 4	365	0	365	0
Junc 5	370	0	370	0
Junc 6	380	0	380	0
Junc 39	381	0	381	0
Junc 40	452	0	452	0
Junc 41	495	0	661.73	72.24
Junc T2	584	0	628.93	19.47
Junc T1	619	0	628.46	4.1
Junc 42	436	0	702.01	115.26
Junc 43	436	0	701.71	115.13
Junc 44	452	0	689.93	103.1
Junc 45	381	0	685.35	131.88
Junc 46	380	0	685.31	132.29
Junc 47	370	0	684.95	136.47
Junc 48	365	0	684.85	138.59
Resvr ER-4res	381	-2.75	381	0
Resvr ER-3res	380	-2.63	380	0
Resvr ER-2res	370	-1.01	370	0
Resvr ER-1res	365	-0.03	365	0
Resvr TWB-1res	436	-18.42	436	0
Resvr TWB-2res	436	-18.43	436	0
Resvr ER-6res	452	-6.74	452	0

Table 3 – Network Link Simulation Results

Link ID	Flow GPM	Velocity fps	Unit Headloss ft./Kft
Pipe C11a	2.75	0.14	0.04
Pipe C11b	5.38	0.28	0.15
Pipe C11c	6.39	0.33	0.2
Pipe E1a	18.42	0.96	1.43
Pipe C18a	6.74	0.35	0.22
Pipe E1b	36.85	1.92	5.16
Pipe F4	6.74	0.35	0.22
Pipe F3	6.74	0.35	0.22
Pipe F2	43.58	2.27	7.04
Pipe F1	43.58	2.27	7.04
Pipe C11d	6.42	0.33	0.2
Pipe F1-2	80	2.52	6.37
Pipe F2-2	80	2.52	6.37
Pipe F3-2	80	2.52	6.37
Pipe F4-2	80	2.52	6.37
Pipe F-5	80	2.52	6.37
Pipe F-6	80	2.52	6.37
Pipe F-7	80	2.52	6.37
Pipe F-8	80	2.52	6.37
Pipe M1	80	2.52	6.37
Pipe M2	80	2.52	6.37
Pipe M3	80	2.52	6.37
Pipe M4	80	2.52	6.37
Pipe M5	80	2.52	6.37
Pipe M6	40	2.08	8.07
Pipe N1	40	2.08	9.23
Pipe C6	50	2.61	9.08
Pipe C10	50	2.61	9.08
Pipe C9	50	2.61	9.08
Pipe C8	50	2.61	9.08
Pipe C7	50	2.61	9.08
Pipe C5	50	2.61	9.08
Pipe C1	50	2.61	9.08
Pipe C3	30	0.95	1.04
Pipe C6-2	80	2.52	6.37
Pipe C5-2	80	2.52	6.37
Pipe C7-2	80	2.52	6.37

Link ID	Flow GPM	Velocity fps	Unit Headloss ft./Kft
Pipe C8-2	80	2.52	6.37
Pipe C9-2	80	2.52	6.37
Pipe C10-2	80	2.52	6.37
Pipe C18b	6.74	0.35	0.22
Pipe T1	18.42	0.96	1.43
Pipe T2	18.43	0.96	1.43
Pipe E4	2.75	0.14	0.03
Pipe E3	2.63	0.14	0.03
Pipe E2	1.01	0.05	0
Pipe E1	0.03	0	0
Pipe E6	6.74	0.35	0.21
Pipe C2	80	4.17	194.32
Pipe Vault1	18.42	4.82	126.57
Pipe Vault2	18.43	4.82	126.68
Pipe 2	6.74	1.76	18.49
Pipe 3	2.75	0.72	3.01
Pipe 4	2.63	0.69	2.75
Pipe 5	1.01	0.26	0.45
Pipe 6	0.03	0.01	0
Pump TWB-1	18.42	0	-266.02
Pump ER-1	0.03	0	-319.85
Pump ER-2	1.01	0	-314.95
Pump ER-3	2.63	0	-305.31
Pump ER-4	2.75	0	-304.35
Pump ER-6	6.74	0	-237.93
Pump TWB-2	18.43	0	-265.71
Pump Booster	0	0	0
Valve TCS2_PRV	40	2.08	21.85
Valve TCS1_PRV	40	2.08	0

Final (100%) Design Submittal for the Final Groundwater Remedy
PG&E Topock Compressor Station
Needles, California

Structural Calculations
(for Attached Table of Contents)

11/18/2015

Prepared for:

Pacific Gas and Electric Company

Prepared and Reviewed by:

Matthew Lotycz
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Arcadis, U.S., Inc.

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STATE OF CALIFORNIA

11/18/15

ARCADIS
Design & Consultancy for natural and built assets

ARCADIS

SUBJECT: PG&E – TOPOK
ARCADIS STRUCTURAL CALCULATIONS
JOB NO:

BY: MSL DATE: 6/18/14
CHKD: MSL 12/8/14
MSL DATE: 10/27/15

PAGE
SHEET 1

PG&E TOPOK
ARCADIS STRUCTURAL CALCULATIONS

A – GENERAL SITE LOCATION & CODE INFORMATION

B – HQ PARKING CANOPY STRUCTURE

C – IRZ CARBON SUBSTRATE & TW-BENCH STORAGE TANK FOUNDATION

D – IRZ UNLOADING PAD

E – MW-20 BENCH CARBON AMENDMENT BUILDING (PRE-ENGINEERED STEEL BLDG)

F – WELL VAULT – TOP SLAB DESIGN

G – HQ DECON PAD

H – UTILITY PAD

I – WORKSHOP BUILDING

J – AREA 7 RETAINING WALL

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11/18/15

AGM Form 30 12-01

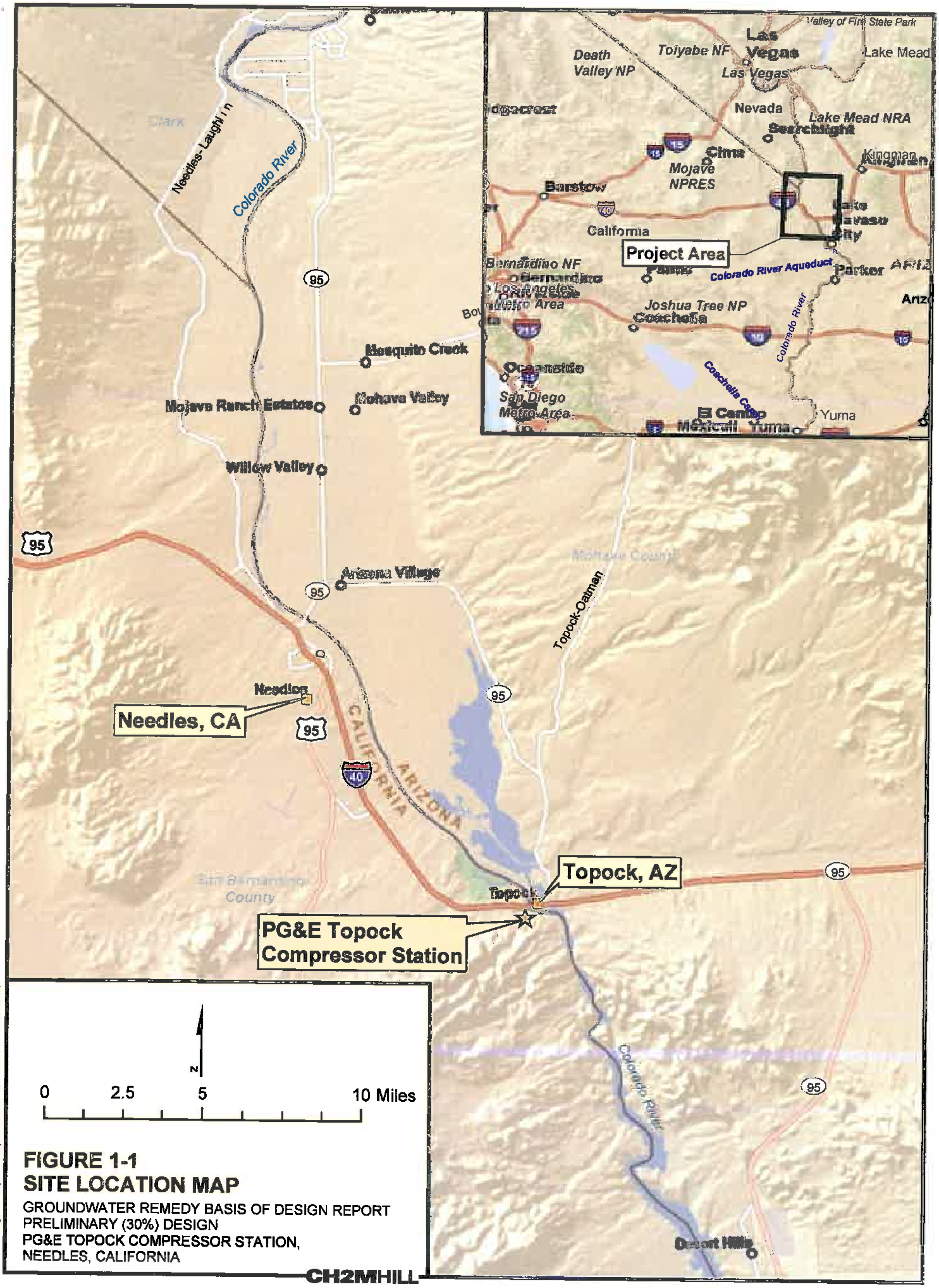

FIGURE 1-1
SITE LOCATION MAP

GROUNDWATER REMEDY BASIS OF DESIGN REPORT
PRELIMINARY (30%) DESIGN
PG&E TOPOCK COMPRESSOR STATION,
NEEDLES, CALIFORNIA

CH2MHILL

A-2

Appendix C
Design Criteria

A-3

Welcome (3) Welcome (2) Welcome the-ten-biggest-american... ARCADIS APEX Free Hotmail ARCADIS APEX (1) ARCADIS Citrix Logon ARCADIS Internet Site

DGS

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- **IMPORTANT CHANGES TO EFFECTIVE DATE OF PARTS OF 2013 CALIFORNIA BUILDING STANDARDS CODE**

California Energy Code, Part 6 – Effective July 1, 2014
The 2013 California Energy Code, Part 6, Title 24, California Code of Regulations now goes into effect on July 1, 2014. Until July 1, 2014, the 2010 California Energy Code, Part 6 is the effective code. The 2010 California Energy Code will remain in effect until July 1, 2014.

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Welcome to the **2013 California Codes** website.

You will be able to view the new 2013 California Building Code in an Adobe Reader format. *The files found on this site are in a read only format* and are not available for printing. This site has been updated with the January 1, 2014 Errata.

You will need to have Adobe ; Reader ; 8.0 or higher installed to be able to read these files. If you do not have Adobe® Reader® 8.0 or higher you can download it for free at www.adobe.com.

Use your arrow buttons or scroll bar to move between code sections and pages in the document.

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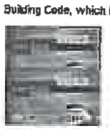


California Building Code California Code of Regulations, Title 24, Part 2, Volumes 1 and 2

Building Volume 1

- 2013 California Building Code Volume 1 cover
- 2013 California Building Code Volume 1 Title Page
- Copyright Page
- Preface and Acknowledgements
- California Agency Information Contact List
- Marginal Markings
- Effective Use of the IBC/CBC

Local Amendments - Educational Webinar

The July publication of the 2013 California Building Standards Code, which goes into effect on January 1, 2014 has prompted jurisdictions statewide to adopt the new code and complete local amendments as necessary.

The California Building Standards Commission (BSC) in collaboration with the International Code Council, California Building Officials, and Stuart Tom, Chief Building Official, City of Glendale recently presented a webinar on the code adoption process for local jurisdictions. This timely and instructive presentation is one hour and thirteen minutes in length:

- **Webinar via YouTube**
- **Webinar slide presentation only (pdf)**

The 2013 codes, which remain in effect through 2016 are available online both on this website and on the submitting agencies websites:

Residential Construction:
California Department of Housing and Community Development, www.hcd.ca.gov

Access Compliance:
California Department of General Services, Division of the State Architect, www.dgs.ca.gov/dsa/Programs/progCodes.aspx

****Updated Accessibility Regulations and Supporting Materials****

School Construction:
California Department of General Services, Division of the State Architect, www.dgs.ca.gov/dsa

Hospitals and Clinic Construction:
California Office of Statewide Health Planning and Development, www.oshpd.ca.gov

Fire and Panic Safety:
Office of the State Fire Marshal, http://osfm.fire.ca.gov/

Commission meetings webcast:

Live streaming video by Ustream

The link is active five (5) minutes prior to meeting start times. Please be aware of the approximate sixty (60) second delay in the webcast when commenting on an agenda item via teleconference.

CHAPTER 35

REFERENCED STANDARDS

This chapter lists the standards that are referenced in various sections of this document. The standards are listed herein by the promulgating agency of the standard, the standard identification, the effective date and title, and the section or sections of this document that reference the standard. The application of the referenced standards shall be as specified in *Chapter 1, Scope and Administration, Division I,* Sections *1.1.5 and 1.1.7, and in Chapter 1, Scope and Administration, Division II,* Section 102.4.

[DSA-SS, DSA-SS-CC & OSHPD 1 & 4] Reference to other chapters. *In addition to the code sections referenced, the standards listed in this chapter are applicable to the respective code sections in Chapters 16A, 17A, 18A, 19A, 21A, 22A and 34A.*

AA

Aluminum Association
1525 Wilson Boulevard, Suite 600
Arlington, VA 22209

Standard reference number	Title	Referenced in code section number
ADM1—05	Aluminum Design Manual: Part 1-A Specification for Aluminum Structures, Allowable Stress Design; and Part 1-B—Aluminum Structures, Load and Resistance Factor Design	1604.3.5, 2002.1
ASM 35—00	Aluminum Sheet Metal Work in Building Construction (Fourth Edition)	2002.1

AAMA

American Architectural Manufacturers Association
1827 Waldon Office Square, Suite 550
Schaumburg, IL 60173

Standard reference number	Title	Referenced in code section number
1402—86	Standard Specifications for Aluminum Siding, Soffit and Fascia	1404.5.1
AAMA/WDMA/CSA 101/I.S.2/A440—08	North American Fenestration Standard/Specifications for Windows, Doors and Skylights	1715.5.1, 2405.5
501.4-09	*Recommended Static Test Method for Evaluating Curtain Wall and Storefront Systems Subjected to Seismic and Wind Induced Interstory Drifts*	*2410.1*
501.6-09	*Recommended Dynamic Test Method for Determining the Seismic Drift Causing Glass Fallout from a Wall*	*2410.1*

ACI

American Concrete Institute
38800 Country Club Drive
Farmington Hills, MI 48331

Standard reference number	Title	Referenced in code section number
216.1—07	Standard Method for Determining Fire Resistance of Concrete and Masonry Construction Assemblies	Table 720.1(2), 721.1
318—11	Building Code Requirements for Structural Concrete	1604.3.2, 1614.3.1, 1614.4.1, 1704.3.1.3, Table 1704.3, 1704.4.1, Table 1704.4, *Table 1705A.2.1, 1705A.2.2.1.2,* 1708. 2, 1808.8.2, Table 1808.8.2, 1808.8.5, 1808.8.6, *1810A.3.10.4,* 1810.2.4.1, 1810.3.2.1.1, 1810.3.2.1.2, 1810.3.8.3.1, 1810.3.8.3.3, 1810.3.9.4.2.1, 1810.3.9.4.2.2, 1810.3.11.1, 1901.2, 1901.3, 1901.4, 1902.1, *1903A,* 1903.1, 1904.1, 1904.2, 1904.3, 1904.4.1, 1904.4.2, 1904.5, *1905A,* 1905.1.1, 1905.2, 1905.3, 1905.4, 1905.5, 1905.6.2, 1905.6.3, 1905.6.4, 1905.6.5, 1905.7, 1905.8, 1905.9, 1905.10, 1905.11, 1905.12, 1905.13, 1906.1, 1906.2, 1906.3, 1906.4, 1907.1, 1907.2, 1907.3, 1907.4, 1907.5, 1907.6, 1907.7.1, 1907.7.2, 1907.7.3, 1907.7.4, 1907.7.5, 1907.7.6, 1907.8, 1907.9, 1907.10, 1907.11, 1907.12, 1907.13, 1908.1, 1908.1.1, 1908.1.2, 1908.1.3, 1908.1.4, 1908.1.5, 1908.1.6, 1908.1.7, 1908.1.8, 1908.1.9, 1908.1.10, 1909.1, 1909.3, 1909.4, 1909.5, 1909.6, 1912.1, *1913A.5, 1913A.7.2, 1913.2, 1913.3,* 2108.3, 2205.3
355.2-07	*Qualification of Post-Installed Mechanical Anchors in Concrete & Commentary*	*616A.1.19*
440.2R-08	*Guide for the Design and Construction of Externally Bonded FRP Systems for Strengthening Concrete Structures*	*1914A.3*
503.7—07	*Specification for Crack Repair by Epoxy Injection*	*1914A.2*

ACI—continued

506—05	*Guide to Shotcrete*	*1913.4.5, 1910A.1, 1910A.3, 1910A.12, 1914A.2*
530—11	Building Code Requirements for Masonry Structures	1405.5, 1405.5.2, 1405.9, 1604.3.4, 1704.5, 1704.5.1, Table 1704.5.1, 1704.5.2, 1704.5.3, Table 1704.5.3, 1807.1.6.3.2, 1808.9, 2101.2.2, 2101.2.3, 2101.2.4, 2101.2.5, 2101.2.6, 2103.1.3.6, 2106.1, 2107.1, 2107.2, 2107.3, 2107.4, 2107.5, 2108.1, 2108.2, 2108.3, 2109.1, 2109.1.1, 2109.2, 2109.2.1, 2109.3, 2110.1, *2114.10, 2114.11*
530.1—08	Specifications for Masonry Structures	1405.5.1, Table 1704.5.1, Table 1704.5.3, 1807.1.6.3, 2103.8, 2103.11, 2103.12, 2103.13, 2104.1, 2104.1.1, 2104.1.2, 2104.1.3, 2104.2, 2104.3, 2104.4, 2105.2.2.1.1, 2105.2.2.1.2, 2105.2.2.1.3

AF&PA

American Forest & Paper Association
1111 19th St, NW Suite 800
Washington, DC 20036

Standard reference number	Title	Referenced in code section number
WCD No. 4—89	Wood Construction Data—Plank and Beam Framing for Residential Buildings	2306.1.2
WFCM—01	Wood Frame Construction Manual for One- and Two-family Dwellings	1609.1.1, 1609.1.1.1, 2301.2, 2308.1, 2308.2.1
NDS—2012	National Design Specification (NDS) for Wood Construction with 2012 Supplement *and addendum*	*1905A.1.21, 721.6.3.2,* 1716.1.1, 1716.1.4, 1809.12, 1810.3.2.4, Table 1810.3.2.6, 2302.1, 2304.12, 2306.1, Table 2306.2.1(1), Table 2306.2.1(2), Table 2306.3, Table 2306.6, 2307.1, 2307.1.1
AF&PA—93	Span Tables for Joists and Rafters	2306.1.1, 2308.8, 2308.10.2, 2308.10.3
ANSI/AF&PA PWF—07	Permanent Wood Foundation Design Specification	1805.2, 1807.1.4, 2304.9.5.2
ANSI/AF&PA SDPWS—08	Special Design Provisions for Wind and Seismic	1613.6.1, 2305.1, 2306.1, 2306.2.1, 2306.2.2, 2306.2.3, 2306.3, Table 2306.3, 2306.4, 2306.5, 2306.6, 2306.7, Table 2306.7, 2307.1, 2307.1.1

AISC

American Institute of Steel Construction
One East Wacker Drive, Suite 700
Chicago, IL 60601-18021

Standard reference number	Title	Referenced in code section number
341—10	Seismic Provisions for Structural Steel Buildings, including Supplement No. 1 dated 2005	1613.6.2, *1705A.2.1, 1707.2.2,* 1708.3, *2212.2, 2205A,* 2205.2.1, 2205.2.2, 2205.3, 2205.3.1, *2206A*
358-10	*Prequalified Connections for Special and Intermediate Steel Moment Frames for Seismic Applications including Supplement No. 1*	*2205A, 2206A.2, 2212.3, 3413A*
360—10	Specification for Structural Steel Buildings	1604.3.3, Table 1704.3, 1704.3.3, *1705A.2.1, Table 1705A.2.1,* 2203.1, 2203.2, *2204A.2.2,* 2205.1, 2205.3, *2206A.2, 2212.1.1, 2212.3, 2212A.1.2, 2212A.2.1*

AISI

American Iron and Steel Institute
1140 Connecticut Avenue, 705
Suite 705
Washington, DC 20036

Standard reference number	Title	Referenced in code section number
AISI S100—07*/S2-10*	North American Specification for the Design of Cold-formed Steel Structural Members	1604.3.3, *1905A.1, 1913.3.8,* 2203.1, 2203.2, 2209.1, *2210A.2,* 2210.2, 2210.4, 2210.5, *2211A.1, 2212A.1.2*
S200—07	North American Standard for Cold-formed Steel Framing—General Provisions	2203.1, 2203.2, 2210.1
S210—07	North American Standard for Cold-formed Steel Framing—Floor and Roof System Design	2210.5
S211—07	North American Standard for Cold-formed Steel Framing—Wall Stud Design	2210.4
S212—07	North American Standard for Cold-formed Steel Framing—Header Design	2210.2
S213—07	North American Standard for Cold-formed Steel Framing—Lateral Design with Supplement 1, dated 2010	2210.6, *2213A.2.1, 2212.5.3*
S214—07	North American Standard for Cold-formed Steel Framing—Truss Design, with Supplement 2, dated 2008	2210.3.11, *2211A.3, 2212.5.1.2*
S230—07	Standard for Cold-formed Steel Framing—Prescriptive Method for One- and [illegible]	[illegible]1, 1609.1.1.1, 2210.7

APA

APA - Engineered Wood Association
7011 South 19th
Tacoma, WA 98466

Standard reference number	Title	Referenced in code section number
APA PDS—04	Panel Design Specification	2306.1
APA PDS Supplement 1—90	Design and Fabrication of Plywood Curved Panels (revised 1995)	2306.1
APA PDS Supplement 2—92	Design and Fabrication of Plywood-lumber Beams (revised 1998)	2306.1
APA PDS Supplement 3—90	Design and Fabrication of Plywood Stressed-skin Panels (revised 1996)	2306.1
APA PDS Supplement 4—90	Design and Fabrication of Plywood Sandwich Panels (revised 1993)	2306.1
APA PDS Supplement 5—95	Design and Fabrication of All-plywood Beams (revised 1995)	2306.1
EWS R540—02	Builders Tips: Proper Storage and Handling of Glulam Beams	2306.1
EWS S475—01	Glued Laminated Beam Design Tables	2306.1
EWS S560—03	Field Notching and Drilling of Glued Laminated Timber Beams	2306.1
EWS T300—05	Glulam Connection Details	2306.1
EWS X440—03	Product Guide—Glulam	2306.1
EWS X450—01	Glulam in Residential Construction—Western Edition	2306.1

APSP

The Association of Pool & Spa Professionals
2111 Eisenhower Avenue
Alexandria, VA 22314

Standard reference number	Title	Referenced in code section number
ANSI/APSP 7—06	Standard for Suction Entrapment Avoidance in Swimming Pools, Wading Pools, Spas, Hot Tubs and Catch Basins	3109.5

ASABE

American Society of Agricultural and Biological Engineers
2950 Niles Road
St. Joseph, MI 49085

Standard reference number	Title	Referenced in code section number
EP 484.2 (2003)	Diaphragm Design of Metal-clad, Post-frame Rectangular Buildings	2306.1
EP 486.1 (2000)	Shallow-post Foundation Design	2306.1
EP 559 (1997)	Design Requirements and Bending Properties for Mechanically Laminated Columns	2306.1

ASCE/SEI

American Society of Civil Engineers
Structural Engineering Institute
1801 Alexander Bell Drive
Reston, VA 20191-4400

Standard reference number	Title	Referenced in code section number
3—91	Structural Design of Composite Slabs	1604.3.3, 2209.2.1
5—11	Building Code Requirements for Masonry Structures	1405.6, 1405.6.2, 1405.10, 1604.3.4, 1704.5, 1704.5.1, Table 1704.5.1, 1704.5.2, 1704.5.3, Table 1704.5.3, 1807.1.6.3.2, 1808.9, 2101.2.2, 2101.2.3, 2101.2.4, 2101.2.5, 2101.2.6, 2103.1.3.6, 2106.1, 2107.1, 2107.2, 2107.3, 2107.4, 2107.5, 2108.1, 2108.2, 2108.3, 2109.1, 2109.1.1, 2109.2, 2109.2.1, 2109.3, 2110.1, *2114.10, 2114.11*
6—08	Specification for Masonry Structures	1405.6.1, Table 1704.5.1, Table 1704.5.3, 1807.1.6.3, 2103.8, 2103.11, 2103.12, 2103.13, 2104.1, 2104.1.1, 2104.1.2, 2104.1.3, 2104.2, 2104.3, 2104.4, 2105.2.2.1.1, 2105.2.2.1.2, 2105.2.2.1.3

ASCE—continued

7—10	Minimum Design Loads for Buildings and Other Structures including Supplements No. 1 and 2, excluding Chapter 14 and Appendix 11A	*104.11*, 202, *Table 1504.8*, *1509.7.1*, 1602.1, 1604.3, 1604.8.2, 1604.10, 1605.1, 1605.2.2, 1605.3.1.2, 1605.3.2, 1607.11.1, 1608.1, 1608.2, 1609.1.1, 1609.1.1.2.1, 1609.1.1.2.2, 1609.1.2, 1609.3, 1609.4.4, 1609.5.1, 1609.5.3, 1609.6, 1609.6.1, 1609.6.1.1, 1609.6.2, Table 1609.6.2(2), 1609.6.3, 1609.6.4.1, 1609.6.4.2, 1611.2, 1612.2, 1612.4, 1613.1, 1613.2, Table 1613.5.3(1), Table 1613.5.3(2), 1613.5.6, 1613.5.6.1, 1613.5.6.2, 1613.6, 1613.6.1, 1613.6.2, 1613.6.3, 1613.6.4, 1613.6.5, 1613.6.6, 1613.6.7, 1613.7, *1603A.2*, *1613A*, *1616A*, *1616.9*, *1616.10*, 1702.1, 1705.3.4, 1708.1, 1708.5, *1803A.6*, 1808.3.1, 1810.3.6.1, 1810.3.9.4, 1810.3.11.2, 1810.3.12, *1905A.1.21*, 1908.1.1, 1908.1.2, 1908.1.9, *1913.3.8*, *2114A.1*, *2114.13*, 2205.2.1, 2205.3, 2205.3.1, 2208.1, *2210A.2*, *2212A.2.4*, Table 2304.6.1, Table 2306.7, Table 2308.10.1, 2404.1, *2410.1.1*, *2410.1.2*, 2505.1, 2505.2, 3404.4, 3404.5, *3419.7.2*
8—02	Standard Specification for the Design of Cold-formed Stainless Steel Structural Members	1604.3.3, 2209.1
19—*10*	Structural Applications of Steel Cables for Buildings	2207.1, 2207.2
24—05	Flood Resistant Design and Construction	1203.3.2, 1612.4, 1612.5, 3001.2, G103.1, G401.3, G401.4
29—05	Standard Calculation Methods for Structural Fire Protection	721.1
32—01	Design and Construction of Frost Protected Shallow Foundations	1809.5
41—06	*Seismic Rehabilitation of Existing Buildings including Supplement No. 1*	*1603A.2*, *1616A.1.30*, *3401.5*, *3412A*, *3413A*, *3417.5*, *3417.8*, *3418.1*, *3419.1*, *3419.2*, *3419.5*, *3419.7.2*, *3419.8*, *3419.9*, *3420.1*, *3421.2.2*, *3412A*, *3413A*

ASME

American Society of Mechanical Engineers
Three Park Avenue
New York, NY 10016-5990

Standard reference number	Title	Referenced in code section number
A17.1/CSA B44—2007 (with A17.1a/CSA B44a—08 addenda)	Safety Code for Elevators and Escalators	907.3.3, 911.1.5, 1007.4, 11B-407.1, 11B-407.2.2, 11B-407.4.9, 11B-408.1, 11B-409.1, 11B-410.1, 11B-810.9, 1607.8.1, 1607.9.1, 1613.6.5, 3001.2, 3001.4, 3002.5, 3003.2, 3007.1, 3007.2, 3008.2, 3008.2.1, 3008.7.6, 3008.8.1, 3411.8.2
A18.1—2008	Safety Standard for Platform Lifts and Stairway Chairlifts	2702.2.6, 3411.8.3
A90.1—03	Safety Standard for Belt Manlifts	3001.2
B16.18—2001 (Reaffirmed 2005)	Cast Copper Alloy Solder Joint Pressure Fittings	909.13.1
B16.22—2001 (Reaffirmed 2005)	Wrought Copper and Copper Alloy Solder Joint Pressure Fittings	909.13.1
B20.1—2006	Safety Standard for Conveyors and Related Equipment	3001.2, 3005.3
BPE—2009	*Bio-processing Equipment Standard*	
B31.3—2004	Process Piping	415.8.6.1

ASTM

ASTM International
100 Barr Harbor Drive
West Conshohocken, PA 19428-2959

Standard reference number	Title	Referenced in code section number
A 36/A 36M—05	Specification for Carbon Structural Steel	1810.3.2.3
A 153/A 153M—05	Specification for Zinc Coating (Hot-dip) on Iron and Steel Hardware	*2304*, 2304.9.5
A227—06 (2011)	*Standard Specification for Steel Wire, Cold-Drawn for Mechanical Springs*	*1211.1.1*
A229—12	*Standard Specification for Steel Wire, Quenched and Tempered for Mechanical Springs*	*1211.1.1*
A 240/A 240M—07	Standard Specification for Chromium and Chromium-nickel Stainless Steel Plate, Sheet and Strip for Pressure Vessels and for General Applications	Table 1507.4.3(1)
A 252—98 (2002)	Specification for Welded and Seamless Steel Pipe Piles	1810.3.2.3
A 283/A 283M—03	Specification for Low and Intermediate Tensile Strength Carbon Steel Plates	1810.3.2.3
A 307—04e01	Specification for Carbon Steel Bolts and Studs, 60,000 psi Tensile Strength	1911.1
A370—10	*Standard Test Methods and Definitions for Mechanical Testing of Steel Products*	*3413A.1.3*
A 416/A 416M—06	Specification for Steel Strand, Uncoated Seven-wire for Prestressed Concrete	1810.3.2.2
A 463/A 463M—05	Standard Specification for Steel Sheet, Aluminum-coated, by the Hot-dip Process	Table 1507.4.3(2)
A 572/A 572M—07	Specification for High-strength Low-alloy Columbium-vanadium Structural Steel	1810.3.2.3
A 588/A 588M—05	Specification for High-strength Low-alloy Structural Steel with 50 ksi (345 MPa) Minimum Yield Point to 4 inches (100 mm) Thick	1810.3.2.3
A 615/A 615M—04a	Specification for Deformed and Plain Billet-steel Bars for Concrete Reinforcement	1708.2, 1810.3.10.2
A 653/A 653M—07	[illegible]	Table 1507.4.3(2), 2304.9.5.1

AWPA

American Wood Protection Association
P.O. Box 361784
Birmingham, AL 35236-1784

Standard reference number	Title	Referenced in code section number
C1—03	All Timber Products—Preservative Treatment by Pressure Processes	1505.6
M4—06	Standard for the Care of Preservative-treated Wood Products	1810.3.2.4.1, 2303.1.8
U1—07	USE CATEGORY SYSTEM: User Specification for Treated Wood Except Section 6, Commodity Specification H	1403.5, Table 1507.9.6, 1807.1.4, 1807.3.1, 1809.12, 1810.3.2.4.1, 2303.1.8, 2304.11.2, 2304.11.4, 2304.11.6, 2304.11.7, *J106.2.2*

AWS

American Welding Society
550 N.W. LeJeune Road
Miami, FL 33126

Standard reference number	Title	Referenced in code section number
D1.1—[illegible]	*Structural Welding Code—Steel*	Table 1704.3, 1704.3.1.1, *Table 1705A.2.1, 1705A.2.2.5, 2212.6.2, 2213A.2*
D1.3—*08*	Structural Welding Code—Sheet Steel	Table 1704.3, 1704.3.1.2, *Table 1705A.2.1, 1705A.2.2.1.1*
D1.4—*11*	Structural Welding Code—Reinforcing Steel	Table 1704.3, 1704.3.1.3, Table 1704.4, *Table 1705A.2.1, 1705.2.2.1.2, 2107A.3, 2107A.4*
D1.8—09	*Structural Welding Code – Seismic Supplement*	*1704A.3.1.4, 1705A.2.2.5, 2204A.1.1, 2204A.1.3, 2211.1*
QC1—06	*Standard for AWS Certification of Welding Inspectors*	*1704A.3.1.4, 1705A.2.2.5*

BHMA

Builders Hardware Manufacturers' Association
355 Lexington Avenue, 17th Floor
New York, NY 10017-6603

Standard reference number	Title	Referenced in code section number
A 156.10—11	Power Operated Pedestrian Doors	11B-404.2.9, 11B-404.3, 1008.1.4.2
A 156.19—07	Standard for Power Assist and Low Energy Operated Doors	11B-404.2.9, 11B-404.3, 11B-408.3.2.1, 11B-409.3.1, 1008.1.4.2

CGSB

Canadian General Standards Board
Place du Portage 111, 6B1
11 Laurier Street
Gatineau, Quebec, Canada KIA 1G6

Standard reference number	Title	Referenced in code section number
37-GP-52M (1984)	Roofing and Waterproofing Membrane, Sheet Applied, Elastomeric	1504.7, 1507.12.2
37-GP-56M (1980)	Membrane, Modified, Bituminous, Prefabricated and Reinforced for Roofing—with December 1985 Amendment	1507.11.2
CAN/CGSB 37.54—95	Polyvinyl Chloride Roofing and Waterproofing Membrane	1507.13.2

CPA

Composite Panel Association
19465 Deerfield Avenue, Suite 306
Leesburg, VA 20176

Standard reference number	Title	Referenced in code section number
ANSI A135.4—2004	Basic Hardboard	1404.3.1, 2303.1.6
ANSI A135.5—2004	Prefinished Hardboard Paneling	2303.1.6, 2304.6.2
ANSI A135.6—1998	Hardboard Siding	1404.3.2, 2303.1.6

STRUCTURAL CALCULATIONS

FOR

Topok

~~San Francisco~~, CA
Needles

Code Search

Code: International Building Code 2012

Occupancy:

Occupancy Group = U Utility & Miscellaneous

Risk Category & Importance Factors:

Risk Category = II ✓

Wind factor = 1.00 ✓
Snow factor = 1.00
Seismic factor = 1.00

Type of Construction:

Fire Rating:

Roof = 0.0 hr
Floor = 0.0 hr

Building Geometry:

Roof angle (θ)	0.25 / 12 ✓	1.2 deg ✓
Building length (L)	116.0 ft ✓	
Least width (B)	18.0 ft ✓	
Mean Roof Ht (h)	11.3 ft	
Parapet ht above grd	0.0 ft	
Minimum parapet ht	0.0 ft	

Live Loads:

<u>Roof</u> 0 to 200 sf: 20 psf ✓
200 to 600 sf: 24 - 0.02Area, but not less than 12 psf
over 600 sf: 12 psf

<u>Floor:</u>

Typical Floor	50 psf
Partitions	15 psf
Corridors above first floor	80 psf
Lobbies & first floor corridors	100 psf
Balconies (exterior)	50 psf

ARCADIS
1100 Superior Suite 1250
Cleveland, OH
Phone

JOB TITLE Topok
Parking Canopy Structure
JOB NO. .   SHEET NO. B3
CALCULATED BY CMW   DATE 11.24.14
CHECKED BY MSL   DATE 12/23/14

Wind Loads :

Ultimate Wind Speed	110 mph
Directionality (Kd)	0.85
Exposure Category	C
Enclosure Classif.	Open Building
Internal pressure	+/-0.00
Kh case 1	0.849
Kh case 2	0.849
Type of roof	Gable

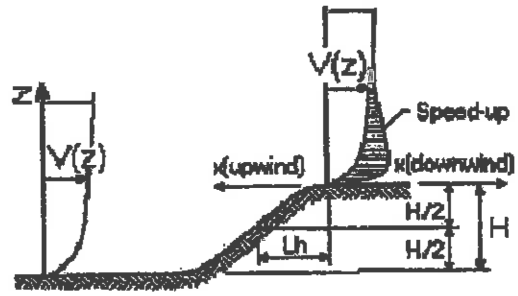
Topographic Factor (Kzt)

Topography	Flat
Hill Height (H)	80.0 ft
Half Hill Length (Lh)	100.0 ft
Actual H/Lh =	0.80
Use H/Lh =	0.50
Modified Lh =	160.0 ft
From top of crest: x =	50.0 ft
Bldg up/down wind?	downwind

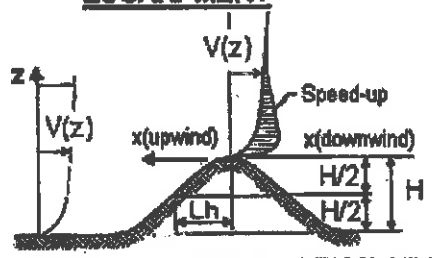
H/Lh= 0.50	K_1 =	0.000
x/Lh = 0.31	K_2 =	0.792
z/Lh = 0.09	K_3 =	1.000

At Mean Roof Ht:

$Kzt = (1+K_1K_2K_3)^2$ = 1.00



ESCARPMENT



2D RIDGE or 3D AXISYMMETRICAL HILL

Gust Effect Factor

h =	11.3 ft
B =	18.0 ft
/z (0.6h) =	15.0 ft

Flexible structure if natural frequency < 1 Hz (T > 1 second).
However, if building h/B < 4 then probably rigid structure (rule of thumb).
h/B = 0.63   Rigid structure

G = 0.85 Using rigid structure default

Rigid Structure

ē =	0.20
ℓ =	500 ft
z_{min} =	15 ft
c =	0.20
g_Q, g_v =	3.4
L_z =	427.1 ft
Q =	0.95
I_z =	0.23
G =	0.90 use G = 0.85

Flexible or Dynamically Sensitive Structure

Natural Frequency (η_1) =	0.0 Hz				
Damping ratio (β) =	0				
/b =	0.65				
/α =	0.15				
Vz =	92.9				
N_1 =	0.00				
R_n =	0.000				
R_h =	28.282	η =	0.000	h =	11.3 ft
R_B =	28.282	η =	0.000		
R_L =	28.282	η =	0.000		
g_R =	0.000				
R =	0.000				
G =	0.000				

ARCADIS
1100 Superior Suite 1250
Cleveland, OH
Phone

Enclosure Classification

Test for Enclosed Building: A building that does not qualify as open or partially enclosed.

Test for Open Building: All walls are at least 80% open. ✓
$A_o \geq 0.8A_g$

Test for Partially Enclosed Building:

	Input	
Ao	0.0	sf
Ag	0.0	sf
Aoi	0.0	sf
Agi	0.0	sf

	Test
$A_o \geq 1.1A_{oi}$	YES
A_o > 4' or $0.01A_g$	NO
$A_{oi} / A_{gi} \leq 0.20$	NO

Building is NOT Partially Enclosed ✓

Conditions to qualify as Partially Enclosed Building. Must satisfy all of the following:

$A_o \geq 1.1A_{oi}$
$A_o >$ smaller of 4' or $0.01 A_g$
$A_{oi} / A_{gi} \leq 0.20$

Where:
Ao = the total area of openings in a wall that receives positive external pressure.
Ag = the gross area of that wall in which Ao is identified.
Aoi = the sum of the areas of openings in the building envelope (walls and roof) not including Ao.
Agi = the sum of the gross surface areas of the building envelope (walls and roof) not including Ag.

Reduction Factor for large volume partially enclosed buildings (Ri) :

If the partially enclosed building contains a single room that is unpartitioned , the internal pressure coefficient may be multiplied by the reduction factor Ri.

Total area of all wall & roof openings (Aog): 0 sf
Unpartitioned internal volume (Vi) : 0 cf
Ri = 1.00

Altitude adjustment to constant 0.00256 (caution - see code) :

Altitude = 0 feet
Constant = 0.00256

Average Air Density = 0.0765 lbm/ft^3

ARCADIS
1100 Superior Suite 1250
Cleveland, OH
Phone

JOB TITLE Topok
Parking Canopy Structure
JOB NO.
SHEET NO. B5
CALCULATED BY CMW DATE 11.24.14
CHECKED BY MSL DATE 12/23/14

Wind Loads - Open Buildings: 0.25 ≤ h/L ≤ 1.0

Ultimate Wind Pressures

Type of roof = Monoslope Free Roofs ✓
Wind Flow = Obstructed ✓

G = 0.85 ✓
Roof Angle = 1.2 deg ✓

Main Wind Force Resisting System

Kz = Kh (case 2) = 0.85

NOTE: The code requires the MWFRS be designed for a minimum pressure of 16 psf.

Base pressure (qh) = 22.4 psf ✓

Roof pressures - Wind Normal to Ridge

Wind Flow	Load Case		Wind Direction γ = 0 & 180 deg	
			Cnw	Cnl
Obstructed Wind Flow	A	Cn =	-0.50 ✓	-1.20 ✓
		p =	-9.5 psf	-22.8 psf
	B	Cn =	-1.10 ✓	-0.60 ✓
		p =	-20.9 psf	-11.4 psf

NOTE: 1). Cnw and Cnl denote combined pressures from top and bottom roof surfaces.
2). Cnw is pressure on windward half of roof. Cnl is pressure on leeward half of roof.
3). Positive pressures act toward the roof. Negative pressures act away from the roof.

Roof pressures - Wind Parallel to Ridge, γ = 90 deg

Wind Flow	Load Case		Horizontal Distance from Windward Edge		
			≤ h	> h ≤ 2h	> 2h
Obstructed Wind Flow	A	Cn =	-1.20 ✓	-0.90 ✓	-0.60 ✓
		p =	-22.8 psf	-17.1 psf	-11.4 psf
	B	Cn =	0.50 ✓	0.50 ✓	0.30 ✓
		p =	9.5 psf	9.5 psf	5.7 psf

h = 11.3 ft
2h = 22.5 ft

Fascia Panels -Horizontal pressures

qp = 22.4 psf ✓

Windward fascia: 33.5 psf ✓ (GCpn = +1.5)
Leeward fascia: -22.4 psf ✓ (GCpn = -1.0)

Components & Cladding - roof pressures

Kz = Kh (case 1) = 0.85 ✓
Base pressure (qh) = 22.4 psf ✓
G = 0.85 ✓

a = 3.0 ft ✓

a^2 = 9.0 sf
$4a^2$ = 36.0 sf

	Effective Wind Area	Obstructed Wind Flow					
		zone 3		zone 2		zone 1	
		positive	negative	positive	negative	positive	negative
C_N	≤ 9 sf	1.10 ✓	-3.84 ✓	0.86 ✓	-1.93 ✓	0.55 ✓	-1.28 ✓
	>9, ≤ 36 sf	0.86 ✓	-1.93 ✓	0.86 ✓	-1.93 ✓	0.55 ✓	-1.28 ✓
	> 36 sf	0.55 ✓	-1.28 ✓	0.55 ✓	-1.28 ✓	0.55 ✓	-1.28 ✓
Wind pressure	≤ 9 sf	20.8 psf ✓	-72.9 psf ✓	16.4 psf ✓	-36.6 psf ✓	10.4 psf ✓	-24.3 psf ✓
	>9, ≤ 36 sf	16.4 psf ✓	-36.6 psf ✓	16.4 psf ✓	-36.6 psf ✓	10.4 psf ✓	-24.3 psf ✓
	> 36 sf	10.4 psf ✓	-24.3 psf ✓	10.4 psf ✓	-24.3 psf ✓	10.4 psf ✓	-24.3 psf ✓

The C&C pressure shall not be less than 16 psf acting in either direction normal to the surface.

ARCADIS
1100 Superior Suite 1250
Cleveland, OH
Phone

JOB TITLE Topok
Parking Canopy Structure
JOB NO.
SHEET NO. B-5A
CALCULATED BY CMW DATE 11.24.14
CHECKED BY MSL DATE 12/8/14
12/23/14

Wind Loads - Open Buildings: 0.25 ≤ h/L ≤ 1.0

Ultimate Wind Pressures

Type of roof = Monoslope Free Roofs
Wind Flow = Clear

G = 0.85 ✓
Roof Angle = 1.2 deg ✓

NOTE: The code requires the MWFRS be designed for a minimum pressure of 16 psf.

Main Wind Force Resisting System

Kz = Kh (case 2) = 0.85

Base pressure (qh) = **22.4 psf** ✓

Roof pressures - Wind Normal to Ridge

Wind Flow	Load Case		Wind Direction γ = 0 & 180 deg	
			Cnw	Cnl
Clear Wind Flow	A	Cn =	1.20 ✓	0.30 ✓
		p =	22.8 psf ✓	5.7 psf ✓
	B	Cn =	-1.10	-0.10
		p =	-20.9 psf	-1.9 psf

NOTE: 1). Cnw and Cnl denote combined pressures from top and bottom roof surfaces.
2). Cnw is pressure on windward half of roof. Cnl is pressure on leeward half of roof.
3). Positive pressures act toward the roof. Negative pressures act away from the roof.

Roof pressures - Wind Parallel to Ridge, γ = 90 deg

Wind Flow	Load Case		Horizontal Distance from Windward Edge		
			≤ h	>h ≤ 2h	> 2h
Clear Wind Flow	A	Cn =	-0.80 ✓	-0.60 ✓	-0.30
		p =	-15.2 psf	-11.4 psf	-5.7 psf
	B	Cn =	0.80 ✓	0.50 ✓	0.30 ✓
		p =	15.2 psf	9.5 psf	5.7 psf

h = 11.3 ft
2h = 22.5 ft

Fascia Panels -Horizontal pressures

qp = 22.4 psf ✓

Windward fascia: 33.5 psf (GCpn = +1.5)
Leeward fascia: -22.4 psf (GCpn = -1.0)

Components & Cladding - roof pressures

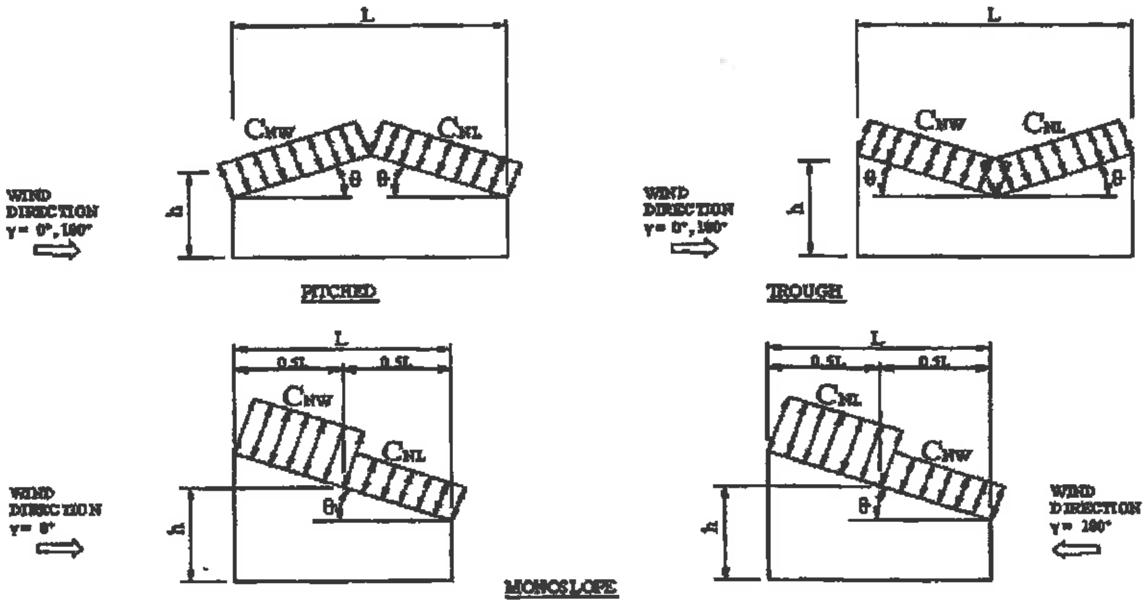
Kz = Kh (case 1) = 0.85
Base pressure (qh) = **22.4 psf**
G = 0.85

a = 3.0 ft

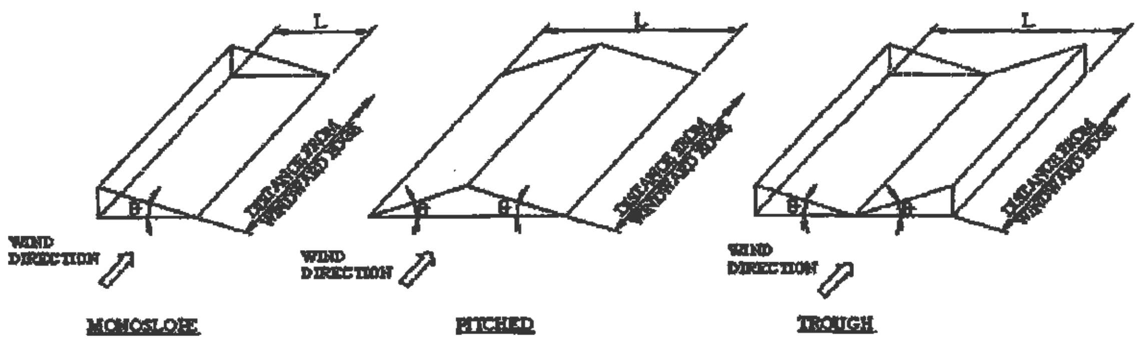
a^2 = 9.0 sf
$4a^2$ = 36.0 sf

	Effective Wind Area	Clear Wind Flow					
		zone 3		zone 2		zone 1	
		positive	negative	positive	negative	positive	negative
C_N	≤ 9 sf	2.53	-3.44	1.90	-1.76	1.26	-1.15
	>9, ≤ 36 sf	1.90 ✓	-1.76 ✓	1.90 ✓	-1.76 ✓	1.26 ✓	-1.15 ✓
	> 36 sf	1.26	-1.15	1.26	-1.15	1.26	-1.15
Wind pressure	≤ 9 sf	48.0 psf	-65.4 psf	36.0 psf	-33.5 psf	24.0 psf	-21.8 psf
	>9, ≤ 36 sf	36.0 psf	-33.5 psf ✓	36.0 psf	-33.5 psf	24.0 psf	-21.8 psf
	> 36 sf	24.0 psf	-21.8 psf ✓	24.0 psf	-21.8 psf	24.0 psf	-21.8 psf

Location of Wind Pressure Zones

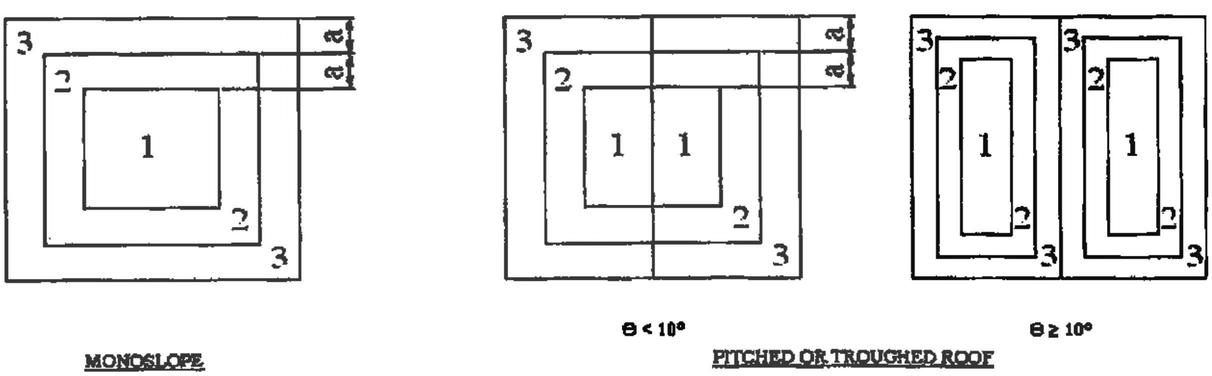


WIND DIRECTION γ = 0°, 180°



WIND DIRECTION γ = 90°

MAIN WIND FORCE RESISTING SYSTEM



COMPONENTS AND CLADDING

ARCADIS		
1100 Superior Suite 1250	JOB TITLE	Topok
Cleveland, OH		Parking Canopy Structure
Phone	JOB NO.	SHEET NO. 37
	CALCULATED BY CMW	DATE 11.24.14
	CHECKED BY MGL	DATE 12/23/14

Wind Loads - Rooftop Structures & Equipment

Ultimate Wind Pressures

Building (L) = 116.0 ft
Building (B) = 18.0 ft
Directionality (Kd) = 0.85

Rooftop Structures & Equipment #1

Equipment length parallel to L = 15.0 ft
Equipment length parallel to B = 10.0 ft
Height of equipment = 10.0 ft
Base pressure (qh) = 22.4 psf

Vertical wind pressure		Wind normal to building B		Wind normal to building L	
Ar =	150.0 sf	Ar =	100.0 sf	Ar =	150.0 sf
GCr =	1.500	GCr =	1.51	GCr =	1.89
F = qhGCr Ar =	33.5 Ar (psf)	F = qhGCr Ar =	33.7 Ar (psf)	F = qhGCr Ar =	42.1 Ar (psf) ✓
Fv =	5.0 kips	Fh =	3.4 kips	Fh =	6.3 kips ✓

Rooftop Structures & Equipment #2

Equipment length parallel to L = 15.0 ft
Equipment length parallel to B = 10.0 ft
Height of equipment = 10.0 ft
Base pressure (qh) = 22.4 psf

Vertical wind pressure		Wind normal to building B		Wind normal to building L	
Ar =	150.0 sf	Ar =	100.0 sf	Ar =	150.0 sf
GCr =	1.500	GCr =	1.51	GCr =	1.89
F = qhGCr Ar =	33.5 Ar (psf)	F = qhGCr Ar =	33.7 Ar (psf)	F = qhGCr Ar =	42.1 Ar (psf) ✓
Fv =	5.0 kips	Fh =	3.4 kips	Fh =	6.3 kips ✓

ARCADIS
1100 Superior Suite 1250
Cleveland, OH
Phone

JOB TITLE Topok
Parking Canopy Structure
JOB NO. SHEET NO. B8
CALCULATED BY CMW DATE 11.24.14
CHECKED BY MSL DATE 12/23/14

Wind Loads - Other Structures:

Ultimate Wind Pressures

Importance Factor =	1.00		
Gust Effect Factor (G) =	0.85	Wind Speed =	110 mph
Kzt =	1.00	Exposure =	C

A. Solid Freestanding Walls & Solid Signs (& open signs with less than 30% open)

Dist to sign top (h)	8.0 ft	s/h =	1.00
Height (s)	8.0 ft	B/s =	25.00
Width (B)	200.0 ft	Lr/s =	0.00
Wall Return (Lr) =		Kz =	0.849
Directionality (Kd)	0.85	qz =	22.4 psf
Percent of open area to gross area	0.0%	Open reduction factor =	1.00

Case A & B

C_f =	1.30 ✓
F = qz G Cf As =	24.7 As ✓
As =	10.0 sf
F =	247 lbs

Case C reduction factors
Factor if s/h>0.8 = 0.80
Wall return factor for Cf at 0 to s = 1.00

Case C

Horiz dist from windward edge	Cf	F=qzGCfAs (psf)
0 to s	3.29	62.5 As
s to 2s	2.07	39.2 As
2s to 3s	1.59	30.1 As
3s to 4s	1.31	24.8 As
4s to 5s	1.23	23.4 As
5s to 10s	0.78	16.0 As
>10s	0.44	16.0 As

B. Open Signs & Lattice Frameworks (openings 30% or more of gross area)

Height to centroid of Af (z)	15.0 ft	Kz =	0.849
		Base pressure (qz) =	22.4 psf
Width (zero if round)	0.0 ft		
Diameter (zero if rect)	2.0 ft	D(qz)^.5 =	9.46
Percent of open area to gross area	35.0%	ϵ =	0.65
Directionality (Kd)	0.85	C_f =	1.1

$F = q_z G C_f A_f$ =	20.9 Af ✓
Solid Area: A_f =	10.0 sf
F =	209 lbs

C. Chimneys, Tanks, Rooftop Equipment (h>60') & Similar Structures

Height to centroid of Af (z)	15.0 ft	Kz =	0.849
Cross-Section	Square	Base pressure (qz) =	23.7 psf
Directionality (Kd)	0.90	h/D =	15.00
Height (h)	15.0 ft		
Width (D)	1.0 ft		
Type of Surface	N/A		

Square (wind along diagonal)		Square (wind normal to face)	
Cf =	1.28	C_f =	1.67
F = qz G Cf Af =	25.7 Af	$F = q_z G C_f A_f$ =	33.5 Af ✓
Af =	sf	A_f =	10.0 sf
F =	0 lbs	F =	335 lbs

D. Trussed Towers

Height to centroid of Af (z)	15.0 ft	Kz =	0.849
ϵ =	0.27	Base pressure (qz) =	26.3 psf
Tower Cross Section	square		
Member Shape	flat	Diagonal wind factor =	1.2
Directionality (Kd)	1.00	Round member factor =	1.000

Square (wind along tower diagonal)		Square (wind normal to face)	
Cf =	3.24	C_f =	2.70
F = qz G Cf Af =	72.4 Af	$F = q_z G C_f A_f$ =	60.3 Af ✓
Solid Area: Af =	10.0 sf	Solid Area: A_f =	10.0 sf
F =	724 lbs	F =	603 lbs

ARCADIS
1100 Superior Suite 1250
Cleveland, OH
Phone

JOB TITLE	Topok		
	Parking Canopy Structure		
JOB NO.		SHEET NO.	B9
CALCULATED BY	CMW	DATE	11.24.14
CHECKED BY	MSL	DATE	12/23/14

Snow Loads :

Roof slope	=	1.2 deg ✓
Horiz. eave to ridge dist (W)	=	9.0 ft ✓
Roof length parallel to ridge (L)	=	116.0 ft ✓

Type of Roof			Hip and gable w/ trussed systems
Ground Snow Load	Pg	=	0.0 psf
Risk Category		=	II
Importance Factor	I	=	1.0 ✓
Thermal Factor	Ct	=	1.00
Exposure Factor	Ce	=	1.0
$Pf = 0.7{*}Ce{*}Ct{*}I{*}Pg$		=	0.0 psf
Unobstructed Slippery Surface (per Section 7.4)			yes
Sloped-roof Factor	Cs	=	1.00
Balanced Snow Load	Ps	=	0.0 psf
Rain on Snow Surcharge Angle			0.18 deg
Code Maximum Rain Surcharge			5.0 psf
Rain on Snow Surcharge		=	0.0 psf
Ps plus rain surcharge		=	0.0 psf
Minimum Snow Load	Pm	=	0.0 psf
Uniform Roof Design Snow Load		=	0.0 psf ✓

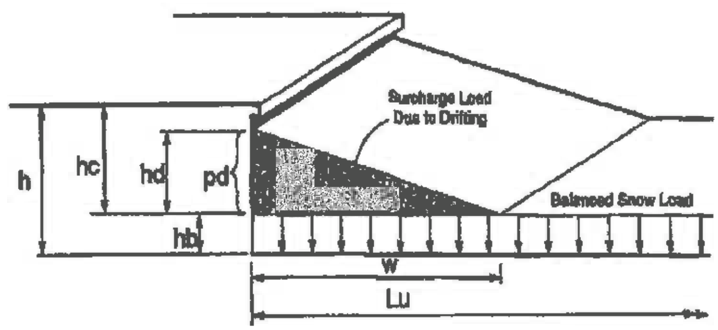
NOTE: Alternate spans of continuous beams and other areas shall be loaded with half the design roof snow load so as to produce the greatest possible effect - see code.

Unbalanced Snow Loads - for Hip & Gable roofs only

Required if slope is between 7 on 12 =	30.26 deg	
and 2.38 deg =	2.38 deg	Unbalanced snow loads are not required
Windward snow load =	0.0 psf	
Leeward snow load =	0.0 psf	

Windward Snow Drifts 1 - Against walls, parapets, etc more than 15' long

Upwind fetch	lu	=	220.0 ft
Projection height	h	=	5.2 ft
Snow density	g	=	14.0 pcf
Balanced snow height	hb	=	0.00 ft
	hc	=	5.20 ft
#DIV/0! #DIV/0!	#DIV/0!		
Drift height	hd	=	#DIV/0!
Drift width	w	=	#DIV/0!
Surcharge load:	$pd = \gamma{*}hd$	=	#DIV/0! ✓
Balanced Snow load:		=	0.0 psf
			#DIV/0!



Windward Snow Drifts 2 - Against walls, parapets, etc > 15'

Upwind fetch	lu	=	220.0 ft
Projection height	h	=	5.2 ft
Snow density	g	=	14.0 pcf
Balanced snow height	hb	=	0.00 ft
	hc	=	5.20 ft
#DIV/0! #DIV/0!	#DIV/0!		
Drift height	hd	=	#DIV/0!
Drift width	w	=	#DIV/0!
Surcharge load:	$pd = \gamma{*}hd$	=	#DIV/0!
Balanced Snow load:		=	0.0 psf ✓
			#DIV/0!

Seismic Loads:

Risk Category : II ✓
Importance Factor (I) : 1.00 ✓
Site Class : D ✓

Ss (0.2 sec) = 23.00 %g
S1 (1.0 sec) = 12.00 %g

Fa =	1.600	Sms =	0.368	S_{DS} =	0.245 ✓	Design Category =	B ✓
Fv =	2.320	Sm1 =	0.278	S_{D1} =	0.186 ✓	Design Category =	C ✓

Seismic Design Category = C ✓
Number of Stories: 1
Structure Type: Moment-resisting frame systems of steel ✓
Horizontal Struct Irregularities: No plan Irregularity
Vertical Structural Irregularities: No vertical Irregularity
Flexible Diaphragms: No
Building System: **Moment-resisting Frame Systems**
Seismic resisting system: **Steel ordinary moment frames**
System Structural Height Limit: **Height not limited**
Actual Structural Height (hn) = 11.3 ft

DESIGN COEFFICIENTS AND FACTORS

Response Modification Coefficient (R) = 3.5 ✓
Over-Strength Factor (Ωo) = 3
Deflection Amplification Factor (Cd) = 3
S_{DS} = 0.245 ✓
S_{D1} = 0.186

Seismic Load Effect (E) = ρQ_E +/- $0.2S_{DS}D$ = ρQ_E +/- 0.049D
Special Seismic Load Effect (Em) = $\Omega o\ Q_E$ +/- $0.2S_{DS}D$ = 3.0 Q_E +/- 0.049D

ρ = redundancy coefficient
Q_E = horizontal seismic force
D = dead load

PERMITTED ANALYTICAL PROCEDURES

Simplified Analysis - Use Equivalent Lateral Force Analysis

Equivalent Lateral-Force Analysis - Permitted
Building period coef. (C_T) = 0.028
Approx fundamental period (Ta) = $C_T h_n^x$ = 0.194 sec x= 0.80
User calculated fundamental period (T) = 0 sec
Long Period Transition Period (TL) = ASCE7 map = 12
Seismic response coef. (Cs) = $S_{DS}I/R$ = 0.070
need not exceed Cs = Sd1 I /RT = 0.273
but not less than Cs = 0.044SdsI = 0.011
USE Cs = 0.070 ✓
Design Base Shear V = 0.070W ✓

Cu = 1.53
Tmax = CuTa = 0.297
Use T = 0.194

Modal & Seismic Response Analysis - Permitted (see code for procedure)

ALLOWABLE STORY DRIFT

Structure Type: All other structures
Allowable story drift = 0.020hsx where hsx is the story height below level x

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Cleveland, OH
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JOB TITLE Topok
Parking Canopy Structure
JOB NO. SHEET NO. B11
CALCULATED BY CMW DATE 11.24.14
CHECKED BY MSL DATE 12/23/14

Roof Design Loads

Items	Description	Multiple	psf (max)	psf (min)
Decking	Metal Roof deck, 1.5, 22 ga. ✓		2.14 ~~1.7~~ ✓	1.51 ~~1.2~~ ✓
Framing	Steel roof joists & girders		3.0 ✓	2.0 ✓
Framing	Steel roof joists & girders		3.0 ✓	2.0 ✓
~~0~~	~~0~~		~~0.0~~	~~0.0~~
			~~0.0~~	~~0.0~~
Mech & Elec	Mech. & Elec.		2.0 ✓	0.0
Misc.	~~Misc.~~ SOLAR PANELS		~~0.5~~ 10	0.0
			~~0.0~~	~~0.0~~
			20.1	5.5
		Actual Dead Load	○ 10.2	~~5.2~~
		Use this DL Instead	◉ 20.0	◉ 9.0
		Live Load	20.0	0.0
		Snow Load	0.0	0.0
		Wind (zone 2 - 100sf)	16.4	-36.6
ASD Loading		D + Lr	40.0	-
		D + 0.75(0.6*W + Lr)	42.4	-
		0.6*D + 0.6*W	-	-16.6
LRFD Loading		1.2D + 1.6 Lr + 0.5W	64.2	-
		1.2D + 1.0W + 0.5Lr	50.4	-
		0.9D + 1.0W	-	-28.5

Roof Live Load Reduction **Roof angle** 0.25 / 12 1.2 deg

0 to 200 sf: 20.0 psf
200 to 600 sf: 24 - 0.02Area, but not less than 12 psf
over 600 sf: 12.0 psf

	300 sf	18.0 psf
	400 sf	16.0 psf
	500 sf	14.0 psf
User Input:	450 psf	15.0 psf

CONSERVATIVE B/C 9" & 6" GAPS B/W ADJACENT PANELS
49.38#/(6.917FT x 4FT) = 1.78 psf + 3 psf RACKING = 4.78 psf < 5 psf ✓OK
B-12

Lotycz, Matt

From: Sidoti, John
Sent: Wednesday, November 19, 2014 8:46 AM
To: Lotycz, Matt
Subject: RE: Topock
Attachments: BYD 3BB PV Module-UL-40mm (P6C-36)-June.2013 .pdf_DC020385.pdf

RACKING EQUIPMENT / HARDWARE

50#/(6.41'x3.26') = 2.39 psf x 2 = 4.79 psf ≈ 5 psf

This module is 77"x39.1" (6.4' x 3.25'), and about 50 lbs.

So, we might have a 35 x 2 arrangement on the roof, with about 70 modules, or 3500 lbs. This does not include the roof racking equipment, but I think you are in good shape with 10 lbs/SF.

+3500# RACKING EQUIP (CONSERVATIVE)
7,000# / (12FT x 116FT LONG) = 5.03 psf (ALL IN 12FT WIDTH) < 10 psf ✓OK DESIGNED FOR

This is all rough and ready, just a ballpark at this point.

John Sidoti, PE | Electrical Engineer | john.sidoti@arcadis-us.com

ARCADIS U.S., Inc. | 222 South Main St., Suite 300 | Akron, OH, 44308
T: 330.434.1995 (Main) | 330.515.5682 (Direct) Connect with us! www.arcadis-us.com | LinkedIn | Twitter | Facebook

ARCADIS, Imagine the result
Please consider the environment before printing this email.

-----Original Message-----
From: Lotycz, Matt
Sent: Wednesday, November 19, 2014 8:39 AM
To: Sidoti, John
Cc: Baxter, Jonathan
Subject: RE: Topock

John - since we did not hear from Jon, let's move forward on 120 foot long (12 cars).

Matt

-----Original Message-----
From: Lotycz, Matt
Sent: Monday, November 17, 2014 4:28 PM
To: Sidoti, John
Cc: Baxter, Jonathan (Jonathan.Baxter@arcadis-us.com)
Subject: RE: Topock

Will do. I will have some structural drawings for the pre-eng Workshop building later this week (CAD exports for you to use as backgrounds showing columns, column lines, building height, etc.). However, structural drawings for the parking structure will not be ready till early to mid-next week at the earliest. You can see the attached pdf showing the 18 foot parking structure width by 100 feet long (10 cars) or 120 feet long (12 cars).

Jon B - please confirm parking structure length you want me to show on my drawings, 100 feet long (10 cars) or 120 feet long (12 cars)? Thanks.

Lotycz, Matt B-13

From:	Sidoti, John
Sent:	Wednesday, November 26, 2014 9:46 AM
To:	Lotycz, Matt
Cc:	Baxter, Jonathan
Subject:	Topock CHQ photovoltaic layout
Attachments:	BYD 3BB PV Module-UL-40mm (P6C-36)-June.2013 .pdf_DOC020385.pdf; S-15-07 with solar layouts.dwg; 141103sm_-_quick_start_installation_guide.pdf; design.unirac.pdf

Hey Matt—

I want to coordinate with you on the solar layout for the workshop and the parking structure.

A few items:

- I used/attached S-15-07 to show some proposed layouts. For the workshop, I have two potential layouts—one on the north side and one on the south. Let me know if you have a preference. Note that north side photovoltaics would be tilted. On the right side, I just showed a rough dimension outline for the parking structure, with the proposed layout.
- The "BYD..." PDF shows dimensions and weight of the photovoltaic panel.
- The "141103sm..." PDF is an installation guide to give you a picture of what the rack system looks like.
- The "design.unirac" PDF is the results from an online tool from Solar Mount. I ran this for an 8x5 arrangement of modules. The roof type says "shingle", but I just did this preliminarily to see if it provides any value for you. It has some basic loading information.

Call me after you've had a chance to review.

Thanks,

John

John Sidoti, PE | Electrical Engineer | john.sidoti@arcadis-us.com

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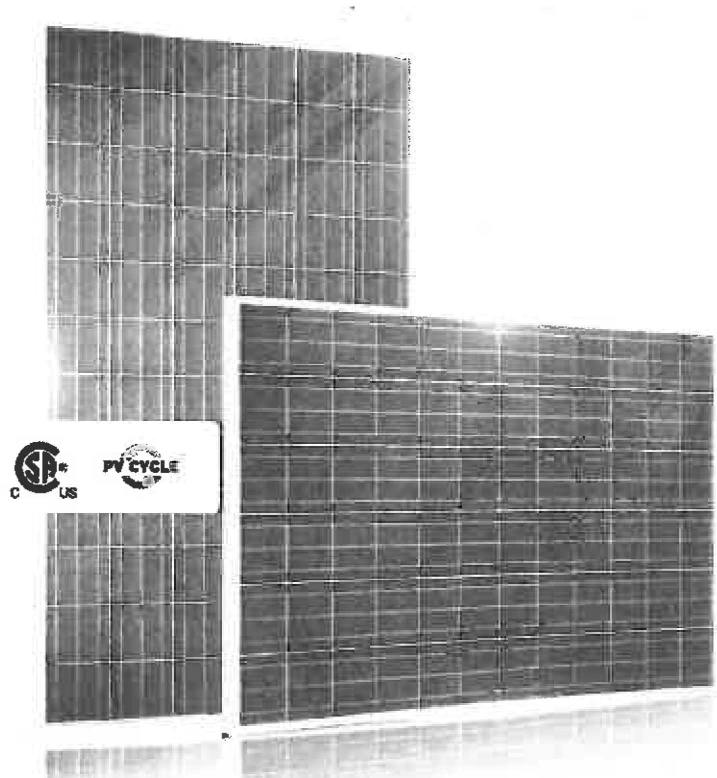
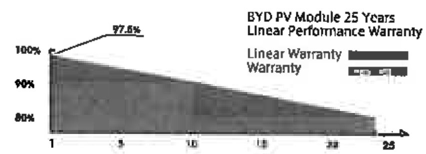
BYD P6C-36 Series-3BB

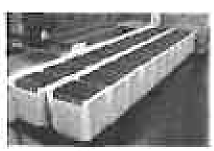
285W 290W 295W 300W 305W



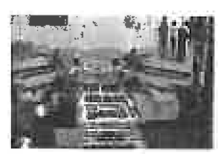
- Average cell efficiency up to17.6%
  Excellent optical performance
- Positive tolerance 0~5W
  Reliability for output performance
- 12 years for product
  25 years linear Warranty
- Residential roof top systems
  On/Off-grid commercial systems
  On/Off-grid utility systems
- 45lb/ft2 Mechanical Load Test
  Class C fire class rating
- ULC/ORD-C1703-01, UL 1703-3rd Edition,
  ISO9001:2008, ISO14001:2004



Production Process


Wafer Production


Cell Production

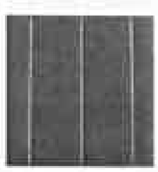

Module Production


Module

About BYD

BYD (HK:1211), one of the world's top PV manufacturers, produces from wafer to module, committing to high quality sustainable products and continuous improvement. Integrating with Electrical Vehicles and Battery Energy Storage technology makes BYD the world-leading solution provider from energy generating to consumption and storage

New Technology



NES

A high technology that is widely used in BYD photovoltaic products, increasing the average cell efficiency up to 17.6%

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Tel: +86-755-89888888
Fax: +86-755-84202222
Email: bydenergy@byd.com
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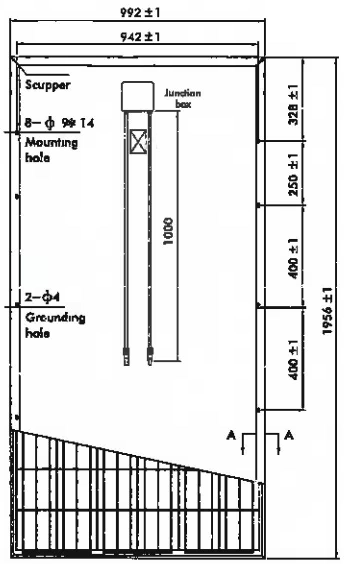
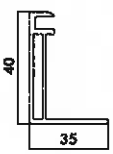
Edition No. EN-BYD-June-2013

BYD P6C-36 Series-3BB

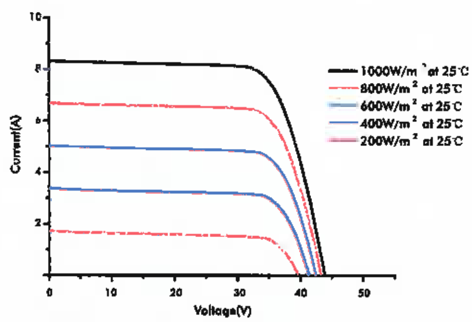
Build Your Dreams

285W 290W 295W 300W 305W





Section(A-A)



Mechanical Specifications

Cell	Polycrystalline Silicon solar cells 156mm * 156 mm / 6 inch
No. of Cells	72 (6*12) pcses
Dimension of Module	1956 mm * 992 mm * 40 mm / 77.0 inch * 39.1 inch * 1.6 inch
Weight	22.4kg / 49.38 lbs
Front Glass	3.2 mm tempered glass with ARC
Frame	Anodized aluminum alloy
Junction Box	IP67
Plug Connector	IP67
Bypass-Diodes	3 pcses
Type of Connector	202 (MC4-compatible)
Cable Section Area	4 mm² / 0.0062 Sq in
Cable Length	2 * 1000 mm / 2 * 39.4 inch

2.36psf

Temperature Coefficients

Nominal Operating Cell Temperature (NOCT)	46°C± 2°C
Short-Circuit Current Temperature Coefficient	0.06%/°C
Open-Circuit Voltage Temperature Coefficient	-0.34%/°C
Peak Power Temperature Coefficient	-0.43%/°C

Package Information

Package	40' HC
Pcs / Pallet	25
Pallet / Container	22
Pcs / Container	550

BYD P6C-36 Series Electrical Specification

STC

Item / Module	BYD 285P6C-36	BYD 290P6C-36	BYD 295P6C-36	BYD 300P6C-36	BYD 305P6C-36
Open Circuit Voltage (Voc)	44.30 V	44.60 V	44.90 V	45.19 V	45.49 V
Maximum Operating Voltage (Vmp)	35.40 V	35.65 V	35.76 V	35.97 V	36.18 V
Short Circuit Current (Isc)	8.60 A	8.67 A	8.75 A	8.83 A	8.91 A
Maximum Operating Current (Imp)	8.07 A	8.16 A	8.25 A	8.34 A	8.43 A
Maximum Power in STC (Pmax)	285 Wp	290 Wp	295 Wp	300 Wp	305 Wp
Module Efficiency	14.69%	14.95%	15.20%	15.46%	15.72%
Operating Temperature	-40 to 85°C				
Max. Fuse Current Rating	15 A				
Maximum System Voltage	1000 VDC				
Power Tolerance	0~5W				
Application Classes	Class A				

According to chart on original Option B layout

STC: IRRADIANCE 1000W/m², Module Temperature 25°C, AM=1.5   Ave. efficiency reduction of 4.5% at 200W/m²

NOCT

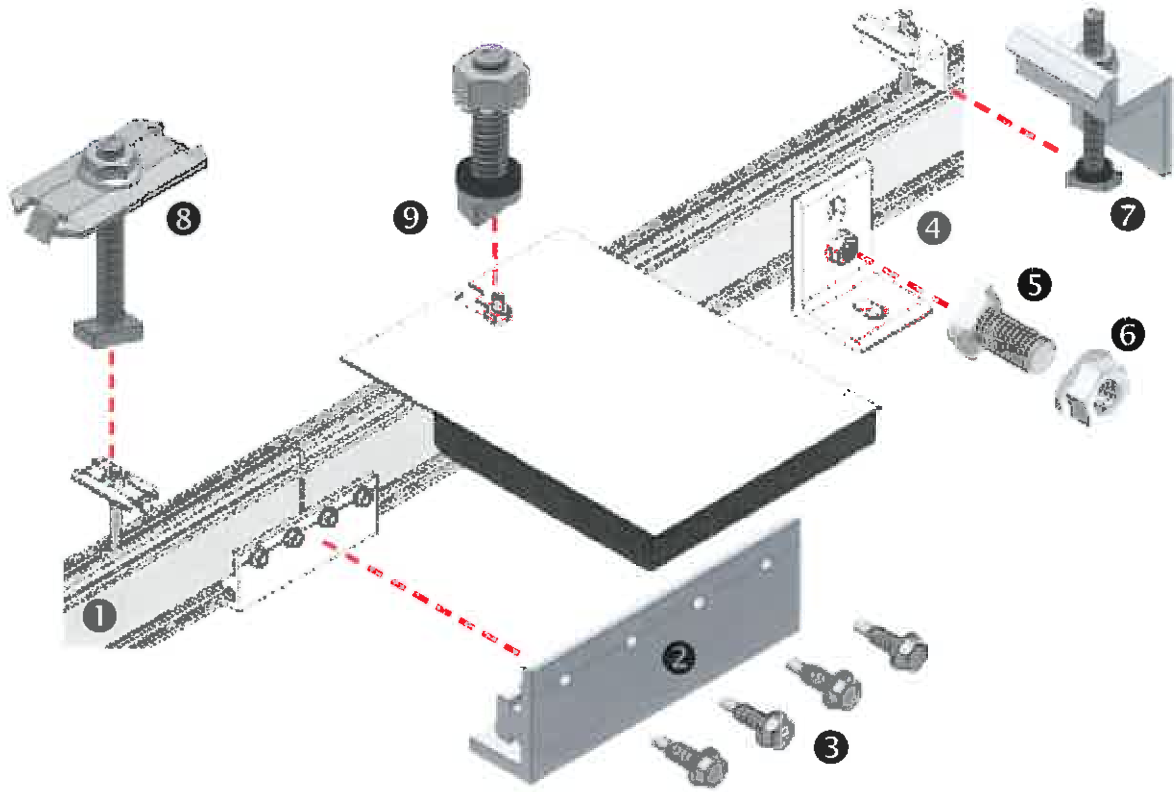
Item / Module	BYD 285P6C-36	BYD 290P6C-36	BYD 295P6C-36	BYD 300P6C-36	BYD 305P6C-36
Open Circuit Voltage (Voc)	40.75 V	41.04	41.33 V	41.62 V	41.89 V
Maximum Operating Voltage (Vmp)	32.25 V	32.50 V	32.79 V	32.97V	33.20V
Short Circuit Current (Isc)	6.96 A	7.06 A	7.10 A	7.14 A	7.18 A
Maximum Operating Current (Imp)	6.42 A	6.48 A	6.51 A	6.57 A	6.61 A
Maximum Power in NOCT (Pmax)	207.1 Wp	210.7 Wp	213.6 Wp	216.6Wp	219.5 Wp

NOCT: open-circuit module operation temperature at 800W/m2 irradiance, 20°C ambient temperature, 1m/s wind speed

SM SOLAR MOUNT

INSTALLATION GUIDE

PUB14NOV03



1 RAIL: Supports PV modules. Use at least two per row of modules. Aluminum extrusion, available in mill, clear anodized, or dark anodized.

2 RAIL SPLICE: Non structural splice joins and aligns rail sections into single length of rail. It can form either a rigid or thermal expansion joint, 4 inches long, predrilled. Anodized aluminum extrusion available in clear or dark.

3 SELF-DRILLING SCREW: (No. 12 x ¾") – Use 4 per rigid splice or 2 per expansion joint. Stainless steel. Supplied with splice. In combination with rail splice, provides rail to rail bond at rigid joint.

4 L-FOOT: Use to secure rails through roofing material to building structure. Refer to loading tables or U-Builder for spacing.

5 L-FOOT T- BOLT: (3/8" x ¾") – Use one per L-foot to secure rail to L-foot. Stainless steel. Supplied with L-foot. In combination with flange nut, provides electrical bond between rail and L-foot.

6 FLANGE NUT (3/8"): Use one per L-foot to secure rail to L-foot. Stainless steel. Supplied with L-foot.

7 MODULE END CLAMP: Provides bond from rail to end clamp. Pre-assembled aluminum clamp available in clear or dark finish. Supplied neoprene washers keep clamp and bolt upright for ease of assembly.

8 MODULE MID CLAMP: Pre-assembled clamp provides module to module and module to rail bond. Stainless steel clamp and T-bolt. Available in clear and dark finish.

9 MICRO-INVERTER MOUNTING BOLT: Pre-assembled bolt and nut Attaches micro-inverter to rail. Neoprene washer at base keeps bolt upright for ease of assembly.

NOTE - POSITION INDICATOR: T-Bolts have a slot in the hardware end corresponding to the direction of the T-Head.

Wrenches and Torque

	Wrench Size	Recommended Torque (ft-lbs)
1/4" Hardware ●●●	7/16"	*10
3/8" Hardware ●	9/16"	*30
#12 Hardware ●	5/16"	10

Torques are not designed for use with wood connectors
*w/Anti-seize.

Anti-Seize*

Stainless steel hardware can seize up, a process called galling. To significantly reduce its likelihood:

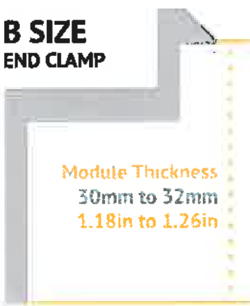
1. Apply minimal lubricant to bolts, preferably anti-seize commonly found at auto parts stores
2. Shade hardware prior to installation, and
3. Avoid spinning stainless on nuts onto bolts at high speed.

MODULE COMPATIBILITY

INSTALLATION GUIDE

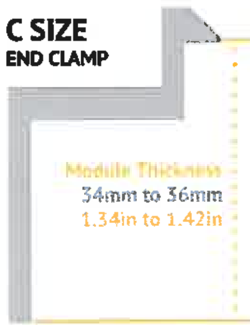
SM SOLAR MOUNT

B SIZE
END CLAMP



Module Thickness
30mm to 32mm
1.18in to 1.26in

C SIZE
END CLAMP



Module Thickness
34mm to 36mm
1.34in to 1.42in

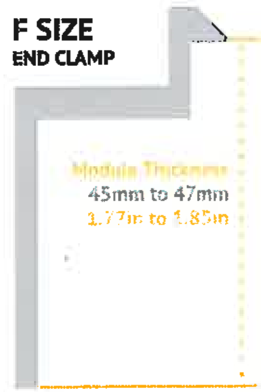
D SIZE
END CLAMP

Module Thickness
38mm to 40mm
1.50in to 1.57in

K SIZE
END CLAMP

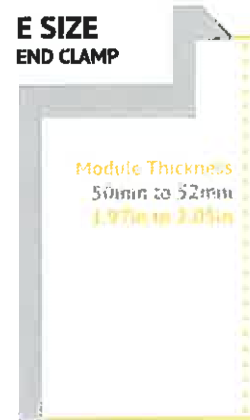
Module Thickness
39mm to 41mm
1.54in to 1.61in

F SIZE
END CLAMP

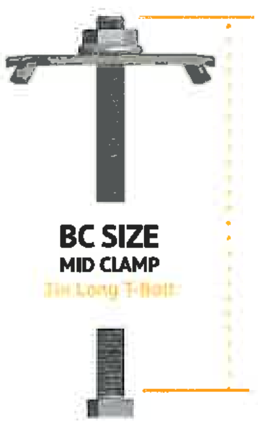


Module Thickness
45mm to 47mm
1.77in to 1.85in

E SIZE
END CLAMP



Module Thickness
50mm to 52mm
1.97in to 2.05in



BC SIZE
MID CLAMP
3in Long T-Bolt

DK SIZE
MID CLAMP
2.25in Long T-Bolt

EF SIZE
MID CLAMP
2.5in Long T-Bolt

PLANNING YOUR SOLARMOUNT INSTALLATIONS

The installation can be laid out with rails parallel to the rafters or perpendicular to the rafters. Note that SOLARMOUNT rails make excellent straight edges for doing layouts.

Center the installation area over the structural members as much as possible.

Leave enough room to safely move around the array during installation. Some building codes and fire codes require minimum clearances around such installations, and the installer should check local building code requirements for compliance.

The length of the installation area is equal to:

- the total width of the modules,
- plus ¼" inch for each space between modules (for mid-clamp),
- plus approximately 3 inches (1½ inches for each end clamp).

LAYING OUT L-FEET FOR TOP CLAMPS

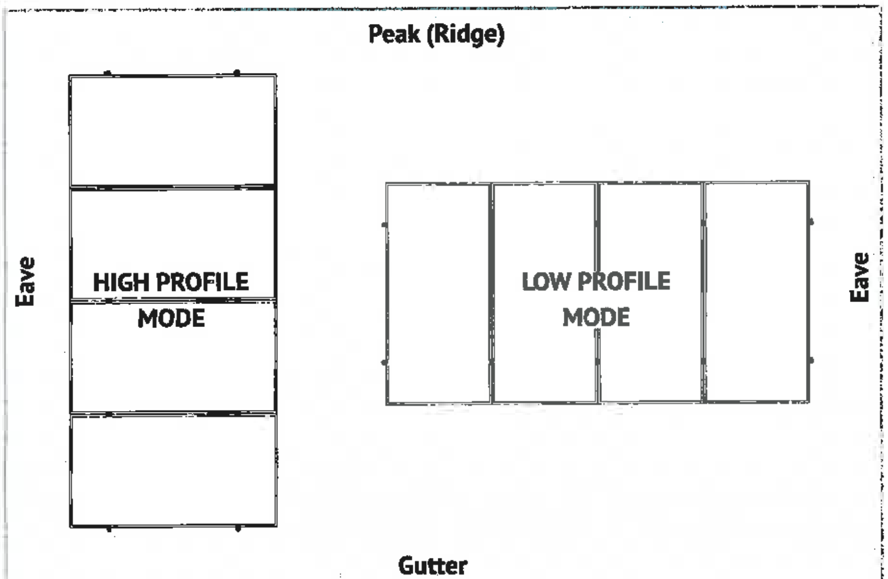
L-feet, in conjunction with proper flashing equipment and techniques, can be used for attachment through existing roofing material, such as asphalt shingles, sheathing or sheet metal to the building structure.

Locate and mark the position of the L-feet lag screw holes within the installation area as shown below. Follow manufacturer module guide for rail spacing based on appropriate mounting locations.

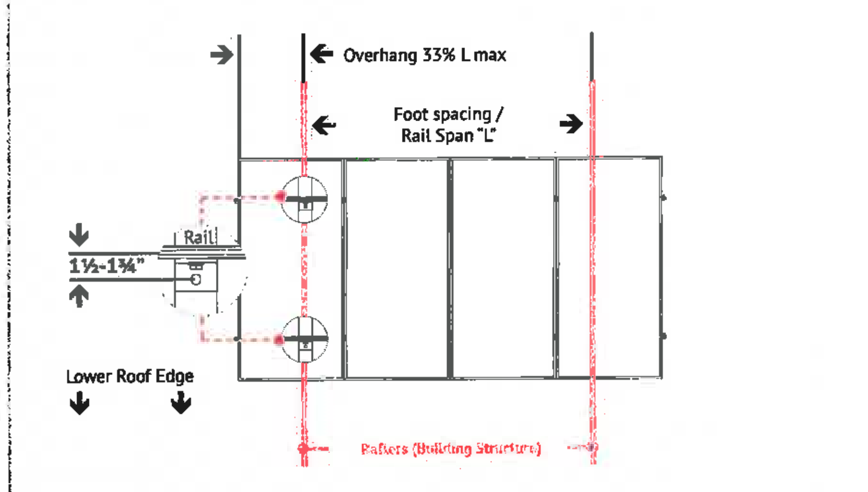
If multiple rows are to be installed adjacent to one another, it is not likely that each row will be centered above the rafters. Adjust as needed, following the guidelines below as closely as possible.

this shows parallel or perpendicular arrangements

RAILS MAY BE PLACED PARALLEL OR PERPENDICULAR TO RAFTERS



LAYOUT WITH RAILS PERPENDICULAR TO RAFTERS (RECOMMENDED)



Note: Modules must be centered symmetrically on the rails (+/- 2")

ROOF ATTACHMENT & L-FEET

ROOF PREPARATION: Layout and install flashing at rafter locations determined per design and engineering guide.

DRILL PILOT HOLES: Center the roof attachment over the rafter and drill a pilot hole(s) for the lag bolt(s)

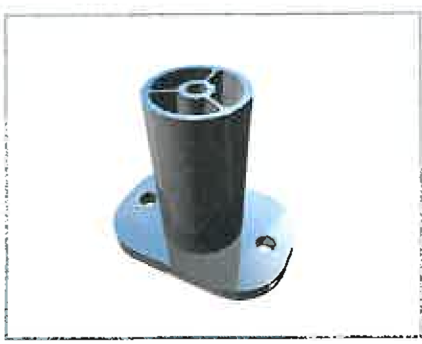
NOTE: Determine lag bolt size and embedment depth per design guide instructions.

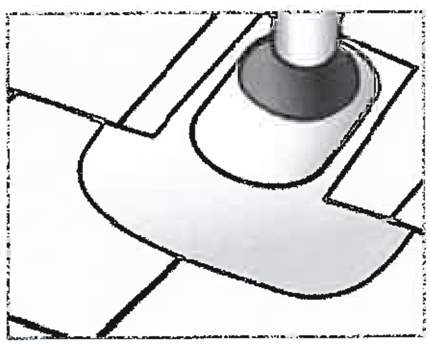
Quick Tip: Pre-drill the pilot hole through the flat flashing lag bolt location for easier installation.

FLAT FLASHING INSTALLATION: Insert the Flat Flashing so the top part is under the next row of shingles and the hole lines up with the pilot hole.

INSTALL LAG BOLTS & L-FOOT: Insert the lag bolt through the L-Foot in the order shown in the illustration. Verify proper orientation before tightening lag bolts.

See Unirac Flat Flashing Manual for Additional Details.





2 PIECE ALUMINUM STANDOFF WITH FLASHING & L-FOOT:

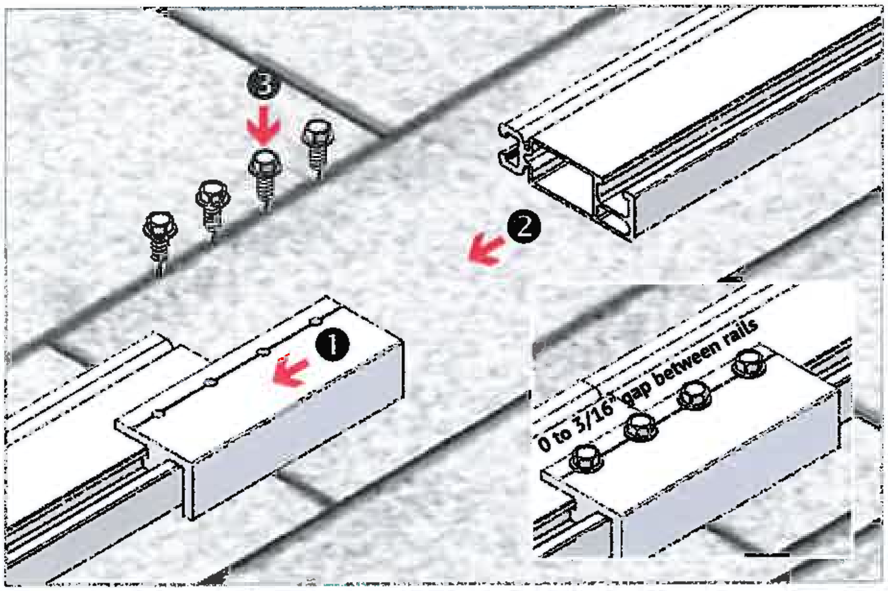
- If necessary cut an opening in the roofing material over a rafter to accommodate the flashing riser.
- Install the standoff, ensuring that both lag bolts are screwed into the rafter.
- Insert the flashing under the shingle above and over the shaft of the standoff. (No-Calk™ collar does not require sealing of the flashing and standoff shaft)
- Add L-Foot to top with bolt that secures the EPDM washer to the top of the standoff.

See Standoffs & Flashings Installation Manual 907.2 for Additional Details.

TOP MOUNT TILE HOOK & L-FOOT:

- Remove or slide up the roof tile, position the roof hook above the roof rafter
- Place Tile Hook in the middle of the underlying interlocking tile's valley. Drill 3/16 inch pilot holes through the underlayment into the center of the rafters. Securely fasten each tile hook to the rafters with two 5/16" x 3½" lag screws. Slide down or re-insert the tile
- Attach L Foot to tile roof hook

See Tile Hook Universal Mount Installation Manual for Additional Information

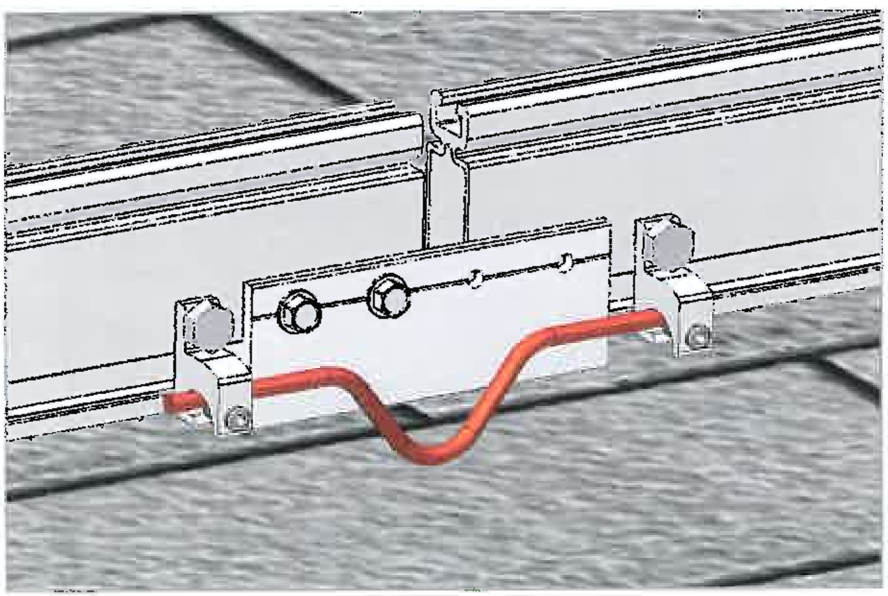


SPLICE INSTALLATION (IF REQUIRED PER SYSTEM DESIGN)

If your installation uses SOLARMOUNT splice bars, attach the rails together before mounting to the L-feet / footings. Use splice bars only with flush installations or those that use low-profile tilt legs. A rail should always be supported by more than one footing on both sides of the splice. There should be a gap between rails, up to 3/16" at the splice connections.

TORQUE VALUE (See Note on PG. 1)

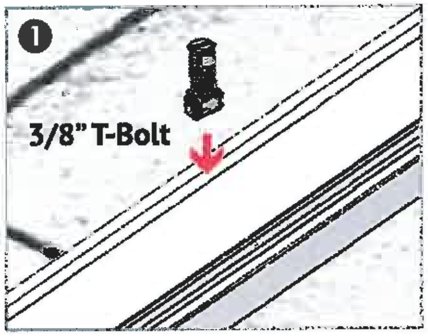
Hex head socket size 5/16" - Do not exceed 10 Ft-lbs. Do not use Anti-Seize



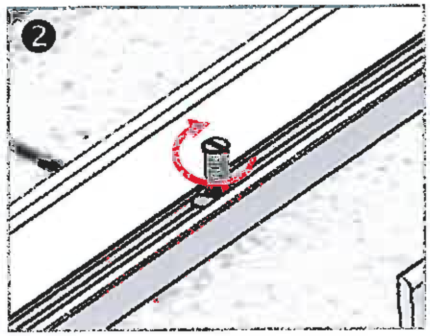
EXPANSION JOINT USED AS THERMAL BREAK

Expansion joints prevent buckling of rails due to thermal expansion. Splice bars may be used for thermal expansion joints. To create a thermal expansion joint, slide the splice bar into the footing slots of both rail lengths. Leave approximately ½" between the rail segments. Secure the splice bar with two screws on one side only. Footings (such as L-feet or standoffs) should be secured normally on both sides of the splice. No PV module or mounting hardware component should straddle the expansion joint. Modules must clearly end before the joint with mounting hardware (top mount end clamps) terminating on that rail. The next set of modules would then start after the splice with mounting hardware beginning on the next rail. **A thermal break is required every 40 feet of continuously connected rail. For additional concerns on thermal breaks in your specific project, please consult a licensed structural engineer. Runs of rail less than 40 feet in length, with more than two pairs spliced together, are an acceptable installation for the SolarMount systems.**

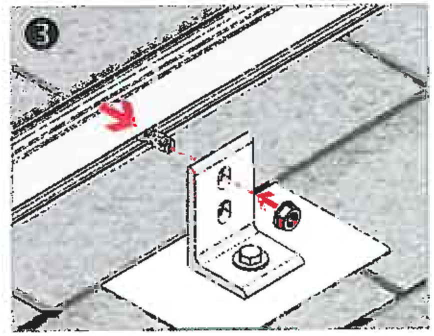
Bonding connection for splice used as a thermal break. Option shown uses two Ilsco lugs (Model No. GBL-4DBT P/N GBL-4DBT - see product datasheet for more details) and solid copper wire



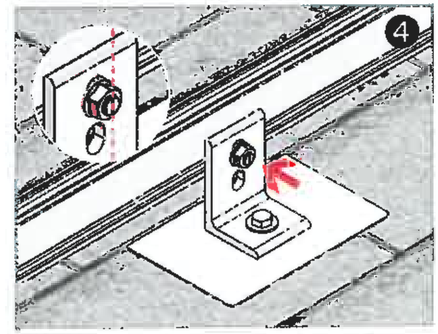
PLACE T-BOLT INTO RAIL: Insert 3/8" T-bolt into rail at L-foot locations.



SECURE T-BOLT: Apply Anti-Seize to bolt. Rotate T-bolt into position

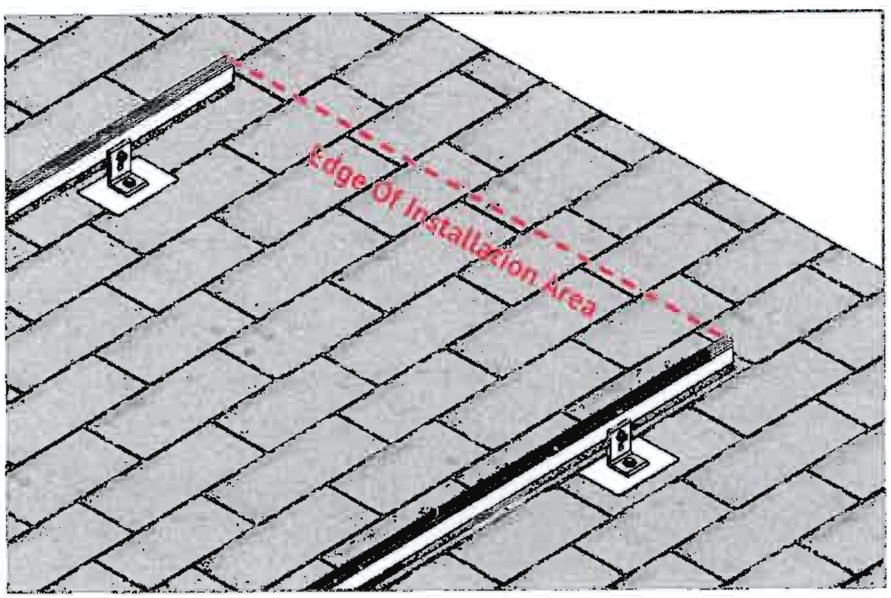


CONNECT RAIL TO L-FOOT: Raise rail to upright position and attach to L-feet to T-Bolt with 3/8" Serrated Flange Nut. Use either slot to obtain desired height and alignment.



ALIGN POSITION INDICATOR: Hand tighten nut until rail alignment is complete. Verify that position indicator on bolt is vertical (perpendicular to rail)

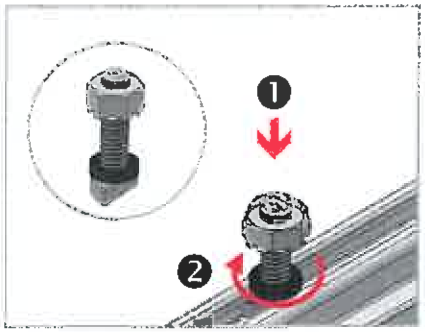
TORQUE VALUE (See Note on PG. 1)
3/8" nut to 30 ft-lbs



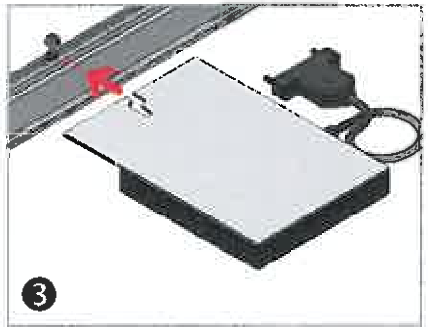
ALIGN RAILS:
Align one pair of rail ends to the edge of the installation area. The opposite pair of rail ends will overhang installation area. Do not trim them off until the installation is complete. If the rails are perpendicular to the rafters, either end of the rails can be aligned, but the first module must be installed at the aligned end.

If the rails are parallel to the rafters, the aligned end of the rails must face the lower edge of the roof. Securely tighten all hardware after alignment is complete.

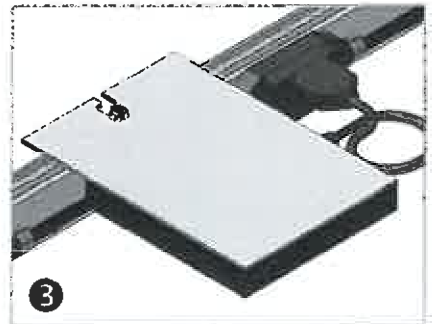
Mount modules to the rails as soon as possible. Large temperature changes may bow the rails within a few hours if module placement is delayed.



INSTALL MICROINVERTER MOUNT T-BOLT: Apply anti-seize and install pre-assembled ¼" x 1" bonding t-bolts into top ¼" rail slot at micro inverter locations. Rotate bolts into position.

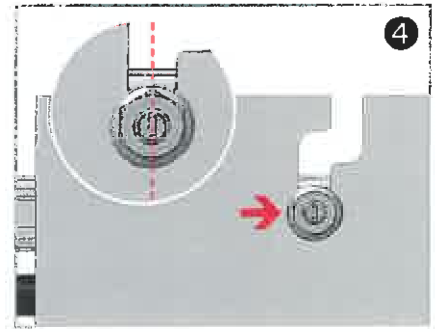


INSTALL MICROINVERTER: Install micro-inverter on to rail. Engage with bolt.

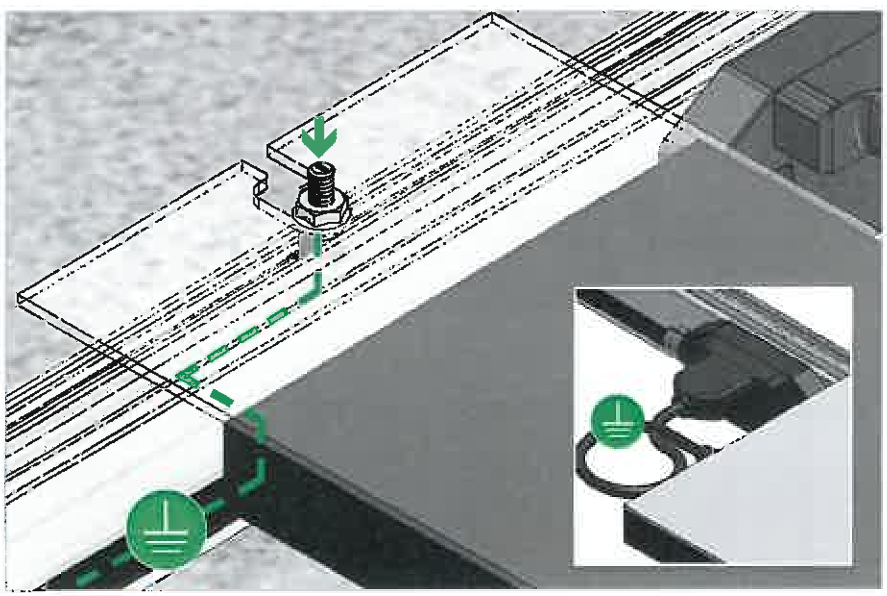


INSTALL MICROINVERTER:

TORQUE VALUE (See Note on PG. 1)
1/4" nut to 10 ft-lbs w/Anti-Seize



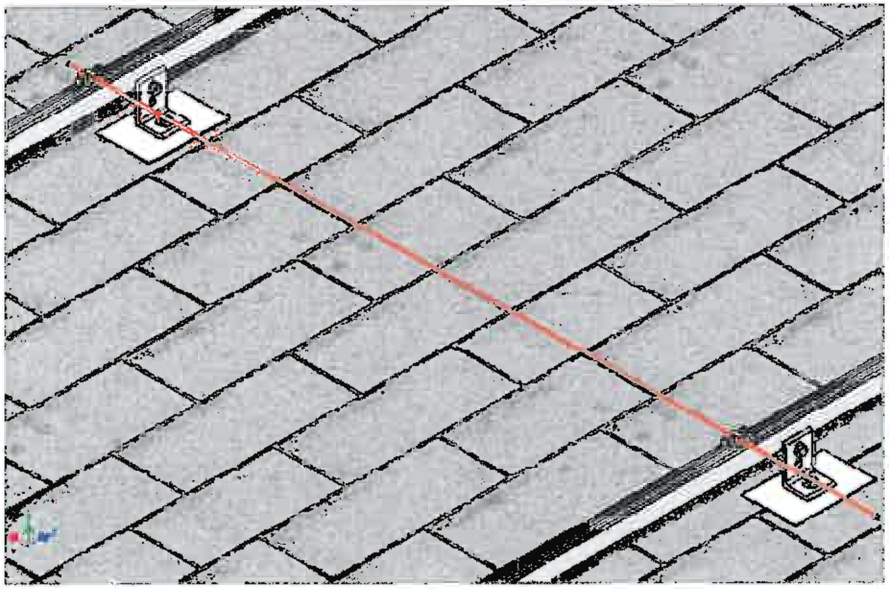
ALIGN POSITION INDICATOR: Verify that position indicator on bolt is perpendicular to rail



SM EQUIPMENT GROUNDING THROUGH ENPHASE MICROINVERTERS

The Enphase M215, M250 and C250 microinverters have integrated grounding capabilities built in. In this case, the DC circuit is isolated from the AC circuit, and the AC equipment grounding conductor (EGC) is built into the Enphase Engage integrated grounding (IG) cabling.

A minimum of one Enphase microinverter with integrated ground must be present on a single trunk cable. The microinverter is bonded to the SOLARMOUNT rail via the mounting hardware. Complete equipment grounding is achieved through the Enphase Engage cabling with integrated grounding (IG). No additional EGC grounding cables are required, as all fault current is carried to ground through the Engage cable.

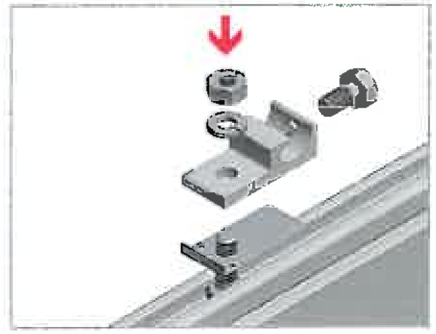


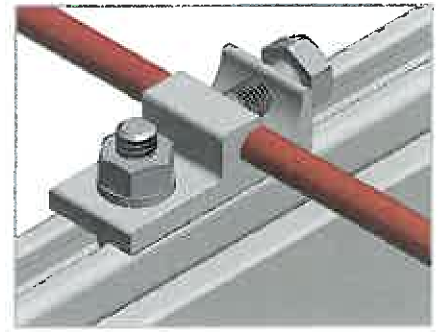
GROUNDING LUG MOUNTING DETAILS:

Details are provided for both the WEEB and Ilsco products. The WEEBLug has a grounding symbol located on the lug assembly. The Ilsco lug has a green colored set screw for grounding indication purposes. Installation must be in accordance with NFPA NEC 70, however the electrical designer of record should refer to the latest revision of NEC for actual grounding conductor cable size

GROUNDING LUG - BOLT SIZE & DRILL SIZE		
GROUND LIG	**BOLT SIZE**	**DRILL SIZE**
WEEBLug	7/16"	N/A - Place in Top SM Rail Slot
ILSCO Lug	#10-32	7/32"

- Torque value depends on conductor size.
- See product data sheet for torque value.

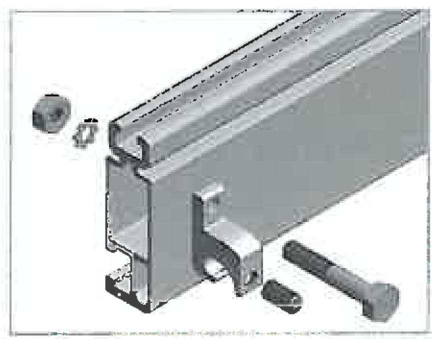


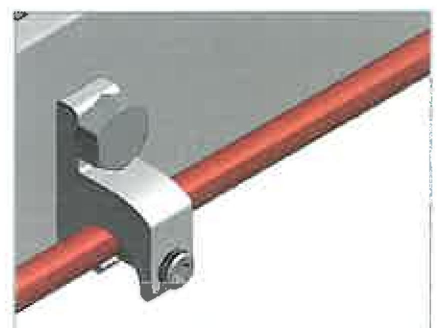


WEEBLUG CONDUCTOR - UNIRAC P/N 008002S:

Apply Anti Seize and insert a bolt in the aluminum rail and through the clearance hole in the stainless steel flat washer. Place the stainless steel flat washer on the bolt, oriented so the dimples will contact the aluminum rail. Place the lug portion on the bolt and stainless steel flat washer. Install stainless steel flat washer, lock washer and nut. Tighten the nut until the dimples are completely embedded into the rail and lug.

See product data sheet for more details, Model No. WEEB-LUG-6.7





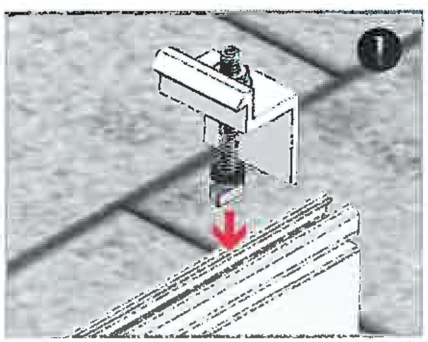
ILSCO LAY-IN LUG CONDUCTOR - UNIRAC P/N 008009P: Alternate Grounding Lug - Drill and bolt thru both rail walls per table.

See product data sheet for more details, Model No. GBL-4DBT

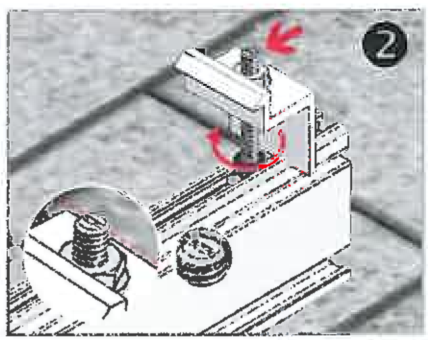
END CLAMP & FIRST MODULE

INSTALL MODULE END CLAMPS: The end clamp is supplied as an assembly with a bonding t-bolt, serrated flange nut, and two neoprene washers. One washer retains the clamp at the top of the assembly. The other washer should be against the bolt head during assembly. This will enable the clamp to remain upright for module installation.

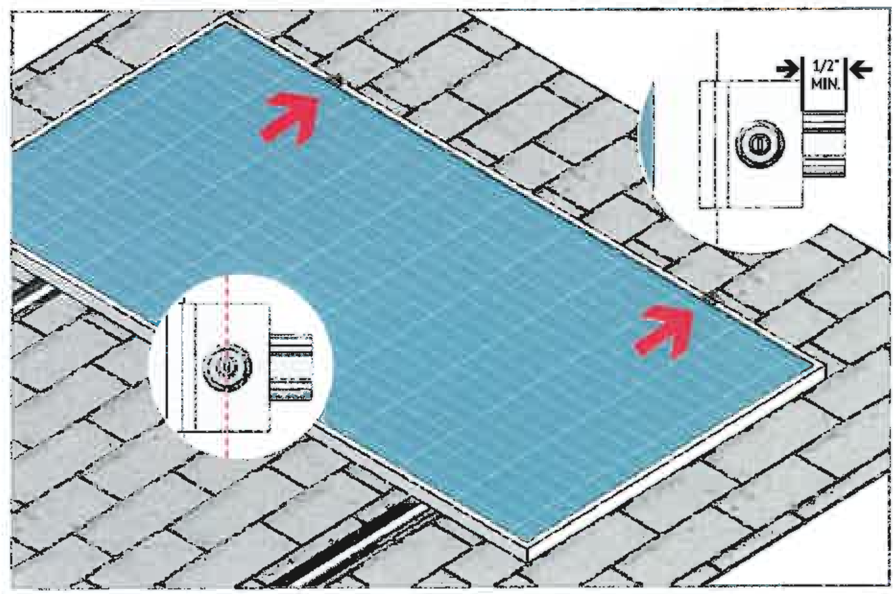
End clamps are positioned on rails prior to the first end module and installed after the last end module.



INSERT END CLAMP T-BOLT: Insert 1/4" T-bolt into rail.

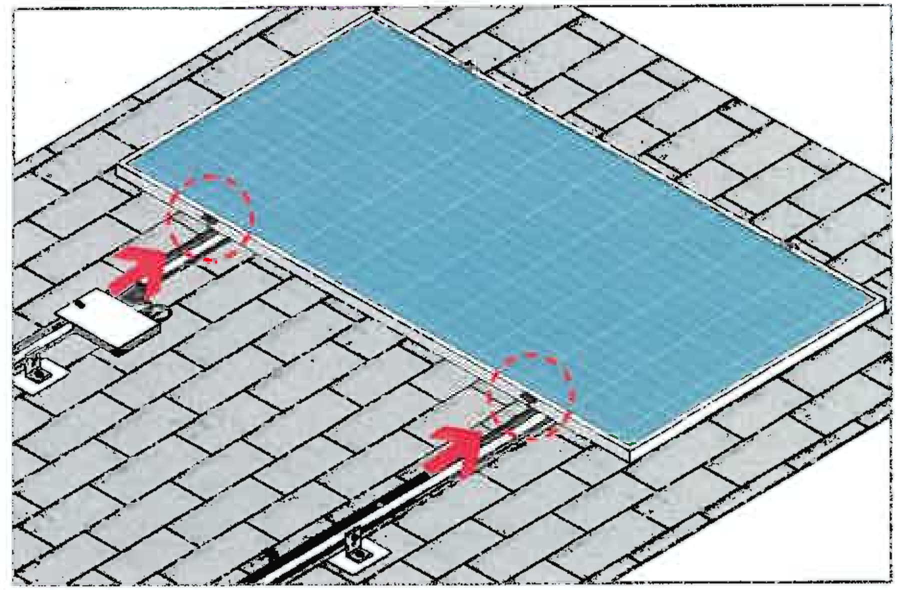


ROTATE END CLAMP T-BOLT: Rotate T-Bolt into position. Verify that the position indicator on the bolt is perpendicular to the rail



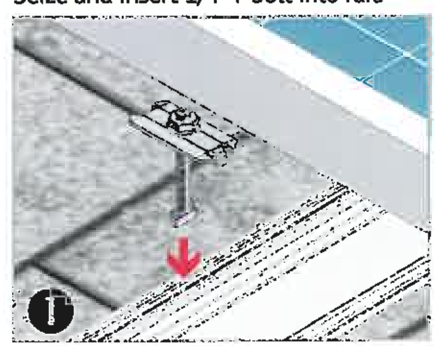
INSTALL FIRST MODULE: Install the first end module on to rails. Engage module frame with end clamps. Verify that the position indicator on the bolt is perpendicular to the rail.

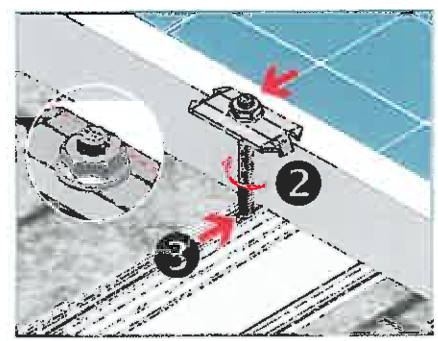
TORQUE VALUE (See Note on PG. 1)
1/4" nuts to 10 ft-lbs. w/Anti Seize



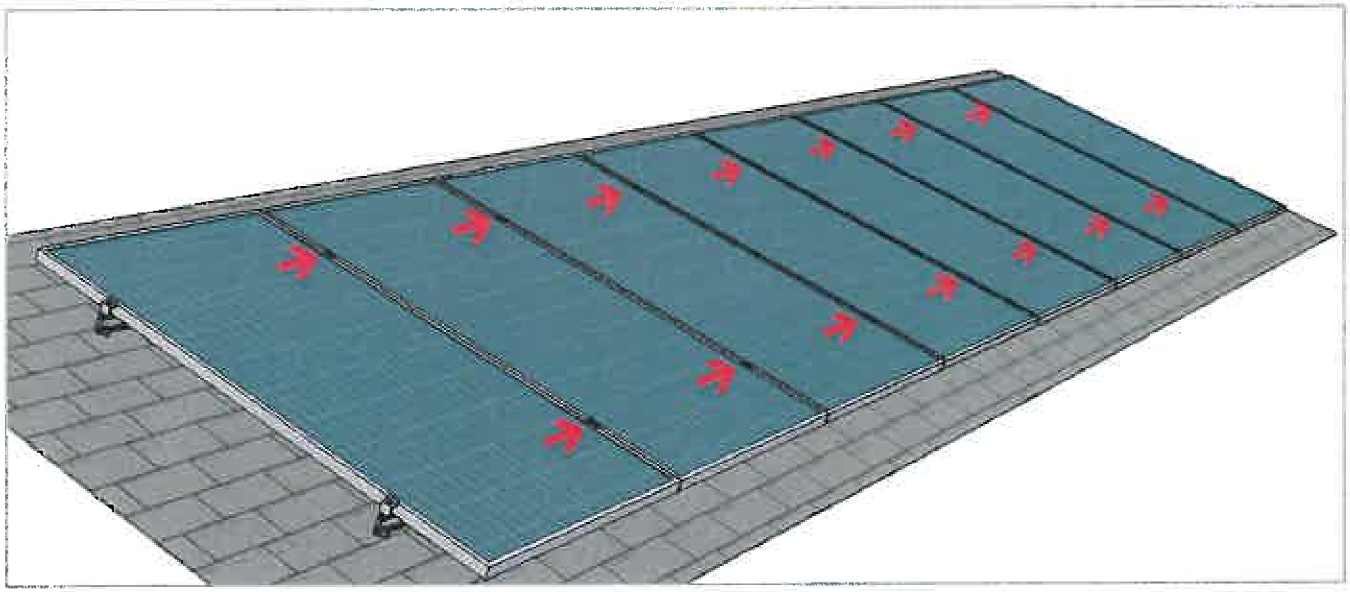
Mid clamp is supplied as an assembly with a bonding t-bolt and a retaining washer to hold the clamp upright for module installation. Clamp assemblies may be positioned in rail near point of use prior to module placement.

INSERT MID CLAMP T-BOLT: Apply Anti-Seize and insert 1/4" T-bolt into rail.



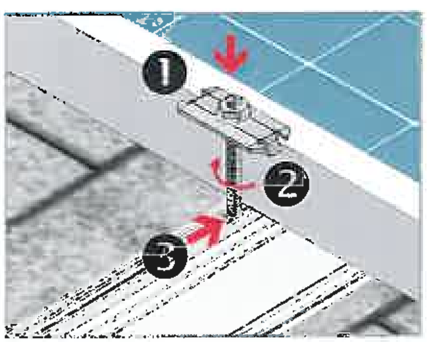


ROTATE MID CLAMP T-BOLT: Rotate bolt into position and slide until bolt and clamp are against module frame. Do not tighten nut until next module is in position. Verify that the position indicator on the bolt is perpendicular to the rail



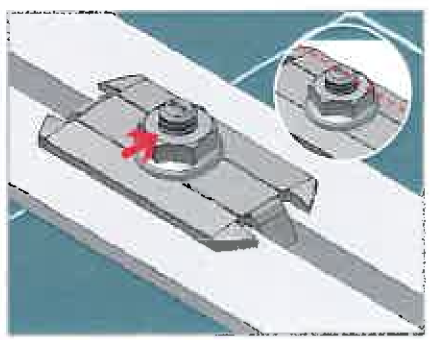
FINISH MODULE INSTALLATION:
Proceed with module installation. Engage each module with the previously positioned clamp assembly:

- Install remaining mid-clamps
- Install End Clamps
- Position alignment marks
- Cut Rail to Desired Length



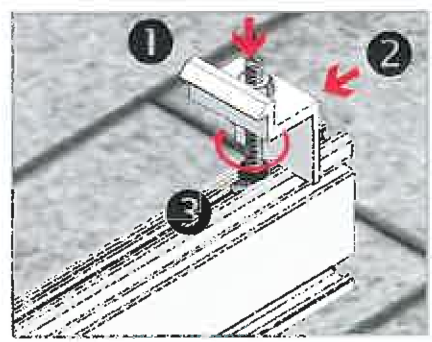
INSTALL REMAINING MID-CLAMPS:
Proceed with module installation. Engage each module with previously positioned mid clamp assemblies.

NOTE: Apply Anti-Seize to each Mid Clamp prior to installation



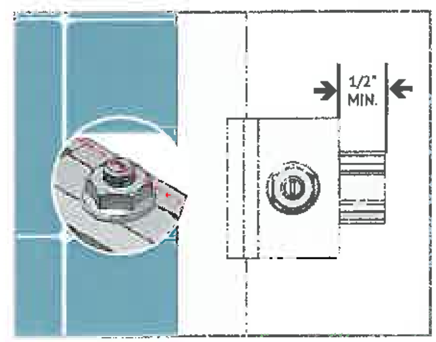
POSITION ALIGNMENT MARKS:
Verify that alignment marks are perpendicular to rail.

TORQUE VALUE (See Note on PG. 1)
1/4" nuts to 10 ft-lbs. w/Anti Seize

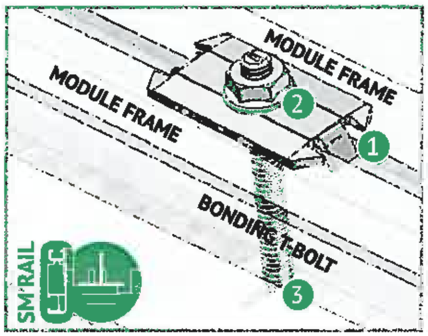


INSTALL END CLAMPS:
Apply Anti-Seize and install final end clamps in same manner as first end clamps. Slide clamps against module.

TORQUE VALUE (See Note on PG. 1)
1/4" nuts to 10 ft-lbs. w/Anti Seize

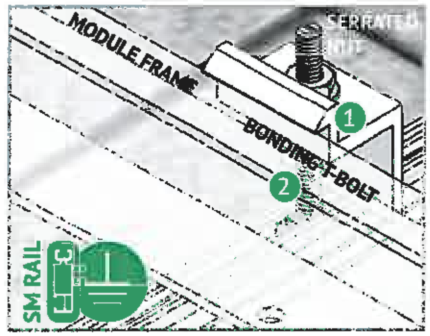


ALIGN POSITION MARKS & CUT RAIL:
Trim off any excess rail, being careful not to cut into the roof. Allow ½" between the end clamp and the end of the rail



BONDING MID CLAMP ASSEMBLY

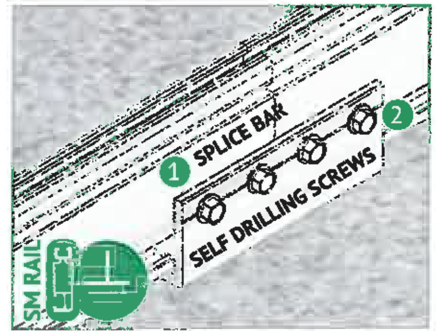
1. Stainless steel mid clamp points, 2 per module, pierce module frame anodization to bond module to module through clamp.
2. Serrated flange nut bonds stainless steel clamp to stainless steel T-bolt
3. Serrated T-bolt head penetrates rail anodization to bond T-bolt, nut, clamp, and modules to grounded SM rail



END CLAMP ASSEMBLY

1. Serrated flange nut bonds aluminum end clamp to stainless steel T-bolt
2. Serrated T-bolt head penetrates rail anodization to bond T-bolt, nut, and end clamp to grounded SM rail

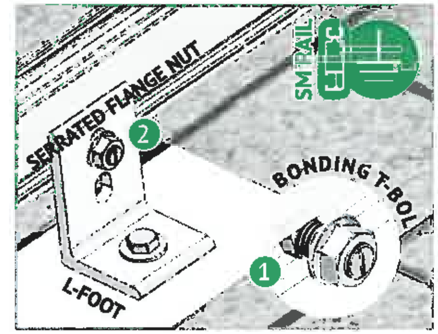
[illegible]



BONDING RAIL SPLICE BAR

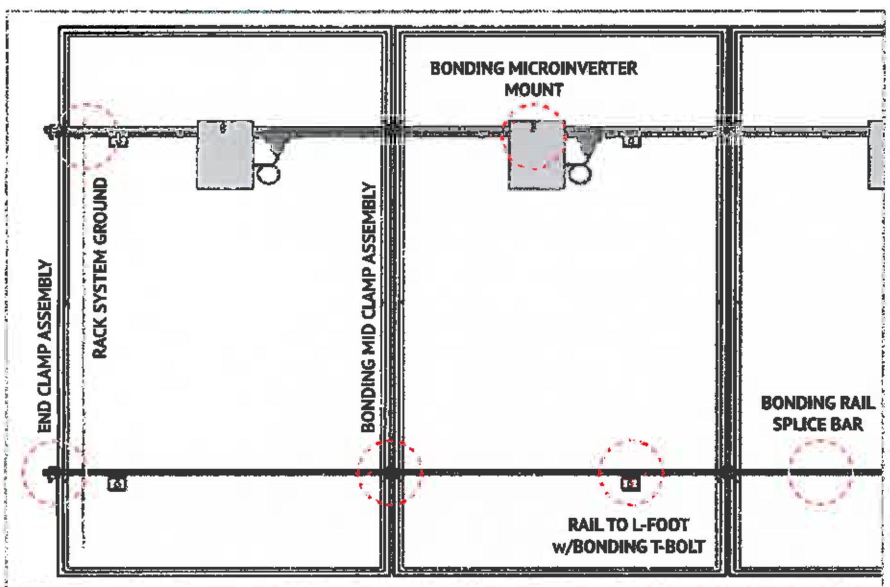
1. Stainless steel self drilling screws drill and tap into splice bar and rail creating bond between splice bar and each rail section
2. Aluminum splice bar spans across rail gap to create rail to rail bond. Rail on at least one side of splice will be grounded.

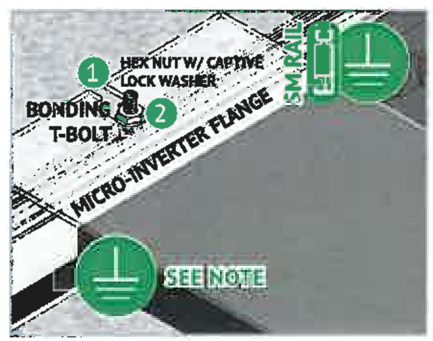
Note: Splice bar and rolled connections are non-structural. The splice bar function is rail alignment and bonding.



RAIL TO L-FOOT w/BONDING T-BOLT

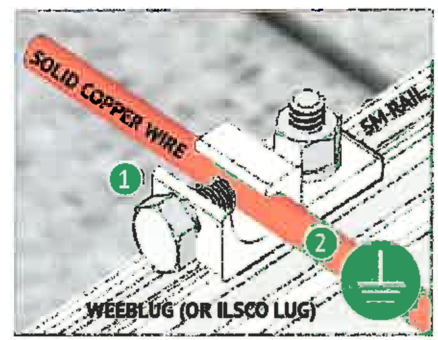
1. Serrated flange nut removes L-foot anodization to bond L-Foot to stainless steel T-bolt
2. Serrated T-bolt head penetrates rail anodization to bond T-bolt, nut, and L-foot to grounded SM rail





BONDING MICROINVERTER MOUNT

1. Hex nut with captive lock washer bonds metal microinverter flange to stainless steel T-bolt
2. Serrated T-bolt head penetrates rail anodization to bond T-bolt, nut, and L-foot to grounded SM rail [illegible]



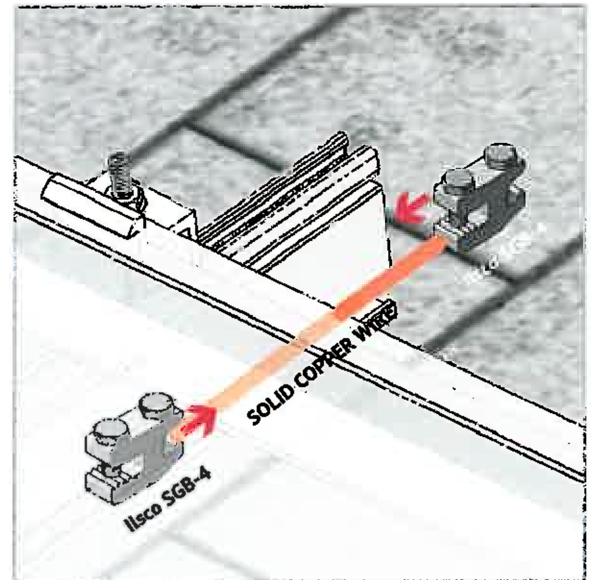
RACK SYSTEM GROUND

1. Weeb washer dimples pierce anodized rail to create bond between rail and lug
2. Solid copper wire connected to lug is routed to provide final system ground connection.

[illegible]

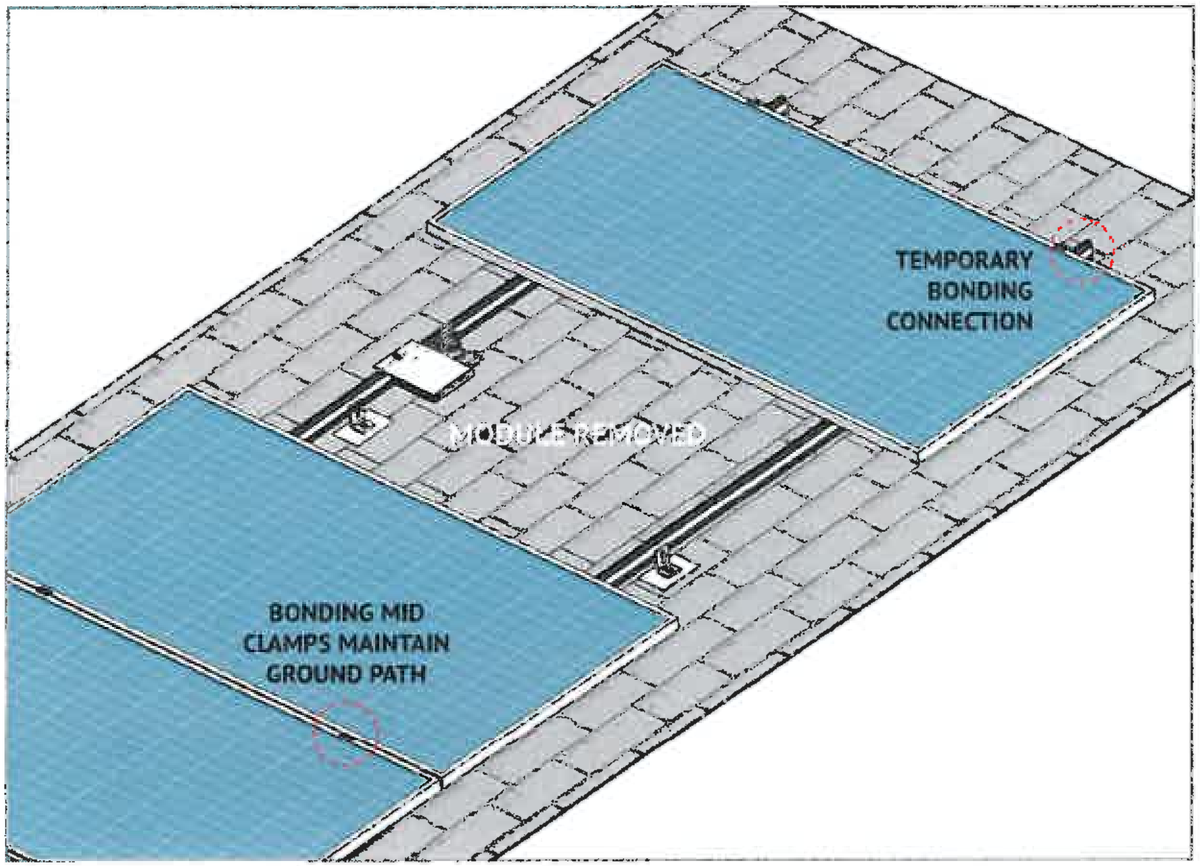
BONDING CONNECTION GROUND PATHS

TEMPORARY BONDING CONNECTION DURING ARRAY MAINTENANCE: When removing modules for replacement or system maintenance, any module left in place that is secured with a bonding mid clamp will be properly grounded. If a module adjacent to the end module of a row is removed or if any other maintenance condition leaves a module without a bonding mid clamp, a temporary bonding connection must be installed as shown.



TEMPORARY BONDING CONNECTION

- Attach Ilsco SGB4 to wall of rail
- Attach Ilsco SGB4 to module frame
- Install solid copper wire jumper to Ilsco lugs



UNIRAC
A HILTI GROUP COMPANY

Engineering Report

Project Title: None

Nov. 26, 2014, 8:20 a.m.

Project ID: 96010b11

Name:

Address:

City, State: Needles, CA 92363

Module: BYD BYD 300P6-36
300 Watts

SOLARMOUNT
40 - 300 Watt Panels

834 ft^2
12.0 KWs

Bill of Materials

Parts and Accessories

Legend: Base System Part Accessory

Part Number	Part Type	Description	Quantity	Suggested Quantity	Unit Price (USD)	Total List Price (USD)
320168M	Rail	SM RAIL 168" MILL	20	20	70.75	1415.00
303018C	Splice	BND SPLICE BAR SERRATED CLR	10	10	7.85	78.50
302024C	End Clamp	SM ENDCLAMP E CLR AL	20	20	3.55	71.00
302028C	Mid Clamp	SM BND MIDCLAMP EF SS	70	70	4.15	290.50
304001C	Roof Attachment	L-FOOT SERRATED W/ T-BOLT, CLR	100	100	4.35	435.00
008009P	Grounding Lug	ILSCO LAY IN LUG	5	5	8.40	42.00

Base System	Accessories	Total Price
$1855.00	$477.00	$2332.00
$0.15 per watt	$0.04 per watt	$0.19 per watt

This design is to be evaluated to the product appropriate Unirac Code Compliant Installation Manual which references International Building Code 2003, 2006, 2009, 2012 and ASCE 7-02, ASCE 7-05, ASCE 7-10 and California Building Code 2010. The installation of products related to this design is subject to requirements in the above mentioned installation manual.

Detailed Parts Descriptions

320168M SM RAIL 168" MILL
Structural aluminum extrusion containing slots that accept module and roof attachment hardware, electrical bonding accessories, and splice bars.

Rail
20

303018C BND SPLICE BAR SERRATED CLR
Aluminum extrusion for joining adjacent lengths of rail to one another. Can also function as thermal expansion joint. Includes self drilling screws.

Splice
10

302024C SM ENDCLAMP E CLR AL
Mounts **50-52 mm (1.97-2.05 in) thick** PV modules to rail by clamping module frame from above. Includes T bolt and nut. **If mounting on short side of module frame, confirm this is acceptable with PV module manufacturer.**

End Clamp
20

302028C SM BND MIDCLAMP EF SS
Located between adjacent PV modules, mounts **24-41 mm (0.94-1.61 in) thick** modules to rail by clamping module frame from above. Includes T bolt and nut. **If mounting on short side of module frame, confirm this is acceptable with PV**

Mid Clamp
70

304001C L-FOOT SERRATED W/ T-BOLT, CLR
Angle bracket connecting rail to roof or roof mounting accessory with serration on both mounting surfaces. **Lag bolts sold separately.**

Roof Attachment
100

008009P ILSCO LAY IN LUG
For electrical bonding of PV modules and rails. Accepts 4-14 AWG copper wires. Tin plated copper body, 1/4" stainless steel fasteners.

Grounding Lug
5

UNIRAC
A HILTI GROUP COMPANY

Engineering Report

Project Title: None

Nov. 26, 2014, 8:20 a.m.

Project ID: 96010b11

Name:

Address:

City, State: Needles, CA 92363

Module: BYD BYD 300P6-36
300 Watts

SOLARMOUNT
40 - 300 Watt Panels

834 ft²
12.0 KWs

Engineering Report

Plan Review

Roof Point Load Up: -93 lbs

Roof Point Load Down: 133 lbs

Total Number of Modules:	40
Total KW:	12.0 KW
Rows/ Columns:	5 / 8 (no gaps)
NS Dimension:	~385.1 in
EW Dimension:	~316.8 in
Loads Used for Design	
- Building Code:	ASCE 7-05
- Wind Speed:	85 mph
- Ground Snow Load:	0 psf
- Seismic (Ss):	2.15
- Wind Exposure:	B
Loads Determined by Zip	
- City, State:	Needles, CA
- Wind Speed:	85 mph
- Ground Snow Load:	None psf

Inspection

Maximum Rail Span (Zone 1): 87"

Selected Rail Span: 36"

Product:	SOLARMOUNT
Module Manufacturer:	BYD
Model:	BYD 300P6-36
Module Watts:	300 watts
Module Length:	77.01 "
Module Width:	39.01 "
Module Thickness:	1.97 "
Module Orientation:	Portrait
Maximum Rail Cantilever:	12.00 "
Expansion Joints:	Every 40'
Rails Direction:	EW
Building Height:	30 ft
Roof Pitch:	0-7°
Roof Type:	Shingle

UNIRAC
A HILTI GROUP COMPANY

Engineering Report

Project Title: None

Nov. 26, 2014, 8:20 a.m.

Project ID: 96010b11

Name:

Address:

City, State: Needles, CA 92363

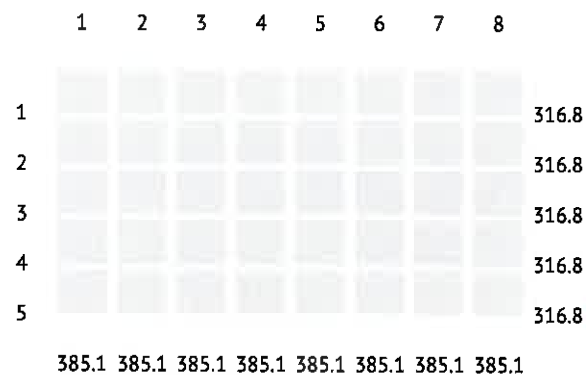
Module: BYD BYD 300P6-36
300 Watts

SOLARMOUNT
40 - 300 Watt Panels

834 ft^2
12.0 KWs

Installation and Design Plan

Layout



Row	Modules	Zone	Rail Type	Splices	Roof Attachments
1	8	Zone 1	SM RAIL 168" MILL | 320168M | $70 (4)	2	20
2	8	Zone 1	SM RAIL 168" MILL | 320168M | $70 (4)	2	20
3	8	Zone 1	SM RAIL 168" MILL | 320168M | $70 (4)	2	20
4	8	Zone 1	SM RAIL 168" MILL | 320168M | $70 (4)	2	20
5	8	Zone 1	SM RAIL 168" MILL | 320168M | $70 (4)	2	20

Maximum Rail Span (Zone 1*):	87"
Selected Rail Span:	36"
Maximum Rail Cantilever:	12.00 "
Module Orientation:	Portrait
Rail Direction:	EW

*Zone 2 and 3 Rail Spans must be independently verified

B-14

UNIRAC

Engineering Report

Project Title: None

Nov. 26, 2014, 12:08 p.m.

Project ID: c37b2ec5

Name:

Address:

City, State: Needles, CA 92363

Module: BYD BYD 300P6-36

300 Watts

SOLARMOUNT

40 - 300 Watt Panels

834 ft^2

12.0 KWs

Engineering Report

Plan Review

Roof Point Load Up: -48 lbs

Roof Point Load Down: 65 lbs

Total Number of Modules:	40
Total KW:	12.0 KW
Rows/ Columns:	8 / 5 (no gaps)
NS Dimension:	~195.0 in
EW Dimension:	~620.8 in
Loads Used for Design	
- Building Code:	ASCE 7-10
- Wind Speed:	110 mph
- Ground Snow Load:	0 psf
- Seismic (Ss):	2.15
- Wind Exposure:	B
Loads Determined by Zip	
- City, State:	Needles, CA
- Wind Speed:	110 mph
- Ground Snow Load:	None psf

Inspection

Maximum Rail Span (Zone 1): 131"

Selected Rail Span: 36"

Product:	SOLARMOUNT
Module Manufacturer:	BYD
Model:	BYD 300P6-36
Module Watts:	300 watts
Module Length:	77.01 "
Module Width:	39.01 "
Module Thickness:	1.97 "
Module Orientation:	Landscape
Maximum Rail Cantilever:	12.00 "
Expansion Joints:	Every 40'
Rails Direction:	EW
Building Height:	15 ft
Roof Pitch:	0-7°
Roof Type:	Standing Seam Metal

UNIRAC

Engineering Report

Project Title: None

Project ID: c37b2ec5

Name:

Address:

City, State: Needles, CA 92363

Module: BYD BYD 300P6-36

300 Watts

Nov. 26, 2014, 12:08 p.m.

SOLARMOUNT

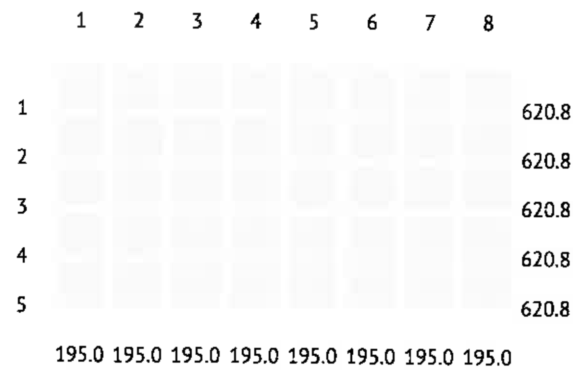
40 - 300 Watt Panels

834 ft^2

12.0 KWs

Installation and Design Plan

Layout



Row	Modules	Zone	Rail Type	Splices	Roof Attachments
1	8	Zone 1	SM RAIL 168" MILL | 320168M | $70 (2) SM RAIL 240" MILL | 320240M | $101 (4)	4	38
2	8	Zone 1	SM RAIL 168" MILL | 320168M | $70 (2) SM RAIL 240" MILL | 320240M | $101 (4)	4	38
3	8	Zone 1	SM RAIL 168" MILL | 320168M | $70 (2) SM RAIL 240" MILL | 320240M | $101 (4)	4	38
4	8	Zone 1	SM RAIL 168" MILL | 320168M | $70 (2) SM RAIL 240" MILL | 320240M | $101 (4)	4	38
5	8	Zone 1	SM RAIL 168" MILL | 320168M | $70 (2) SM RAIL 240" MILL | 320240M | $101 (4)	4	38

Maximum Rail Span (Zone 1*):	131"
Selected Rail Span:	36"
Maximum Rail Cantilever:	12.00 "
Module Orientation:	Landscape
Rail Direction:	EW

*Zone 2 and 3 Rail Spans must be independently verified

B-14

UNIRAC

Engineering Report

Project Title: None

Nov. 26, 2014, 12:08 p.m.

Project ID: c37b2ec5

Name:

Address:

City, State: Needles, CA 92363

Module: BYD BYD 300P6-36

300 Watts

SOLARMOUNT

40 - 300 Watt Panels

834 ft^2

12.0 KWs

Bill of Materials

Parts and Accessories

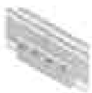
Legend: Base System Part Accessory

Part Number	Part Type	Description	Quantity	Suggested Quantity	Unit Price (USD)	Total List Price (USD)
320240M	Rail	SM RAIL 240" MILL	20	20	101.10	2022.00
320168M	Rail	SM RAIL 168" MILL	10	10	70.75	707.50
303018C	Splice	BND SPLICE BAR SERRATED CLR	20	20	7.85	157.00
302024C	End Clamp	SM ENDCLAMP E CLR AL	40	40	3.55	142.00
302028C	Mid Clamp	SM BND MIDCLAMP EF SS	60	60	4.15	249.00
304001C	Roof Attachment	L-FOOT SERRATED W/ T-BOLT, CLR	190	190	4.35	826.50
008009P	Grounding Lug	ILSCO LAY IN LUG	25	25	8.40	210.00

Base System	Accessories	Total Price
$3277.50	$1036.50	$4314.00
$0.27 per watt	$0.09 per watt	$0.36 per watt

This design is to be evaluated to the product appropriate Unirac Code Compliant Installation Manual which references International Building Code 2003, 2006, 2009, 2012 and ASCE 7-02, ASCE 7-05, ASCE 7-10 and California Building Code 2010. The installation of products related to this design is subject to requirements in the above mentioned Installation manual.

Detailed Parts Descriptions

	320240M	**SM RAIL 240" MILL** Structural aluminum extrusion containing slots that accept module and roof attachment hardware, electrical bonding accessories, and splice bars.	Rail 20
	320168M	**SM RAIL 168" MILL** Structural aluminum extrusion containing slots that accept module and roof attachment hardware, electrical bonding accessories, and splice bars.	Rail 10
	303018C	**BND SPLICE BAR SERRATED CLR** Aluminum extrusion for joining adjacent lengths of rail to one another. Can also function as thermal expansion joint. Includes self drilling screws.	Splice 20
	302024C	**SM ENDCLAMP E CLR AL** Mounts 50-52 mm (1.97-2.05 in) thick PV modules to rail by clamping module frame from above. Includes T bolt and nut. If mounting on short side of module frame, confirm this is acceptable with PV module manufacturer.	End Clamp 40
	302028C	**SM BND MIDCLAMP EF SS** Located between adjacent PV modules, mounts 24-41 mm (0.94-1.61 in) thick modules to rail by clamping module frame from above. Includes T bolt and nut. If mounting on short side of module frame, confirm this is acceptable with PV	Mid Clamp 60
	304001C	**L-FOOT SERRATED W/ T-BOLT, CLR** Angle bracket connecting rail to roof or roof mounting accessory with serration on both mounting surfaces. Lag bolts sold separately.	Roof Attachment 190
	008009P	**ILSCO LAY IN LUG** For electrical bonding of PV modules and rails. Accepts 4-14 AWG copper wires. Tin plated copper body, 1/4" stainless steel fasteners.	Grounding Lug 25

ARCADIS

SUBJECT: TOPOCK
PARKING CANOPY
JOB NO:

BY: CMW DATE: 12/2/14
CHKD: MSL DATE: 12/23/14

PAGE B15
SHEET 1

INPUT LOADS TO RISA 3

DEAD LOAD = 12.5 PSF (MAX) ← 2.14 psf (DECK DL) + 2 PSF FLC + 8.36 PSF SOLAR ⟩ 5.03 PSF (B-12)

LIVE LOAD = 20 PSF ✓ SEE SHT B-15A THRU B-15D

SNOW = N/A

OUTSIDE PURLIN

WIND: A: METAL DECK 3FT WIDE PANEL X 18FT LONG = 54 SF
B = (28FT X 5.81FT TRIB) = 162.75 SF INCLUDING END ZONE
768 ⟩ 36 SF

8'-0" CANTILEVER + 20'-0" SPAN

ZONE 3 = +24.0 PSF, -24.3 PSF

∴ FROM SHT B5, ZONE 1,2,3 ↓ PRESSURE = 10.4 PSF

INSIDE PURLIN TRIB AREA = 28FT x 6.375FT = 178 SF ⟶ ZONE 2 & 3 B) ↑ PRESSURE = -24.3 PSF, +24, 24.3 PSF

WINDWARD FASCIA = 33.5 PSF →

(CONSERVATIVELY ALSO APPLY TO COLUMNS)

DETERMINE PURLIN LOADS:

1) LRFD #3 ~ 1.2 DL + 1.6 L_R + 0.5 W (↓) + 0.5 W →

~~[struck out]~~

3) LRFD # 4 ~ 1.2 DL + 1.0 W (↓) + 1.0 W → + 0.5 L_R ~~LL~~

~~[struck out]~~

5) LRFD # 6 ~ 0.9 DL + 1.0 W (↓) + 1.0 W →

6) LRFD # 6A ~ 0.9 DL + 1.0 W (↑) + 1.0 W →

∗ USE RISA TO DETERMINE LOADS TO PURLINS TO BE INPUT INTO FRAME ANALYSIS (SHEET B-17)

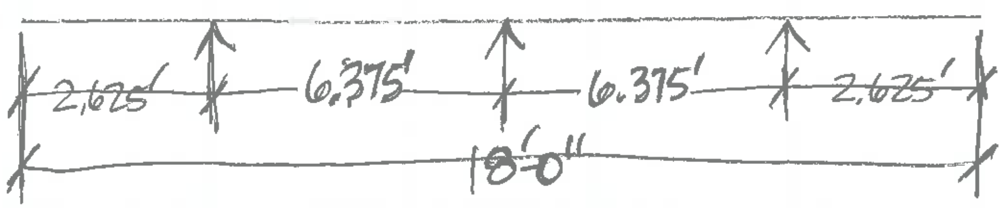
ARCADIS

SUBJECT: TOFOK
PARKING CANOPY
JOB NO:

BY: MSL DATE: 12/8/14
CHKD: DATE:

METAL DECK

**** USE 1.5B 20GA TO MEET MFG RECOMMENDED CANTILEVERED MAX SPANS (SHT B-15B)**



→ TRIB FOR C/C LOADS ON METAL DECK TO PURLIN = 3' WIDE × 9 FT TRIB = 27 SF

36.01 psf ↓ (SHT B-5) & 36.6 psf ↑ (SHT B-5) →

→ (36.6 psf × 0.6)↑ − (2 psf × 0.6) = 20.76 psf ↑

→ @ METAL DECK TO PURLIN

= 20.76 psf × 9 FT TRIB × 3 FT WIDE = 561# OVER 3'-0" WIDE

- 4 ATTACHMENTS (TEK SCREWS) @ PURLIN = 561#/4 = 140# UNF
  - L ACTUALLY 6 ATTACHMENTS
- PER SHT B-15C → #12-24 T/S = 3020# ULTIMATE / 4 FS = 755# > ✓OK

→ TRIB FOR METAL DECK DESIGN (1.5B 22GA) = 3' WIDE × 18 FT TRIB = 54 SF

10.4 psf & −24.3 psf (SHT B-5) → 0.6D + 0.6W UNF = 13.38 psf ↑

24.0 psf & −21.8 psf (SHT B-5A) → 0.9D + 1.0W FACT = 22.5 psf ↑

→ D + 0.75(0.6W + L_r) UNF = 38.3 psf ↓

1.2D + 1.6L_r + 0.5W FACT = 59.0 psf ↓

D_{MAX} = 12.5 psf, D_{MIN} = 2 psf

→ NEG M = ~~0.203~~ 0.22 KIF FACT × (38.3/59) psf UNF = ~~0.132~~ 0.143 KIF UNF

(RISA-2D SHT B-17)

< 77.3 psf ✓OK (SHT B-15B)

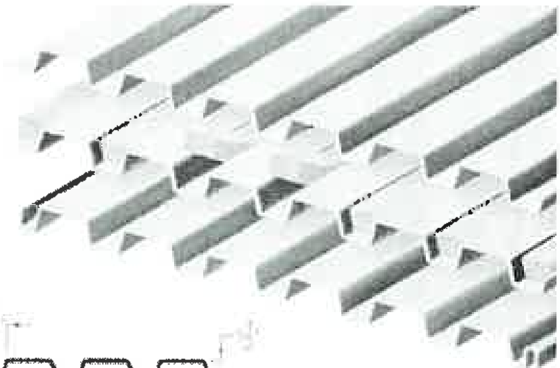
- S_p = 0.186 IN³/FT

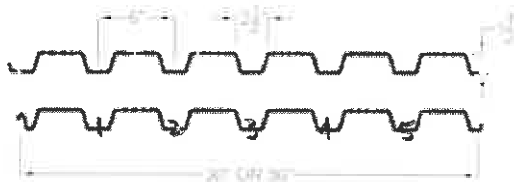
3 EQUAL SPANS
- $M_{ALL} = 0.10wL^2 = 0.10(77.3 psf)(6.375 FT)^2$ = 314.2 #-F UNF >> ✓OK

B-15B

1.5 B, BI, BA, BIA, BSV

Maximum Sheet Length 42'-0
Extra charge for lengths under 6'-0
ICC ER-3415
FM Global Approved[2]





Interlocking side lap is not drawn to show actual detail.

SECTION PROPERTIES

Deck type	Design thickness in.	W psf	I_p in^4/ft	S_p in^3/ft	I_n in^4/ft	S_n in^3/ft	V_a lbs/ft	F_y ksi
B24	0.0239	1.46	0.107	0.120	0.135	0.131	2634	60
B22	0.0295	1.78	0.155	0.186	0.183	0.192	1818	33
B20	0.0358	2.14	0.201	0.234	0.222	0.247	2193	33
B19	0.0418	2.49	0.246	0.277	0.260	0.289	2546	33
B18	0.0474	2.82	0.289	0.318	0.295	0.327	2870	33
B16	0.0598	3.54	0.373	0.408	0.373	0.411	3578	33

ACOUSTICAL INFORMATION

Deck Type	Absorption Coefficient						Noise Reduction Coefficient[1]
	125	250	500	1000	2000	4000	
1.5BA, 1.5BIA	.11	.18	.66	1.02	0.61	0.33	0.60

[1] Source: Riverbank Acoustical Laboratories.
Test was conducted with 1.50 pcf fiberglass batts and 2 inch polyisocyanurate foam insulation for the SDI.

USE 20GA FOR CANTILEVER REQUIREMENT

Type B (wide rib) deck provides excellent structural load carrying capacity per pound of steel utilized, and its nestable design eliminates the need for die-set ends.

1" or more rigid insulation is required for Type B deck.

Acoustical deck (Type BA, BIA) is particularly suitable in structures such as auditoriums, schools, and theatres where sound control is desirable. Acoustic perforations are located in the vertical webs where the load carrying properties are negligibly affected (less than 5%).

Inert, non-organic glass fiber sound absorbing batts are placed in the rib openings to absorb up to 60% of the sound striking the deck.

Batts are field installed and may require separation.

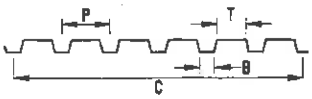
VERTICAL LOADS FOR TYPE 1.5B

No. of Spans	Deck Type	Max. SDI Const. Span	Allowable Total (PSF) / Load Causing Deflection of L/240 or 1 inch (PSF) — Span (ft.-in.) ctr to ctr of supports: 5-0	5-6	6-0	6-6	7-0	7-6	8-0	8-6	9-0	9-6	10-0
1	B24	4'-8	115 / 56	95 / 42	80 / 32	68 / 26	59 / 20	51 / 17	45 / 14	40 / 11	35 / 10	32 / 8	29 / 7
	B22	5'-7	98 / 81	81 / 61	68 / 47	58 / 37	50 / 30	44 / 24	38 / 20	34 / 17	30 / 14	27 / 12	25 / 10
	B20	6'-5	123 / 105	102 / 79	86 / 61	73 / 48	63 / 38	55 / 31	48 / 26	43 / 21	38 / 18	34 / 15	31 / 13
	B19	7'-1	146 / 129	121 / 97	101 / 75	86 / 59	74 / 47	65 / 38	57 / 31	51 / 26	45 / 22	40 / 19	36 / 16
	B18	7'-8	168 / 152	138 / 114	116 / 88	99 / 69	85 / 55	74 / 45	65 / 37	58 / 31	52 / 26	46 / 22	42 / 19
	B16	8'-8	215 / 196	178 / 147	149 / 113	127 / 89	110 / 71	96 / 58	84 / 48	74 / 40	66 / 34	60 / 29	54 / 24
2	B24	5'-10	124 / 153	103 / 115	86 / 88	74 / 70	64 / 56	56 / 45	49 / 37	43 / 31	39 / 26	35 / 22	31 / 19
	B22	6'-11	100 / 213	83 / 160	70 / 124	59 / 97	51 / 78	45 / 63	39 / 52	35 / 43	31 / 37	28 / 31	25 / 27
	B20	7'-9	128 / 267	106 / 201	89 / 155	76 / 122	66 / 97	57 / 79	51 / 65	45 / 54	40 / 46	36 / 39	32 / 33
	B19	8'-5	150 / 320	124 / 240	104 / 185	89 / 145	77 / 116	67 / 95	59 / 78	52 / 65	47 / 55	42 / 47	38 / 40
	B18	9'-1	169 / 369	140 / 277	118 / 213	101 / 168	87 / 134	76 / 109	67 / 90	59 / 75	53 / 63	48 / 54	43 / 46
	B16	10'-3	213 / 471	176 / 354	149 / 273	127 / 214	110 / 172	95 / 140	84 / 115	74 / 96	66 / 81	60 / 69	54 / 59
3	B24	5'-10	154 / 120	128 / 90	108 / 69	92 / 55	79 / 44	69 / 35	61 / 29	54 / 24	48 / 21	43 / 17	39 / 15
	B22	6'-11	124 / 167	103 / 126	87 / 97	74 / 76	64 / 61	56 / 50	49 / 41	43 / 34	39 / 29	35 / 24	31 / 21
	B20	7'-9	159 / 209	132 / 157	111 / 121	95 / 95	82 / 76	72 / 62	63 / 51	56 / 43	50 / 36	45 / 31	40 / 26
	B19	8'-5	186 / 250	154 / 188	130 / 145	111 / 114	96 / 91	84 / 74	74 / 61	65 / 51	58 / 43	52 / 37	47 / 31
	B18	9'-1	210 / 289	174 / 217	147 / 167	126 / 132	108 / 105	95 / 86	83 / 71	74 / 59	66 / 50	59 / 42	54 / 36
	B16	10'-3	264 / 369	219 / 277	185 / 214	158 / 168	136 / 135	119 / 109	105 / 90	93 / 75	83 / 63	74 / 54	67 / 46

Notes: 1. Minimum exterior bearing length required is 1.50 inches. Minimum interior bearing length required is 3.00 inches. If these minimum lengths are not provided, web crippling must be checked.
2. FM Global approved numbers and spans available on page 21.

@ 6.375ft = 77.3psf

TECHNICAL PRODUCT INFORMATION



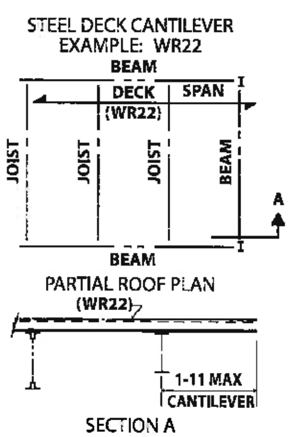
Approximate Dimensions in Inches

	Deck Type	Gauge	Indiana				Nebraska				South Carolina				Texas				Alabama / New York			
			C	P	T	B	C	P	T	B	C	P	T	B	C	P	T	B	C	P	T	B
ROOF	1.5B, 1.5BI, 1.5BA, 1.5BIA 1.5BSV	24 22 20 19 18 16	NA 36 36 36 36 36	6.00	3.50	1.75	30 36 36 36 36 36	6.00	3.50	1.75	36 36 36 36 36 36	6.00	3.50	1.75	NA 36 36 36 36 36	6.00	3.50	1.75	36 36 36 36 36 36	6.00	3.50	1.75
ROOF	1.5F	22 20 18	30	6.00	4.25	0.50	36	6.00	4.25	0.50	36	6.00	4.25	0.50	36	6.00	4.25	0.50	36	6.00	4.25	0.50
ROOF	1.5A	22 20 18	36	6.00	5.00	0.38	36	6.00	5.00	0.38	36	6.00	5.00	0.38	NA	-	-	-	NA	-	-	-
ROOF	3N, 3NI, 3NA, 3NIA	22 20 18 16	24	8.00	5.38	1.88	24	8.00	5.38	1.88	24	8.00	5.38	1.88	24	8.00	5.38	1.88	24	8.00	5.38	1.88
ROOF	1.0E	26 24 22 20	36	4.00	1.13	1.13	32	4.00	1.01	1.25	33	3.67	0.90	0.90	33	3.67	1.00	1.00	36	4.00	1.13	1.13
NON-COMPOSITE	0.6C and 0.6CSV	28 26 24 22	NA 30 30 NA	2.50	0.62	0.62	NA 36 36 36	3.04	0.63	0.63	35 35 35 35	2.50	0.75	0.75	30 35 35 35	2.50	0.62	0.62	30 30 30 30	2.50	0.75	0.75
NON-COMPOSITE	1.0C and 1.0CSV	26 24 22 20	36	4.00	1.13	1.13	32	4.00	1.25	1.01	33	3.67	0.90	0.90	33	3.67	1.00	1.00	36	4.00	1.13	1.13
NON-COMPOSITE	1.3C and 1.3CSV	26 24 22 20	NA	-	-	-	NA	-	-	-	NA	-	-	-	32	4.57	1.06	1.06	NA	-	-	-
NON-COMPOSITE	1.5C	24 22 20 18	NA 36 36 36	6.00	1.75	3.50	30 36 36 36	6.00	1.75	3.50	36 36 36 36	6.00	1.75	3.50	30 36 36 36	6.00	1.75	3.50	36 36 36 36	6.00	1.75	3.50
NON-COMPOSITE	2C	22 20 18 16	36	12.0	5.00	5.00	36	12.0	5.00	5.00	36	12.0	5.00	5.00	36	12.0	5.00	5.00	36	12.0	5.00	5.00
NON-COMPOSITE	3C	22 20 18 16	36	12.0	4.75	4.75	36	12.0	4.75	4.75	36	12.0	4.75	4.75	36	12.0	4.75	4.75	36	12.0	4.75	4.75
COMPOSITE	1.5VL and 1.5VLI	22 20 19 18 16	36	6.00	3.50	1.75	36	6.00	3.50	1.75	36	6.00	3.50	1.75	36	6.00	3.50	1.75	36	6.0	3.50	1.75
COMPOSITE	1.5VLR	22 20 19 18 16	36	6.00	1.75	3.50	36	6.00	1.75	3.50	36	6.00	1.75	3.50	36	6.00	1.75	3.50	36	6.0	1.75	3.50
COMPOSITE	2VLI	22 20 19 18 16	36	12.0	5.00	5.00	36	12.0	5.00	5.00	36	12.0	5.00	5.00	36	12.0	5.00	5.00	36	12.0	5.00	5.00
COMPOSITE	3VLI	22 20 19 18 16	36	12.0	4.75	4.75	36	12.0	4.75	4.75	36	12.0	4.75	4.75	36	12.0	4.75	4.75	36	12.0	4.75	4.75

RECOMMENDED MAXIMUM SPANS FOR CONSTRUCTION AND MAINTENANCE LOADS STANDARD FOR 1½ INCH AND 3 INCH ROOF DECK						
	TYPE	SPAN CONDITION	SPAN		MAX. RECOMMENDED SPANS ROOF DECK CANTILEVER	
			FT.-IN.	METERS	FT.-IN.	METERS
NARROW RIB DECK	NR22	1	3'-10"	1.15 m	1'-0"	.30 m
	NR22	2 or more	4'-9"	1.45 m		
	NR20	1	4'-10"	1.45 m	1'-2"	.35 m
	NR20	2 or more	5'-11"	1.80 m		
	NR18	1	5'-11"	1.80 m	1'-7"	.45 m
	NR18	2 or more	6'-11"	2.10 m		
INTERMEDIATE RIB DECK	IR22	1	4'-6"	1.35 m	1'-2"	.35 m
	IR22	2 or more	5'-6"	1.65 m		
	IR20	1	5'-3"	1.60 m	1'-5"	.40 m
	IR20	2 or more	6'-3"	1.90 m		
WIDE RIB DECK	WR22	1	5'-6"	1.65 m	1'-11"	.55 m
	WR22	2 or more	6'-6"	1.75 m		
	WR20	1	6'-3"	1.90 m	2'-4"	.70 m
	WR20	2 or more	7'-5"	2.25 m		
	WR18	1	7'-6"	2.30 m	2'-10"	.85 m
	WR18	2 or more	8'-10"	2.70 m		
DEEP RIB DECK	3DR22	1	11'-0"	3.35 m	3'-5"	1.05 m
	3DR22	2 or more	13'-0"	3.95 m		
	3DR20	1	12'-6"	3.80 m	3'-11"	1.20 m
	3DR20	2 or more	14'-8"	4.45 m		
	3DR18	1	15'-0"	4.55 m	4'-9"	1.45 m
	3DR18	2 or more	17'-8"	5.40 m		

2'-7½" W/ STIFFENED EDGE ✓ OK

CANTILEVER DESIGN



Notes:

1. Adjacent span: Limited to those spans determined in Section 2.4 of Roof Deck Standards. In those instances where the adjacent span is less than 3 times the cantilever span, the individual manufacturer should be consulted for the appropriate cantilever span. ✓
2. Sidelaps must be attached at end of cantilever and at a maximum of 12 inches (300 mm) on center from end. ✓
3. No permanent suspended loads are to be supported by the steel deck. ✓
4. The deck must be completely attached to the supports and at the sidelaps before any load is applied to the cantilever. ✓
5. Service loads may be more severe than indicated in section 2.4.A.7.

Vulcraft Steel Deck — FM Global Approved Spans

Maximum Vulcraft deck spans approved for use in FM Global constructions are shown below. The Engineer of Record must investigate the design as published by FM Global for the required attachment of the steel deck to the supporting structure, deck-to-deck fastening, attachment of insulation to the roof deck, etc. Reference shall be made to: https://roofnav.fmglobal.com

6'-4½" c/c (2) INTERIOR SPANS

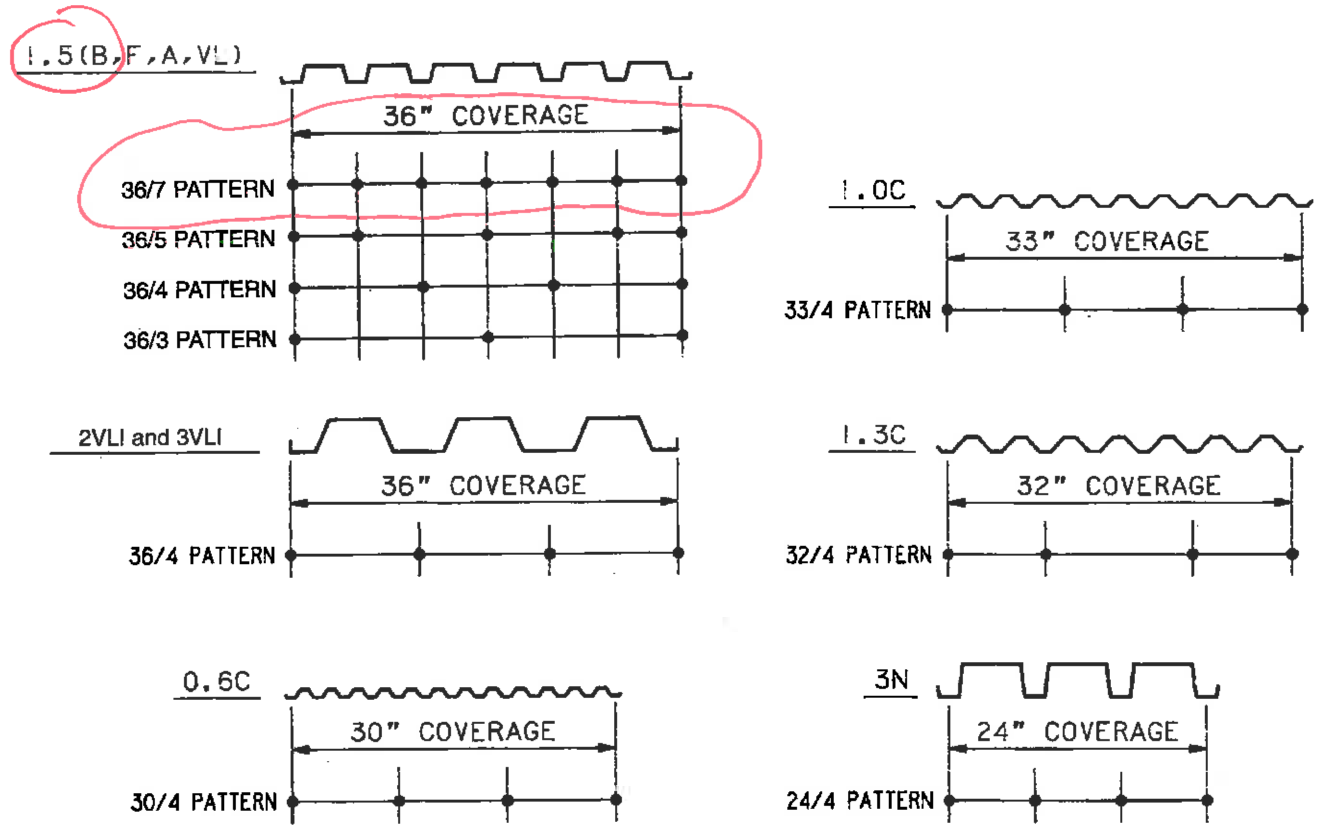
Roof Deck

	FM Span / Profile					
Gauge	1.5B, 1.5BI	1.5BA, 1.5 BIA	1.5F	1.5A	3N, 3NI	3NA, 3NIA
22	6' - 0"	5' - 9"	4' - 11"	4' - 0"	12' - 0"	12' - 7"
20	6' - 6"	6' - 4"	5' - 5"	5' - 3"	13' - 5"	13' - 11"
18	7' - 5"	7' - 3"	6' - 3"	6' - 0"	15' - 10"	16' - 1"
16	9' - 4"	7' - 11"	—	—	18' - 1"	18' - 3"

Cellular Deck

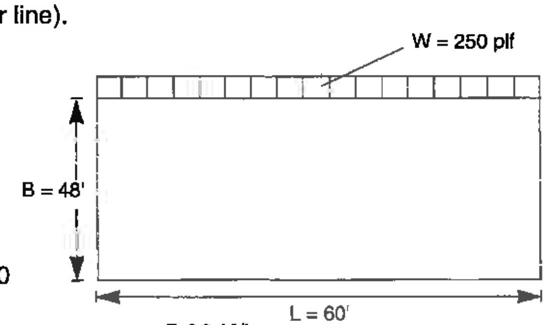
	FM Span / Profile	
Gauges	1.5BP, 1.5BPA	3NP, 3NPA
20/20	6' - 6"	13' - 5"
20/18	6' - 6"	13' - 5"
18/20	7' - 5"	15' - 10"
18/18	7' - 5"	15' - 10"
18/16	7' - 5"	15' - 10"
16/18	9' - 4"	18' - 1"
16/16	9' - 4"	18' - 1"

TYPICAL FASTENER LAYOUT



DIAPHRAGM SHEAR STRENGTH AND STIFFNESS DESIGN EXAMPLE

For roof plan shown, calculate the deflection of diaphragm (Δ_{CL} center line).



Joist spacing = 5'-0"
Deck: 1.5B 22 (WR) in 15'-0" panels
(3 span condition)
Fasteners: Support – 36/3 pattern
W/ 5/8" puddle welds
Sidelap – 1 #10 TEK

From diaphragm strength tables: $K_1 = 0.617$, $D_B = 2209$, and $K_2 = 870$

$$G' = \frac{K_2}{3.78 + \frac{0.3D_B}{\text{Span}} + 3K_1\,\text{Span}} = \frac{870}{3.78 + \frac{0.3(2209)}{5} + 3(0.617)(5)} = 5.98\ \text{K/in}$$

$$\Delta_{\text{CL}} = \frac{WL^2}{8xBxG'} = \frac{0.250\,(60)^2}{8\,(48)\,(5.98)} = 0.39\ \text{in}$$

Strength Check

$$R = WL/2 = \frac{250\,(60)}{2} = 7500\ \text{lbs} \qquad S = \frac{7500}{48} = 156\ \text{plf} < 224\ \text{plf (from page 86) OK}$$

1.5 (B, BI, F, A) 20 ALLOWABLE DIAPHRAGM SHEAR STRENGTH (PLF)

SUPPORT FASTENERS: 5/8" puddle welds[1]

SIDELAP FASTENERS: welded[2]

Factor of safety = 2.35

	# OF SIDELAP FASTENERS	DIAPHRAGM SHEAR STRENGTH (PLF) DECK SPAN (FT.-IN.) 3.00	3.50	4.00	4.50	5.00	5.50	6.00	6.50	7.00	7.50	8.00	8.50	9.00	9.50	10.00	K1
36/7	0	581	505	441	390	349	316	288	264	244	226	211	197	185	175	167	0.535
	1	757	665	592	532	482	437	399									0.317
	2	910	808	725	656	598	549	507	469	434	404	377	354	333			0.225
	3	1039	934	845	770	705	650	602	561	524	492	437	387	345	310	279	0.174
	4	1148	1043	952	873	804	744	692	646	570	497	437	387	345	310	279	0.142
	5	1238	1137	1046	966	894	832	776	661	570	497	437	387	345	310	279	0.120
	6	1313	1217	1128	1048	976	912	776	661	570	497	437	387	345	310	279	0.104
	7	1375	1285	1200	1122	1050	924	776	661	570	497	437	387	345	310	279	0.092
	8	1426	1343	1262	1187	1116	924	776	661	570	497	437	387	345	310	279	0.082
	9	1470	1392	1317	1244	1118	924	776	661	570	497	437	387	345	310	279	0.074
	10	1506	1435	1364	1295	1118	924	776	661	570	497	437	387	345	310	279	0.068

D_B = 97 D_F = 169 D_A = 266 K2= 1056

36/5	0	514	452	402	361	323	292	266	244	225	209	194	182	171	161	153	0.542
	1	659	589	531	483	441	406	376									0.351
	2	771	701	640	587	542	501	466	436	408	384	361	339	319			0.242
	3	856	790	730	677	629	586	548	514	484	457	432	387	345	310	279	0.184
	4	920	860	804	752	704	661	621	585	553	497	437	387	345	310	279	0.149
	5	968	915	863	814	768	725	686	649	570	497	437	387	345	310	279	0.125
	6	1006	959	912	866	822	781	742	661	570	497	437	387	345	310	279	0.108
	7	1035	993	951	909	868	829	776	661	570	497	437	387	345	310	279	0.094
	8	1058	1021	983	945	907	870	776	661	570	497	437	387	345	310	279	0.084
	9	1076	1043	1009	974	939	905	776	661	570	497	437	387	345	310	279	0.076
	10	1091	1062	1031	1000	967	924	776	661	570	497	437	387	345	310	279	0.069

D_B = 567 D_F = 663 D_A = 728 K2= 1056

36/4	0	393	346	309	273	244	220	200	183	168	156	145	135	127	120	114	0.802
	1	530	478	433	395	362	334	310									0.394
	2	626	576	531	491	455	423	395	370	348	328	310	292	275			0.261
	3	693	648	606	567	531	499	469	442	418	396	376	357	340	310	279	0.195
	4	738	700	663	627	593	561	532	504	479	456	434	387	345	310	279	0.156
	5	771	739	706	674	642	612	584	557	532	497	437	387	345	310	279	0.130
	6	794	767	739	710	682	654	627	602	570	497	437	387	345	310	279	0.111
	7	812	788	764	739	713	688	663	639	570	497	437	387	345	310	279	0.097
	8	825	805	784	761	739	716	693	661	570	497	437	387	345	310	279	0.086
	9	835	818	799	780	759	739	718	661	570	497	437	387	345	310	279	0.078
	10	843	828	812	794	776	758	739	661	570	497	437	387	345	310	279	0.071

D_B = 802 D_F = 909 D_A = 959 K2= 1056

36/3	0	329	294	265	241	217	196	178	163	150	138	129	120	112	106	101	1.070
	1	427	395	365	338	314	293	274									0.450
	2	484	457	431	407	384	362	342	324	307	292	278	265	253			0.285
	3	517	496	475	454	434	414	395	378	361	345	330	317	304	292	279	0.208
	4	538	522	505	487	470	452	435	419	403	388	374	360	345	310	279	0.164
	5	551	538	525	510	495	480	466	451	436	422	409	387	345	310	279	0.135
	6	560	550	539	527	514	502	489	476	463	450	437	387	345	310	279	0.115
	7	567	558	549	539	529	518	506	495	483	472	437	387	345	310	279	0.100
	8	572	565	557	548	539	530	520	510	500	489	437	387	345	310	279	0.089
	9	575	569	563	555	548	539	531	522	513	497	437	387	345	310	279	0.080
	10	578	573	567	561	554	547	540	532	524	497	437	387	345	310	279	0.072

D_B = 1652 D_F = 1816 D_A = 1827 K2= 1056

1 A 3/8" x 1-1/4" arc seam weld shall be used with F deck or A deck.

2 The shaded values do not comply with the minimum spacing requirements for sidelap connections and shall not be used except with properly spaced button-punched sidelaps with 1.5BI deck.

$$G' = \frac{K_2}{3.78 + \frac{0.3 \cdot D_X}{SPAN} + 3 \cdot K_1 \cdot SPAN}, \text{ Kips/inch}$$

SPAN is in feet

Substitute D_B, D_F, or D_A for D_X

DIAPHRAGM

1.5 (B, F, A) 20 ALLOWABLE DIAPHRAGM SHEAR STRENGTH (PLF)
SUPPORT FASTENERS: 5/8" puddle welds[1]
SIDELAP FASTENERS: #10 TEK screws

Factor of safety = 2.35

	# OF SIDELAP FASTENERS	DIAPHRAGM SHEAR STRENGTH (PLF) DECK SPAN (FT.-IN.)															
		3.00	3.50	4.00	4.50	5.00	5.50	6.00	6.50	7.00	7.50	8.00	8.50	9.00	9.50	10.00	K1
	0	581	505	441	390	349											0.535
	1	670	585	519	463	414	375	342									0.415
	2	754	662	589	530	480	434	397	365	337	313	293	274	256			0.340
	3	832	735	656	592	538	493	451	415	384	357	333	313	294	279	265	0.287
	4	904	803	720	652	594	545	504	465	431	401	374	351	331	310	279	0.249
36/7	5	971	867	781	709	648	596	551	512	477	444	415	387	345	310	279	0.219
	6	1032	927	839	764	700	645	597	556	520	488	437	387	345	310	279	0.196
	7	1089	983	893	816	749	692	642	599	560	497	437	387	345	310	279	0.178
	8	1140	1036	944	866	797	738	686	640	570	497	437	387	345	310	279	0.162
	9	1187	1084	993	913	843	782	728	661	570	497	437	387	345	310	279	0.149
	10	1230	1129	1038	957	886	824	769	661	570	497	437	387	345	310	279	0.138

D_B = 97 D_F = 169 D_A = 266 K2= 1056

	0	514	452	402	361	323											0.642
	1	589	523	468	423	386	351	320									0.477
	2	656	587	529	481	439	404	374	344	318	296	276	259	243			0.380
	3	715	645	585	534	490	452	420	391	365	339	317	297	280	265	251	0.315
	4	767	697	637	584	538	498	463	433	405	381	358	336	316	299	279	0.270
36/5	5	812	744	683	630	583	541	505	472	443	418	394	374	345	310	279	0.236
	6	852	786	726	672	624	582	544	510	480	453	428	387	345	310	279	0.209
	7	886	823	764	711	663	620	581	546	515	486	437	387	345	310	279	0.188
	8	916	856	799	747	699	656	616	580	548	497	437	387	345	310	279	0.171
	9	942	885	830	779	732	689	649	613	570	497	437	367	345	310	279	0.156
	10	965	911	658	809	763	720	680	644	570	497	437	387	345	310	279	0.144

D_B = 567 D_F = 663 D_A = 728 K2= 1056

	0	393	346	309	273	244											0.802
	1	466	415	373	338	308	279	254									0.561
	2	528	476	431	393	360	332	308	284	262	243	227	212	199			0.431
	3	580	528	482	443	408	378	352	328	308	287	268	251	236	223	212	0.350
	4	623	573	528	488	452	420	392	368	345	326	308	289	272	258	245	0.294
36/4	5	659	612	568	528	492	459	430	404	381	360	341	323	308	292	277	0.254
	6	689	645	603	563	528	495	466	439	414	392	372	354	337	310	279	0.224
	7	715	673	633	595	560	528	498	471	446	423	402	383	345	310	279	0.200
	8	736	697	659	623	589	557	528	500	475	452	430	387	345	310	279	0.180
	9	753	718	682	648	615	584	555	527	502	479	437	387	345	310	279	0.164
	10	768	736	702	670	638	608	580	553	527	497	437	387	345	310	279	0.151

D_B = 802 D_F = 909 D_A = 959 K2= 1056

	0	329	294	265	241	217											1.070
	1	384	349	319	292	269	249	232									0.679
	2	426	393	363	336	312	291	272	255	240	226	210	197	185			0.498
	3	458	428	400	374	350	328	308	290	274	260	246	234	221	209	199	0.393
	4	482	455	429	405	381	360	340	322	305	290	276	263	251	240	230	0.324
36/3	5	501	477	454	431	408	388	368	350	333	317	303	289	277	265	255	0.276
	6	516	495	473	452	431	412	393	375	358	342	328	314	301	289	278	0.240
	7	527	509	489	470	451	432	414	397	380	365	350	336	323	310	279	0.213
	8	537	520	503	485	467	450	433	416	400	385	371	357	344	310	279	0.191
	9	544	529	514	498	481	465	449	433	418	403	389	376	345	310	279	0.173
	10	550	537	523	508	493	478	463	448	434	419	406	387	345	310	279	0.158

D_B = 1652 D_F = 1816 D_A = 1827 K2= 1056

1 A 3/8" x 1-1/4" arc seam weld shall be used with F deck or A deck.

$$G' = \frac{K_2}{3.78 + \frac{0.3 * D_X}{SPAN} + 3 * K_1 * SPAN}, \text{ Kips/inch}$$

SPAN is in feet

Substitute D_B, D_F, or D_A for D_X

DIAPHRAGM

1.5 (B, F, A) 20 ALLOWABLE DIAPHRAGM SHEAR STRENGTH (PLF)

SUPPORT FASTENERS: #12 TEK screws
SIDELAP FASTENERS: #10 TEK screws

Factor of safety = 2.35

	# OF SIDELAP FASTENERS	DIAPHRAGM SHEAR STRENGTH (PLF) — DECK SPAN (FT.-IN.) 3.00	3.50	4.00	4.50	5.00	5.50	6.00	6.50	7.00	7.50	8.00	8.50	9.00	9.50	10.00	K1
36/7	0	343	298	261	239	206											0.605
	1	430	377	335	301	272	246	224									0.456
	2	508	450	402	363	331	303	279	257	237	221	206	193	182			0.366
	3	576	515	464	421	385	354	328	305	284	254	247	232	218	207	196	0.306
	4	636	573	520	475	436	402	373	348	325	306	288	270	255	241	229	0.263
	5	687	625	571	524	483	448	417	389	365	343	324	306	291	276	262	0.230
	6	730	671	617	569	527	490	458	428	402	379	358	340	323	307	279	0.205
	7	768	710	658	611	568	530	496	466	438	414	392	372	345	310	279	0.185
	8	800	745	694	645	605	567	532	501	473	447	424	387	345	310	279	0.168
	9	827	776	727	681	639	601	566	534	505	478	437	387	345	310	279	0.154
	10	851	803	756	712	671	632	597	565	536	497	437	387	345	310	279	0.142

D_B = 97 D_F = 169 D_A = 266 K2= 1056

	# OF SIDELAP FASTENERS	3.00	3.50	4.00	4.50	5.00	5.50	6.00	6.50	7.00	7.50	8.00	8.50	9.00	9.50	10.00	K1
36/5	0	304	267	238	213	191											0.726
	1	376	335	302	274	250	230	211									0.522
	2	435	393	358	327	301	278	258	241	225	210	197	184	173			0.408
	3	482	441	406	374	346	322	300	281	264	248	235	222	210	199	189	0.334
	4	519	481	446	415	387	361	338	318	299	283	268	254	242	230	220	0.283
	5	548	513	481	450	422	396	373	352	333	315	299	284	271	259	247	0.246
	6	572	540	509	483	453	428	404	383	363	345	328	313	299	286	274	0.217
	7	590	562	534	506	480	455	432	411	391	372	355	339	325	310	279	0.195
	8	606	580	554	528	504	480	457	436	416	398	380	364	345	310	279	0.176
	9	618	595	571	547	524	501	480	459	440	421	404	387	345	310	279	0.161
	10	628	607	586	564	542	520	500	480	460	442	425	387	345	310	279	0.148

D_B = 567 D_F = 663 D_A = 728 K2= 1056

	# OF SIDELAP FASTENERS	3.00	3.50	4.00	4.50	5.00	5.50	6.00	6.50	7.00	7.50	8.00	8.50	9.00	9.50	10.00	K1
36/4	0	232	205	182	161	144											0.907
	1	301	270	244	222	204	188	173									0.610
	2	353	323	296	272	251	233	217	203	191	179	167	157	148			0.459
	3	391	363	337	313	292	273	256	240	227	214	203	192	183	174	165	0.368
	4	419	394	370	347	327	307	290	274	259	246	233	222	212	203	194	0.307
	5	439	418	396	375	355	337	319	303	288	274	261	250	239	229	219	0.264
	6	455	436	417	397	379	361	344	329	314	300	287	275	263	253	243	0.231
	7	467	450	433	416	399	382	366	351	336	323	310	297	286	275	265	0.206
	8	476	461	446	431	415	400	385	370	356	343	330	318	306	295	279	0.185
	9	483	471	457	443	429	415	401	387	373	361	348	336	325	310	279	0.168
	10	489	478	466	453	440	427	414	401	389	376	364	353	341	310	279	0.154

D_B = 802 D_F = 909 D_A = 959 K2= 1056

	# OF SIDELAP FASTENERS	3.00	3.50	4.00	4.50	5.00	5.50	6.00	6.50	7.00	7.50	8.00	8.50	9.00	9.50	10.00	K1
36/3	0	194	174	156	142	128											1.209
	1	245	225	207	191	177	165	154									0.733
	2	276	259	243	228	214	201	190	179	169	160	152	145	138			0.526
	3	297	283	269	255	242	230	219	208	198	189	180	172	165	158	152	0.410
	4	310	299	287	275	264	253	242	232	222	213	204	196	188	181	174	0.336
	5	319	310	300	290	280	270	260	251	241	233	224	216	208	201	194	0.285
	6	325	318	310	301	292	284	275	266	257	249	241	233	226	219	212	0.247
	7	330	324	317	310	302	294	286	278	271	263	255	248	241	234	227	0.216
	8	334	328	322	316	309	303	296	289	281	274	267	260	254	247	241	0.195
	9	336	332	327	321	315	309	303	297	290	284	277	271	265	258	252	0.177
	10	338	334	330	325	320	315	309	304	298	292	286	280	274	268	262	0.161

D_B = 1652 D_F = 1816 D_A = 1827 K2= 1056

$$G' = \frac{K_2}{3.78 + \frac{0.3 \cdot D_X}{SPAN} + 3 \cdot K_1 \cdot SPAN}\text{, Kips/inch}$$

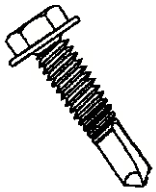
SPAN is in feet Substitute D_B, D_F, or D_A for D_X

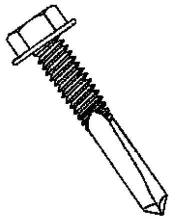
B-15C

TEKS SELF-DRILLING FASTENERS

Product Report No. 02703

Selector Guide





Part Number	Description	Head Style	Drill Point	Drill & Tap Capacity	Max. Material Attachment	Box Qty
1088000	12-24 x 7/8"	HWH	#4	.125-.250	.325	5,000
1414000	12-24 x 1-1/4"	HWH	#4.5	.125-.375	.575	4,000
1006000	12-24 x 1-1/4"	HWH	#5	.125-.500	.375	4,000
1070000	12-24 x 1-1/2"	HWH	#5	.125-.500	.625	2,500
1071000	12-24 x 1-1/2"	**HWH	#5	.125-.500	.625	2,500
1072000	12-24 x 2"	HWH	#5	.125-.500	1.125	2,000
1074000	1/4-28 x 3"	*HWH	#5	.125-.500	2.150	1,000
1075000	1/4-28 x 4"	*HWH	#5	.125-.500	3.150	500
1641000	1/4-28 x 5"	HWH	#5	.125-.500	4.150	250
1431000	1/4-28 x 6"	HWH	#5	.125-.500	5.150	250
1590000	1/4-28 x 8"	HWH	#5	.125-.500	7.150	150

Applications

- Metal deck, clips, liner panels or accessories to structural steel or bar joist.
- Longer fasteners can be used in retrofit clip and sheet applications.

All available with bonded washer.

* 5/16" Across Flats HWH ** 3/8" Across Flats HWH

Performance Data

PULLOUT VALUES (average lbs. ultimate)

Fastener Dia.	Fastener Pt.	Steel Gauge 16	14	12	3/16	1/4
12	4	-	-	1532	3485	3844
	4.5	-	-	1508	3865	4101
	5	-	-	1527	3701	3999
1/4	5	-	-	1507	3300	5059

FASTENER VALUES

Fastener (dia-tpi)	Tensile (lbs. min.)	Shear (avg. lbs. ult.)	Torque (min. in. lbs.)
12-24 T/4	3020	2100	100
12-24 T/4.5	3020	2100	100
12-24 T/5	3020	2100	100
1/4-28 T/5	5577	3310	234

SHEET STEEL GAUGES

Gauge No.	12	14	16	18	20	22	24	26
Decimal Equivalent	.105"	.075"	.060"	.048"	.036"	.030"	.024"	.018"

SHEAR VALUES (average lbs. ultimate)

Fastener Dia.	Fastener Pt.	Steel Gauge (lapped) 16	14	12	1/8	1/4
12	4	-	-	2048	2030	-
	4.5	-	-	2641	2887	2897
	5	-	-	2650	2700	2762
1/4	5	1597	2005	2350	2792	3310

Note: Teks fasteners are not categorized as structural bolts. Proper design criteria and strengths must be used for satisfactory application. The values listed are ultimate averages achieved under laboratory conditions and apply to Buildex manufactured fasteners only. Appropriate safety factors should be applied to these values for design purposes.

Installation Guidelines

- A standard screwgun with a depth sensitive nosepiece should be used to install Teks. For optimal fastener performance, the screwgun should be a minimum of 6 amps and have an RPM range of 0-2500. (Maximum 1800 RPM is recommended for Teks 5 fasteners)
- Adjust the screwgun nosepiece to properly seat the fastener.
- New magnetic sockets must be correctly set before use. Remove chip build-up as needed.
- The fastener is fully seated when the head is flush with the work surface.
- Overdriving may result in torsional failure of the fastener or stripout of the substrate.
- The fastener must penetrate beyond the metal structure a minimum of 3 pitches of thread.

ITW Buildex

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Itasca, Illinois 60143
630-595-3500 Fax: 630-595-3549
www.itwbuildex.com

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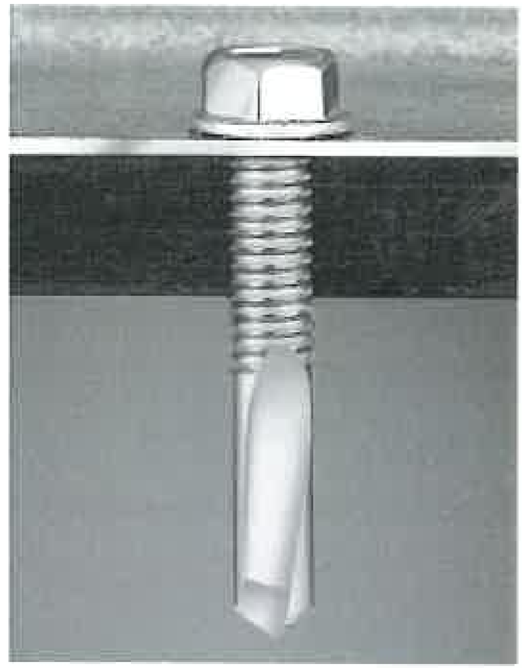
ITW Buildex

TEKS®

Self-Drilling Fasteners

First in performance!! Over 40 years of consistent drilling.

The original self-drillers for heavy duty applications.



Applications

- Metal deck to structural steel or bar joist.
- Clips to structural steel or bar joist.
- Liner panels to structural steel or bar joist.
- Accessories to structural steel or bar joist.
- Longer length fasteners can be used in retrofit clip and sheet applications.

Product Features

- Unique double fluted point has precise cutting edges to improve drill performance in 1/4" thru 1/2" steel.
- Engineered for fast drilling and smooth tapping with less effort.
- Climaseal® finish provides excellent corrosion resistance and lower tapping torque.
- Attachments up to 7.2" of material including 1/2" steel.
- 1/4 Diameter has notched threads to reduce tapping torque.

Product Specifications

Diameter..........................#12, 1/4
Thread Form...................12-24, 1/4-28
Head Style.......................#12: 5/16" HWH
1/4: 5/16" HWH
1/4: 3/8" HWH
Drill Point........................Teks 4
Teks 4.5
Teks 5
Finish..............................Climaseal

Head Style

Hex Washer Head

Approvals and Listings

Factory Mutual (J.I. 2 X 9A2 AM), ICC ER-3056, ICC ESR-1976

ARCADIS

SUBJECT: TOROK
PARKING CANOPY
JOB NO:

BY: CMW DATE: 11/25/14
CHKD: MSL DATE: 12/9/14

PAGE B16
SHEET

(3C10x15.3 + 2L3x3x1/4) + 2C10x15.3x12'-6" + (2L3x3x1/4 x12') / (20FT x 18FT) = 3.09psf + 1.51psf = 4.6psf

DL MAX 12.5psf, 4.6psf, 18 FWDS C_s

SEISMIC : (10.2 + 10) PSF × 0.07 = 1.42 PSF (1.20)

44.7#/FT ÷ 22.4 PSF ULTIMATE WIND FASCIA LOAD (SHT B-5 & B5A) > 1.42 PSF (1.20) ∴ WIND CONTROLS LATERAL LOADS ✓

(10" + 1.5IN DECK + 4.5IN SLOPE) x 33.5psf

ROOF MEMBER DESIGN:

LOAD CASE 3 (LRFD) = 1.2DL + 1.6L_R + 0.5W

LOAD CASE 4 (LRFD) = 1.2DL + 1.0W + L

LOAD CASE 6 (LRFD) = 0.9D + 1.0W

- SEE RISA ANALYSIS FOR LOADS ON ROOF PURLINS

° TRIB WIDTH = 20'-0"

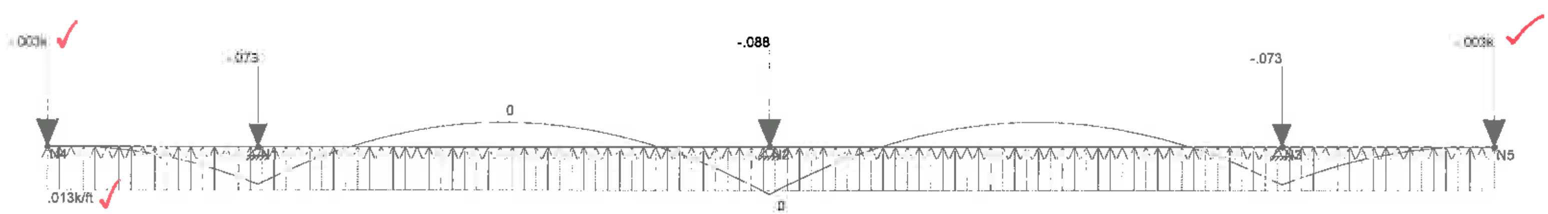
DL (TOTAL) = 20.2 PSF × 20'-0" = 404 #/FT
LIVE LOAD = 20 PSF × 20'-0" = 400 #/FT
WIND = -22.8 PSF × 20'-0" = 456 #/FT
DL (UPLIFT) = 10.2 PSF × 20'-0" = 204 #/FT

} UNFACTORED LOADS INPUT TO RISA

FROM B17: MAX PER FOOT R_x = 295 #/FT (FACTORED)

[(12.5psf ROOF SOLAR DL & DECK DL) + 4.6psf ROOF UNDERFRAMING DL] × 116' × 18' (35705#)
+ (12 × 10'-8" × 19#/FT) (2432#) = 38137# × (C_s = 0.07) = 2.67K ← SHOW 2750# ON DWGS

B-17



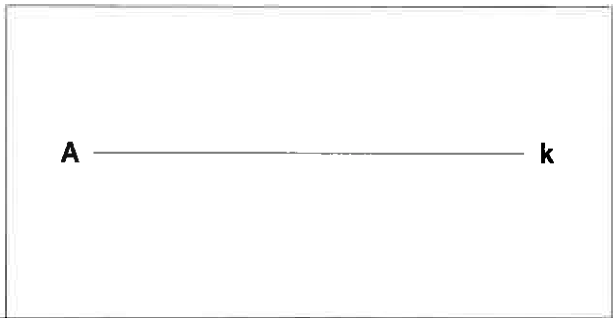
Loads: LC 1, 0.6D + 0.6W
Results for LC 1, 0.6D + 0.6W
Member Bending Moments (k-ft)
Y-direction Reaction units are k and k-ft

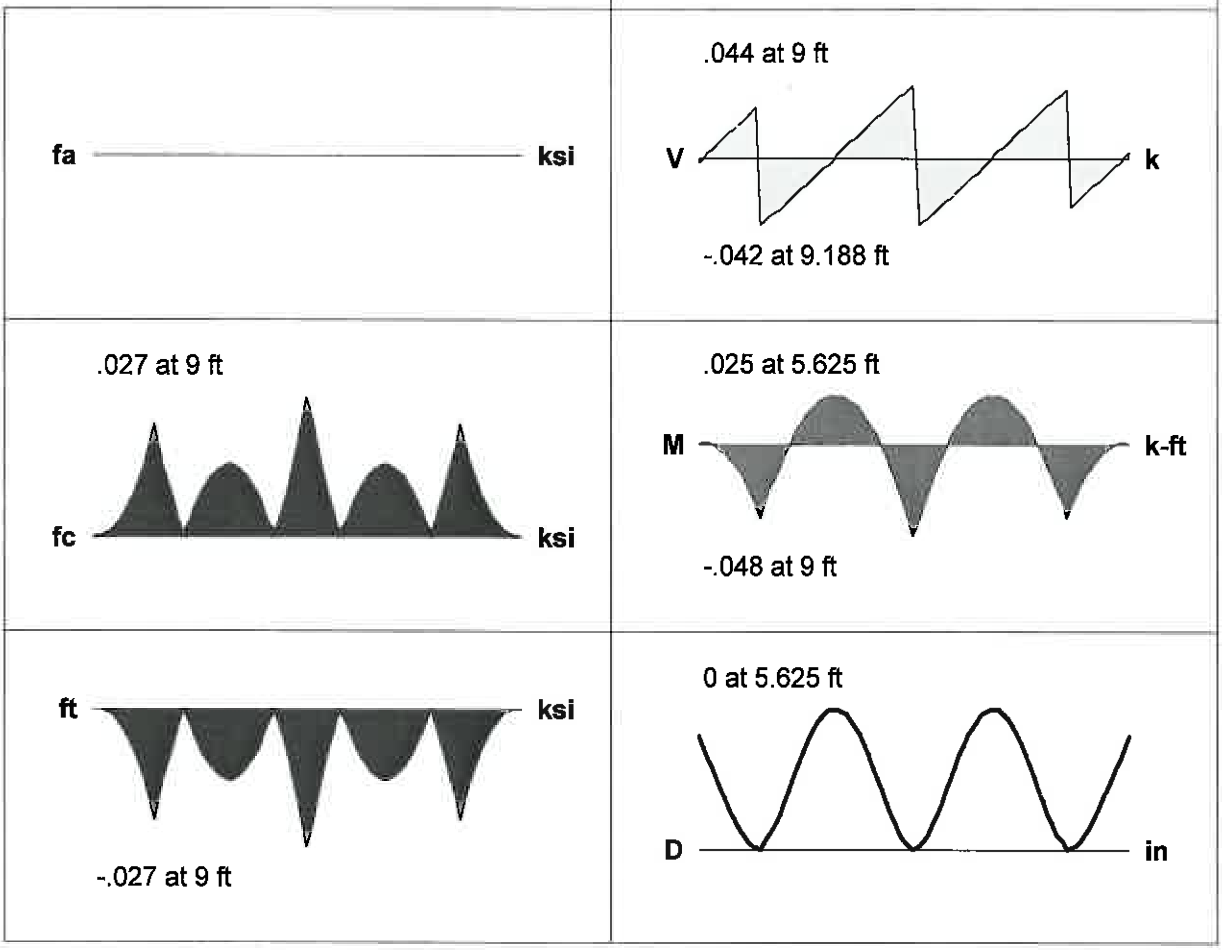
UNFACTORED

ARCADIS	Topok Parking Canopy Structure	SK - 1
Matt Lotycz		Dec 9, 2014 at 9:38 AM
		ROOF LOADS_COMPONENTS AND CLADDIN

Beam: ***M1***

Shape: **C12x20.7**
Material: **A36 Gr.36**
Length: **18 ft**
I Joint: **N4**
J Joint: **N5**
LC 1: 0.6D + 0.6W UNFACTORED
Code Check: **No Calc**
Report Based On 97 Sections





AISC 14th(360-10): ASD Code Check
Direct Analysis Method

- P-Delta analysis required for all AISC 360-10 Load Combinations -

Max Defl Ratio **L/10000**

Joint Coordinates and Temperatures

	Label	X [ft]	Y [ft]	Temp [F]
1	N1	2.625	0	0
2	N2	9	0	0
3	N3	15.375	0	0
4	N4	0	0	0
5	N5	18	0	0

Joint Loads and Enforced Displacements (BLC 1 : DEAD LOAD (TOTAL))

	Joint Label	L,D,M	Direction	Magnitude[(k,k-ft), (in,rad), (k*s^2/ft...
1	N4	L	Y	-.005
2	N5	L	Y	-.005

Joint Loads and Enforced Displacements (BLC 5 : DEAD LOAD (NO SOLAR))

	Joint Label	L,D,M	Direction	Magnitude[(k,k-ft), (in,rad), (k*s^2/ft...
1	N4	L	Y	-.005
2	N5	L	Y	-.005

Member Distributed Loads (BLC 1 : DEAD LOAD (TOTAL))

	Member Label	Direction	Start Magnitude[k/ft,F]	End Magnitude[k/ft,F]	Start Location[ft,%]	End Location[ft,%]
1	M1	Y	-.013	-.013	0	%100

Member Distributed Loads (BLC 2 : LIVE LOAD)

	Member Label	Direction	Start Magnitude[k/ft,F]	End Magnitude[k/ft,F]	Start Location[ft,%]	End Location[ft,%]
1	M1	Y	-.02	-.02	0	%100

Member Distributed Loads (BLC 3 : WIND)

	Member Label	Direction	Start Magnitude[k/ft,F]	End Magnitude[k/ft,F]	Start Location[ft,%]	End Location[ft,%]
1	M1	Y	-.024	-.024	0	%100

Member Distributed Loads (BLC 4 : WIND (UPLIFT))

	Member Label	Direction	Start Magnitude[k/ft,F]	End Magnitude[k/ft,F]	Start Location[ft,%]	End Location[ft,%]
1	M1	Y	.024	.024	0	%100

Member Distributed Loads (BLC 5 : DEAD LOAD (NO SOLAR))

	Member Label	Direction	Start Magnitude[k/ft,F]	End Magnitude[k/ft,F]	Start Location[ft,%]	End Location[ft,%]
1	M1	Y	-.002	-.002	0	%100

Basic Load Cases

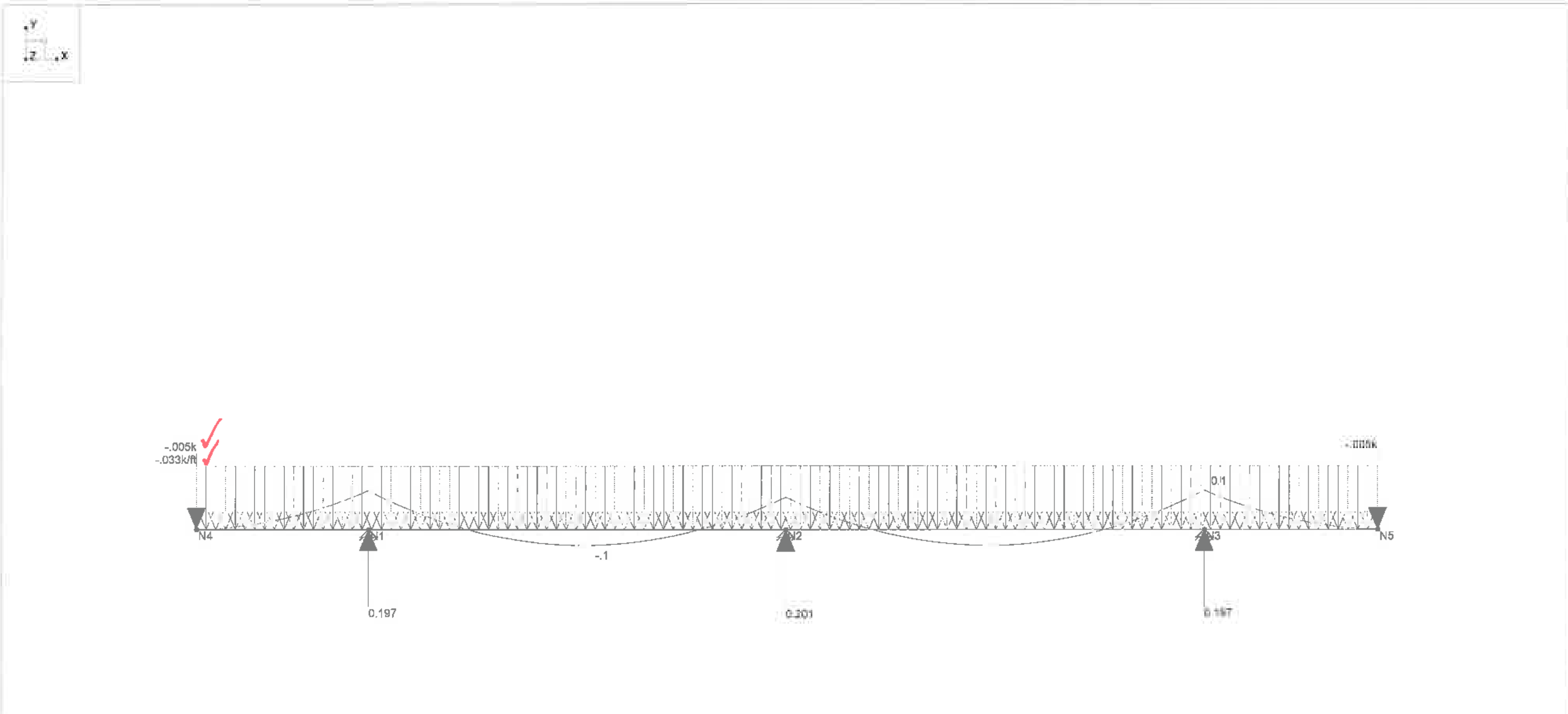
	BLC Description	Category	X Gravity	Y Gravity	Joint	Point	Distributed
1	DEAD LOAD (TOTAL)	None			2		1
2	LIVE LOAD	None					1
3	WIND	None					1
4	WIND (UPLIFT)	None					1
5	DEAD LOAD (NO SOLAR)	None			2		1

Load Combination Design

	Description	ASIF	CD	ABIF	Service	Hot Rolled	Cold Form...	Wood	Concrete	Masonry	Footings	Aluminum
1	0.6D + 0.6W					Yes	Yes	Yes	Yes	Yes	Yes	Yes
2	D + Lr					Yes	Yes	Yes	Yes	Yes	Yes	Yes

Load Combination Design (Continued)

	Description	ASIF	CD	ABIF	Service	Hot Rolled	Cold Form...	Wood	Concrete	Masonry	Footings	Aluminum
3	D + 0.75(0.6...					Yes	Yes	Yes	Yes	Yes	Yes	Yes
4	0.9D+1.0W					Yes	Yes	Yes	Yes	Yes	Yes	Yes
5	1.2D+1.6Lr+...					Yes	Yes	Yes	Yes	Yes	Yes	Yes
6	DL max					Yes	Yes	Yes	Yes	Yes	Yes	Yes
7	DL min (w/o ...					Yes	Yes	Yes	Yes	Yes	Yes	Yes
8	Lr					Yes	Yes	Yes	Yes	Yes	Yes	Yes
9	W+					Yes	Yes	Yes	Yes	Yes	Yes	Yes
10	W- (uplift)					Yes	Yes	Yes	Yes	Yes	Yes	Yes

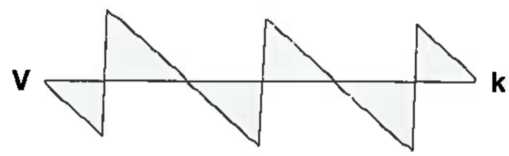


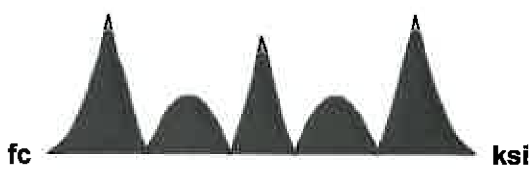
Loads: LC 2, D + Lr
Results for LC 2, D + Lr
Member Bending Moments (k-ft)
Y-direction Reaction units are k and k-ft

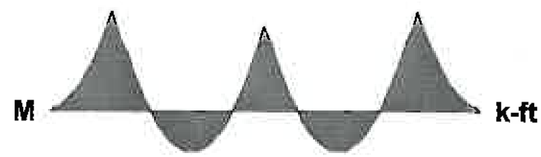
ARCADIS	Topok Parking Canopy Structure	SK - 2
Matt Lotycz		Dec 9, 2014 at 9:39 AM
		ROOF LOADS_COMPONENTS AND CLADDIN..

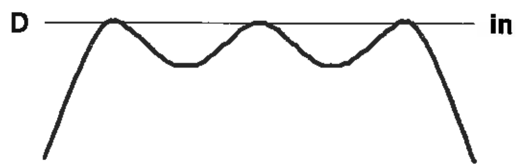
Beam: ***M1***

Shape: **C12x20.7**
Material: **A36 Gr.36**
Length: **18 ft**
I Joint: **N4**
J Joint: **N5**
LC 2: D + Lr UNFACTORED
Code Check: **No Calc**
Report Based On 97 Sections





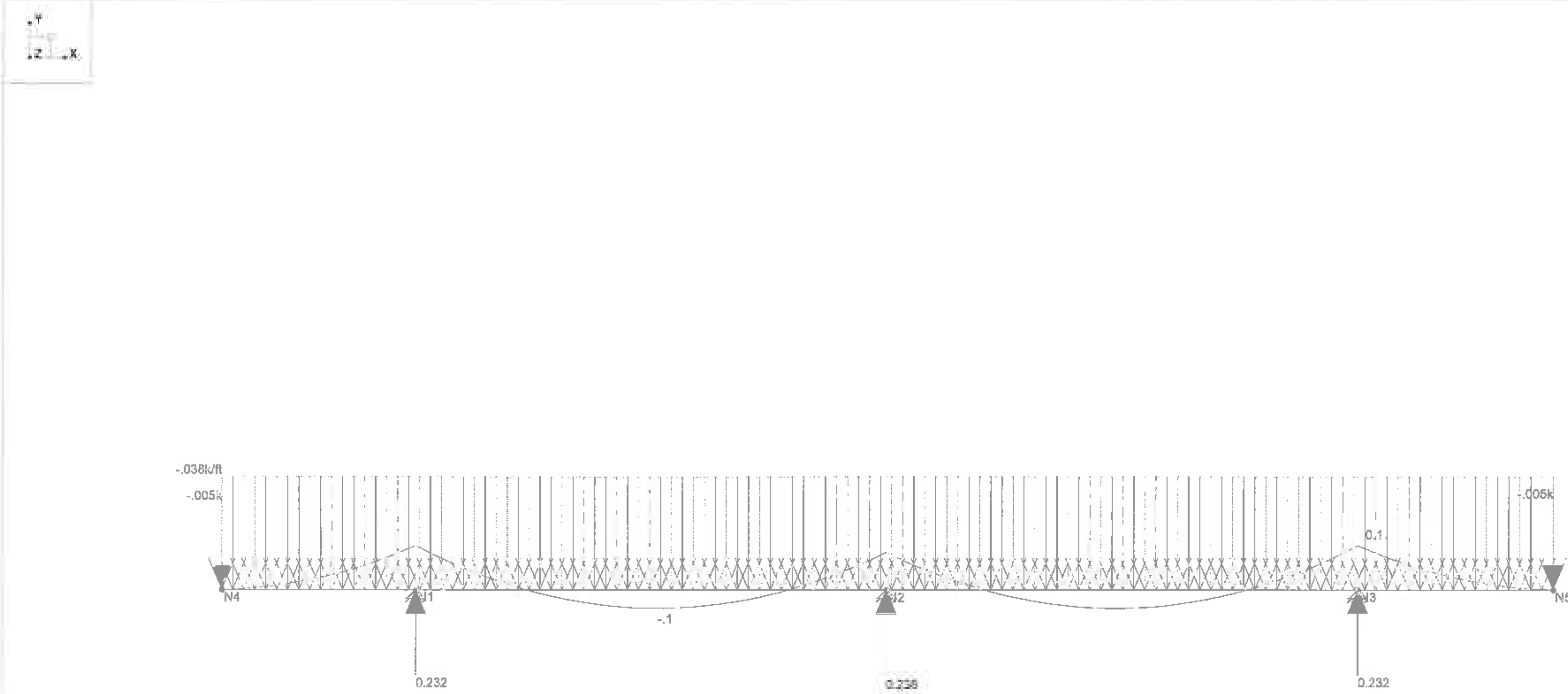




AISC 14th(360-10): ASD Code Check
Direct Analysis Method

- P-Delta analysis required for all AISC 360-10 Load Combinations -

Max Defl Ratio **L/10000**



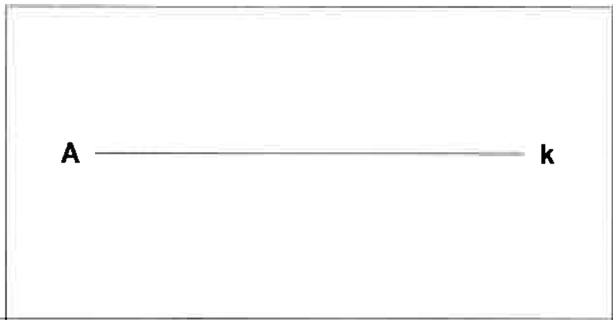
Loads: LC 3, D + 0.75(0.6W+Lr)
Results for LC 3, D + 0.75(0.6W+Lr)
Member Bending Moments (k-ft)
Y-direction Reaction units are k and k-ft

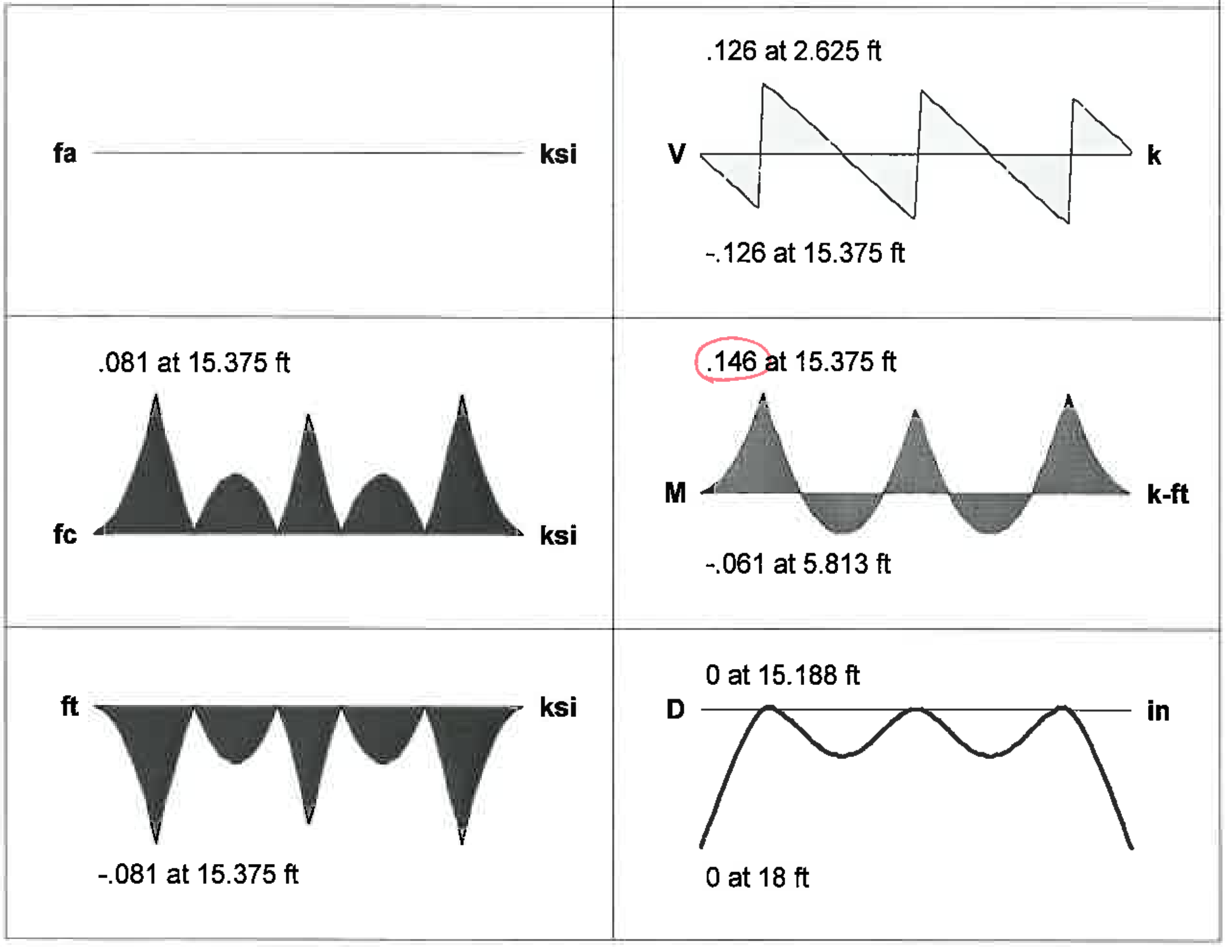
UNFACTORED

ARCADIS	Topok Parking Canopy Structure	SK - 3
Matt Lotycz		Dec 9, 2014 at 9:40 AM
		ROOF LOADS_COMPONENTS AND CLADDIN.

Beam: ***M1***

Shape: **C12x20.7**
Material: **A36 Gr.36**
Length: **18 ft**
I Joint: **N4**
J Joint: **N5**
LC 3: D + 0.75(0.6W+Lr) UNFACTORED
Code Check: **No Calc**
Report Based On 97 Sections

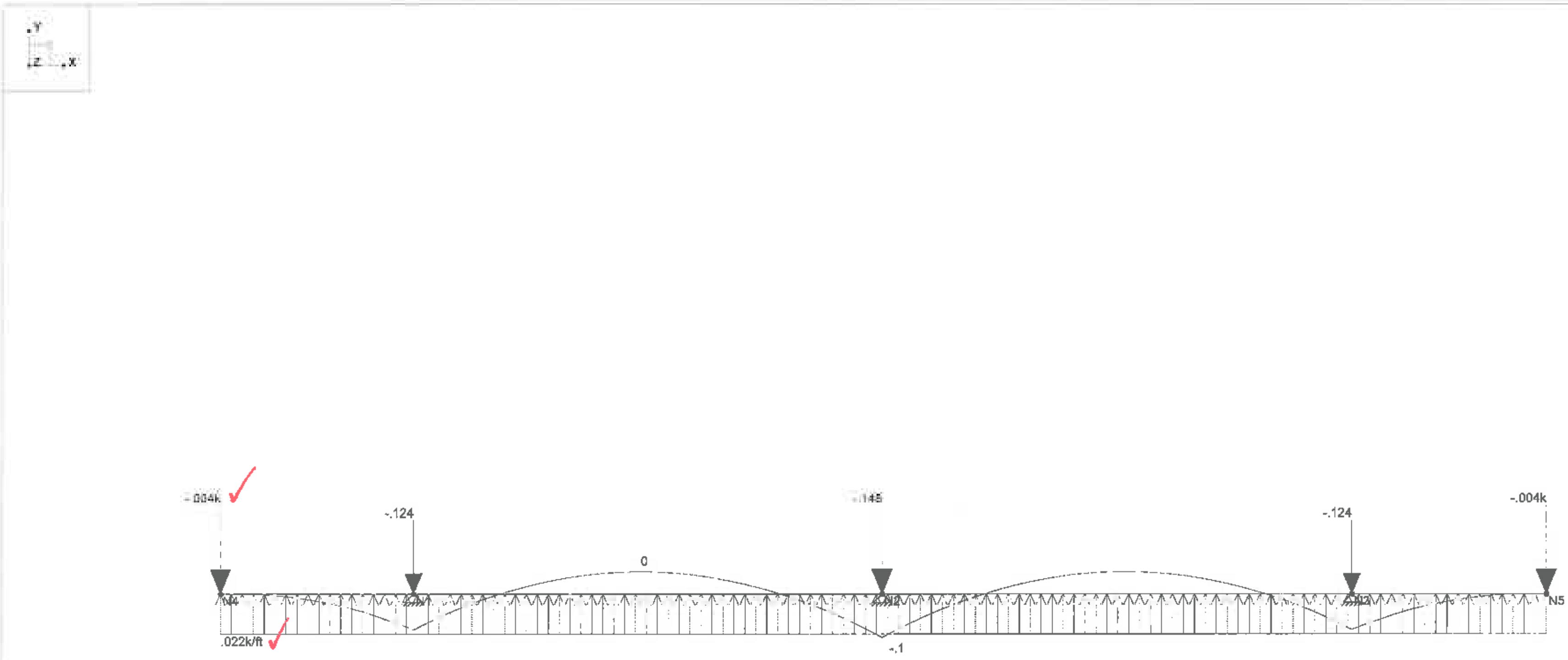




AISC 14th(360-10): ASD Code Check
Direct Analysis Method

- P-Delta analysis required for all AISC 360-10 Load Combinations -

Max Defl Ratio **L/10000**



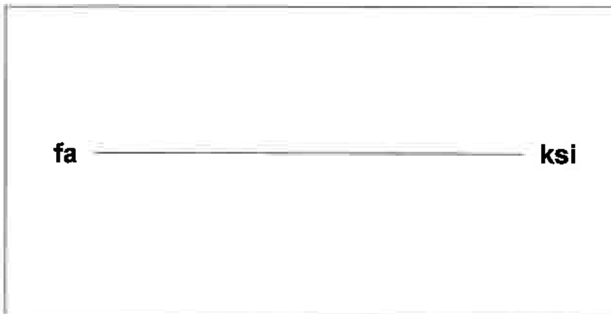
Loads: LC 4, 0.9D+1.0W
Results for LC 4, 0.9D+1.0W
Member Bending Moments (k-ft)
Y-direction Reaction units are k and k-ft

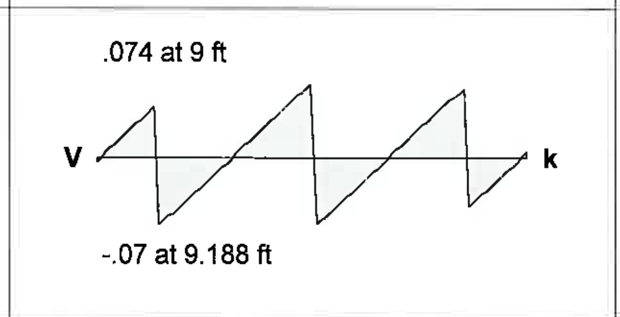
FACTORED

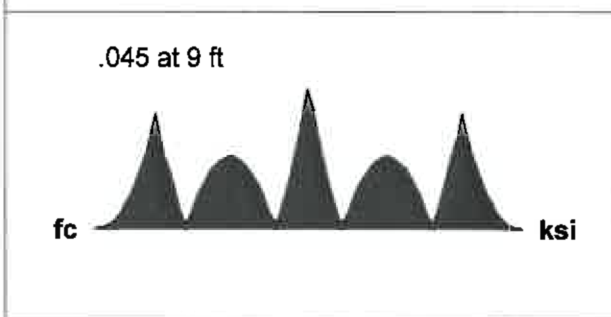
ARCADIS	Topok Parking Canopy Structure	SK - 4
Matt Lotycz		Dec 9, 2014 at 9:40 AM
		ROOF LOADS_COMPONENTS AND CLADDIN

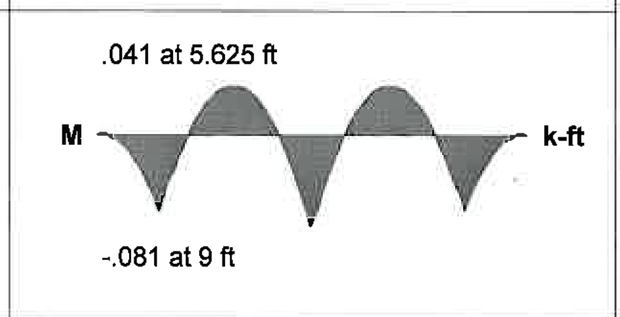
Beam: ***M1***

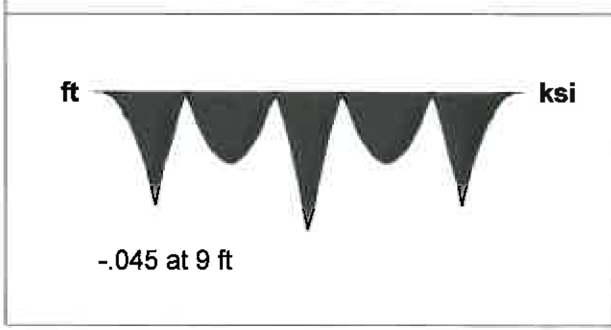
Shape: **C12x20.7**
Material: **A36 Gr.36**
Length: **18 ft**
I Joint: **N4**
J Joint: **N5**
LC 4: 0.9D+1.0W FACTORED
Code Check: **No Calc**
Report Based On 97 Sections

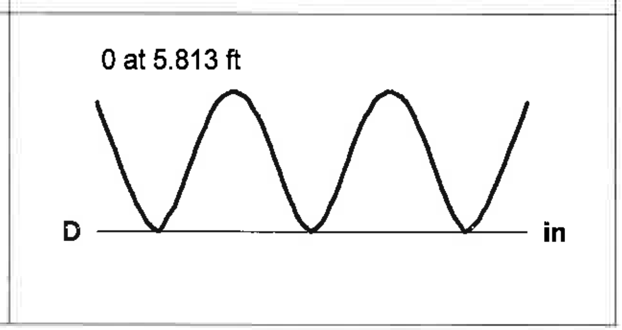








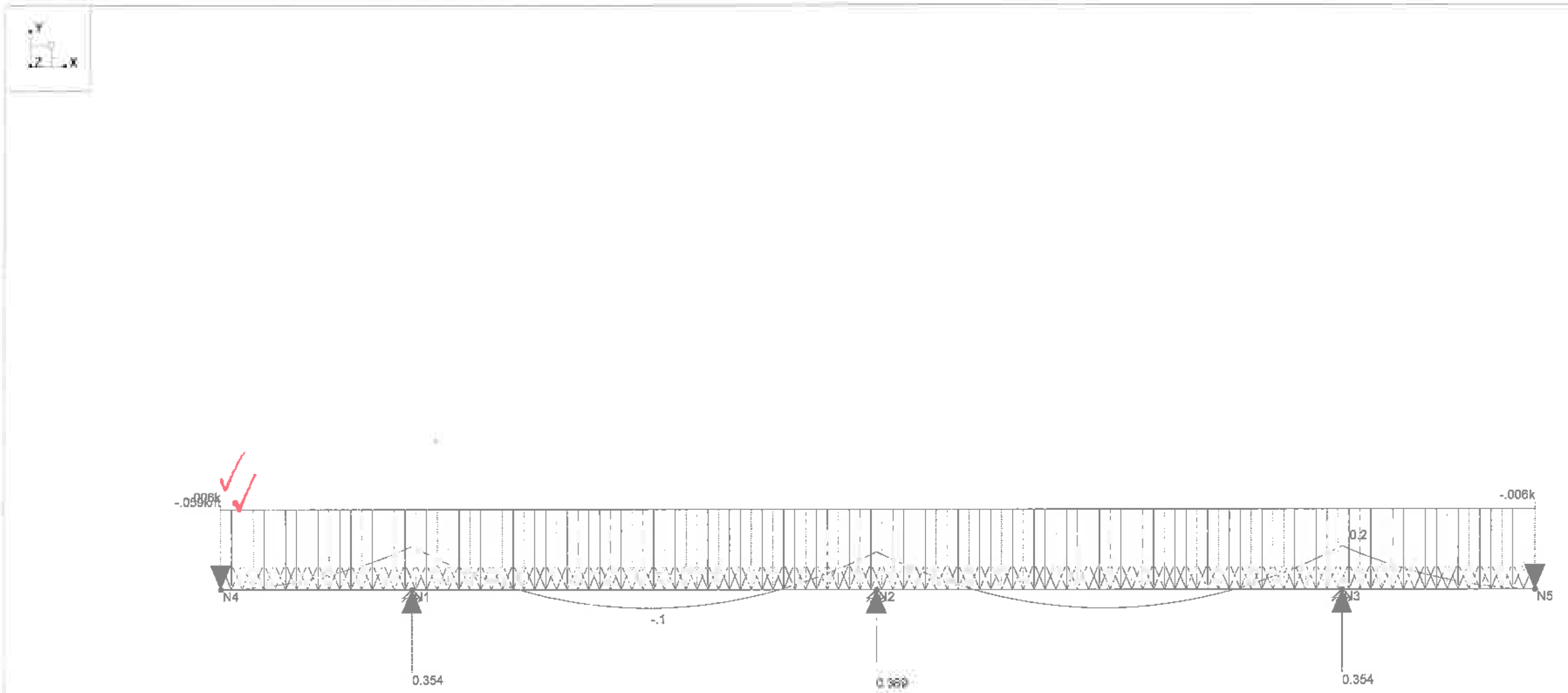




AISC 14th(360-10): ASD Code Check
Direct Analysis Method

- P-Delta analysis required for all AISC 360-10 Load Combinations -

Max Defl Ratio **L/10000**



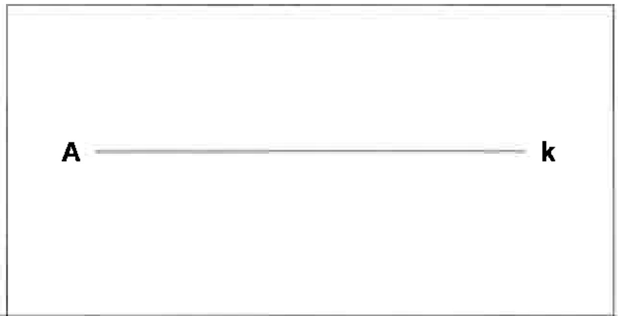
FACTORED

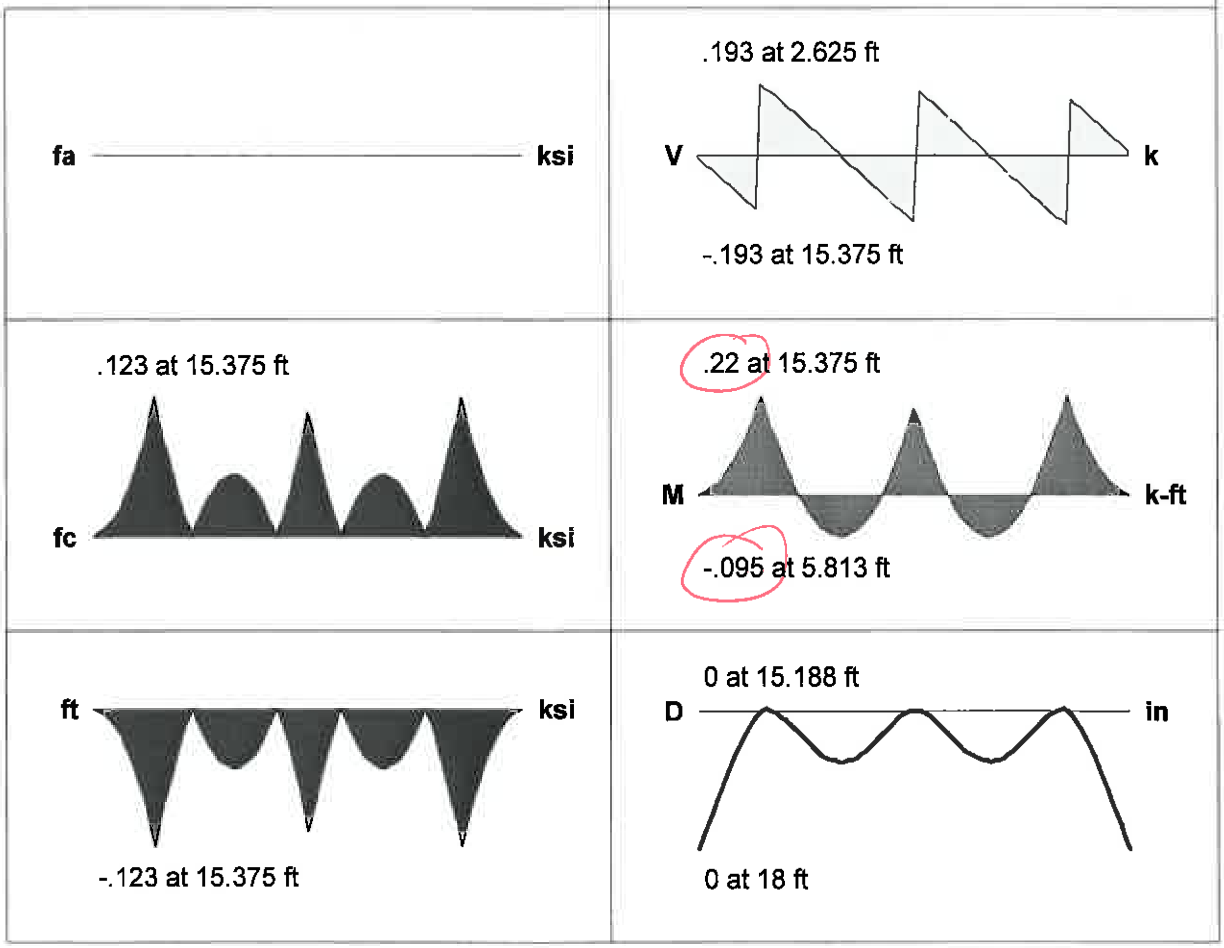
Loads: LC 5, 1.2D+1.6Lr+0.5W
Results for LC 5, 1.2D+1.6Lr+0.5W
Member Bending Moments (k-ft)
Y-direction Reaction units are k and k-ft

ARCADIS	Topok Parking Canopy Structure	SK - 5
Matt Lotycz		Dec 9, 2014 at 9:40 AM
		ROOF LOADS_COMPONENTS AND CLADDIN..

Beam: ***M1***

Shape: **C12x20.7**
Material: **A36 Gr.36**
Length: **18 ft**
I Joint: **N4**
J Joint: **N5**
LC 5: 1.2D+1.6Lr+0.5W FACTORED
Code Check: **No Calc**
Report Based On 97 Sections

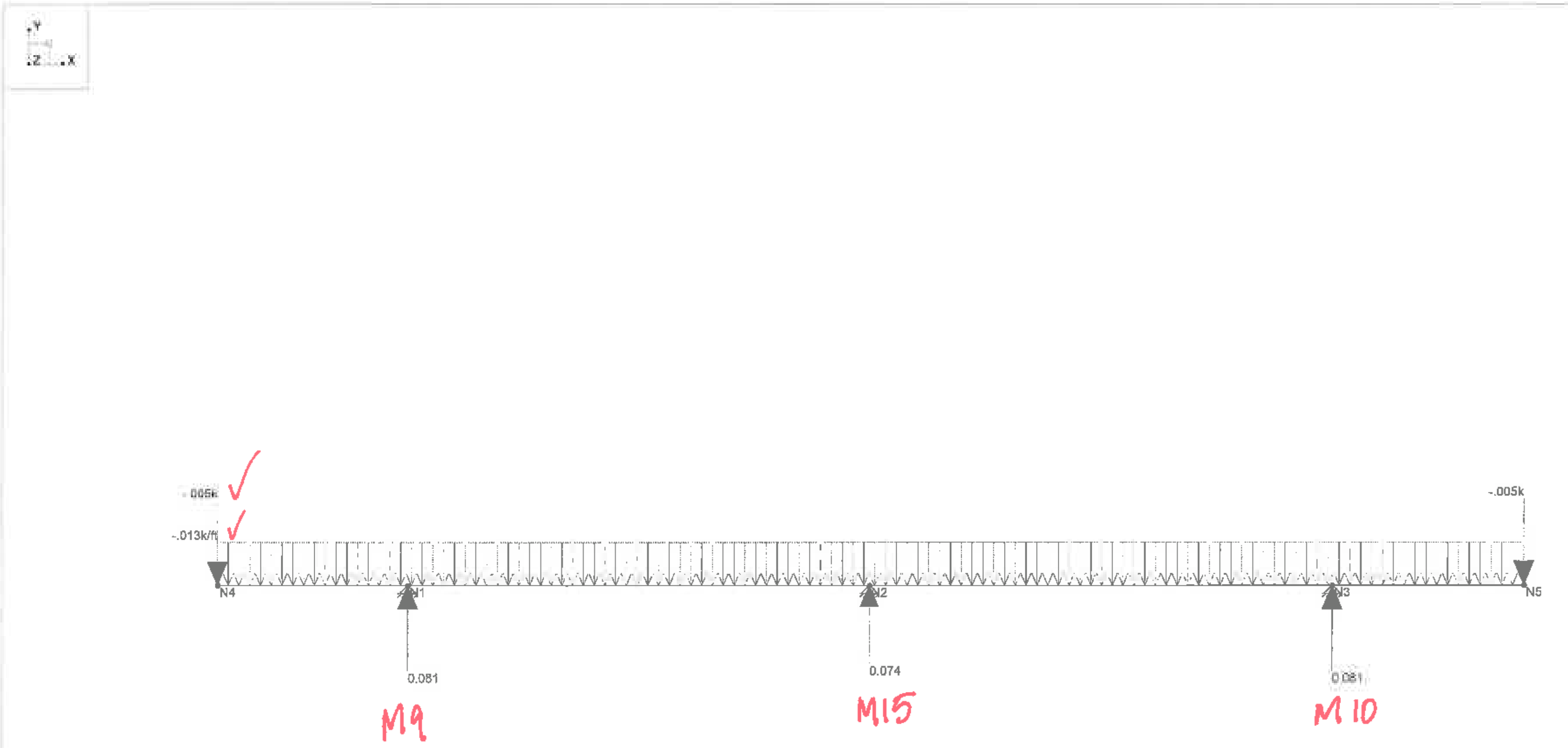




AISC 14th(360-10): ASD Code Check
Direct Analysis Method

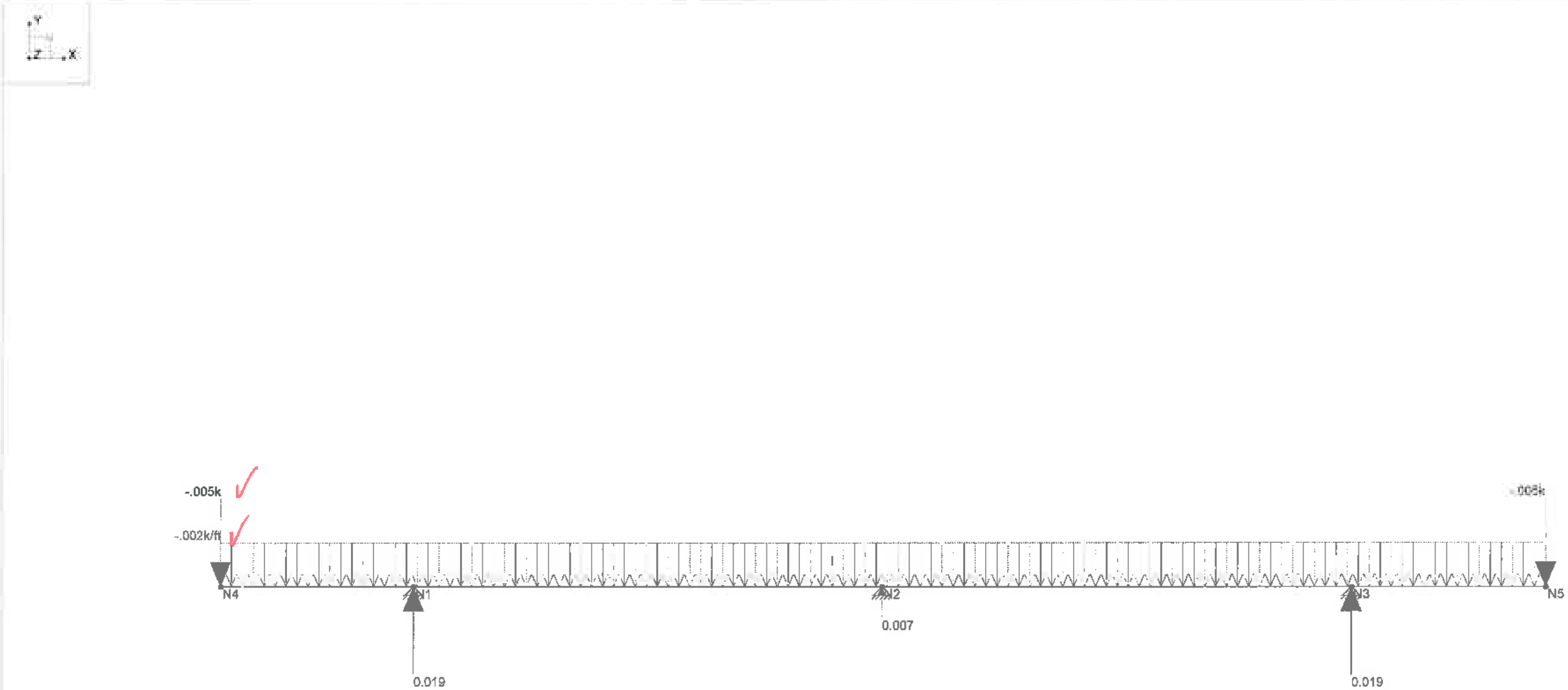
- P-Delta analysis required for all AISC 360-10 Load Combinations -

Max Defl Ratio **L/10000**



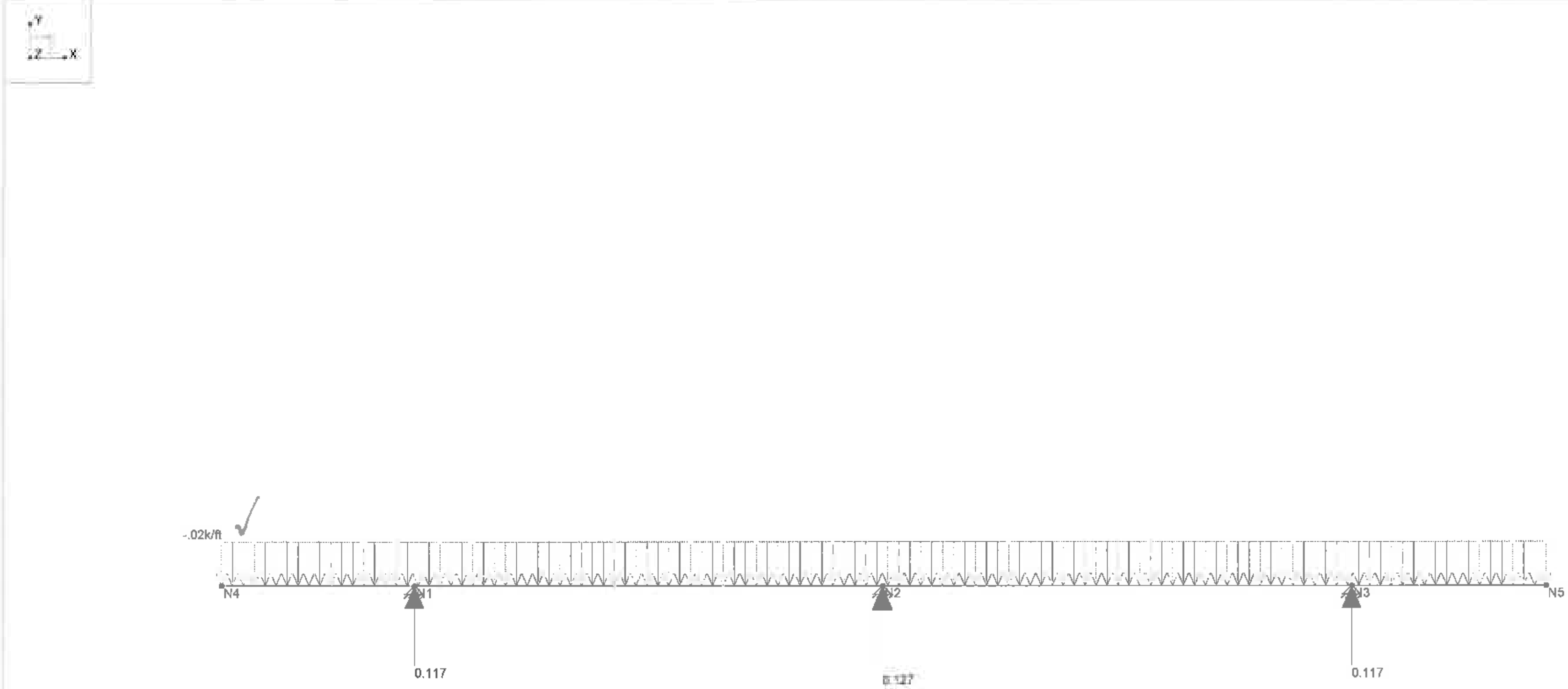
Loads: LC 6, DL max
Results for LC 6, DL max
Y-direction Reaction units are k and k-ft

ARCADIS	Topok Parking Canopy Structure	SK - 6
Matt Lotycz		Dec 9, 2014 at 9:42 AM
		ROOF LOADS_COMPONENTS AND CLADDIN...



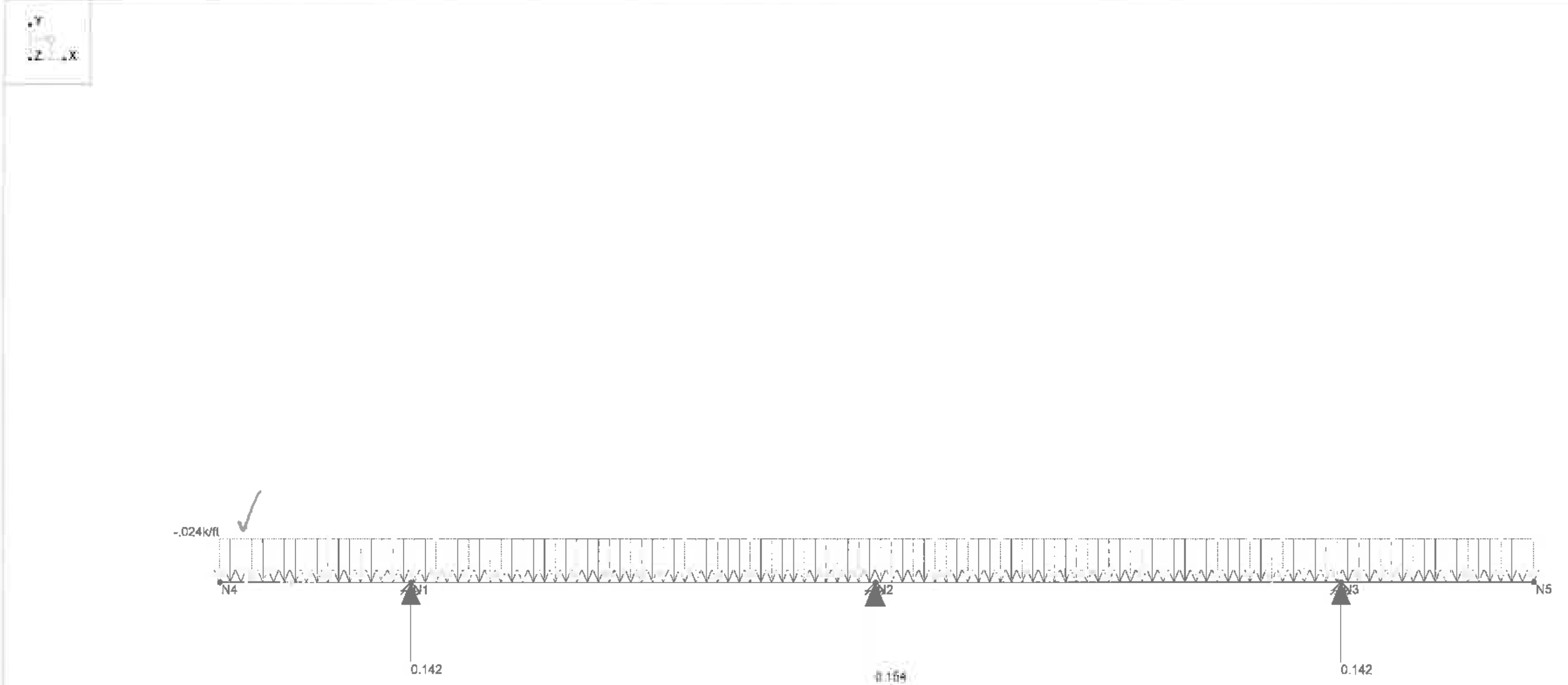
Loads: LC 7, DL min (w/o solar)
Results for LC 7, DL min (w/o solar)
Y-direction Reaction units are k and k-ft

ARCADIS	Topok Parking Canopy Structure	SK - 7
Matt Lotycz		Dec 9, 2014 at 9:42 AM
		ROOF LOADS_COMPONENTS AND CLADDIN



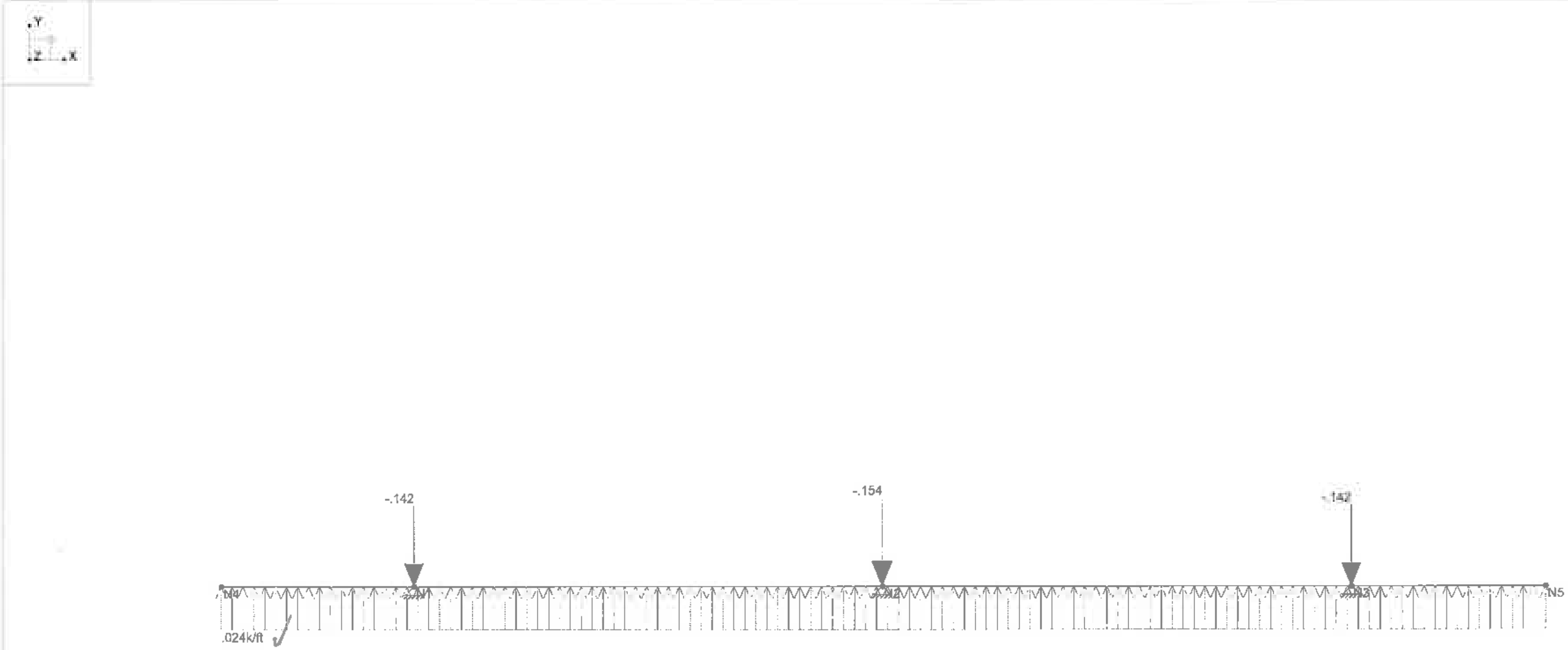
Loads: LC 8, Lr
Results for LC 8, Lr
Y-direction Reaction units are k and k-ft

ARCADIS	Topok Parking Canopy Structure	SK - 8
Matt Lotycz		Dec 9, 2014 at 9:42 AM
		ROOF LOADS_COMPONENTS AND CLADDIN...



Loads: LC 9, W+
Results for LC 9, W+
Y-direction Reaction units are k and k-ft

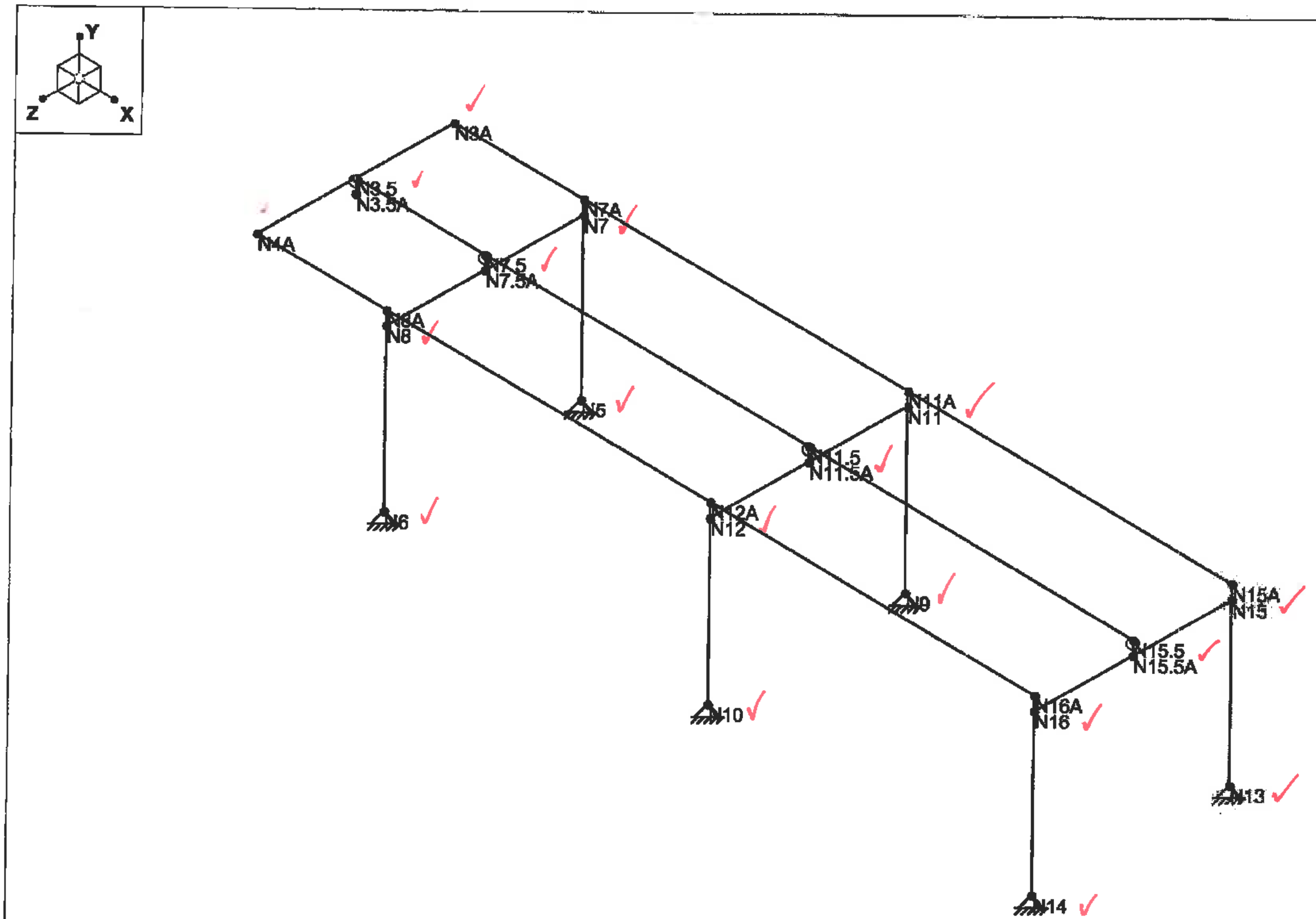
ARCADIS	Topok Parking Canopy Structure	SK - 9
Matt Lotycz		Dec 9, 2014 at 9:42 AM
		ROOF LOADS_COMPONENTS AND CLADDIN..



Loads: LC 10, W- (uplift)
Results for LC 10, W- (uplift)
Y-direction Reaction units are k and k-ft

ARCADIS	Topok Parking Canopy Structure	SK - 10
Matt Lotycz		Dec 9, 2014 at 9:43 AM
		ROOF LOADS_COMPONENTS AND CLADDIN.

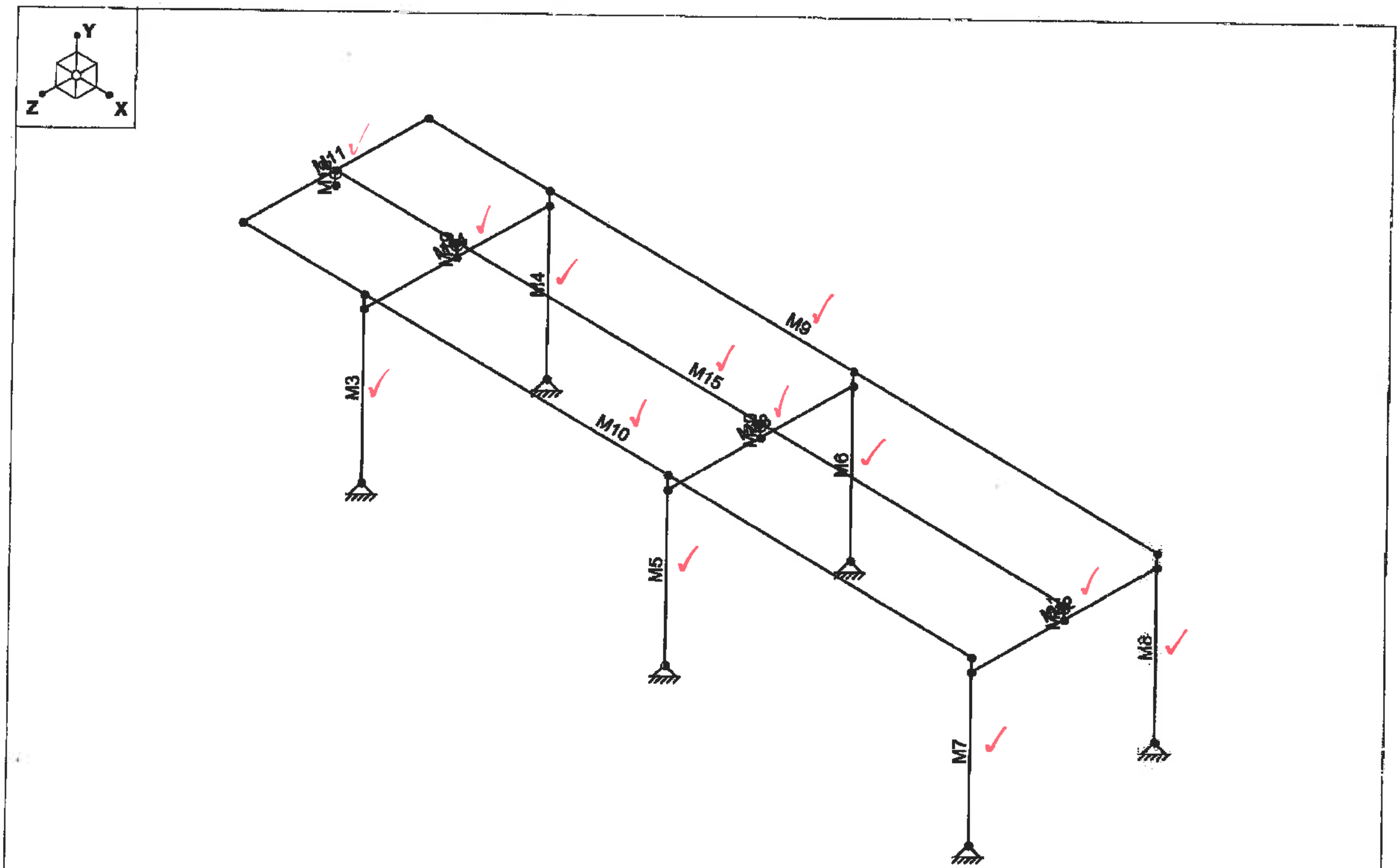
B18



		SK - 3
		Dec 10, 2014 at 12:01 PM
		CANOPY 3D_1.r3d

B18

B18A



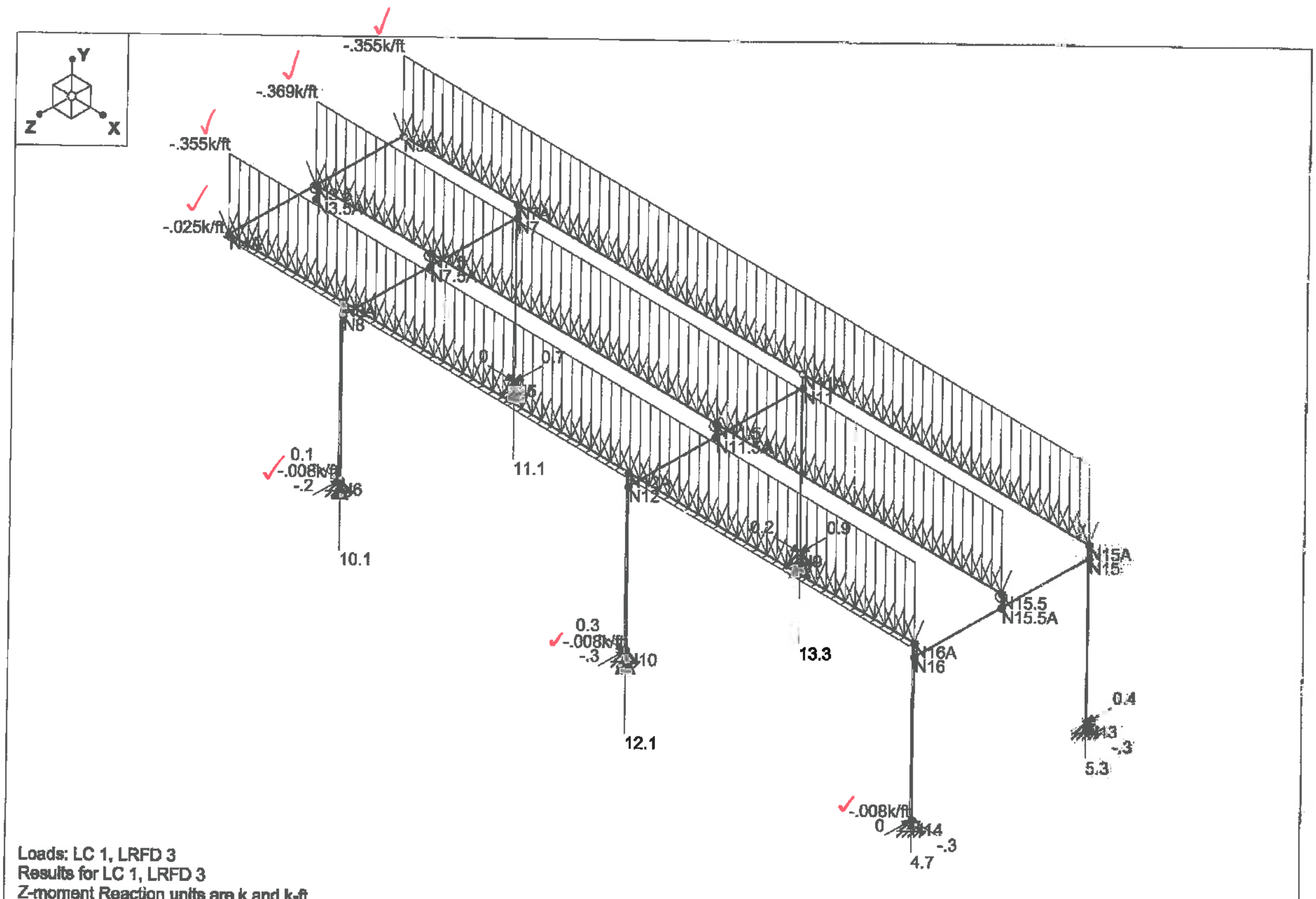
SK - 2

Dec 10, 2014 at 12:00 PM

CANOPY 3D_1.r3d

B18A

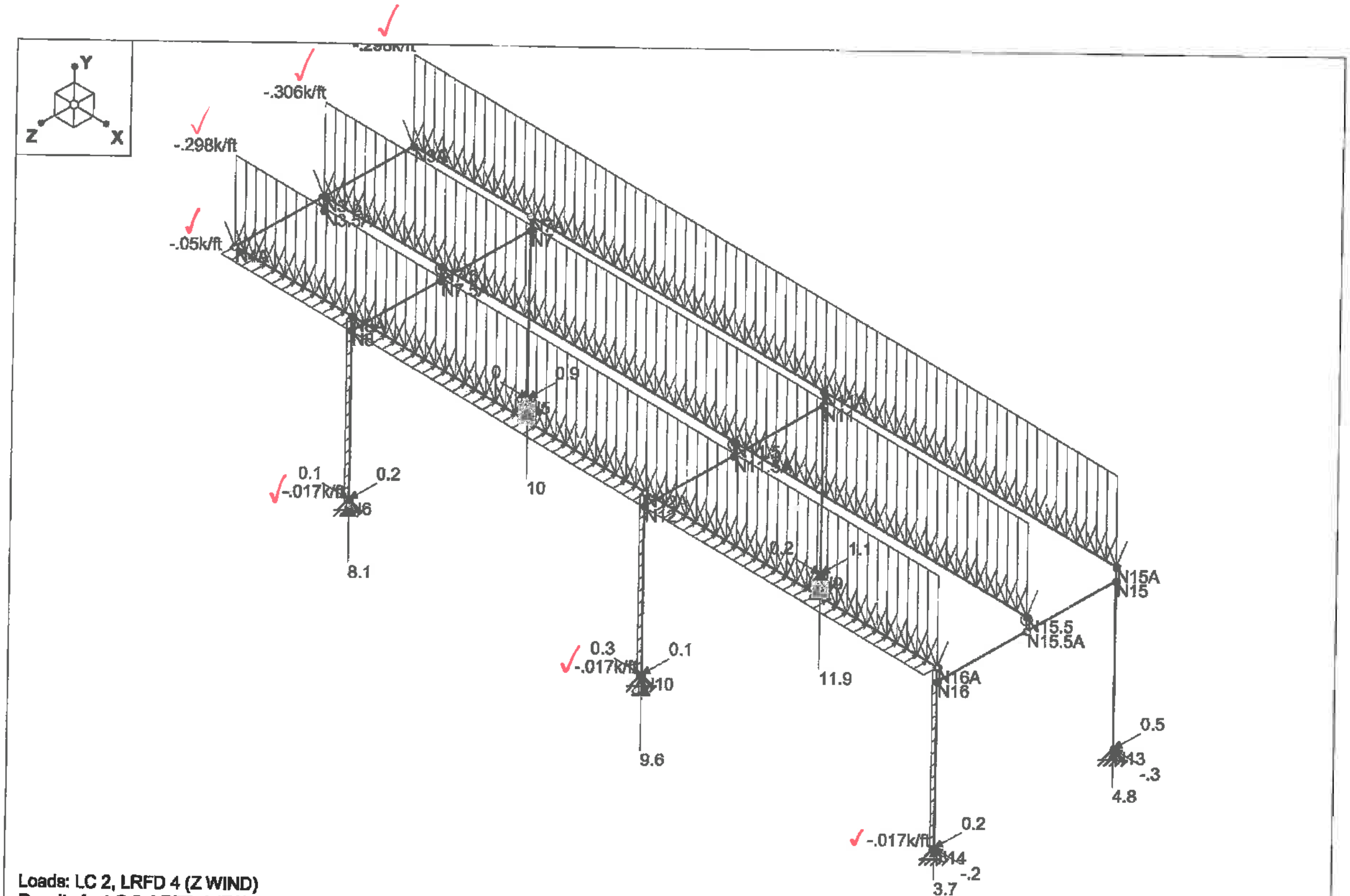
B19



Loads: LC 1, LRFD 3
Results for LC 1, LRFD 3
Z-moment Reaction units are k and k-ft

	SK - 4
	Dec 10, 2014 at 12:03 PM
	CANOPY 3D_1.r3d

B19

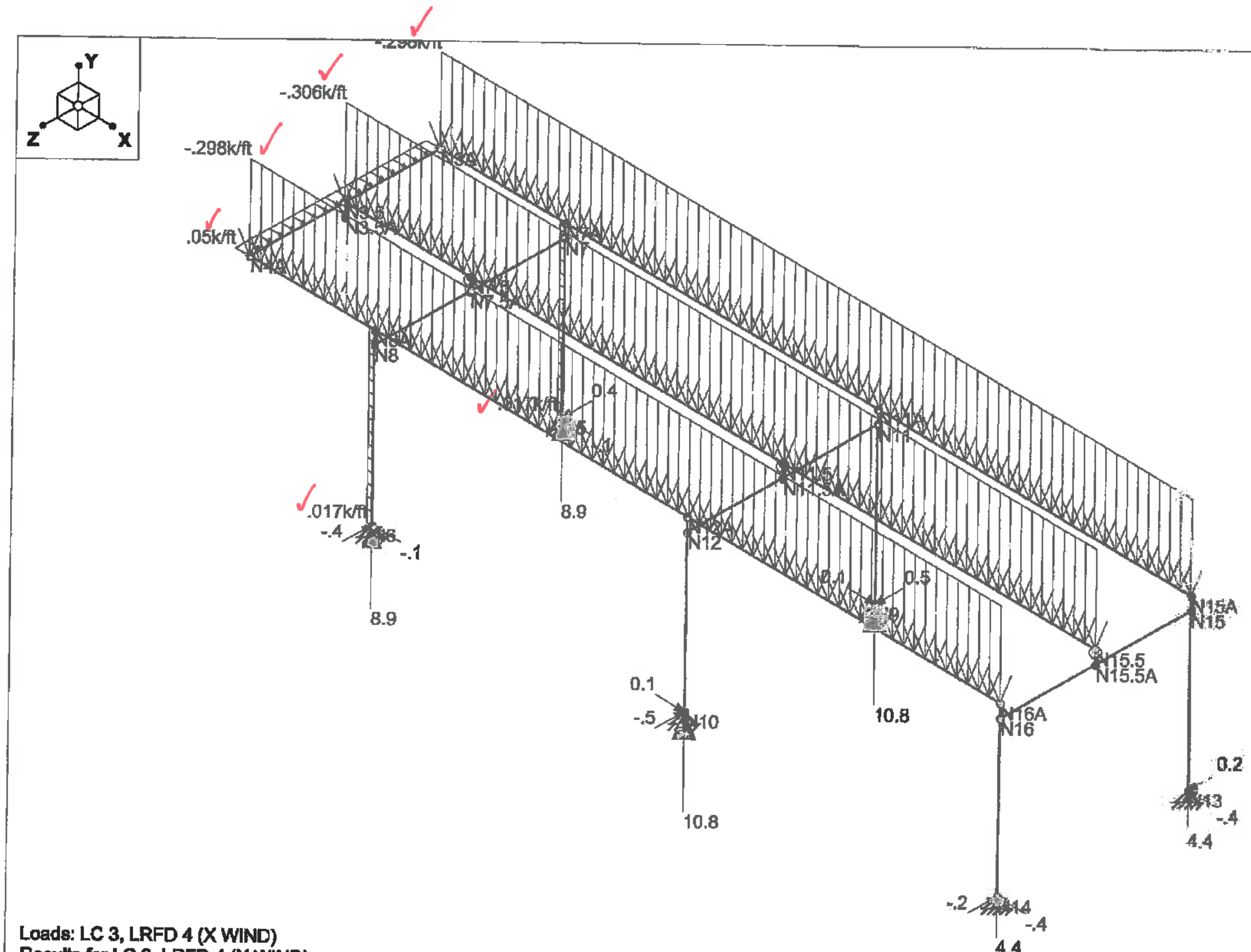


Loads: LC 2, LRFD 4 (Z WIND)
Results for LC 2, LRFD 4 (Z WIND)
Z-moment Reaction units are k and k-ft

SK - 5

Dec 10, 2014 at 12:04 PM

CANOPY 3D_1.r3d

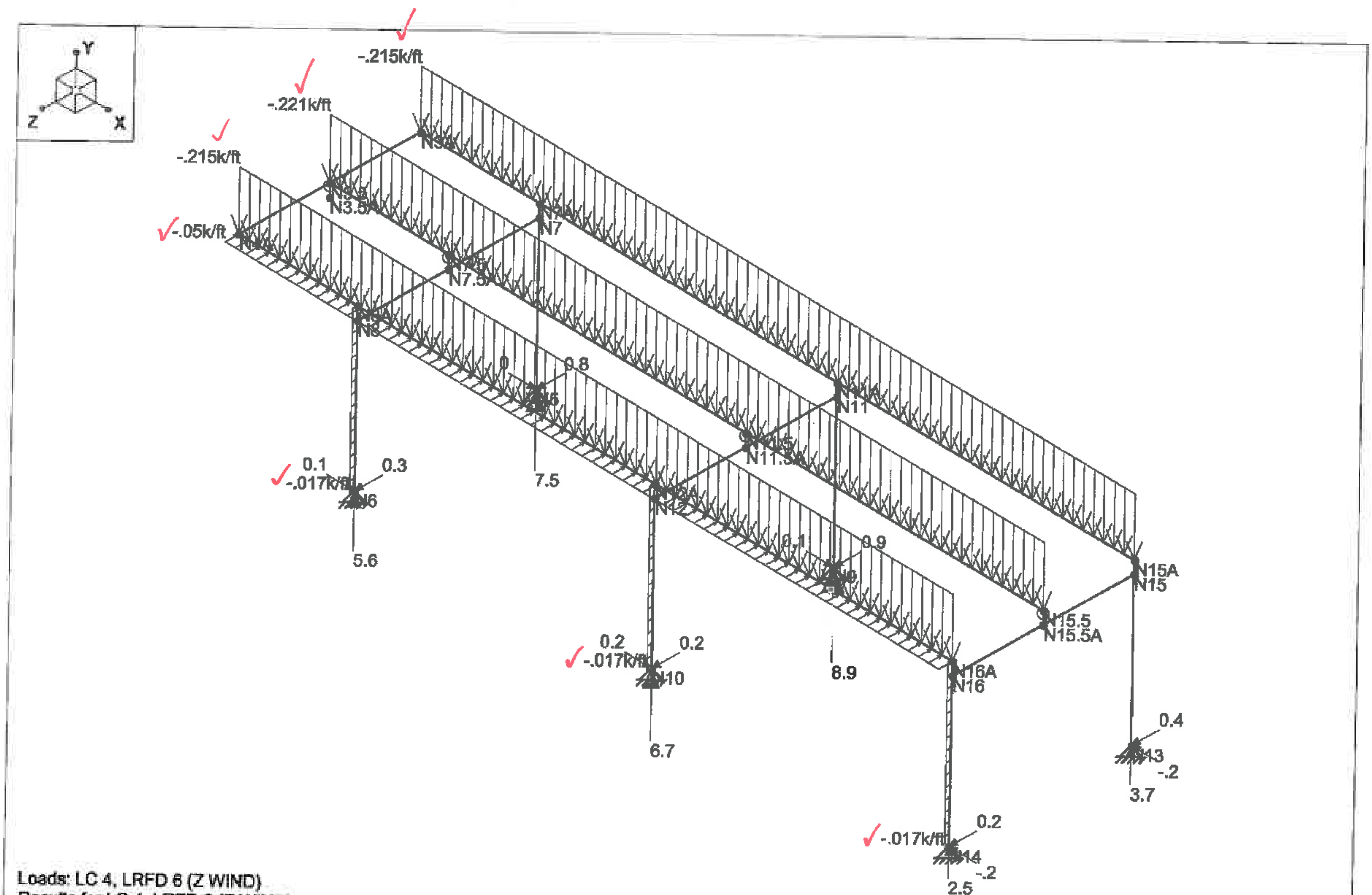


Loads: LC 3, LRFD 4 (X WIND)
Results for LC 3, LRFD 4 (X WIND)
Z-moment Reaction units are k and k-ft

SK - 6

Dec 10, 2014 at 12:04 PM

CANOPY 3D_1.r3d

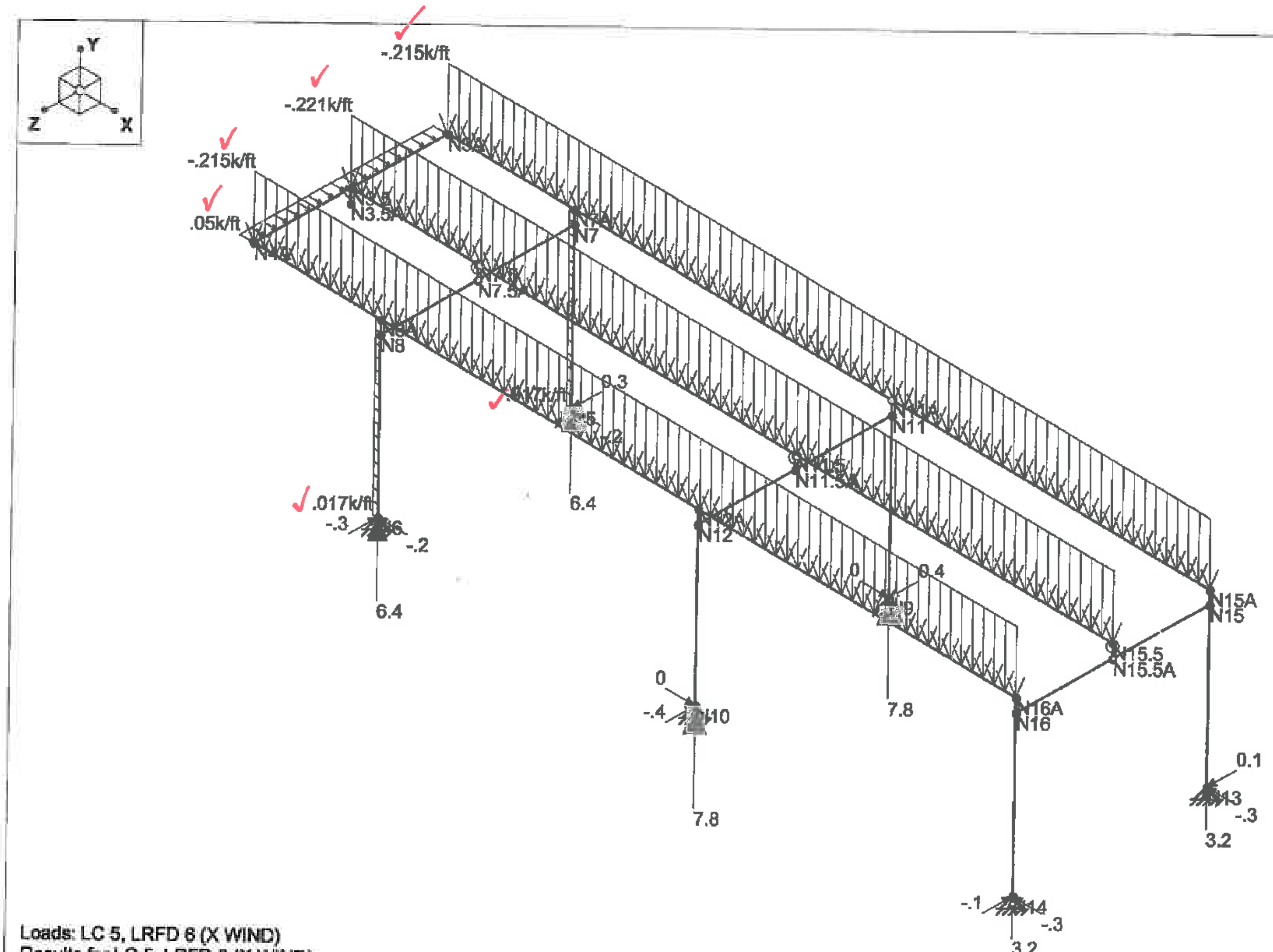


Loads: LC 4, LRFD 6 (Z WIND)
Results for LC 4, LRFD 6 (Z WIND)
Z-moment Reaction units are k and k-ft

SK - 8

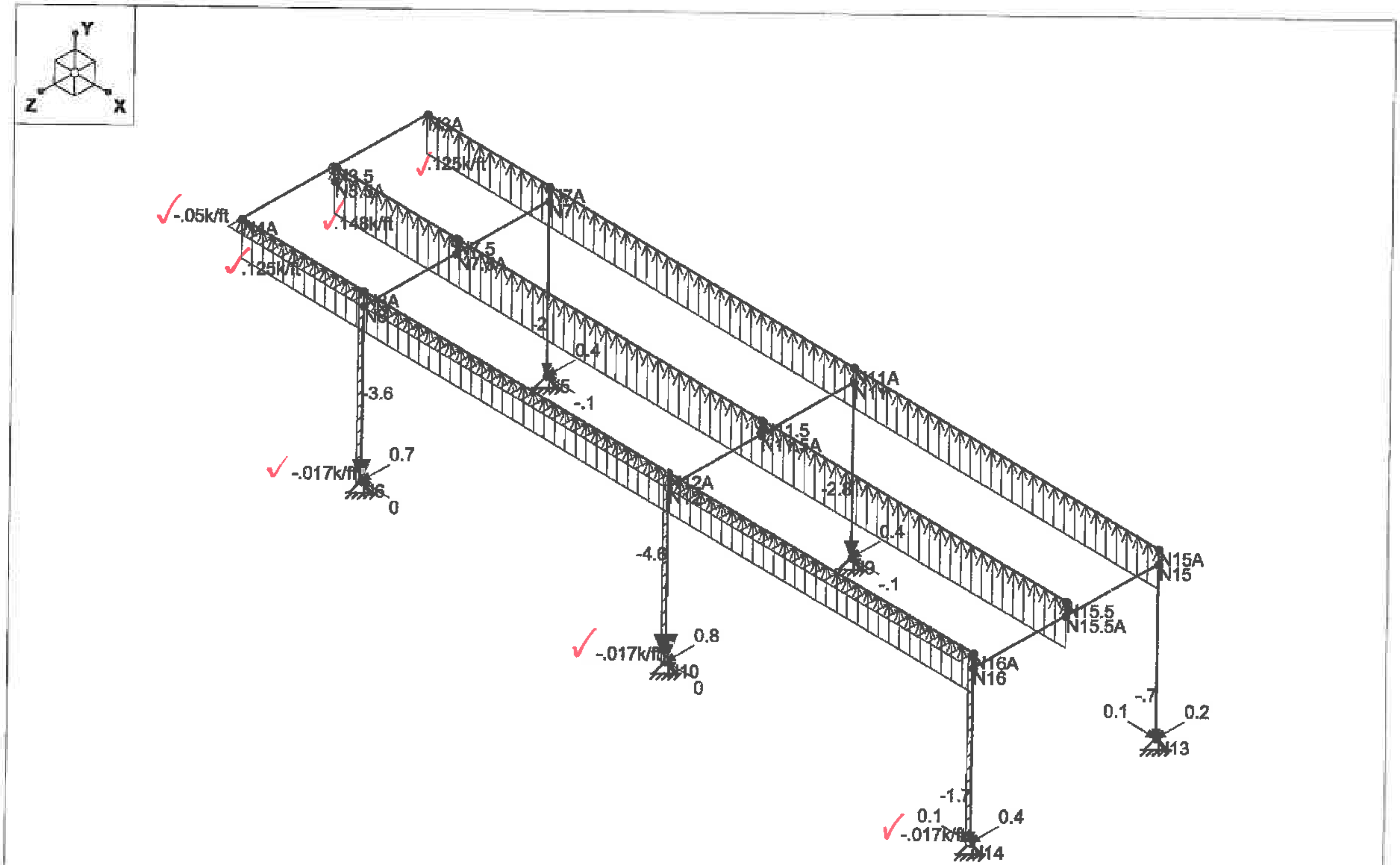
Dec 10, 2014 at 12:06 PM

CANOPY 3D_1.r3d



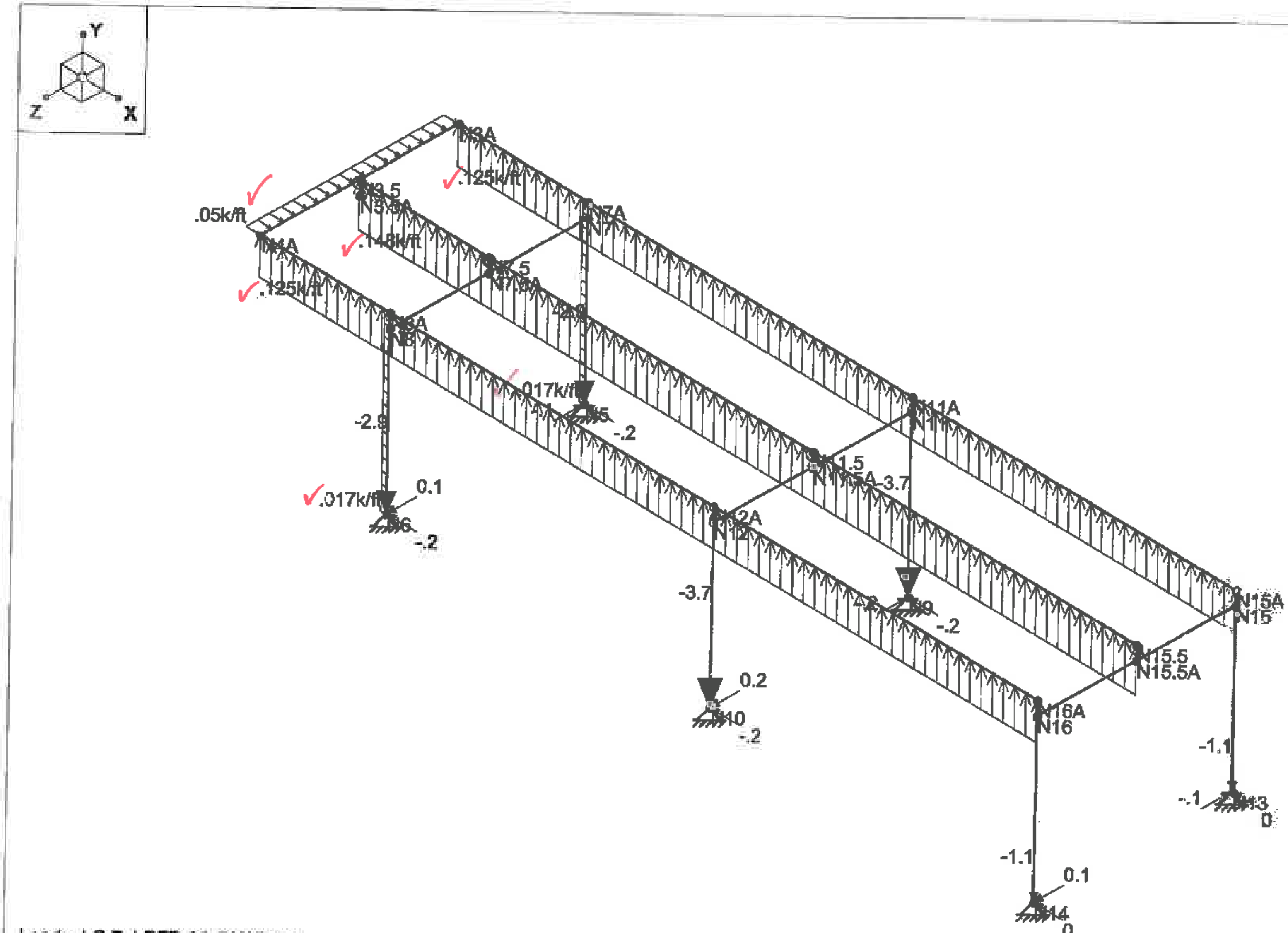
Loads: LC 5, LRFD 6 (X WIND)
Results for LC 5, LRFD 6 (X WIND)
Z-moment Reaction units are k and k-ft

SK - 9
Dec 10, 2014 at 12:06 PM
CANOPY 3D_1.r3d



Loads: LC 6, LRFD 6A (Z WIND)
Results for LC 6, LRFD 6A (Z WIND)
Z-moment Reaction units are k and k-ft

SK - 10
Dec 10, 2014 at 12:07 PM
CANOPY 3D_1.r3d



Loads: LC 7, LRFD 6A (X WIND)
Results for LC 7, LRFD 6A (X WIND)
Z-moment Reaction units are k and k-ft

SK - 11
Dec 10, 2014 at 12:07 PM
CANOPY 3D_1.r3d

Hot Rolled Steel Properties

	Label	E [ksi]	G [ksi]	Nu	Therm (\1E...	Density[k/ft...	Yield[ksi]	Ry	Fu[ksi]	Rt
1	A36 Gr.36	29000	11154	.3	.65	.49	36	1.5	58	1.2
2	A572 Gr.50	29000	11154	.3	.65	.49	50	1.1	65	1.1
3	A992	29000	11154	.3	.65	.49	50	1.1	65	1.1
4	A500 Gr.B RND	29000	11154	.3	.65	.49	42	1.4	58	1.3
5	A500 Gr.B Rect	29000	11154	.3	.65	.49	46	1.4	58	1.3
6	A53 Gr.B	29000	11154	.3	.65	.49	35	1.6	60	1.2

Joint Coordinates and Temperatures

	Label	X [ft]	Y [ft]	Z [ft]	Temp [F]	Detach From Diap...
1	N5	8	0	0	0	
2	N6	8	0	12	0	
3	N7	8	9.833	0	0	
4	N8	8	9.833	12	0	
5	N9	28	0	0	0	
6	N10	28	0	12	0	
7	N11	28	9.833	0	0	
8	N12	28	9.833	12	0	
9	N13	48	0	0	0	
10	N14	48	0	12	0	
11	N15	48	9.833	0	0	
12	N16	48	9.833	12	0	
13	N3.5	0	10.67	6	0	
14	N7.5	8	10.67	6	0	
15	N11.5	28	10.67	6	0	
16	N15.5	48	10.67	6	0	
17	N3.5A	0	9.833	6	0	
18	N7.5A	8	9.833	6	0	
19	N11.5A	28	9.833	6	0	
20	N15.5A	48	9.833	6	0	
21	N4A	0	10.67	12	0	
22	N3A	0	10.67	0	0	
23	N16A	48	10.67	12	0	
24	N15A	48	10.67	0	0	
25	N8A	8	10.67	12	0	
26	N7A	8	10.67	0	0	
27	N12A	28	10.67	12	0	
28	N11A	28	10.67	0	0	

Joint Boundary Conditions

	Joint Label	X [k/in]	Y [k/in]	Z [k/in]	X Rot.[k-ft/rad]	Y Rot.[k-ft/rad]	Z Rot.[k-ft/rad]	Footing
1	N6	Reaction	Reaction	Reaction				
2	N5	Reaction	Reaction	Reaction				
3	N10	Reaction	Reaction	Reaction				
4	N9	Reaction	Reaction	Reaction				
5	N14	Reaction	Reaction	Reaction				
6	N13	Reaction	Reaction	Reaction				
7	N3.5A							
8	N7.5A							
9	N11.5A							
10	N15.5A							

Hot Rolled Steel Design Parameters

	Label	Shape	Length[ft]	Lbyy[ft]	Lbzz[ft]	Lcomp top[ft]	Lcomp bot[ft]	L-torq...	Kyy	Kzz	Cb	Function
1	M3	HSS6x6x4	10.67									Lateral
2	M4	HSS6x6x4	10.67									Lateral
3	M5	HSS6x6x4	10.67									Lateral
4	M6	HSS6x6x4	10.67									Lateral
5	M7	HSS6x6x4	10.67									Lateral
6	M8	HSS6x6x4	10.67									Lateral
7	M9	C10x15.3	48			1	10					Lateral
8	M10	C10x15.3	48			1	10					Lateral
9	M11	C10x15.3	12									Lateral
10	M12	C10x15.3	12									Lateral
11	M13	C10x15.3	12									Lateral
12	M14	C10x15.3	12									Lateral
13	M15	C10x15.3	48			1	10					Lateral

Member Distributed Loads (BLC 1 : DEAD LOAD (TOTAL))

	Member Label	Direction	Start Magnitude[k/ft,F]	End Magnitude[k/ft,F]	Start Location[ft,%]	End Location[ft,%]
1	M10	Y	-.081	-.081	0	%100
2	M9	Y	-.081	-.081	0	%100
3	M15	Y	-.074	-.074	0	%100

Member Distributed Loads (BLC 2 : DEAD LOAD (NO SOLAR))

	Member Label	Direction	Start Magnitude[k/ft,F]	End Magnitude[k/ft,F]	Start Location[ft,%]	End Location[ft,%]
1	M10	Y	-.019	-.019	0	%100
2	M9	Y	-.019	-.019	0	%100
3	M15	Y	-.007	-.007	0	%100

Member Distributed Loads (BLC 3 : LIVE LOAD)

	Member Label	Direction	Start Magnitude[k/ft,F]	End Magnitude[k/ft,F]	Start Location[ft,%]	End Location[ft,%]
1	M10	Y	-.117	-.117	0	%100
2	M9	Y	-.117	-.117	0	%100
3	M15	Y	-.127	-.127	0	%100

Member Distributed Loads (BLC 4 : WIND (DOWN))

	Member Label	Direction	Start Magnitude[k/ft,F]	End Magnitude[k/ft,F]	Start Location[ft,%]	End Location[ft,%]
1	M10	Y	-.142	-.142	0	%100
2	M9	Y	-.142	-.142	0	%100
3	M15	Y	-.154	-.154	0	%100

Member Distributed Loads (BLC 5 : WIND (UPLIFT))

	Member Label	Direction	Start Magnitude[k/ft,F]	End Magnitude[k/ft,F]	Start Location[ft,%]	End Location[ft,%]
1	M10	Y	.142	.142	0	%100
2	M9	Y	.142	.142	0	%100
3	M15	Y	.154	.154	0	%100

Member Distributed Loads (BLC 6 : WIND (Z))

	Member Label	Direction	Start Magnitude[k/ft,F]	End Magnitude[k/ft,F]	Start Location[ft,%]	End Location[ft,%]
1	M10	Z	-.05	-.05	0	%100
2	M3	Z	-.017	-.017	0	%100
3	M5	Z	-.017	-.017	0	%100
4	M7	Z	-.017	-.017	0	%100

Member Distributed Loads (BLC 7 : WIND (X))

Member Label	Direction	Start Magnitude[k/ft,F]	End Magnitude[k/ft,F]	Start Location[ft,%]	End Location[ft,%]

Member Distributed Loads (BLC 7 : WIND (X)) (Continued)

	Member Label	Direction	Start Magnitude[k/ft,F]	End Magnitude[k/ft,F]	Start Location[ft,%]	End Location[ft,%]
1	M11	X	.05	.05	0	%100
2	M3	X	.017	.017	0	%100
3	M4	X	.017	.017	0	%100

Basic Load Cases

	BLC Description	Category	X Gravity	Y Gravity	Z Gravity	Joint	Point	Distributed	Area(Me...	Surface(...
1	DEAD LOAD (TOTAL)	None		-1				3		
2	DEAD LOAD (NO SOLAR)	None		-1				3		
3	LIVE LOAD	None						3		
4	WIND (DOWN)	None						3		
5	WIND (UPLIFT)	None						3		
6	WIND (Z)	None						4		
7	WIND (X)	None						3		

Load Combinations

	Description	Solve	PD...	SR...	BLC	Factor	BLC	Factor	BLC	Factor	BLC	Factor	BLC	Factor	BLC	Factor	BLC	Factor	BLC	Factor
1	LRFD 3	Yes	Y		1	1.2	3	1.6	4	.5	6	.5								
2	LRFD 4 (Z WIND)	Yes	Y		1	1.2	4	1	6	1	3	.5								
3	LRFD 4 (X WIND)	Yes	Y		1	1.2	4	1	7	1	3	.5								
4	LRFD 6 (Z WIND)	Yes	Y		1	.9	4	1	6	1										
5	LRFD 6 (X WIND)	Yes	Y		1	.9	4	1	7	1										
6	LRFD 6A (Z WIND)	Yes	Y		2	.9	5	1	6	1										
7	LRFD 6A (X WIND)	Yes	Y		2	.9	5	1	7	1										
8	ASD 3				1	1	3	1												
9	ASD 5				1	1	4	.6	6	.6										
10	ASD 5A				2	1	5	.6	6	.6										
11	ASD 6				1	1	3	.75	4	.45	6	.45								
12	ASD 6A				2	1	3	.75	5	.45	6	.45								
13	ASD 7				1	.6	4	.6	6	.6										
14	ASD 7A				2	.6	5	.6	6	.6										

Joint Reactions

	LC	Joint Label	X [k]	Y [k]	Z [k]	MX [k-ft]	MY [k-ft]	MZ [k-ft]
1	1	N6	.075	10.132	-.166	0	0	0
2	1	N5	.048	11.15	.715	0	0	0
3	1	N10	.289	12.138	-.292	0	0	0
4	1	N9	.249	13.303	.875	0	0	0
5	1	N14	-.312	4.702	-.032	0	0	0
6	1	N13	-.348	5.287	.37	0	0	0
7	1	Totals:	0	56.713	1.469			
8	1	COG (ft):	X: 24.05	Y: 10.531	Z: 6			
9	2	N6	.076	8.052	.195	0	0	0
10	2	N5	.021	10.034	.9	0	0	0
11	2	N10	.268	9.641	.11	0	0	0
12	2	N9	.19	11.902	1.057	0	0	0
13	2	N14	-.242	3.69	.185	0	0	0
14	2	N13	-.313	4.844	.489	0	0	0
15	2	Totals:	0	48.164	2.938			
16	2	COG (ft):	X: 24.059	Y: 10.507	Z: 6			
17	3	N6	-.147	8.928	-.376	0	0	0
18	3	N5	-.147	8.928	.376	0	0	0
19	3	N10	.076	10.76	-.5	0	0	0
20	3	N9	.076	10.76	.5	0	0	0

Joint Reactions (Continued)

	LC	Joint Label	X [k]	Y [k]	Z [k]	MX [k-ft]	MY [k-ft]	MZ [k-ft]
21	3	N14	-.41	4.394	-.182	0	0	0
22	3	N13	-.41	4.394	.182	0	0	0
23	3	Totals:	-.963	48.164	0			
24	3	COG (ft):	X: 24.059	Y: 10.507	Z: 6			
25	4	N6	.062	5.595	.3	0	0	0
26	4	N5	.008	7.499	.794	0	0	0
27	4	N10	.205	6.715	.25	0	0	0
28	4	N9	.128	8.878	.921	0	0	0
29	4	N14	-.167	2.532	.235	0	0	0
30	4	N13	-.236	3.663	.438	0	0	0
31	4	Totals:	0	34.881	2.938			
32	4	COG (ft):	X: 24.061	Y: 10.501	Z: 6			
33	5	N6	-.162	6.437	-.27	0	0	0
34	5	N5	-.162	6.437	.27	0	0	0
35	5	N10	.012	7.785	-.361	0	0	0
36	5	N9	.012	7.785	.361	0	0	0
37	5	N14	-.331	3.219	-.132	0	0	0
38	5	N13	-.331	3.219	.132	0	0	0
39	5	Totals:	-.963	34.881	0			
40	5	COG (ft):	X: 24.061	Y: 10.501	Z: 6			
41	6	N6	-.014	-3.638	.71	0	0	0
42	6	N5	-.067	-1.98	.38	0	0	0
43	6	N10	-.035	-4.612	.809	0	0	0
44	6	N9	-.11	-2.757	.372	0	0	0
45	6	N14	.145	-1.741	.427	0	0	0
46	6	N13	.081	-.69	.24	0	0	0
47	6	Totals:	0	-15.418	2.938			
48	6	COG (ft):	X: 23.862	Y: 11.052	Z: 6			
49	7	N6	-.241	-2.902	.143	0	0	0
50	7	N5	-.241	-2.902	-.143	0	0	0
51	7	N10	-.231	-3.697	.195	0	0	0
52	7	N9	-.231	-3.697	-.195	0	0	0
53	7	N14	-.009	-1.111	.064	0	0	0
54	7	N13	-.009	-1.111	-.064	0	0	0
55	7	Totals:	-.963	-15.418	0			
56	7	COG (ft):	X: 23.862	Y: 11.052	Z: 6			

Joint Deflections

	LC	Joint Label	X [in]	Y [in]	Z [in]	X Rotation [rad]	Y Rotation [rad]	Z Rotation [rad]
1	1	N5	0	0	0	-5.391e-3	-5.983e-4	2.061e-3
2	1	N6	0	0	0	-2.264e-3	1.315e-3	2.6e-3
3	1	N7	-.211	-.011	-.325	2.617e-3	-5.983e-4	1.229e-3
4	1	N8	-.262	-.01	-.325	-3.833e-3	1.315e-3	1.44e-3
5	1	N9	0	0	0	-6.296e-3	-4.002e-4	2.922e-3
6	1	N10	0	0	0	-2.176e-3	-4.504e-5	3.515e-3
7	1	N11	-.226	-.013	-.359	3.558e-3	-4.002e-4	-1.194e-4
8	1	N12	-.278	-.012	-.36	-4.914e-3	-4.504e-5	8.654e-6
9	1	N13	0	0	0	-2.806e-3	-3.559e-5	3.739e-4
10	1	N14	0	0	0	-1.342e-3	-4.122e-3	9.413e-4
11	1	N15	-.181	-.005	-.175	1.205e-3	-3.559e-5	3.896e-3
12	1	N16	-.233	-.004	-.175	-1.855e-3	-4.122e-3	4.068e-3
13	1	N3.5	-.244	-.382	-.398	9.168e-5	-4.265e-4	2.442e-3
14	1	N7.5	-.244	-.206	-.322	2.573e-4	-6.6e-4	-2.969e-4
15	1	N11.5	-.244	-.267	-.357	2.893e-4	-4.164e-4	-1.549e-3
16	1	N15.5	-.244	-.097	-.174	1.375e-4	3.111e-4	7.903e-3
17	1	N3.5A	-.22	-.382	-.399	9.168e-5	-4.265e-4	0

Joint Deflections (Continued)

	LC	Joint Label	X [in]	Y [in]	Z [in]	X Rotation [rad]	Y Rotation [rad]	Z Rotation [rad]
18	1	N7.5A	-.247	-.205	-.325	2.573e-4	-6.6e-4	1.335e-3
19	1	N11.5A	-.26	-.267	-.36	2.893e-4	-4.164e-4	-5.538e-5
20	1	N15.5A	-.164	-.097	-.175	1.375e-4	3.111e-4	3.982e-3
21	1	N4A	-.275	-.378	-.398	-1.245e-4	-4.567e-4	4.65e-3
22	1	N3A	-.222	-.365	-.398	3.069e-4	-6.76e-4	4.503e-3
23	1	N16A	-.276	-.005	-.194	-1.874e-3	-4.269e-3	4.631e-3
24	1	N15A	-.223	-.005	-.163	1.205e-3	-4.872e-5	4.52e-3
25	1	N8A	-.275	-.01	-.364	-3.866e-3	1.389e-3	1.231e-3
26	1	N7A	-.222	-.011	-.298	2.615e-3	-6.081e-4	1.082e-3
27	1	N12A	-.275	-.012	-.41	-4.958e-3	-3.721e-5	-6.101e-4
28	1	N11A	-.223	-.013	-.324	3.562e-3	-3.954e-4	-6.554e-4
29	2	N5	0	0	0	-8.761e-3	-7.993e-4	1.355e-3
30	2	N6	0	0	0	-6.13e-3	2.239e-3	2.413e-3
31	2	N7	-.143	-.01	-.632	1.576e-3	-7.993e-4	9.288e-4
32	2	N8	-.243	-.008	-.632	-3.944e-3	2.239e-3	1.342e-3
33	2	N9	0	0	0	-9.948e-3	-5.384e-4	2.068e-3
34	2	N10	0	0	0	-6.467e-3	-3.125e-4	3.231e-3
35	2	N11	-.156	-.011	-.697	2.312e-3	-5.384e-4	-1.868e-4
36	2	N12	-.258	-.009	-.698	-4.942e-3	-3.125e-4	6.501e-5
37	2	N13	0	0	0	-4.697e-3	-7.203e-4	-5.238e-5
38	2	N14	0	0	0	-3.49e-3	-7.531e-3	1.062e-3
39	2	N15	-.119	-.005	-.346	6.66e-4	-7.203e-4	3.157e-3
40	2	N16	-.22	-.003	-.346	-1.95e-3	-7.531e-3	3.493e-3
41	2	N3.5	-.191	-.327	-.777	1.803e-4	-8.39e-4	2.104e-3
42	2	N7.5	-.191	-.174	-.627	5.006e-4	-1.309e-3	-2.332e-4
43	2	N11.5	-.19	-.227	-.692	5.611e-4	-8.173e-4	-1.324e-3
44	2	N15.5	-.19	-.082	-.343	2.713e-4	6.387e-4	6.712e-3
45	2	N3.5A	-.17	-.327	-.779	1.803e-4	-8.39e-4	0
46	2	N7.5A	-.193	-.174	-.632	5.006e-4	-1.309e-3	1.136e-3
47	2	N11.5A	-.204	-.227	-.697	5.611e-4	-8.173e-4	-6.089e-5
48	2	N15.5A	-.122	-.082	-.346	2.713e-4	6.387e-4	3.325e-3
49	2	N4A	-.256	-.331	-.777	-9.519e-6	-1.118e-3	4.061e-3
50	2	N3A	-.152	-.305	-.777	3.682e-4	-1.124e-3	3.772e-3
51	2	N16A	-.257	-.004	-.366	-1.987e-3	-7.829e-3	3.943e-3
52	2	N15A	-.153	-.005	-.339	6.659e-4	-7.391e-4	3.726e-3
53	2	N8A	-.256	-.008	-.673	-4.007e-3	2.39e-3	1.143e-3
54	2	N7A	-.152	-.01	-.616	1.573e-3	-8.234e-4	8.503e-4
55	2	N12A	-.256	-.01	-.749	-5.025e-3	-2.886e-4	-4.959e-4
56	2	N11A	-.153	-.012	-.674	2.315e-3	-5.363e-4	-5.852e-4
57	3	N5	0	0	0	-1.299e-3	-1.221e-5	-5.551e-4
58	3	N6	0	0	0	1.299e-3	1.221e-5	-5.551e-4
59	3	N7	.021	-.009	0	2.645e-3	-1.221e-5	4.296e-4
60	3	N8	.021	-.009	0	-2.645e-3	1.221e-5	4.296e-4
61	3	N9	0	0	0	-1.728e-3	3.071e-4	1.797e-4
62	3	N10	0	0	0	1.728e-3	-3.071e-4	1.797e-4
63	3	N11	.009	-.01	0	3.519e-3	3.071e-4	-6.022e-4
64	3	N12	.009	-.01	0	-3.519e-3	-3.071e-4	-6.022e-4
65	3	N13	0	0	0	-6.294e-4	1.162e-3	-1.804e-3
66	3	N14	0	0	0	6.294e-4	-1.162e-3	-1.804e-3
67	3	N15	.044	-.004	0	1.282e-3	1.162e-3	2.527e-3
68	3	N16	.044	-.004	0	-1.282e-3	-1.162e-3	2.527e-3
69	3	N3.5	.052	-.291	0	0	0	1.73e-3
70	3	N7.5	.052	-.169	0	0	0	-4.465e-4
71	3	N11.5	.052	-.223	0	0	0	-1.243e-3
72	3	N15.5	.051	-.082	0	0	0	6.512e-3
73	3	N3.5A	.069	-.291	0	0	0	0
74	3	N7.5A	.047	-.169	0	0	0	4.296e-4

Joint Deflections (Continued)

	LC	Joint Label	X [in]	Y [in]	Z [in]	X Rotation [rad]	Y Rotation [rad]	Z Rotation [rad]
75	3	N11.5A	.039	-.223	0	0	0	-6.022e-4
76	3	N15.5A	.117	-.082	0	0	0	2.527e-3
77	3	N4A	.017	-.279	0	-2.341e-4	-6.05e-4	3.545e-3
78	3	N3A	.017	-.279	0	2.341e-4	6.05e-4	3.545e-3
79	3	N16A	.015	-.004	-.013	-1.282e-3	-1.142e-3	3.291e-3
80	3	N15A	.015	-.004	.013	1.282e-3	1.142e-3	3.291e-3
81	3	N8A	.016	-.009	-.027	-2.644e-3	4.409e-5	5.419e-4
82	3	N7A	.016	-.009	.027	2.644e-3	-4.409e-5	5.419e-4
83	3	N12A	.016	-.011	-.036	-3.522e-3	-2.891e-4	-7.429e-4
84	3	N11A	.016	-.011	.036	3.522e-3	2.891e-4	-7.429e-4
85	4	N5	0	0	0	-8.095e-3	-7.097e-4	7.77e-4
86	4	N6	0	0	0	-6.198e-3	2.171e-3	1.796e-3
87	4	N7	-.085	-.007	-.606	8.752e-4	-7.097e-4	6.053e-4
88	4	N8	-.181	-.005	-.607	-3.15e-3	2.171e-3	1.005e-3
89	4	N9	0	0	0	-9.104e-3	-4.583e-4	1.279e-3
90	4	N10	0	0	0	-6.582e-3	-3.295e-4	2.4e-3
91	4	N11	-.094	-.009	-.666	1.392e-3	-4.583e-4	-1.796e-4
92	4	N12	-.192	-.006	-.667	-3.909e-3	-3.295e-4	6.388e-5
93	4	N13	0	0	0	-4.442e-3	-8.06e-4	-2.352e-4
94	4	N14	0	0	0	-3.584e-3	-7.347e-3	8.397e-4
95	4	N15	-.067	-.003	-.339	3.233e-4	-8.06e-4	2.209e-3
96	4	N16	-.165	-.002	-.339	-1.582e-3	-7.347e-3	2.532e-3
97	4	N3.5	-.127	-.236	-.75	1.742e-4	-8.125e-4	1.514e-3
98	4	N7.5	-.127	-.126	-.602	4.808e-4	-1.287e-3	-1.806e-4
99	4	N11.5	-.126	-.165	-.661	5.368e-4	-7.897e-4	-9.632e-4
100	4	N15.5	-.126	-.06	-.336	2.66e-4	6.678e-4	4.884e-3
101	4	N3.5A	-.112	-.236	-.752	1.742e-4	-8.125e-4	0
102	4	N7.5A	-.128	-.126	-.607	4.808e-4	-1.287e-3	8.049e-4
103	4	N11.5A	-.136	-.165	-.666	5.368e-4	-7.897e-4	-5.786e-5
104	4	N15.5A	-.077	-.06	-.339	2.66e-4	6.678e-4	2.37e-3
105	4	N4A	-.191	-.242	-.75	3.563e-5	-1.138e-3	2.969e-3
106	4	N3A	-.091	-.217	-.75	3.11e-4	-1.058e-3	2.691e-3
107	4	N16A	-.192	-.003	-.356	-1.619e-3	-7.644e-3	2.851e-3
108	4	N15A	-.092	-.004	-.335	3.23e-4	-8.22e-4	2.643e-3
109	4	N8A	-.191	-.006	-.639	-3.212e-3	2.322e-3	8.54e-4
110	4	N7A	-.091	-.008	-.597	8.713e-4	-7.353e-4	5.713e-4
111	4	N12A	-.191	-.007	-.707	-3.99e-3	-3.036e-4	-3.512e-4
112	4	N11A	-.091	-.009	-.652	1.394e-3	-4.573e-4	-4.381e-4
113	5	N5	0	0	0	-9.332e-4	6.574e-5	-1.049e-3
114	5	N6	0	0	0	9.332e-4	-6.574e-5	-1.049e-3
115	5	N7	.072	-.006	0	1.9e-3	6.574e-5	1.323e-4
116	5	N8	.072	-.006	0	-1.9e-3	-6.574e-5	1.323e-4
117	5	N9	0	0	0	-1.249e-3	3.549e-4	-5.204e-4
118	5	N10	0	0	0	1.249e-3	-3.549e-4	-5.204e-4
119	5	N11	.064	-.007	0	2.543e-3	3.549e-4	-5.767e-4
120	5	N12	.064	-.007	0	-2.543e-3	-3.549e-4	-5.767e-4
121	5	N13	0	0	0	-4.551e-4	1.024e-3	-1.905e-3
122	5	N14	0	0	0	4.551e-4	-1.024e-3	-1.905e-3
123	5	N15	.088	-.003	0	9.266e-4	1.024e-3	1.609e-3
124	5	N16	.088	-.003	0	-9.266e-4	-1.024e-3	1.609e-3
125	5	N3.5	.106	-.202	0	0	0	1.159e-3
126	5	N7.5	.106	-.121	0	0	0	-3.827e-4
127	5	N11.5	.106	-.161	0	0	0	-8.846e-4
128	5	N15.5	.106	-.059	0	0	0	4.685e-3
129	5	N3.5A	.118	-.202	0	0	0	0
130	5	N7.5A	.102	-.121	0	0	0	1.323e-4
131	5	N11.5A	.097	-.161	0	0	0	-5.767e-4

Joint Deflections (Continued)

	LC	Joint Label	X [in]	Y [in]	Z [in]	X Rotation [rad]	Y Rotation [rad]	Z Rotation [rad]
132	5	N15.5A	153	-.059	0	0	0	1.609e-3
133	5	N4A	.07	-.193	0	-1.808e-4	-6.493e-4	2.475e-3
134	5	N3A	.07	-.193	0	1.808e-4	6.493e-4	2.475e-3
135	5	N16A	.069	-.003	-.009	-9.266e-4	-1.006e-3	2.229e-3
136	5	N15A	.069	-.003	.009	9.266e-4	1.006e-3	2.229e-3
137	5	N8A	.07	-.007	-.019	-1.898e-3	-3.318e-5	2.793e-4
138	5	N7A	.07	-.007	.019	1.898e-3	3.318e-5	2.793e-4
139	5	N12A	.069	-.008	-.026	-2.545e-3	-3.354e-4	-5.895e-4
140	5	N11A	.069	-.008	.026	2.545e-3	3.354e-4	-5.895e-4
141	6	N5	0	0	0	-5.719e-3	-3.476e-4	-1.007e-3
142	6	N6	0	0	0	-6.682e-3	1.887e-3	-1.187e-4
143	6	N7	.093	.002	-.526	-1.89e-3	-3.476e-4	-3.307e-4
144	6	N8	.009	.004	-.526	-8.943e-5	1.887e-3	1.965e-5
145	6	N9	0	0	0	-6.02e-3	-1.633e-4	-1.178e-3
146	6	N10	0	0	0	-7.343e-3	-4.204e-4	-2.015e-4
147	6	N11	.095	.003	-.567	-2.342e-3	-1.633e-4	-6.046e-5
148	6	N12	.01	.005	-.568	1.87e-4	-4.204e-4	1.546e-4
149	6	N13	0	0	0	-3.494e-3	-1.237e-3	-4.115e-4
150	6	N14	0	0	0	-3.986e-3	-6.596e-3	5.297e-4
151	6	N15	.082	0	-.316	-1.009e-3	-1.237e-3	-1.266e-3
152	6	N16	-.003	.002	-.316	-1.644e-4	-6.596e-3	-9.887e-4
153	6	N3.5	.07	.074	-.662	1.536e-4	-7.224e-4	-2.72e-4
154	6	N7.5	.07	.06	-.522	4.178e-4	-1.213e-3	4.141e-4
155	6	N11.5	.07	.083	-.563	4.593e-4	-6.974e-4	4.083e-4
156	6	N15.5	.071	.028	-.313	2.48e-4	7.657e-4	-2.509e-3
157	6	N3.5A	.067	.074	-.664	1.536e-4	-7.224e-4	0
158	6	N7.5A	.074	.06	-.526	4.178e-4	-1.213e-3	-1.555e-4
159	6	N11.5A	.074	.083	-.567	4.593e-4	-6.974e-4	4.705e-5
160	6	N15.5A	.045	.028	-.316	2.48e-4	7.657e-4	-1.127e-3
161	6	N4A	.008	.062	-.662	1.674e-4	-1.232e-3	-7.847e-4
162	6	N3A	.095	.084	-.662	1.382e-4	-8.035e-4	-1.03e-3
163	6	N16A	.008	.002	-.318	-2.006e-4	-6.896e-3	-1.238e-3
164	6	N15A	.095	0	-.326	-1.009e-3	-1.242e-3	-1.415e-3
165	6	N8A	.008	.004	-.528	-1.516e-4	2.038e-3	3.296e-5
166	6	N7A	.095	.002	-.545	-1.892e-3	-3.8e-4	-2.155e-4
167	6	N12A	.008	.005	-.567	1.077e-4	-3.877e-4	2.149e-4
168	6	N11A	.095	.003	-.591	-2.34e-3	-1.672e-4	1.368e-4
169	7	N5	0	0	0	4.933e-4	3.856e-4	-2.574e-3
170	7	N6	0	0	0	-4.933e-4	-3.856e-4	-2.574e-3
171	7	N7	.226	.003	0	-1.005e-3	3.856e-4	-7.231e-4
172	7	N8	.226	.003	0	1.005e-3	-3.856e-4	-7.231e-4
173	7	N9	0	0	0	6.731e-4	5.453e-4	-2.703e-3
174	7	N10	0	0	0	-6.731e-4	-5.453e-4	-2.703e-3
175	7	N11	.229	.004	0	-1.371e-3	5.453e-4	-4.011e-4
176	7	N12	.229	.004	0	1.371e-3	-5.453e-4	-4.011e-4
177	7	N13	0	0	0	2.195e-4	4.229e-4	-1.831e-3
178	7	N14	0	0	0	-2.195e-4	-4.229e-4	-1.831e-3
179	7	N15	.214	.001	0	-4.47e-4	4.229e-4	-1.773e-3
180	7	N16	.214	.001	0	4.47e-4	-4.229e-4	-1.773e-3
181	7	N3.5	.272	.103	0	0	0	-5.703e-4
182	7	N7.5	.272	.064	0	0	0	2.47e-4
183	7	N11.5	.272	.087	0	0	0	4.779e-4
184	7	N15.5	.272	.029	0	0	0	-2.703e-3
185	7	N3.5A	.267	.103	0	0	0	0
186	7	N7.5A	.275	.064	0	0	0	-7.231e-4
187	7	N11.5A	.277	.087	0	0	0	-4.011e-4
188	7	N15.5A	.245	.029	0	0	0	-1.773e-3

Joint Deflections (Continued)

	LC	Joint Label	X [in]	Y [in]	Z [in]	X Rotation [rad]	Y Rotation [rad]	Z Rotation [rad]
189	7	N4A	.232	.104	0	-2.195e-5	-8.268e-4	-1.209e-3
190	7	N3A	.232	.104	0	2.195e-5	8.268e-4	-1.209e-3
191	7	N16A	.232	.001	.005	4.476e-4	-4.103e-4	-1.764e-3
192	7	N15A	.232	.001	-.005	-4.476e-4	4.103e-4	-1.764e-3
193	7	N8A	.232	.003	.01	1.007e-3	-3.494e-4	-4.571e-4
194	7	N7A	.232	.003	-.01	-1.007e-3	3.494e-4	-4.571e-4
195	7	N12A	.231	.004	.014	1.37e-3	-5.201e-4	4.817e-6
196	7	N11A	.231	.004	-.014	-1.37e-3	5.201e-4	4.817e-6

Member Section Forces

	LC	Member Label	Sec	Axial[k]	y Shear[k]	z Shear[k]	Torque[k-ft]	y-y Mo...	z-z Mo...
1	1	M3	1	10.132	-.111	-.122	0	0	0
2			2	10.075	-.111	-.144	0	-.355	.295
3			3	10.017	-.111	-.167	0	-.771	.59
4			4	9.96	-.111	-.189	0	-1.246	.885
5			5	6.993	-.154	.444	-.312	.007	1.215
6	1	M4	1	11.15	-.079	.763	0	0	0
7			2	11.093	-.079	.763	0	2.036	.211
8			3	11.036	-.079	.763	0	4.072	.423
9			4	10.979	-.079	.763	0	6.108	.634
10			5	6.962	-.076	.005	.041	-.004	.844
11	1	M5	1	12.138	-.334	-.233	0	0	0
12			2	12.081	-.334	-.256	0	-.653	.891
13			3	12.024	-.334	-.278	0	-1.365	1.783
14			4	11.967	-.334	-.301	0	-2.137	2.674
15			5	8.006	-.288	.583	-.033	.004	3.527
16	1	M6	1	13.303	-.29	.939	0	0	0
17			2	13.246	-.29	.939	0	2.505	.773
18			3	13.189	-.29	.939	0	5.011	1.547
19			4	13.132	-.29	.939	0	7.516	2.32
20			5	8.011	-.239	-.057	-.02	-.003	3.051
21	1	M7	1	4.702	.298	-.021	0	0	0
22			2	4.645	.298	-.044	0	-.087	-.795
23			3	4.588	.298	-.066	0	-.233	-1.59
24			4	4.531	.298	-.089	0	-.44	-2.385
25			5	3.103	.408	.245	.619	-.003	-3.271
26	1	M8	1	5.287	.336	.382	0	0	0
27			2	5.23	.336	.382	0	1.02	-.896
28			3	5.173	.336	.382	0	2.04	-1.791
29			4	5.116	.336	.382	0	3.059	-2.687
30			5	3.128	.316	-.002	.055	.002	-3.565
31	1	M9	1	.03	-.165	-.027	-.005	.106	-.008
32			2	.093	2.313	.007	0	-.044	1.869
33			3	.093	-2.171	.007	0	.036	1.014
34			4	.337	1.356	-.005	.002	.003	-7.067
35			5	.337	-3.128	-.005	.002	-.055	3.565
36	1	M10	1	-.002	-.164	.044	.008	.006	-.009
37			2	.137	2.344	.145	0	.024	2.111
38			3	.137	-2.14	-.155	0	-.039	.884
39			4	.429	1.382	.064	-.003	.416	-7.051
40			5	.429	-3.103	-.236	-.003	-.619	3.271
41	1	M11	1	.044	.164	.002	-.009	-.006	-.008
42			2	.044	.109	.002	-.009	-.002	-.418
43			3	.044	-.055	.03	-.009	-.075	-.663
44			4	.027	-.11	.03	.008	.015	-.416
45			5	.027	-.165	.03	.008	.106	-.005

Member Section Forces (Continued)

	LC	Member Label	Sec	Axial[k]	y Shear[k]	z Shear[k]	Torque[k-ft]	y-y Mo...	z-z Mo...
46	1	M12	1	.358	1.372	.116	0	-.619	.405
47			2	.358	1.317	.116	0	-.27	-3.628
48			3	.365	-1.822	.011	0	.078	-7.503
49			4	.365	-1.877	.011	0	.021	-1.956
50			5	.365	-1.931	.011	0	.055	3.756
51	1	M13	1	.902	3.909	-.003	0	.033	2.214
52			2	.902	3.854	-.003	0	.023	-9.431
53			3	.902	-4.959	-.006	0	.018	-20.911
54			4	.886	-5.014	-.006	0	0	-5.934
55			5	.886	-5.069	-.006	0	-.02	9.19
56	1	M14	1	.657	2.913	-.064	0	.312	1.239
57			2	.657	2.858	-.064	0	.12	-7.419
58			3	.681	-3.852	.015	0	-.072	-15.931
59			4	.681	-3.907	.015	0	-.004	-4.291
60			5	.681	-3.962	.015	0	.041	7.513
61	1	M15	1	-.029	.109	-.017	0	.078	.017
62			2	-.108	2.112	.007	0	-.049	-.076
63			3	-.108	-2.536	.007	0	.04	2.468
64			4	-.105	1.565	-.008	0	.002	-9.221
65			5	-.105	-3.082	-.008	0	-.091	-.121
66	1	M18	1	0	0	0	0	0	0
67			2	0	0	0	0	0	0
68			3	0	0	0	0	0	0
69			4	0	0	0	0	0	0
70			5	0	0	0	0	0	0
71	1	M19	1	6.65	-.083	.022	-.023	0	-.069
72			2	6.65	-.083	.022	-.023	.005	-.052
73			3	6.65	-.083	.022	-.023	.009	-.035
74			4	6.65	-.083	.022	-.023	.014	-.017
75			5	6.65	-.083	.022	-.023	.018	0
76	1	M20	1	8.748	-.019	-.019	-.006	0	-.016
77			2	8.748	-.019	-.019	-.006	-.004	-.012
78			3	8.748	-.019	-.019	-.006	-.008	-.008
79			4	8.748	-.019	-.019	-.006	-.012	-.004
80			5	8.748	-.019	-.019	-.006	-.016	0
81	1	M21	1	3.082	.144	.007	.091	0	.121
82			2	3.082	.144	.007	.091	.001	.091
83			3	3.082	.144	.007	.091	.003	.06
84			4	3.082	.144	.007	.091	.004	.03
85			5	3.082	.144	.007	.091	.006	0
86	2	M3	1	8.052	-.102	.263	0	0	0
87			2	7.995	-.102	.219	0	.643	.272
88			3	7.938	-.102	.174	0	1.166	.544
89			4	7.881	-.102	.129	0	1.57	.817
90			5	5.942	-.228	.848	-.638	.008	1.193
91	2	M4	1	10.034	-.041	.985	0	0	0
92			2	9.977	-.041	.985	0	2.628	.108
93			3	9.92	-.041	.985	0	5.257	.217
94			4	9.863	-.041	.985	0	7.885	.325
95			5	5.882	-.075	.044	.101	-.002	.463
96	2	M5	1	9.641	-.302	.2	0	0	0
97			2	9.584	-.302	.156	0	.475	.805
98			3	9.527	-.302	.111	0	.83	1.61
99			4	9.47	-.302	.066	0	1.066	2.415
100			5	6.758	-.288	1.091	-.101	.004	3.208
101	2	M6	1	11.902	-.215	1.169	0	0	0
102			2	11.845	-.215	1.169	0	3.117	.573

Member Section Forces (Continued)

	LC	Member Label	Sec	Axial[k]	y Shear[k]	z Shear[k]	Torque[k-ft]	y-y Mo...	z-z Mo...
103			3	11.788	-.215	1.169	0	6.234	1.147
104			4	11.731	-.215	1.169	0	9.351	1.72
105			5	6.769	-.19	-.043	-.009	-.002	2.273
106	2	M7	1	3.69	.232	.202	0	0	0
107			2	3.633	.232	.157	0	.479	-.618
108			3	3.575	.232	.112	0	.838	-1.236
109			4	3.518	.232	.067	0	1.078	-1.854
110			5	2.615	.481	.48	1.258	-.003	-2.682
111	2	M8	1	4.844	.306	.511	0	0	0
112			2	4.787	.306	.511	0	1.364	-.816
113			3	4.73	.306	.511	0	2.727	-1.632
114			4	4.673	.306	.511	0	4.091	-2.448
115			5	2.666	.3	.005	.079	.001	-3.258
116	2	M9	1	.054	-.149	-.048	-.003	.18	-.007
117			2	.121	1.941	.01	0	-.066	1.471
118			3	.121	-1.851	.01	0	.055	.931
119			4	.315	1.126	-.008	.001	.02	-5.982
120			5	.315	-2.666	-.008	.001	-.079	3.258
121	2	M10	1	-.009	-.148	.082	.009	.045	-.008
122			2	.206	2.002	.292	0	.031	1.946
123			3	.206	-1.79	-.308	0	-.066	.676
124			4	.497	1.176	.127	-.003	.817	-5.951
125			5	.497	-2.615	-.473	-.003	-1.258	2.682
126	2	M11	1	.082	.148	.009	-.008	-.045	-.009
127			2	.082	.093	.009	-.008	-.017	-.37
128			3	.082	-.039	.054	-.008	-.145	-.567
129			4	.048	-.094	.054	.007	.017	-.367
130			5	.048	-.149	.054	.007	.18	-.003
131	2	M12	1	.466	.847	.253	0	-1.258	-1.584
132			2	.466	.792	.253	0	-.498	-4.041
133			3	.481	-1.841	-.001	0	.263	-6.346
134			4	.481	-1.896	-.001	0	.083	-.741
135			5	.481	-1.951	-.001	0	.079	5.029
136	2	M13	1	1.105	2.66	-.023	0	.101	-2.074
137			2	1.105	2.605	-.023	0	.031	-9.972
138			3	1.105	-4.8	.003	0	-.039	-17.705
139			4	1.075	-4.855	.003	0	-.017	-3.191
140			5	1.075	-4.91	.003	0	-.009	11.457
141	2	M14	1	.794	1.885	-.141	0	.638	-2.486
142			2	.794	1.83	-.141	0	.216	-8.059
143			3	.842	-3.817	.044	0	-.206	-13.506
144			4	.842	-3.872	.044	0	-.031	-1.972
145			5	.842	-3.927	.044	0	.101	9.727
146	2	M15	1	-.045	.077	-.034	0	.156	.015
147			2	-.23	1.769	.015	0	-.097	-.046
148			3	-.23	-2.126	.015	0	.079	2.097
149			4	-.256	1.319	-.015	0	.003	-7.776
150			5	-.256	-2.576	-.015	0	-.176	-.237
151	2	M18	1	0	0	0	0	0	0
152			2	0	0	0	0	0	0
153			3	0	0	0	0	0	0
154			4	0	0	0	0	0	0
155			5	0	0	0	0	0	0
156	2	M19	1	5.587	-.187	.044	-.042	0	-.156
157			2	5.587	-.187	.044	-.042	.01	-.117
158			3	5.587	-.187	.044	-.042	.019	-.078
159			4	5.587	-.187	.044	-.042	.028	-.039

Member Section Forces (Continued)

	LC	Member Label	Sec	Axial[k]	y Shear[k]	z Shear[k]	Torque[k-ft]	y-y Mo...	z-z Mo...
160			5	5.587	-.187	.044	-.042	.037	0
161	2	M20	1	7.34	-.041	-.037	-.014	0	-.035
162			2	7.34	-.041	-.037	-.014	-.007	-.026
163			3	7.34	-.041	-.037	-.014	-.015	-.017
164			4	7.34	-.041	-.037	-.014	-.023	-.009
165			5	7.34	-.041	-.037	-.014	-.031	0
166	2	M21	1	2.576	.283	.014	.176	0	.237
167			2	2.576	.283	.014	.176	.003	.178
168			3	2.576	.283	.014	.176	.006	.119
169			4	2.576	.283	.014	.176	.009	.059
170			5	2.576	.283	.014	.176	.012	0
171	3	M3	1	8.928	.15	-.376	0	0	0
172			2	8.871	.104	-.376	0	-1.003	-.339
173			3	8.814	.059	-.376	0	-2.006	-.556
174			4	8.757	.014	-.376	0	-3.009	-.653
175			5	5.834	-.083	-.012	-.135	.005	-.585
176	3	M4	1	8.928	.15	.376	0	0	0
177			2	8.871	.104	.376	0	1.003	-.339
178			3	8.814	.059	.376	0	2.006	-.556
179			4	8.757	.014	.376	0	3.009	-.653
180			5	5.834	-.083	.012	.135	-.005	-.585
181	3	M5	1	10.76	-.075	-.5	0	0	0
182			2	10.703	-.075	-.5	0	-1.334	.199
183			3	10.646	-.075	-.5	0	-2.668	.398
184			4	10.589	-.075	-.5	0	-4.003	.596
185			5	6.749	-.1	.043	-.076	.003	.816
186	3	M6	1	10.76	-.075	.5	0	0	0
187			2	10.703	-.075	.5	0	1.334	.199
188			3	10.646	-.075	.5	0	2.668	.398
189			4	10.589	-.075	.5	0	4.003	.596
190			5	6.749	-.1	-.043	.076	-.003	.816
191	3	M7	1	4.394	.413	-.182	0	0	0
192			2	4.336	.413	-.182	0	-.486	-1.101
193			3	4.279	.413	-.182	0	-.972	-2.202
194			4	4.222	.413	-.182	0	-1.458	-3.303
195			5	2.76	.346	-.001	-.084	-.002	-4.349
196	3	M8	1	4.394	.413	.182	0	0	0
197			2	4.336	.413	.182	0	.486	-1.101
198			3	4.279	.413	.182	0	.972	-2.202
199			4	4.222	.413	.182	0	1.458	-3.303
200			5	2.76	.346	.001	.084	.002	-4.349
201	3	M9	1	.173	-.177	-.038	-.005	.182	-.007
202			2	.252	1.866	-.002	0	.004	.94
203			3	.252	-1.926	-.002	0	-.017	1.297
204			4	.359	1.032	-.007	.002	-.002	-6.02
205			5	.359	-2.76	-.007	.002	-.084	4.349
206	3	M10	1	.173	-.177	.038	.005	-.182	-.007
207			2	.252	1.866	.002	0	-.004	.94
208			3	.252	-1.926	.002	0	.017	1.297
209			4	.359	1.032	.007	-.002	.002	-6.02
210			5	.359	-2.76	.007	-.002	.084	4.349
211	3	M11	1	.038	.176	-.173	-.007	.182	-.005
212			2	.038	.121	-.023	-.007	-.112	-.45
213			3	.038	-.066	-.127	.007	.044	-.731
214			4	.038	-.121	.023	.007	-.112	-.45
215			5	.038	-.176	.173	.007	.182	-.005
216	3	M12	1	.175	1.405	-.052	0	.084	1.79

Member Section Forces (Continued)

	LC	Member Label	Sec	Axial[k]	y Shear[k]	z Shear[k]	Torque[k-ft]	y-y Mo...	z-z Mo...
217			2	.175	1.35	-.052	0	-.071	-2.344
218			3	.175	-1.296	.052	0	-.225	-6.313
219			4	.175	-1.35	.052	0	-.071	-2.344
220			5	.175	-1.405	.052	0	.084	1.79
221	3	M13	1	.505	3.785	-.032	0	.076	4.885
222			2	.505	3.73	-.032	0	-.019	-6.387
223			3	.505	-3.675	.032	0	-.114	-17.495
224			4	.505	-3.73	.032	0	-.019	-6.387
225			5	.505	-3.785	.032	0	.076	4.885
226	3	M14	1	.34	2.867	-.045	0	.135	3.711
227			2	.34	2.812	-.045	0	0	-4.808
228			3	.34	2.757	-.045	0	-.133	-13.163
229			4	.34	-2.812	.045	0	0	-4.808
230			5	.34	-2.867	.045	0	.135	3.711
231	3	M15	1	.254	.132	0	0	0	.015
232			2	.165	.175	0	0	0	-.323
233			3	.165	-2.146	0	0	0	2.054
234			4	.102	1.304	0	0	0	-7.653
235			5	.102	-2.591	0	0	0	.063
236	3	M18	1	0	0	0	0	0	0
237			2	0	0	0	0	0	0
238			3	0	0	0	0	0	0
239			4	0	0	0	0	0	0
240			5	0	0	0	0	0	0
241	3	M19	1	5.512	-.093	0	0	0	-.078
242			2	5.512	-.093	0	0	0	-.058
243			3	5.512	-.093	0	0	0	-.039
244			4	5.512	-.093	0	0	0	-.019
245			5	5.512	-.093	0	0	0	0
246	3	M20	1	7.345	-.077	0	0	0	-.065
247			2	7.345	-.077	0	0	0	-.048
248			3	7.345	-.077	0	0	0	-.032
249			4	7.345	-.077	0	0	0	-.016
250			5	7.345	-.077	0	0	0	0
251	3	M21	1	2.591	-.075	0	0	0	-.063
252			2	2.591	-.075	0	0	0	-.047
253			3	2.591	-.075	0	0	0	-.032
254			4	2.591	-.075	0	0	0	-.016
255			5	2.591	-.075	0	0	0	0
256	4	M3	1	5.595	-.075	.346	0	0	0
257			2	5.552	-.075	.301	0	.862	.201
258			3	5.509	-.075	.256	0	1.605	.403
259			4	5.467	-.075	.211	0	2.228	.604
260			5	4.306	-.21	.833	-.637	.006	.917
261	4	M4	1	7.499	-.016	.855	0	0	0
262			2	7.456	-.016	.855	0	2.281	.044
263			3	7.413	-.016	.855	0	4.562	.087
264			4	7.37	-.016	.855	0	6.842	.131
265			5	4.248	-.06	.05	.108	0	.212
266	4	M5	1	6.715	-.223	.31	0	0	0
267			2	6.672	-.223	.265	0	.767	.594
268			3	6.629	-.223	.22	0	1.414	1.188
269			4	6.586	-.223	.175	0	1.942	1.782
270			5	4.885	-.23	1.068	-.109	.003	2.382
271	4	M6	1	8.878	-.139	1	0	0	0
272			2	8.835	-.139	1	0	2.669	.371
273			3	8.793	-.139	1	0	5.337	.742

Member Section Forces (Continued)

	LC	Member Label	Sec	Axial[k]	y Shear[k]	z Shear[k]	Torque[k-ft]	y-y Mo...	z-z Mo...
274			4	8.75	-.139	.1	0	8.006	1.113
275			5	4.896	-.132	-.027	-.004	-.001	1.478
276	4	M7	1	2.532	.161	.246	0	0	0
277			2	2.489	.161	.201	0	.596	-.43
278			3	2.446	.161	.156	0	1.073	-.86
279			4	2.403	.161	.111	0	1.43	-1.29
280			5	1.891	.416	.476	1.257	-.002	-1.934
281	4	M8	1	3.663	.233	.454	0	0	0
282			2	3.62	.233	.454	0	1.212	-.621
283			3	3.577	.233	.454	0	2.423	-1.243
284			4	3.534	.233	.454	0	3.635	-1.864
285			5	1.94	.236	.006	.068	0	-2.487
286	4	M9	1	.053	-.11	-.047	-.001	.174	-.005
287			2	.109	1.395	.009	0	-.059	.992
288			3	.109	-1.348	.009	0	.049	.714
289			4	.243	.804	-.007	0	.022	-4.329
290			5	.243	-1.94	-.007	0	-.068	2.487
291	4	M10	1	-.011	-.109	.081	.007	.052	-.006
292			2	.193	1.454	.292	0	.029	1.452
293			3	.193	-1.29	-.308	0	-.067	.466
294			4	.424	.852	.128	-.002	.812	-4.298
295			5	.424	-1.891	-.472	-.002	-1.257	1.934
296	4	M11	1	.081	.109	.011	-.006	-.052	-.007
297			2	.081	.067	.011	-.006	-.02	-.271
298			3	.081	-.027	.053	-.006	-.144	-.412
299			4	.047	-.068	.053	.005	.015	-.268
300			5	.047	-.109	.053	.005	.174	-.001
301	4	M12	1	.416	.47	.256	0	-1.257	-2.013
302			2	.416	.428	.256	0	-.489	-3.36
303			3	.431	-1.47	-.007	0	.28	-4.595
304			4	.431	-1.511	-.007	0	.09	-.124
305			5	.431	-1.552	-.007	0	.068	4.47
306	4	M13	1	.966	1.661	-.027	0	.109	-3.132
307			2	.966	1.62	-.027	0	.028	-8.054
308			3	.966	-3.732	.005	0	-.053	-12.853
309			4	.937	-3.774	.005	0	-.02	-1.567
310			5	.937	-3.815	.005	0	-.004	9.816
311	4	M14	1	.69	1.12	-.142	0	.637	-3.283
312			2	.69	1.079	-.142	0	.211	-6.581
313			3	.738	-2.999	.048	0	-.216	-9.794
314			4	.738	-3.041	.048	0	-.035	-.733
315			5	.738	-3.082	.048	0	.108	8.45
316	4	M15	1	-.042	.053	-.034	0	.156	.011
317			2	-.232	1.275	.014	0	-.094	-.05
318			3	-.232	-1.537	.014	0	.075	1.525
319			4	-.264	.956	-.014	0	.002	-5.631
320			5	-.264	-1.856	-.014	0	-.168	-.233
321	4	M18	1	0	0	0	0	0	0
322			2	0	0	0	0	0	0
323			3	0	0	0	0	0	0
324			4	0	0	0	0	0	0
325			5	0	0	0	0	0	0
326	4	M19	1	4.033	-.191	.045	-.037	0	-.16
327			2	4.033	-.191	.045	-.037	.01	-.12
328			3	4.033	-.191	.045	-.037	.019	-.08
329			4	4.033	-.191	.045	-.037	.029	-.04
330			5	4.033	-.191	.045	-.037	.038	0

Member Section Forces (Continued)

	LC	Member Label	Sec	Axial[k]	y Shear[k]	z Shear[k]	Torque[k-ft]	y-y Mo...	z-z Mo...
331	4	M20	1	5.305	-.04	-.033	-.017	0	-.034
332			2	5.305	-.04	-.033	-.017	-.007	-.025
333			3	5.305	-.04	-.033	-.017	-.014	-.017
334			4	5.305	-.04	-.033	-.017	-.021	-.008
335			5	5.305	-.04	-.033	-.017	-.028	0
336	4	M21	1	1.856	.279	.014	.168	0	.233
337			2	1.856	.279	.014	.168	.003	.175
338			3	1.856	.279	.014	.168	.006	.117
339			4	1.856	.279	.014	.168	.009	.058
340			5	1.856	.279	.014	.168	.011	0
341	5	M3	1	6.437	.168	-.27	0	0	0
342			2	6.394	.123	-.27	0	-.72	-.389
343			3	6.352	.078	-.27	0	-1.441	-.656
344			4	6.309	.032	-.27	0	-2.161	-.803
345			5	4.202	-.068	-.022	-.137	.003	-.783
346	5	M4	1	6.437	.168	.27	0	0	0
347			2	6.394	.123	.27	0	.72	-.389
348			3	6.352	.078	.27	0	1.441	-.656
349			4	6.309	.032	.27	0	2.161	-.803
350			5	4.202	-.068	.022	.137	-.003	-.783
351	5	M5	1	7.785	-.005	-.361	0	0	0
352			2	7.742	-.005	-.361	0	-.964	.014
353			3	7.699	-.005	-.361	0	-1.928	.029
354			4	7.656	-.005	-.361	0	-2.892	.043
355			5	4.877	-.042	.024	-.083	.002	.088
356	5	M6	1	7.785	-.005	.361	0	0	0
357			2	7.742	-.005	.361	0	.964	.014
358			3	7.699	-.005	.361	0	1.928	.029
359			4	7.656	-.005	.361	0	2.892	.043
360			5	4.877	-.042	-.024	.083	-.002	.088
361	5	M7	1	3.219	.335	-.132	0	0	0
362			2	3.176	.335	-.132	0	-.351	-.894
363			3	3.133	.335	-.132	0	-.703	-1.787
364			4	3.09	.335	-.132	0	-1.054	-2.681
365			5	2.03	.278	-.004	-.078	-.001	-3.527
366	5	M8	1	3.219	.335	.132	0	0	0
367			2	3.176	.335	.132	0	.351	-.894
368			3	3.133	.335	.132	0	.703	-1.787
369			4	3.09	.335	.132	0	1.054	-2.681
370			5	2.03	.278	.004	.078	.001	-3.527
371	5	M9	1	.172	-.136	-.037	-.004	.176	-.005
372			2	.238	1.324	-.002	0	.008	.489
373			3	.238	-1.42	-.002	0	-.019	1.064
374			4	.285	.714	-.007	.001	0	-4.367
375			5	.285	-2.03	-.007	.001	-.078	3.527
376	5	M10	1	.172	-.136	.037	.004	-.176	-.005
377			2	.238	1.324	.002	0	-.008	.489
378			3	.238	-1.42	.002	0	.019	1.064
379			4	.285	.714	.007	-.001	0	-4.367
380			5	.285	-2.03	.007	-.001	.078	3.527
381	5	M11	1	.037	.135	-.172	-.005	.176	-.004
382			2	.037	.094	-.022	-.005	-.115	-.347
383			3	.037	-.053	-.128	.005	.045	-.567
384			4	.037	-.094	.022	.005	-.115	-.347
385			5	.037	-.135	.172	.005	.176	-.004
386	5	M12	1	.125	1.018	-.047	0	.078	1.297
387			2	.125	.977	-.047	0	-.062	-1.695

Member Section Forces (Continued)

	LC	Member Label	Sec	Axial[k]	y Shear[k]	z Shear[k]	Torque[k-ft]	y-y Mo...	z-z Mo...
388			3	.125	-.936	.047	0	-.203	-4.563
389			4	.125	-.977	.047	0	-.062	-1.695
390			5	.125	-1.018	.047	0	.078	1.297
391	5	M13	1	.366	2.738	-.035	0	.083	3.536
392			2	.366	2.697	-.035	0	-.022	-4.616
393			3	.366	-2.656	.035	0	-.126	-12.645
394			4	.366	-2.697	.035	0	-.022	-4.616
395			5	.366	-2.738	.035	0	.083	3.536
396	5	M14	1	.235	2.064	-.047	0	.137	2.677
397			2	.235	2.023	-.047	0	-.004	-3.454
398			3	.235	1.982	-.047	0	-.145	-9.461
399			4	.235	-2.023	.047	0	-.004	-3.454
400			5	.235	-2.064	.047	0	.137	2.677
401	5	M15	1	.256	.105	0	0	0	.011
402			2	.162	1.256	0	0	0	-.313
403			3	.162	-1.556	0	0	0	1.483
404			4	.093	.941	0	0	0	-5.51
405			5	.093	-1.871	0	0	0	.066
406	5	M18	1	0	0	0	0	0	0
407			2	0	0	0	0	0	0
408			3	0	0	0	0	0	0
409			4	0	0	0	0	0	0
410			5	0	0	0	0	0	0
411	5	M19	1	3.963	-.096	0	0	0	-.081
412			2	3.963	-.096	0	0	0	-.061
413			3	3.963	-.096	0	0	0	-.04
414			4	3.963	-.096	0	0	0	-.02
415			5	3.963	-.096	0	0	0	0
416	5	M20	1	5.309	-.076	0	0	0	-.064
417			2	5.309	-.076	0	0	0	-.048
418			3	5.309	-.076	0	0	0	-.032
419			4	5.309	-.076	0	0	0	-.016
420			5	5.309	-.076	0	0	0	0
421	5	M21	1	1.871	-.079	0	0	0	-.066
422			2	1.871	-.079	0	0	0	-.05
423			3	1.871	-.079	0	0	0	-.033
424			4	1.871	-.079	0	0	0	-.017
425			5	1.871	-.079	0	0	0	0
426	6	M3	1	-3.638	.013	.683	0	0	0
427			2	-3.681	.013	.639	0	1.763	-.035
428			3	-3.723	.013	.594	0	3.407	-.07
429			4	-3.766	.013	.549	0	4.931	-.106
430			5	-1.944	-.136	.815	-.641	0	-.016
431	6	M4	1	-1.98	.064	.365	0	0	0
432			2	-2.023	.064	.365	0	.973	-.172
433			3	-2.066	.064	.365	0	1.947	-.344
434			4	-2.108	.064	.365	0	2.92	-.516
435			5	-1.995	.003	.042	.137	.004	-.636
436	6	M5	1	-4.612	.034	.773	0	0	0
437			2	-4.655	.034	.728	0	2.002	-.091
438			3	-4.698	.034	.683	0	3.884	-.181
439			4	-4.741	.034	.638	0	5.646	-.272
440			5	-2.422	-.005	1.036	-.138	0	-.33
441	6	M6	1	-2.757	.106	.351	0	0	0
442			2	-2.8	.106	.351	0	.935	-.284
443			3	-2.843	.106	.351	0	1.87	-.568
444			4	-2.885	.106	.351	0	2.805	-.852

Member Section Forces (Continued)

	LC	Member Label	Sec	Axial[k]	y Shear[k]	z Shear[k]	Torque[k-ft]	y-y Mo...	z-z Mo...
445			5	-2.412	.094	-.019	.016	.002	-1.125
446	6	M7	1	-1.741	-.145	.419	0	0	0
447			2	-1.784	-.145	.374	0	1.059	.386
448			3	-1.827	-.145	.33	0	1.998	.772
449			4	-1.87	-.145	.285	0	2.817	1.158
450			5	-.952	.125	.471	1.262	0	1.318
451	6	M8	1	-.69	-.081	.237	0	0	0
452			2	-.733	-.081	.237	0	.632	.217
453			3	-.776	-.081	.237	0	1.264	.435
454			4	-.819	-.081	.237	0	1.895	.652
455			5	-.91	-.05	.003	.024	-.001	.843
456	6	M9	1	.049	-.02	-.043	.004	.153	.003
457			2	.046	-.681	.005	0	-.034	-.422
458			3	.046	.653	.005	0	.027	-.258
459			4	-.048	-.424	-.004	-.001	.028	2.067
460			5	-.048	.91	-.004	-.001	-.024	-.843
461	6	M10	1	-.015	-.019	.077	0	.077	.002
462			2	.121	-.629	.293	0	.021	-.017
463			3	.121	.705	-.307	0	-.066	-.478
464			4	.127	-.382	.129	0	.795	2.097
465			5	.127	.952	-.471	0	-1.262	-1.318
466	6	M11	1	.077	.019	.015	.002	-.077	0
467			2	.077	-.022	.015	.002	-.031	.004
468			3	.077	.063	.049	-.003	-.143	.133
469			4	.043	.022	.049	-.003	.005	.007
470			5	.043	-.02	.049	-.003	.153	.004
471	6	M12	1	.223	-.961	.271	0	-1.262	-3.71
472			2	.223	-1.002	.271	0	-.449	-.766
473			3	.236	-1.043	.271	0	.365	2.302
474			4	.236	-.007	-.033	0	.122	2.25
475			5	.236	-.048	-.033	0	.024	2.333
476	6	M13	1	.407	-2.362	-.04	0	.138	-7.66
477			2	.407	-2.403	-.04	0	.017	-.513
478			3	.407	-2.444	-.04	0	-.105	6.777
479			4	.382	.558	.016	0	-.033	5.042
480			5	.382	.517	.016	0	.016	3.43
481	6	M14	1	.285	-1.866	-.151	0	.641	-6.596
482			2	.285	-1.907	-.151	0	.189	-.937
483			3	.332	-1.948	-.151	0	-.263	4.844
484			4	.332	.197	.063	0	-.053	4.15
485			5	.332	.156	.063	0	.137	3.619
486	6	M15	1	-.034	-.126	-.034	0	.157	-.005
487			2	-.247	-.704	.012	0	-.084	.424
488			3	-.247	.904	.012	0	.065	-.775
489			4	-.304	-.531	-.012	0	-.003	3.021
490			5	-.304	1.077	-.012	0	-.145	-.258
491	6	M18	1	0	0	0	0	0	0
492			2	0	0	0	0	0	0
493			3	0	0	0	0	0	0
494			4	0	0	0	0	0	0
495			5	0	0	0	0	0	0
496	6	M19	1	-2.186	-.215	.048	-.02	0	-.18
497			2	-2.186	-.215	.048	-.02	.011	-.135
498			3	-2.186	-.215	.048	-.02	.021	-.09
499			4	-2.186	-.215	.048	-.02	.03	-.045
500			5	-2.186	-.215	.048	-.02	.04	0
501	6	M20	1	-3.042	-.058	-.022	-.023	0	-.049

Member Section Forces (Continued)

	LC	Member Label	Sec	Axial[k]	y Shear[k]	z Shear[k]	Torque[k-ft]	y-y Mo...	z-z Mo...
502			2	-3.042	-.058	-.022	-.023	-.004	-.037
503			3	-3.042	-.058	-.022	-.023	-.009	-.024
504			4	-3.042	-.058	-.022	-.023	-.014	-.012
505			5	-3.042	-.058	-.022	-.023	-.019	0
506	6	M21	1	-1.077	.308	.013	.145	0	.258
507			2	-1.077	.308	.013	.145	.002	.193
508			3	-1.077	.308	.013	.145	.005	.129
509			4	-1.077	.308	.013	.145	.008	.064
510			5	-1.077	.308	.013	.145	.01	0
511	7	M3	1	-2.902	.232	.143	0	0	0
512			2	-2.945	.187	.143	0	.381	-.559
513			3	-2.988	.141	.143	0	.762	-.997
514			4	-3.031	.096	.143	0	1.143	-1.313
515			5	-2.033	0	-.025	-.153	-.002	-1.466
516	7	M4	1	-2.902	.232	-.143	0	0	0
517			2	-2.945	.187	-.143	0	-.381	-.559
518			3	-2.988	.141	-.143	0	-.762	-.997
519			4	-3.031	.096	-.143	0	-1.143	-1.313
520			5	-2.033	0	.025	.153	.002	-1.466
521	7	M5	1	-3.697	.219	.195	0	0	0
522			2	-3.739	.219	.195	0	.52	-.585
523			3	-3.782	.219	.195	0	1.039	-1.171
524			4	-3.825	.219	.195	0	1.559	-1.756
525			5	-2.429	.184	.006	-.106	-.001	-2.311
526	7	M6	1	-3.697	.219	-.195	0	0	0
527			2	-3.739	.219	-.195	0	-.52	-.585
528			3	-3.782	.219	-.195	0	-1.039	-1.171
529			4	-3.825	.219	-.195	0	-1.559	-1.756
530			5	-2.429	.184	-.006	.106	.001	-2.311
531	7	M7	1	-1.111	.006	.064	0	0	0
532			2	-1.153	.006	.064	0	.169	-.015
533			3	-1.196	.006	.064	0	.339	-.03
534			4	-1.239	.006	.064	0	.508	-.044
535			5	-.833	-.02	-.005	-.053	0	-.038
536	7	M8	1	-1.111	.006	-.064	0	0	0
537			2	-1.153	.006	-.064	0	-.169	-.015
538			3	-1.196	.006	-.064	0	-.339	-.03
539			4	-1.239	.006	-.064	0	-.508	-.044
540			5	-.833	-.02	.005	.053	0	-.038
541	7	M9	1	.168	-.041	-.033	.002	.153	.003
542			2	.167	-.741	-.005	0	.024	-.841
543			3	.167	.594	-.005	0	-.031	.042
544			4	-.017	-.501	-.006	0	.013	2.032
545			5	-.017	.833	-.006	0	-.053	.038
546	7	M10	1	.168	-.041	.033	-.002	-.153	.003
547			2	.167	-.741	.005	0	-.024	-.841
548			3	.167	.594	.005	0	.031	.042
549			4	-.017	-.501	.006	0	-.013	2.032
550			5	-.017	.833	.006	0	.053	.038
551	7	M11	1	.033	.041	-.168	.003	.153	.002
552			2	.033	0	-.018	.003	-.125	-.06
553			3	.033	-.041	.132	-.003	.046	0
554			4	.033	0	.018	-.003	-.125	-.06
555			5	.033	-.041	.168	-.003	.153	.002
556	7	M12	1	-.069	-.448	-.026	0	.053	-.62
557			2	-.069	-.49	-.026	0	-.026	.787
558			3	-.069	.531	.026	0	-.105	2.318

Member Section Forces (Continued)

	LC	Member Label	Sec	Axial[k]	y Shear[k]	z Shear[k]	Torque[k-ft]	y-y Mo...	z-z Mo...
559			4	-.069	.49	.026	0	-.026	.787
560			5	-.069	.448	.026	0	.053	-.62
561	7	M13	1	-.194	-1.439	-.047	0	.106	-1.922
562			2	-.194	-1.48	-.047	0	-.033	2.456
563			3	-.194	1.521	.047	0	-.173	6.958
564			4	-.194	1.48	.047	0	-.033	2.456
565			5	-.194	1.439	.047	0	.106	-1.922
566	7	M14	1	-.171	-1.04	-.059	0	.153	-1.385
567			2	-.171	-1.081	-.059	0	-.024	1.796
568			3	-.171	-1.122	-.059	0	-.2	5.1
569			4	-.171	1.081	.059	0	-.024	1.796
570			5	-.171	1.04	.059	0	.153	-1.385
571	7	M15	1	.264	-.082	0	0	0	-.005
572			2	.146	-.719	0	0	0	.207
573			3	.146	.889	0	0	0	-.816
574			4	.053	-.546	0	0	0	3.132
575			5	.053	1.062	0	0	0	.04
576	7	M18	1	0	0	0	0	0	0
577			2	0	0	0	0	0	0
578			3	0	0	0	0	0	0
579			4	0	0	0	0	0	0
580			5	0	0	0	0	0	0
581	7	M19	1	-2.245	-.119	0	0	0	-.099
582			2	-2.245	-.119	0	0	0	-.075
583			3	-2.245	-.119	0	0	0	-.05
584			4	-2.245	-.119	0	0	0	-.025
585			5	-2.245	-.119	0	0	0	0
586	7	M20	1	-3.043	-.096	0	0	0	-.08
587			2	-3.043	-.096	0	0	0	-.06
588			3	-3.043	-.096	0	0	0	-.04
589			4	-3.043	-.096	0	0	0	-.02
590			5	-3.043	-.096	0	0	0	0
591	7	M21	1	-1.062	-.048	0	0	0	-.04
592			2	-1.062	-.048	0	0	0	-.03
593			3	-1.062	-.048	0	0	0	-.02
594			4	-1.062	-.048	0	0	0	-.01
595			5	-1.062	-.048	0	0	0	0

Member Section Deflections

	LC	Member Label	Sec	x [in]	y [in]	z [in]	x Rotate[rad]	(n) L/y Ratio	(n) L/z Ratio
1	1	M3	1	0	0	0	1.315e-3	NC	NC
2			2	-.003	.082	-.073	1.315e-3	9372.911	1746.31
3			3	-.005	.159	-.153	1.315e-3	5858.317	835.119
4			4	-.008	.225	-.248	1.315e-3	6696.108	516.934
5			5	-.01	.275	-.364	1.389e-3	NC	351.599
6	1	M4	1	0	0	0	-5.983e-4	NC	NC
7			2	-.003	.065	-.167	-5.983e-4	NC	1382.284
8			3	-.006	.127	-.297	-5.983e-4	8168.533	867.903
9			4	-.009	.181	-.351	-5.983e-4	9335.698	1008.443
10			5	-.011	.222	-.298	-6.081e-4	NC	NC
11	1	M5	1	0	0	0	-4.504e-5	NC	NC
12			2	-.003	.11	-.071	-4.504e-5	3100.544	1795.793
13			3	-.006	.204	-.155	-4.504e-5	1937.857	827.208
14			4	-.01	.264	-.264	-4.504e-5	2214.724	485.63
15			5	-.012	.275	-.41	-3.721e-5	NC	312.072
16	1	M6	1	0	0	0	-4.002e-4	NC	NC

Member Section Forces (Continued)

	LC	Member Label	Sec	Axial[k]	y Shear[k]	z Shear[k]	Torque[k-ft]	y-y Mo...	z-z Mo...
559			4	-.069	.49	.026	0	-.026	.787
560			5	-.069	.448	.026	0	.053	-.62
561	7	M13	1	-.194	-1.439	-.047	0	.106	-1.922
562			2	-.194	-1.48	-.047	0	-.033	2.456
563			3	-.194	1.521	.047	0	-.173	6.958
564			4	-.194	1.48	.047	0	-.033	2.456
565			5	-.194	1.439	.047	0	.106	-1.922
566	7	M14	1	-.171	-1.04	-.059	0	.153	-1.385
567			2	-.171	-1.081	-.059	0	-.024	1.796
568			3	-.171	-1.122	-.059	0	-.2	5.1
569			4	-.171	1.081	.059	0	-.024	1.796
570			5	-.171	1.04	.059	0	.153	-1.385
571	7	M15	1	.264	-.082	0	0	0	-.005
572			2	.146	-.719	0	0	0	.207
573			3	.146	.889	0	0	0	-.816
574			4	.053	-.546	0	0	0	3.132
575			5	.053	1.062	0	0	0	.04
576	7	M18	1	0	0	0	0	0	0
577			2	0	0	0	0	0	0
578			3	0	0	0	0	0	0
579			4	0	0	0	0	0	0
580			5	0	0	0	0	0	0
581	7	M19	1	-2.245	-.119	0	0	0	-.099
582			2	-2.245	-.119	0	0	0	-.075
583			3	-2.245	-.119	0	0	0	-.05
584			4	-2.245	-.119	0	0	0	-.025
585			5	-2.245	-.119	0	0	0	0
586	7	M20	1	-3.043	-.096	0	0	0	-.08
587			2	-3.043	-.096	0	0	0	-.06
588			3	-3.043	-.096	0	0	0	-.04
589			4	-3.043	-.096	0	0	0	-.02
590			5	-3.043	-.096	0	0	0	0
591	7	M21	1	-1.062	-.048	0	0	0	-.04
592			2	-1.062	-.048	0	0	0	-.03
593			3	-1.062	-.048	0	0	0	-.02
594			4	-1.062	-.048	0	0	0	-.01
595			5	-1.062	-.048	0	0	0	0

Member Section Deflections

	LC	Member Label	Sec	x [in]	y [in]	z [in]	x Rotate[rad]	(n) L/y Ratio	(n) L/z Ratio
1	1	M3	1	0	0	0	1.315e-3	NC	NC
2			2	-.003	.082	-.073	1.315e-3	9372.911	1746.31
3			3	-.005	.159	-.153	1.315e-3	5858.317	835.119
4			4	-.008	.225	-.248	1.315e-3	6696.108	516.934
5			5	-.01	.275	-.364	1.389e-3	NC	351.599
6	1	M4	1	0	0	0	-5.983e-4	NC	NC
7			2	-.003	.065	-.167	-5.983e-4	NC	1382.284
8			3	-.006	.127	-.297	-5.983e-4	8168.533	867.903
9			4	-.009	.181	-.351	-5.983e-4	9335.698	1008.443
10			5	-.011	.222	-.298	-6.081e-4	NC	NC
11	1	M5	1	0	0	0	-4.504e-5	NC	NC
12			2	-.003	.11	-.071	-4.504e-5	3100.544	1795.793
13			3	-.006	.204	-.155	-4.504e-5	1937.857	827.208
14			4	-.01	.264	-.264	-4.504e-5	2214.724	485.63
15			5	-.012	.275	-.41	-3.721e-5	NC	312.072
16	1	M6	1	0	0	0	-4.002e-4	NC	NC

Member Section Deflections (Continued)

	LC	Member Label	Sec	x [in]	y [in]	z [in]	x Rotate[rad]	(n) L/y Ratio	(n) L/z Ratio
17			2	-.003	.091	-.195	-4.002e-4	3573.968	1123.195
18			3	-.007	.169	-.343	-4.002e-4	2233.743	705.205
19			4	-.01	.217	-.399	-4.002e-4	2552.856	819.303
20			5	-.013	.223	-.324	-3.954e-4	NC	NC
21	1	M7	1	0	0	0	-4.122e-3	NC	NC
22			2	-.001	.032	-.043	-4.122e-3	3972.726	2969.406
23			3	-.002	.079	-.088	-4.122e-3	1616.876	1455.986
24			4	-.004	.156	-.137	-4.122e-3	822.83	933.386
25			5	-.005	.276	-.194	-4.269e-3	463.579	658.943
26	1	M8	1	0	0	0	-3.559e-5	NC	NC
27			2	-.001	.014	-.087	-3.559e-5	8931.625	2759.545
28			3	-.003	.045	-.155	-3.559e-5	2828.553	1732.635
29			4	-.004	.109	-.186	-3.559e-5	1170.503	2013.129
30			5	-.005	.223	-.163	-4.872e-5	573.422	NC
31	1	M9	1	-.222	-.365	-.398	3.069e-4	1601.834	NC
32			2	-.223	-.044	-.285	2.805e-3	NC	NC
33			3	-.223	-.055	-.328	3.373e-3	NC	NC
34			4	-.223	-.296	-.255	2.619e-3	1978.175	NC
35			5	-.223	-.005	-.163	1.205e-3	NC	NC
36	1	M10	1	-.275	-.378	-.398	-1.245e-4	1542.847	NC
37			2	-.275	-.039	-.552	-4.084e-3	NC	2813.222
38			3	-.275	-.054	-.557	-4.74e-3	NC	2206.054
39			4	-.276	-.297	-.746	-3.725e-3	1973.827	1149.691
40			5	-.276	-.005	-.194	-1.874e-3	NC	NC
41	1	M11	1	.398	-.378	-.275	-4.65e-3	NC	2733.477
42			2	.398	-.382	-.259	-3.546e-3	NC	3895.529
43			3	.398	-.382	-.244	-2.442e-3	NC	6607.149
44			4	.398	-.375	-.236	-3.472e-3	NC	NC
45			5	.398	-.365	-.222	-4.503e-3	NC	NC
46	1	M12	1	.175	-.004	-.233	-4.068e-3	NC	2794.219
47			2	.175	-.069	-.159	-4.025e-3	2249.181	6403.871
48			3	.175	-.097	-.164	-3.982e-3	1564.503	8619.926
49			4	.175	-.061	-.176	-3.939e-3	2585.54	NC
50			5	.175	-.005	-.181	-3.896e-3	NC	NC
51	1	M13	1	.36	-.012	-.278	-8.654e-6	NC	NC
52			2	.36	-.186	-.272	2.336e-5	825.349	NC
53			3	.36	-.267	-.26	5.538e-5	564.387	NC
54			4	.36	-.17	-.243	8.74e-5	916.853	NC
55			5	.359	-.013	-.226	1.194e-4	NC	NC
56	1	M14	1	.325	-.01	-.282	-1.44e-3	NC	NC
57			2	.325	-.144	-.272	-1.387e-3	1073.975	6190.136
58			3	.325	-.205	-.247	-1.335e-3	740.735	NC
59			4	.325	-.129	-.228	-1.282e-3	1215.159	NC
60			5	.325	-.011	-.211	-1.229e-3	NC	NC
61	1	M15	1	-.244	-.382	-.398	9.168e-5	NC	NC
62			2	-.244	-.281	-.309	2.637e-4	NC	NC
63			3	-.244	-.289	-.361	2.829e-4	NC	7666.195
64			4	-.244	-.608	-.271	2.286e-4	1309.533	NC
65			5	-.244	-.097	-.174	1.375e-4	NC	NC
66	1	M18	1	.382	.244	.398	4.265e-4	NC	NC
67			2	.382	.238	.398	4.265e-4	NC	NC
68			3	.382	.232	.399	4.265e-4	NC	NC
69			4	.382	.226	.399	4.265e-4	NC	NC
70			5	.382	.22	.399	4.265e-4	NC	NC
71	1	M19	1	.205	.244	.322	6.6e-4	NC	NC
72			2	.205	.245	.323	6.6e-4	NC	NC
73			3	.205	.246	.324	6.6e-4	NC	NC

Member Section Deflections (Continued)

	LC	Member Label	Sec	x [in]	y [in]	z [in]	x Rotate[rad]	(n) L/y Ratio	(n) L/z Ratio
74			4	.205	.246	.324	6.6e-4	NC	NC
75			5	.205	.247	.325	6.6e-4	NC	NC
76	1	M20	1	.267	.244	.357	4.164e-4	NC	NC
77			2	.267	.248	.358	4.164e-4	NC	NC
78			3	.267	.252	.358	4.164e-4	NC	NC
79			4	.267	.256	.359	4.164e-4	NC	NC
80			5	.267	.26	.36	4.164e-4	NC	NC
81	1	M21	1	.097	.244	.174	-3.111e-4	NC	NC
82			2	.097	.224	.174	-3.111e-4	NC	NC
83			3	.097	.204	.175	-3.111e-4	NC	NC
84			4	.097	.184	.175	-3.111e-4	NC	NC
85			5	.097	.164	.175	-3.111e-4	NC	NC
86	2	M3	1	0	0	0	2.239e-3	NC	NC
87			2	-.002	.077	-.194	2.239e-3	NC	4895.759
88			3	-.004	.148	-.377	2.239e-3	6348.06	3155.385
89			4	-.006	.209	-.538	2.239e-3	7257.256	3813.195
90			5	-.008	.256	-.673	2.39e-3	NC	NC
91	2	M4	1	0	0	0	-7.993e-4	NC	NC
92			2	-.003	.043	-.274	-7.993e-4	NC	1070.819
93			3	-.005	.084	-.498	-7.993e-4	NC	672.352
94			4	-.008	.121	-.626	-7.993e-4	NC	781.273
95			5	-.01	.152	-.616	-8.234e-4	NC	NC
96	2	M5	1	0	0	0	-3.125e-4	NC	NC
97			2	-.003	.101	-.206	-3.125e-4	3433.156	6935.727
98			3	-.005	.188	-.403	-3.125e-4	2145.754	4523.646
99			4	-.008	.244	-.584	-3.125e-4	2452.377	5580.316
100			5	-.01	.256	-.749	-2.886e-4	NC	NC
101	2	M6	1	0	0	0	-5.384e-4	NC	NC
102			2	-.003	.065	-.31	-5.384e-4	4820.149	902.784
103			3	-.006	.119	-.563	-5.384e-4	3012.619	566.824
104			4	-.009	.152	-.7	-5.384e-4	3443.038	658.558
105			5	-.012	.153	-.674	-5.363e-4	NC	NC
106	2	M7	1	0	0	0	-7.531e-3	NC	NC
107			2	0	.036	-.11	-7.531e-3	3594.845	6821.577
108			3	-.002	.083	-.212	-7.531e-3	1548.445	4437.981
109			4	-.003	.153	-.298	-7.531e-3	838.679	5428.696
110			5	-.004	.257	-.366	-7.829e-3	498.259	NC
111	2	M8	1	0	0	0	-7.203e-4	NC	NC
112			2	-.001	0	-.147	-7.203e-4	NC	2063.787
113			3	-.002	.016	-.268	-7.203e-4	7963.602	1295.799
114			4	-.004	.062	-.339	-7.203e-4	2067.966	1505.615
115			5	-.005	.153	-.339	-7.391e-4	836.289	NC
116	2	M9	1	-.152	-.305	-.777	3.682e-4	1920.019	NC
117			2	-.152	-.039	-.601	1.721e-3	NC	8584.889
118			3	-.152	-.047	-.678	2.166e-3	NC	4817.933
119			4	-.153	-.25	-.554	1.655e-3	2348.766	5448.182
120			5	-.153	-.005	-.339	6.659e-4	NC	NC
121	2	M10	1	-.256	-.331	-.777	-9.519e-6	1761.286	NC
122			2	-.256	-.029	-1.036	-4.211e-3	NC	1592.188
123			3	-.256	-.045	-1.048	-4.821e-3	NC	1209.581
124			4	-.256	-.25	-1.414	-3.81e-3	2336.773	609.333
125			5	-.257	-.004	-.366	-1.987e-3	NC	NC
126	2	M11	1	.777	-.331	-.256	-4.061e-3	NC	1392.355
127			2	.777	-.331	-.221	-3.082e-3	NC	2104.873
128			3	.777	-.327	-.191	-2.104e-3	NC	3747.119
129			4	.777	-.318	-.174	-2.938e-3	NC	6611.985
130			5	.777	-.305	-.152	-3.772e-3	NC	NC

Member Section Deflections (Continued)

	LC	Member Label	Sec	x [in]	y [in]	z [in]	x Rotate[rad]	(n) L/y Ratio	(n) L/z Ratio
131	2	M12	1	.346	-.003	-.22	-3.493e-3	NC	1423.207
132			2	.346	-.063	-.098	-3.409e-3	2434.372	6820.816
133			3	.346	-.082	-.122	-3.325e-3	1841.662	NC
134			4	.346	-.047	-.133	-3.241e-3	3371.135	NC
135			5	.346	-.005	-.119	-3.157e-3	NC	NC
136	2	M13	1	.698	-.009	-.258	-6.501e-5	NC	1414.953
137			2	.698	-.168	-.235	-2.059e-6	911.072	1821.809
138			3	.697	-.227	-.204	6.089e-5	663.842	3049.027
139			4	.697	-.135	-.177	1.238e-4	1158.622	6823.167
140			5	.697	-.011	-.156	1.868e-4	NC	NC
141	2	M14	1	.632	-.008	-.243	-1.342e-3	NC	1443.599
142			2	.632	-.131	-.25	-1.239e-3	1173.067	1350.267
143			3	.632	-.174	-.193	-1.136e-3	870.764	2899.134
144			4	.632	-.102	-.164	-1.032e-3	1557.809	7112.262
145			5	.632	-.01	-.143	-9.288e-4	NC	NC
146	2	M15	1	-.191	-.327	-.777	1.803e-4	NC	NC
147			2	-.191	-.238	-.6	5.127e-4	NC	8351.548
148			3	-.19	-.244	-.7	5.49e-4	NC	4119.88
149			4	-.19	-.515	-.526	4.452e-4	1550.328	7743.591
150			5	-.19	-.082	-.343	2.713e-4	NC	NC
151	2	M18	1	.327	.191	.777	8.39e-4	NC	NC
152			2	.327	.185	.778	8.39e-4	NC	NC
153			3	.327	.18	.778	8.39e-4	NC	NC
154			4	.327	.175	.779	8.39e-4	NC	NC
155			5	.327	.17	.779	8.39e-4	NC	NC
156	2	M19	1	.174	.191	.627	1.308e-3	NC	NC
157			2	.174	.191	.628	1.309e-3	NC	NC
158			3	.174	.192	.629	1.309e-3	NC	NC
159			4	.174	.192	.631	1.309e-3	NC	NC
160			5	.174	.193	.632	1.309e-3	NC	NC
161	2	M20	1	.227	.19	.692	8.173e-4	NC	NC
162			2	.227	.194	.693	8.173e-4	NC	NC
163			3	.227	.197	.695	8.173e-4	NC	NC
164			4	.227	.2	.696	8.173e-4	NC	NC
165			5	.227	.204	.697	8.173e-4	NC	NC
166	2	M21	1	.082	.19	.343	-6.387e-4	NC	NC
167			2	.082	.173	.344	-6.387e-4	NC	NC
168			3	.082	.156	.344	-6.387e-4	NC	NC
169			4	.082	.139	.345	-6.387e-4	NC	NC
170			5	.082	.122	.346	-6.387e-4	NC	NC
171	3	M3	1	0	0	0	1.221e-5	NC	NC
172			2	-.002	-.017	.039	1.221e-5	NC	2806.26
173			3	-.005	-.027	.059	1.221e-5	6691.837	1762.009
174			4	-.007	-.028	.042	1.221e-5	8239.441	2047.444
175			5	-.009	-.016	-.027	4.409e-5	NC	NC
176	3	M4	1	0	0	0	-1.221e-5	NC	NC
177			2	-.002	-.017	-.039	-1.221e-5	NC	2806.26
178			3	-.005	-.027	-.059	-1.221e-5	6691.837	1762.009
179			4	-.007	-.028	-.042	-1.221e-5	8239.441	2047.444
180			5	-.009	-.016	.027	-4.409e-5	NC	NC
181	3	M5	1	0	0	0	-3.071e-4	NC	NC
182			2	-.003	.005	.052	-3.071e-4	NC	2109.024
183			3	-.006	.007	.079	-3.071e-4	NC	1324.149
184			4	-.008	0	.056	-3.071e-4	NC	1538.328
185			5	-.011	-.016	-.036	-2.891e-4	8039.304	NC
186	3	M6	1	0	0	0	3.071e-4	NC	NC
187			2	-.003	.005	-.052	3.071e-4	NC	2109.024

Member Section Deflections (Continued)

	LC	Member Label	Sec	x [in]	y [in]	z [in]	x Rotate[rad]	(n) L/y Ratio	(n) L/z Ratio
188			3	-.006	.007	-.079	3.071e-4	NC	1324.149
189			4	-.008	0	-.056	3.071e-4	NC	1538.328
190			5	-.011	-.016	.036	2.891e-4	8039.304	NC
191	3	M7	1	0	0	0	-1.162e-3	NC	NC
192			2	-.001	-.055	.019	-1.162e-3	2509.876	5791.726
193			3	-.002	-.089	.029	-1.162e-3	1568.683	3636.458
194			4	-.003	-.083	.021	-1.162e-3	1792.794	4225.195
195			5	-.004	-.015	-.013	-1.142e-3	NC	NC
196	3	M8	1	0	0	0	1.162e-3	NC	NC
197			2	-.001	-.055	-.019	1.162e-3	2509.876	5791.726
198			3	-.002	-.089	-.029	1.162e-3	1568.683	3636.458
199			4	-.003	-.083	-.021	1.162e-3	1792.794	4225.195
200			5	-.004	-.015	.013	1.142e-3	NC	NC
201	3	M9	1	.017	-.279	0	2.341e-4	2094.316	NC
202			2	.016	-.047	.031	2.819e-3	NC	NC
203			3	.016	-.043	.044	3.346e-3	NC	NC
204			4	.016	-.245	.044	2.626e-3	2398.216	NC
205			5	.015	-.004	.013	1.282e-3	NC	NC
206	3	M10	1	.017	-.279	0	-2.341e-4	2094.316	NC
207			2	.016	-.047	-.031	-2.819e-3	NC	NC
208			3	.016	-.043	-.044	-3.346e-3	NC	NC
209			4	.016	-.245	-.044	-2.626e-3	2398.216	NC
210			5	.015	-.004	-.013	-1.282e-3	NC	NC
211	3	M11	1	0	-.279	.017	-3.545e-3	NC	NC
212			2	0	-.287	.045	-2.638e-3	NC	5010.732
213			3	0	-.291	.052	-1.73e-3	NC	4054.977
214			4	0	-.287	.045	-2.638e-3	NC	5010.732
215			5	0	-.279	.017	-3.545e-3	NC	NC
216	3	M12	1	0	-.004	.044	-2.527e-3	NC	NC
217			2	0	-.054	.091	-2.527e-3	2862.523	3084.449
218			3	0	-.082	.117	-2.527e-3	1860.386	1987.575
219			4	0	-.054	.091	-2.527e-3	2862.523	3084.449
220			5	0	-.004	.044	-2.527e-3	NC	NC
221	3	M13	1	0	-.01	.009	6.022e-4	NC	NC
222			2	0	-.149	.027	6.022e-4	1041.493	8144.689
223			3	0	-.223	.039	6.022e-4	675.928	4826.888
224			4	0	-.149	.027	6.022e-4	1041.493	8144.689
225			5	0	-.01	.009	6.022e-4	NC	NC
226	3	M14	1	0	-.009	.021	-4.296e-4	NC	NC
227			2	0	-.113	.034	-4.296e-4	1384.027	NC
228			3	0	-.169	.047	-4.296e-4	898.12	5527.645
229			4	0	-.113	.034	-4.296e-4	1384.027	NC
230			5	0	-.009	.021	-4.296e-4	NC	NC
231	3	M15	1	.052	-.291	0	0	NC	NC
232			2	.052	-.24	0	0	NC	NC
233			3	.052	-.244	0	0	NC	NC
234			4	.051	-.505	0	0	9867.51	NC
235			5	.051	-.082	0	0	1553.115	NC
236	3	M18	1	.291	-.052	0	0	NC	NC
237			2	.291	-.056	0	0	NC	NC
238			3	.291	-.061	0	0	NC	NC
239			4	.291	-.065	0	0	NC	NC
240			5	.291	-.069	0	0	NC	NC
241	3	M19	1	.169	-.052	0	0	NC	NC
242			2	.169	-.051	0	0	NC	NC
243			3	.169	-.05	0	0	NC	NC
244			4	.169	-.048	0	0	NC	NC

Member Section Deflections (Continued)

	LC	Member Label	Sec	x [in]	y [in]	z [in]	x Rotate[rad]	(n) L/y Ratio	(n) L/z Ratio
245			5	.169	-.047	0	0	NC	NC
246	3	M20	1	.223	-.052	0	0	NC	NC
247			2	.223	-.048	0	0	NC	NC
248			3	.223	-.045	0	0	NC	NC
249			4	.223	-.042	0	0	NC	NC
250			5	.223	-.039	0	0	NC	NC
251	3	M21	1	.082	-.051	0	0	NC	NC
252			2	.082	-.068	0	0	NC	NC
253			3	.082	-.084	0	0	NC	NC
254			4	.082	-.1	0	0	NC	NC
255			5	.082	-.117	0	0	NC	NC
256	4	M3	1	0	0	0	2.171e-3	NC	NC
257			2	-.001	.057	-.196	2.171e-3	NC	3543.058
258			3	-.003	.11	-.376	2.171e-3	8584.778	2286.902
259			4	-.004	.156	-.527	2.171e-3	9815.531	2708.706
260			5	-.006	.191	-.639	2.322e-3	NC	NC
261	4	M4	1	0	0	0	-7.097e-4	NC	NC
262			2	-.002	.025	-.253	-7.097e-4	NC	1234.03
263			3	-.004	.049	-.464	-7.097e-4	NC	774.835
264			4	-.006	.071	-.59	-7.097e-4	NC	900.378
265			5	-.008	.091	-.597	-7.353e-4	NC	NC
266	4	M5	1	0	0	0	-3.295e-4	NC	NC
267			2	-.002	.075	-.209	-3.295e-4	4653.355	4033.418
268			3	-.003	.14	-.403	-3.295e-4	2908.404	2588.574
269			4	-.005	.182	-.571	-3.295e-4	3324.067	3110.657
270			5	-.007	.191	-.707	-3.036e-4	NC	NC
271	4	M6	1	0	0	0	-4.583e-4	NC	NC
272			2	-.002	.04	-.284	-4.583e-4	7451.427	1054.515
273			3	-.005	.073	-.519	-4.583e-4	4657.198	662.093
274			4	-.007	.092	-.655	-4.583e-4	5322.844	769.258
275			5	-.009	.091	-.652	-4.573e-4	NC	NC
276	4	M7	1	0	0	0	-7.347e-3	NC	NC
277			2	0	.028	-.113	-7.347e-3	4570.47	5310.152
278			3	-.001	.064	-.215	-7.347e-3	2000.596	3427.181
279			4	-.002	.116	-.298	-7.347e-3	1104.459	4142.289
280			5	-.003	.192	-.356	-7.644e-3	667.779	NC
281	4	M8	1	0	0	0	-8.06e-4	NC	NC
282			2	0	-.006	-.139	-8.06e-4	NC	2322.699
283			3	-.002	0	-.256	-8.06e-4	NC	1458.366
284			4	-.003	.028	-.327	-8.06e-4	4509.137	1694.518
285			5	-.004	.092	-.335	-8.22e-4	1397.953	NC
286	4	M9	1	-.091	-.217	-.75	3.11e-4	2701.102	NC
287			2	-.091	-.03	-.584	9.758e-4	NC	9260.958
288			3	-.091	-.034	-.655	1.289e-3	NC	5148.18
289			4	-.091	-.18	-.544	9.656e-4	3258.328	5511.305
290			5	-.092	-.004	-.335	3.23e-4	NC	NC
291	4	M10	1	-.191	-.242	-.75	3.563e-5	2406.079	NC
292			2	-.191	-.02	-1	-3.368e-3	NC	1651.627
293			3	-.191	-.032	-1.007	-3.834e-3	NC	1267.343
294			4	-.191	-.181	-1.379	-3.041e-3	3236.617	622.899
295			5	-.192	-.003	-.356	-1.619e-3	NC	NC
296	4	M11	1	.75	-.242	-.191	-2.969e-3	NC	1444.195
297			2	.75	-.24	-.156	-2.241e-3	NC	2221.24
298			3	.75	-.236	-.127	-1.514e-3	NC	4021.453
299			4	.75	-.228	-.111	-2.102e-3	NC	7160.899
300			5	.75	-.217	-.091	-2.691e-3	NC	NC
301	4	M12	1	.339	-.002	-.165	-2.532e-3	NC	1475.867

Member Section Deflections (Continued)

	LC	Member Label	Sec	x [in]	y [in]	z [in]	x Rotate[rad]	(n) L/y Ratio	(n) L/z Ratio
302			2	.339	-.048	-.049	-2.451e-3	3196.364	7714.571
303			3	.339	-.06	-.077	-2.37e-3	2537.95	NC
304			4	.339	-.032	-.085	-2.289e-3	4976.523	8025.823
305			5	.339	-.003	-.067	-2.209e-3	NC	NC
306	4	M13	1	.667	-.006	-.192	-6.388e-5	NC	1467.773
307			2	.667	-.126	-.168	-3.006e-6	1210.225	1944.164
308			3	.666	-.165	-.136	5.786e-5	912.262	3449.581
309			4	.666	-.095	-.112	1.187e-4	1661.374	8049.276
310			5	.666	-.009	-.094	1.796e-4	NC	NC
311	4	M14	1	.607	-.005	-.181	-1.005e-3	NC	1497.463
312			2	.607	-.099	-.186	-9.048e-4	1551.926	1426.403
313			3	.607	-.126	-.128	-8.049e-4	1198.741	3311.081
314			4	.606	-.07	-.102	-7.051e-4	2261.849	8703.712
315			5	.606	-.007	-.085	-6.053e-4	NC	NC
316	4	M15	1	-.127	-.236	-.75	1.742e-4	NC	NC
317			2	-.127	-.173	-.574	4.92e-4	NC	8000.729
318			3	-.126	-.177	-.669	5.256e-4	NC	4569.226
319			4	-.126	-.374	-.504	4.285e-4	2133.105	8959.217
320			5	-.126	-.06	-.336	2.66e-4	NC	NC
321	4	M18	1	.236	.127	.75	8.125e-4	NC	NC
322			2	.236	.123	.75	8.125e-4	NC	NC
323			3	.236	.119	.751	8.125e-4	NC	NC
324			4	.236	.115	.751	8.125e-4	NC	NC
325			5	.236	.112	.752	8.125e-4	NC	NC
326	4	M19	1	.126	.127	.602	1.287e-3	NC	NC
327			2	.126	.127	.603	1.287e-3	NC	NC
328			3	.126	.128	.604	1.287e-3	NC	NC
329			4	.126	.128	.605	1.287e-3	NC	NC
330			5	.126	.128	.607	1.287e-3	NC	NC
331	4	M20	1	.165	.126	.661	7.897e-4	NC	NC
332			2	.165	.129	.662	7.897e-4	NC	NC
333			3	.165	.131	.664	7.897e-4	NC	NC
334			4	.165	.134	.665	7.897e-4	NC	NC
335			5	.165	.136	.666	7.897e-4	NC	NC
336	4	M21	1	.06	.126	.336	-6.678e-4	NC	NC
337			2	.06	.113	.337	-6.678e-4	NC	NC
338			3	.06	.101	.338	-6.678e-4	NC	NC
339			4	.06	.089	.338	-6.678e-4	NC	NC
340			5	.06	.077	.339	-6.678e-4	NC	NC
341	5	M3	1	0	0	0	-6.574e-5	NC	NC
342			2	-.002	-.032	.028	-6.574e-5	8575.841	3907.557
343			3	-.003	-.058	.043	-6.574e-5	5604.454	2453.554
344			4	-.005	-.071	.031	-6.574e-5	6814.923	2851.254
345			5	-.007	-.07	-.019	-3.318e-5	NC	NC
346	5	M4	1	0	0	0	6.574e-5	NC	NC
347			2	-.002	-.032	-.028	6.574e-5	8575.841	3907.557
348			3	-.003	-.058	-.043	6.574e-5	5604.454	2453.554
349			4	-.005	-.071	-.031	6.574e-5	6814.923	2851.254
350			5	-.007	-.07	.019	3.318e-5	NC	NC
351	5	M5	1	0	0	0	-3.549e-4	NC	NC
352			2	-.002	-.017	.037	-3.549e-4	7669.609	2918.757
353			3	-.004	-.034	.057	-3.549e-4	3804.559	1832.555
354			4	-.006	-.051	.041	-3.549e-4	2503.465	2129.039
355			5	-.008	-.069	-.026	-3.354e-4	1844.222	NC
356	5	M6	1	0	0	0	3.549e-4	NC	NC
357			2	-.002	-.017	-.037	3.549e-4	7669.609	2918.757
358			3	-.004	-.034	-.057	3.549e-4	3804.559	1832.555

Member Section Deflections (Continued)

	LC	Member Label	Sec	x [in]	y [in]	z [in]	x Rotate[rad]	(n) L/y Ratio	(n) L/z Ratio
359			4	-.006	-.051	-.041	3.549e-4	2503.465	2129.039
360			5	-.008	-.069	.026	3.354e-4	1844.222	NC
361	5	M7	1	0	0	0	-1.024e-3	NC	NC
362			2	0	-.059	.014	-1.024e-3	3092.859	8011.096
363			3	-.002	-.101	.021	-1.024e-3	1933.049	5029.985
364			4	-.002	-.11	.015	-1.024e-3	2209.212	5844.54
365			5	-.003	-.069	-.009	-1.006e-3	NC	NC
366	5	M8	1	0	0	0	1.024e-3	NC	NC
367			2	0	-.059	-.014	1.024e-3	3092.859	8011.096
368			3	-.002	-.101	-.021	1.024e-3	1933.049	5029.985
369			4	-.002	-.11	-.015	1.024e-3	2209.212	5844.54
370			5	-.003	-.069	.009	1.006e-3	NC	NC
371	5	M9	1	.07	-.193	0	1.808e-4	3037.694	NC
372			2	.07	-.037	.021	2.027e-3	NC	NC
373			3	.07	-.031	.035	2.415e-3	NC	NC
374			4	.069	-.175	.032	1.897e-3	3348.48	NC
375			5	.069	-.003	.009	9.266e-4	NC	NC
376	5	M10	1	.07	-.193	0	-1.808e-4	3037.694	NC
377			2	.07	-.037	-.021	-2.027e-3	NC	NC
378			3	.07	-.031	-.035	-2.415e-3	NC	NC
379			4	.069	-.175	-.032	-1.897e-3	3348.48	NC
380			5	.069	-.003	-.009	-9.266e-4	NC	NC
381	5	M11	1	0	-.193	.07	-2.475e-3	NC	NC
382			2	0	-.199	.1	-1.817e-3	NC	4870.216
383			3	0	-.202	.106	-1.159e-3	NC	3958.96
384			4	0	-.199	.1	-1.817e-3	NC	4870.216
385			5	0	-.193	.07	-2.475e-3	NC	NC
386	5	M12	1	0	-.003	.088	-1.609e-3	NC	NC
387			2	0	-.039	.13	-1.609e-3	3958.762	3463.168
388			3	0	-.059	.153	-1.609e-3	2572.907	2224.705
389			4	0	-.039	.13	-1.609e-3	3958.762	3463.168
390			5	0	-.003	.088	-1.609e-3	NC	NC
391	5	M13	1	0	-.007	.064	5.767e-4	NC	NC
392			2	0	-.107	.083	5.767e-4	1441.037	7238.046
393			3	0	-.161	.097	5.767e-4	935.202	4311.272
394			4	0	-.107	.083	5.767e-4	1441.037	7238.046
395			5	0	-.007	.064	5.767e-4	NC	NC
396	5	M14	1	0	-.006	.072	-1.323e-4	NC	NC
397			2	0	-.081	.088	-1.323e-4	1926.043	9127.613
398			3	0	-.121	.102	-1.323e-4	1249.697	4741.629
399			4	0	-.081	.088	-1.323e-4	1926.043	9127.613
400			5	0	-.006	.072	-1.323e-4	NC	NC
401	5	M15	1	.106	-.202	0	0	NC	NC
402			2	.106	-.175	0	0	NC	NC
403			3	.106	-.177	0	0	NC	NC
404			4	.106	-.364	0	0	2140.65	NC
405			5	.106	-.059	0	0	NC	NC
406	5	M18	1	.202	-.106	0	0	NC	NC
407			2	.202	-.109	0	0	NC	NC
408			3	.202	-.112	0	0	NC	NC
409			4	.202	-.115	0	0	NC	NC
410			5	.202	-.118	0	0	NC	NC
411	5	M19	1	.121	-.106	0	0	NC	NC
412			2	.121	-.105	0	0	NC	NC
413			3	.121	-.104	0	0	NC	NC
414			4	.121	-.103	0	0	NC	NC
415			5	.121	-.102	0	0	NC	NC

Member Section Deflections (Continued)

	LC	Member Label	Sec	x [in]	y [in]	z [in]	x Rotate[rad]	(n) L/y Ratio	(n) L/z Ratio
416	5	M20	1	.161	-.106	0	0	NC	NC
417			2	.161	-.104	0	0	NC	NC
418			3	.161	-.101	0	0	NC	NC
419			4	.161	-.099	0	0	NC	NC
420			5	.161	-.097	0	0	NC	NC
421	5	M21	1	.059	-.106	0	0	NC	NC
422			2	.059	-.117	0	0	NC	NC
423			3	.059	-.129	0	0	NC	NC
424			4	.059	-.141	0	0	NC	NC
425			5	.059	-.153	0	0	NC	NC
426	6	M3	1	0	0	0	1.887e-3	NC	NC
427			2	0	-.004	-.209	1.887e-3	NC	1659.909
428			3	.002	-.007	-.386	1.887e-3	NC	1051.396
429			4	.003	-.009	-.499	1.887e-3	NC	1237.428
430			5	.004	-.008	-.528	2.038e-3	NC	NC
431	6	M4	1	0	0	0	-3.476e-4	NC	NC
432			2	0	-.032	-.18	-3.476e-4	NC	2891.687
433			3	.001	-.06	-.343	-3.476e-4	NC	1815.699
434			4	.002	-.083	-.469	-3.476e-4	NC	2110.045
435			5	.002	-.095	-.545	-3.8e-4	NC	NC
436	6	M5	1	0	0	0	-4.204e-4	NC	NC
437			2	.001	-.006	-.23	-4.204e-4	NC	1456.138
438			3	.002	-.011	-.422	-4.204e-4	NC	921.463
439			4	.004	-.012	-.543	-4.204e-4	NC	1083.349
440			5	.005	-.008	-.567	-3.877e-4	NC	NC
441	6	M6	1	0	0	0	-1.633e-4	NC	NC
442			2	0	-.037	-.19	-1.633e-4	9728.765	3009.338
443			3	.001	-.069	-.363	-1.633e-4	6080.548	1889.43
444			4	.002	-.09	-.501	-1.633e-4	6949.358	2195.129
445			5	.003	-.095	-.591	-1.672e-4	NC	NC
446	6	M7	1	0	0	0	-6.596e-3	NC	NC
447			2	0	.016	-.125	-6.596e-3	7156.358	2835.59
448			3	0	.025	-.23	-6.596e-3	4472.304	1806.572
449			4	.001	.019	-.298	-6.596e-3	5109.399	2142.679
450			5	.002	-.008	-.318	-6.896e-3	NC	NC
451	6	M8	1	0	0	0	-1.237e-3	NC	NC
452			2	0	-.014	-.11	-1.237e-3	9314.175	4454.213
453			3	0	-.032	-.209	-1.237e-3	4062.22	2796.701
454			4	0	-.057	-.284	-1.237e-3	2232.816	3249.607
455			5	0	-.095	-.326	-1.242e-3	1344.252	NC
456	6	M9	1	.095	.084	-.662	1.382e-4	6935.722	NC
457			2	.095	.016	-.539	-1.982e-3	NC	NC
458			3	.095	.018	-.588	-2.251e-3	NC	6109.634
459			4	.095	.087	-.52	-1.808e-3	6692.891	5213.262
460			5	.095	0	-.326	-1.009e-3	NC	NC
461	6	M10	1	.008	.062	-.662	1.674e-4	9609.168	NC
462			2	.008	.024	-.877	-9.974e-5	NC	1911.594
463			3	.008	.019	-.87	5.586e-5	NC	1514.948
464			4	.008	.087	-1.254	-1.558e-5	6764.847	677.241
465			5	.008	.002	-.318	-2.006e-4	NC	NC
466	6	M11	1	.662	.062	.008	7.847e-4	NC	NC
467			2	.662	.068	.044	5.283e-4	NC	NC
468			3	.662	.074	.07	2.72e-4	NC	8070.642
469			4	.662	.079	.082	6.512e-4	NC	NC
470			5	.662	.084	.095	1.03e-3	NC	NC
471	6	M12	1	.316	.002	-.003	9.887e-4	NC	NC
472			2	.316	.011	.087	1.058e-3	NC	2075.159

Member Section Deflections (Continued)

	LC	Member Label	Sec	x [in]	y [in]	z [in]	x Rotate[rad]	(n) L/y Ratio	(n) L/z Ratio
473			3	.316	.028	.045	1.127e-3	5390.202	NC
474			4	.316	.026	.046	1.197e-3	5849.718	9871.968
475			5	.316	0	.082	1.266e-3	NC	NC
476	6	M13	1	.568	.005	.01	-1.546e-4	NC	NC
477			2	.568	.041	.04	-1.008e-4	3850.706	NC
478			3	.567	.083	.074	-4.705e-5	1804.619	6699.342
479			4	.567	.068	.09	6.704e-6	2213.401	9257.888
480			5	.567	.003	.095	6.046e-5	NC	NC
481	6	M14	1	.526	.004	.009	-1.965e-5	NC	NC
482			2	.526	.027	.013	6.793e-5	6059.302	8846.58
483			3	.526	.06	.074	1.555e-4	2536.849	6194.839
484			4	.526	.052	.091	2.431e-4	2932.763	7417.015
485			5	.526	.002	.093	3.307e-4	NC	NC
486	6	M15	1	.07	.074	-.662	1.536e-4	NC	NC
487			2	.07	.097	-.494	4.261e-4	NC	7136.466
488			3	.07	.097	-.571	4.51e-4	NC	6940.679
489			4	.07	.193	-.433	3.748e-4	3753.622	NC
490			5	.071	.028	-.313	2.48e-4	NC	NC
491	6	M18	1	-.074	-.07	.662	7.224e-4	NC	NC
492			2	-.074	-.069	.662	7.224e-4	NC	NC
493			3	-.074	-.068	.663	7.224e-4	NC	NC
494			4	-.074	-.068	.663	7.224e-4	NC	NC
495			5	-.074	-.067	.664	7.224e-4	NC	NC
496	6	M19	1	-.06	-.07	.522	1.213e-3	NC	NC
497			2	-.06	-.071	.523	1.213e-3	NC	NC
498			3	-.06	-.072	.524	1.213e-3	NC	NC
499			4	-.06	-.073	.525	1.213e-3	NC	NC
500			5	-.06	-.074	.526	1.213e-3	NC	NC
501	6	M20	1	-.083	-.07	.563	6.974e-4	NC	NC
502			2	-.083	-.071	.564	6.974e-4	NC	NC
503			3	-.083	-.072	.565	6.974e-4	NC	NC
504			4	-.083	-.073	.566	6.974e-4	NC	NC
505			5	-.083	-.074	.567	6.974e-4	NC	NC
506	6	M21	1	-.028	-.071	.313	-7.657e-4	NC	NC
507			2	-.028	-.064	.314	-7.657e-4	NC	NC
508			3	-.028	-.058	.314	-7.657e-4	NC	NC
509			4	-.028	-.052	.315	-7.657e-4	NC	NC
510			5	-.028	-.045	.316	-7.657e-4	NC	NC
511	7	M3	1	0	0	0	-3.856e-4	NC	NC
512			2	0	-.081	-.015	-3.856e-4	5612.072	7385.052
513			3	.002	-.151	-.023	-3.856e-4	3610.673	4636.523
514			4	.002	-.204	-.016	-3.856e-4	4292.885	5385.737
515			5	.003	-.232	.01	-3.494e-4	NC	NC
516	7	M4	1	0	0	0	3.856e-4	NC	NC
517			2	0	-.081	.015	3.856e-4	5612.072	7385.052
518			3	.002	-.151	.023	3.856e-4	3610.673	4636.523
519			4	.002	-.204	.016	3.856e-4	4292.885	5385.737
520			5	.003	-.232	-.01	3.494e-4	NC	NC
521	7	M5	1	0	0	0	-5.453e-4	NC	NC
522			2	0	-.085	-.02	-5.453e-4	4721.684	5416.122
523			3	.002	-.159	-.031	-5.453e-4	2951.073	3400.694
524			4	.003	-.212	-.022	-5.453e-4	3372.678	3951.548
525			5	.004	-.231	.014	-5.201e-4	NC	NC
526	7	M6	1	0	0	0	5.453e-4	NC	NC
527			2	0	-.085	.02	5.453e-4	4721.684	5416.122
528			3	.002	-.159	.031	5.453e-4	2951.073	3400.694
529			4	.003	-.212	.022	5.453e-4	3372.678	3951.548

Member Section Deflections (Continued)

	LC	Member Label	Sec	x [in]	y [in]	z [in]	x Rotate[rad]	(n) L/y Ratio	(n) L/z Ratio
530			5	.004	-.231	-.014	5.201e-4	NC	NC
531	7	M7	1	0	0	0	-4.229e-4	NC	NC
532			2	0	-.059	-.007	-4.229e-4	NC	NC
533			3	0	-.117	-.01	-4.229e-4	NC	NC
534			4	0	-.175	-.007	-4.229e-4	NC	NC
535			5	.001	-.232	.005	-4.103e-4	NC	NC
536	7	M8	1	0	0	0	4.229e-4	NC	NC
537			2	0	-.059	.007	4.229e-4	NC	NC
538			3	0	-.117	.01	4.229e-4	NC	NC
539			4	0	-.175	.007	4.229e-4	NC	NC
540			5	.001	-.232	-.005	4.103e-4	NC	NC
541	7	M9	1	.232	.104	0	2.195e-5	5614.196	NC
542			2	.232	.01	-.017	-1.079e-3	NC	NC
543			3	.232	.021	0	-1.297e-3	NC	NC
544			4	.231	.091	-.019	-1.001e-3	6406.707	NC
545			5	.232	.001	-.005	-4.476e-4	NC	NC
546	7	M10	1	.232	.104	0	-2.195e-5	5614.196	NC
547			2	.232	.01	.017	1.079e-3	NC	NC
548			3	.232	.021	0	1.297e-3	NC	NC
549			4	.231	.091	.019	1.001e-3	6406.707	NC
550			5	.232	.001	.005	4.476e-4	NC	NC
551	7	M11	1	0	.104	.232	1.209e-3	NC	NC
552			2	0	.103	.265	8.896e-4	NC	4338.099
553			3	0	.103	.272	5.703e-4	NC	3561.507
554			4	0	.103	.265	8.896e-4	NC	4338.099
555			5	0	.104	.232	1.209e-3	NC	NC
556	7	M12	1	0	.001	.214	1.773e-3	NC	NC
557			2	0	.019	.233	1.773e-3	8142.29	7482.603
558			3	0	.029	.245	1.773e-3	5250.369	4663.68
559			4	0	.019	.233	1.773e-3	8142.29	7482.603
560			5	0	.001	.214	1.773e-3	NC	NC
561	7	M13	1	0	.004	.229	4.011e-4	NC	NC
562			2	0	.058	.258	4.011e-4	2662.299	5044.042
563			3	0	.087	.277	4.011e-4	1722.351	3045.574
564			4	0	.058	.258	4.011e-4	2662.299	5044.042
565			5	0	.004	.229	4.011e-4	NC	NC
566	7	M14	1	0	.003	.226	7.231e-4	NC	NC
567			2	0	.042	.254	7.231e-4	3636.772	5169.412
568			3	0	.064	.276	7.231e-4	2352.835	2952.51
569			4	0	.042	.254	7.231e-4	3636.772	5169.412
570			5	0	.003	.226	7.231e-4	NC	NC
571	7	M15	1	.272	.103	0	0	NC	NC
572			2	.272	.096	0	0	NC	NC
573			3	.272	.097	0	0	NC	NC
574			4	.272	.202	0	0	3709.704	NC
575			5	.272	.029	0	0	NC	NC
576	7	M18	1	-.103	-.272	0	0	NC	NC
577			2	-.103	-.271	0	0	NC	NC
578			3	-.103	-.269	0	0	NC	NC
579			4	-.103	-.268	0	0	NC	NC
580			5	-.103	-.267	0	0	NC	NC
581	7	M19	1	-.064	-.272	0	0	NC	NC
582			2	-.064	-.273	0	0	NC	NC
583			3	-.064	-.273	0	0	NC	NC
584			4	-.064	-.274	0	0	NC	NC
585			5	-.064	-.275	0	0	NC	NC
586	7	M20	1	-.087	-.272	0	0	NC	NC

Member Section Deflections (Continued)

	LC	Member Label	Sec	x [in]	y [in]	z [in]	x Rotate[rad]	(n) L/y Ratio	(n) L/z Ratio
587			2	-.087	-.273	0	0	NC	NC
588			3	-.087	-.274	0	0	NC	NC
589			4	-.087	-.275	0	0	NC	NC
590			5	-.087	-.277	0	0	NC	NC
591	7	M21	1	-.029	-.272	0	0	NC	NC
592			2	-.029	-.265	0	0	NC	NC
593			3	-.029	-.258	0	0	NC	NC
594			4	-.029	-.251	0	0	NC	NC
595			5	-.029	-.245	0	0	NC	NC

Envelope Member Section Forces

	Member	Sec		Axial[k]	LC	y Shear[k]	LC	z Shear[k]	LC	Torque[k...	LC	y-y Mom...	LC	z-z Mom...	LC
1	M3	1	max	10.132	1	.232	7	.683	6	0	1	0	1	0	1
2			min	-3.638	6	-.111	1	-.376	3	0	1	0	1	0	1
3		2	max	10.075	1	.187	7	.639	6	0	1	1.763	6	.295	1
4			min	-3.681	6	-.111	1	-.376	3	0	1	-1.003	3	-.559	7
5		3	max	10.017	1	.141	7	.594	6	0	1	3.407	6	.59	1
6			min	-3.723	6	-.111	1	-.376	3	0	1	-2.006	3	-.997	7
7		4	max	9.96	1	.096	7	.549	6	0	1	4.931	6	.885	1
8			min	-3.766	6	-.111	1	-.376	3	0	1	-3.009	3	-1.313	7
9		5	max	6.993	1	0	7	.848	2	-.135	3	.008	2	1.215	1
10			min	-2.033	7	-.228	2	-.025	7	-.641	6	-.002	7	-1.466	7
11	M4	1	max	11.15	1	.232	7	.985	2	0	1	0	1	0	1
12			min	-2.902	7	-.079	1	-.143	7	0	1	0	1	0	1
13		2	max	11.093	1	.187	7	.985	2	0	1	2.628	2	.211	1
14			min	-2.945	7	-.079	1	-.143	7	0	1	-.381	7	-.559	7
15		3	max	11.036	1	.141	7	.985	2	0	1	5.257	2	.423	1
16			min	-2.988	7	-.079	1	-.143	7	0	1	-.762	7	-.997	7
17		4	max	10.979	1	.096	7	.985	2	0	1	7.885	2	.634	1
18			min	-3.031	7	-.079	1	-.143	7	0	1	-1.143	7	-1.313	7
19		5	max	6.962	1	.003	6	.05	4	.153	7	.004	6	.844	1
20			min	-2.033	7	-.083	3	.005	1	.041	1	-.005	3	-1.466	7
21	M5	1	max	12.138	1	.219	7	.773	6	0	1	0	1	0	1
22			min	-4.612	6	-.334	1	-.5	3	0	1	0	1	0	1
23		2	max	12.081	1	.219	7	.728	6	0	1	2.002	6	.891	1
24			min	-4.655	6	-.334	1	-.5	3	0	1	-1.334	3	-.585	7
25		3	max	12.024	1	.219	7	.683	6	0	1	3.884	6	1.783	1
26			min	-4.698	6	-.334	1	-.5	3	0	1	-2.668	3	-1.171	7
27		4	max	11.967	1	.219	7	.638	6	0	1	5.646	6	2.674	1
28			min	-4.741	6	-.334	1	-.5	3	0	1	-4.003	3	-1.756	7
29		5	max	8.006	1	.184	7	1.091	2	-.033	1	.004	1	3.527	1
30			min	-2.429	7	-.288	2	.006	7	-.138	6	-.001	7	-2.311	7
31	M6	1	max	13.303	1	.219	7	1.169	2	0	1	0	1	0	1
32			min	-3.697	7	-.29	1	-.195	7	0	1	0	1	0	1
33		2	max	13.246	1	.219	7	1.169	2	0	1	3.117	2	.773	1
34			min	-3.739	7	-.29	1	-.195	7	0	1	-.52	7	-.585	7
35		3	max	13.189	1	.219	7	1.169	2	0	1	6.234	2	1.547	1
36			min	-3.782	7	-.29	1	-.195	7	0	1	-1.039	7	-1.171	7
37		4	max	13.132	1	.219	7	1.169	2	0	1	9.351	2	2.32	1
38			min	-3.825	7	-.29	1	-.195	7	0	1	-1.559	7	-1.756	7
39		5	max	8.011	1	.184	7	-.006	7	.106	7	.002	6	3.051	1
40			min	-2.429	7	-.239	1	-.057	1	-.02	1	-.003	1	-2.311	7
41	M7	1	max	4.702	1	.413	3	.419	6	0	1	0	1	0	1
42			min	-1.741	6	-.145	6	-.182	3	0	1	0	1	0	1
43		2	max	4.645	1	.413	3	.374	6	0	1	1.059	6	.386	6
44			min	-1.784	6	-.145	6	-.182	3	0	1	-.486	3	-1.101	3
45		3	max	4.588	1	.413	3	.33	6	0	1	1.998	6	.772	6
46			min	-1.827	6	-.145	6	-.182	3	0	1	-.972	3	-2.202	3
47		4	max	4.531	1	.413	3	.285	6	0	1	2.817	6	1.158	6
48			min	-1.87	6	-.145	6	-.182	3	0	1	-1.458	3	-3.303	3
49		5	max	3.103	1	.481	2	.48	2	1.262	6	0	7	1.318	6
50			min	-.952	6	-.02	7	-.005	7	-.084	3	-.003	1	-4.349	3
51	M8	1	max	5.287	1	.413	3	.511	2	0	1	0	1	0	1
52			min	-1.111	7	-.081	6	-.064	7	0	1	0	1	0	1
53		2	max	5.23	1	.413	3	.511	2	0	1	1.364	2	.217	6
54			min	-1.153	7	-.081	6	-.064	7	0	1	-.169	7	-1.101	3
55		3	max	5.173	1	.413	3	.511	2	0	1	2.727	2	.435	6
56			min	-1.196	7	-.081	6	-.064	7	0	1	-.339	7	-2.202	3

COLUMNS M3 thru M8

Envelope Member Section Forces (Continued)

OUTSIDE PURLIN
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BEAMS
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	Member	Sec		Axial[k]	LC	y Shear[k]	LC	z Shear[k]	LC	Torque[k...	LC	y-y Mom...	LC	z-z Mom...	LC
57		4	max	5.116	1	.413	3	.511	2	0	1	4.091	2	.652	6
58			min	-1.239	7	-.081	6	-.064	7	0	1	-.508	7	-3.303	3
59		5	max	3.128	1	.346	3	.006	4	.084	3	.002	1	.843	6
60			min	-.91	6	-.05	6	-.002	1	.024	6	-.001	6	-4.349	3
61	M9	1	max	.173	3	-.02	6	-.027	1	.004	6	.182	3	.003	6
62			min	.03	1	-.177	3	-.048	2	-.005	3	.106	1	-.008	1
63		2	max	.252	3	2.313	1	.01	2	0	6	.024	7	1.869	1
64			min	.046	6	-.741	7	-.005	7	0	1	-.066	2	-.841	7
65		3	max	.252	3	.653	6	.01	2	0	6	.055	2	1.297	3
66			min	.046	6	-2.171	1	-.005	7	0	1	-.031	7	-.258	6
67		4	max	.359	3	1.356	1	-.004	6	.002	1	.028	6	2.067	6
68			min	-.048	6	-.501	7	-.008	2	-.001	6	-.002	3	-7.067	1
69		5	max	.359	3	.91	6	-.004	6	.002	1	-.024	6	4.349	3
70			min	-.048	6	-3.128	1	-.008	2	-.001	6	-.084	3	-.843	6
71	M10	1	max	.173	3	-.019	6	.082	2	.009	2	.077	6	.003	7
72			min	-.015	6	-.177	3	.033	7	-.002	7	-.182	3	-.009	1
73		2	max	.252	3	2.344	1	.293	6	0	1	.031	2	2.111	1
74			min	.121	6	-.741	7	.002	3	0	7	-.024	7	-.841	7
75		3	max	.252	3	.705	6	.005	7	0	1	.031	7	1.297	3
76			min	.121	6	-2.14	1	-.308	2	0	7	-.067	4	-.478	6
77		4	max	.497	2	1.382	1	.129	6	0	7	.817	2	2.097	6
78			min	-.017	7	-.501	7	.006	7	-.003	1	-.013	7	-7.051	1
79		5	max	.497	2	.952	6	.007	3	0	7	.084	3	4.349	3
80			min	-.017	7	-3.103	1	-.473	2	-.003	1	-1.262	6	-1.318	6
81	M11	1	max	.082	2	.176	3	.015	6	.003	7	.182	3	.002	7
82			min	.033	7	.019	6	-.173	3	-.009	1	-.077	6	-.009	2
83		2	max	.082	2	.121	3	.015	6	.003	7	-.002	1	.004	6
84			min	.033	7	-.022	6	-.023	3	-.009	1	-.125	7	-.45	3
85		3	max	.082	2	.063	6	.132	7	.007	3	.046	7	.133	6
86			min	.033	7	-.066	3	-.128	5	-.009	1	-.145	2	-.731	3
87		4	max	.048	2	.022	6	.054	2	.008	1	.017	2	.007	6
88			min	.027	1	-.121	3	.018	7	-.003	6	-.125	7	-.45	3
89		5	max	.048	2	-.02	6	.173	3	.008	1	.182	3	.004	6
90			min	.027	1	-.176	3	.03	1	-.003	6	.106	1	-.005	3
91	M12	1	max	.466	2	1.405	3	.271	6	0	3	.084	3	1.79	3
92			min	-.069	7	-.961	6	-.052	3	0	2	-1.262	6	-3.71	6
93		2	max	.466	2	1.35	3	.271	6	0	3	-.026	7	.787	7
94			min	-.069	7	-1.002	6	-.052	3	0	2	-.498	2	-4.041	2
95		3	max	.481	2	.531	7	.271	6	0	3	.365	6	2.318	7
96			min	-.069	7	-1.841	2	-.007	4	0	2	-.225	3	-7.503	1
97		4	max	.481	2	.49	7	.052	3	0	3	.122	6	2.25	6
98			min	-.069	7	-1.896	2	-.033	6	0	2	-.071	3	-2.344	3
99		5	max	.481	2	.448	7	.052	3	0	3	.084	3	5.029	2
100			min	-.069	7	-1.951	2	-.033	6	0	2	.024	6	-.62	7
101	M13	1	max	1.105	2	3.909	1	-.003	1	0	3	.138	6	4.885	3
102			min	-.194	7	-2.362	6	-.047	7	0	2	.033	1	-7.66	6
103		2	max	1.105	2	3.854	1	-.003	1	0	3	.031	2	2.456	7
104			min	-.194	7	-2.403	6	-.047	7	0	2	-.033	7	-9.972	2
105		3	max	1.105	2	1.521	7	.047	7	0	3	.018	1	6.958	7
106			min	-.194	7	-4.959	1	-.04	6	0	2	-.173	7	-20.911	1
107		4	max	1.075	2	1.48	7	.047	7	0	3	0	1	5.042	6
108			min	-.194	7	-5.014	1	-.006	1	0	2	-.033	7	-6.387	3
109		5	max	1.075	2	1.439	7	.047	7	0	3	.106	7	11.457	2
110			min	-.194	7	-5.069	1	-.006	1	0	2	-.02	1	-1.922	7
111	M14	1	max	.794	2	2.913	1	-.045	3	0	3	.641	6	3.711	3
112			min	-.171	7	-1.866	6	-.151	6	0	2	.135	3	-6.596	6
113		2	max	.794	2	2.858	1	-.045	3	0	3	.216	2	1.796	7

Envelope Member Section Forces (Continued)

	Member	Sec		Axial[k]	LC	y Shear[k]	LC	z Shear[k]	LC	Torque[k...	LC	y-y Mom...	LC	z-z Mom...	LC
114			min	-.171	7	-1.907	6	-.151	6	0	2	-.024	7	-8.059	2
115		3	max	.842	2	2.757	3	.048	4	0	3	-.072	1	5.1	7
116			min	-.171	7	-3.852	1	-.151	6	0	2	-.263	6	-15.931	1
117		4	max	.842	2	1.081	7	.063	6	0	3	0	3	4.15	6
118			min	-.171	7	-3.907	1	.015	1	0	2	-.053	6	-4.808	3
119		5	max	.842	2	1.04	7	.063	6	0	3	.153	7	9.727	2
120			min	-.171	7	-3.962	1	.015	1	0	2	.041	1	-1.385	7
121	M15	1	max	.264	7	.132	3	0	3	0	3	.157	6	.017	1
122			min	-.045	2	-.126	6	-.034	6	0	2	0	3	-.005	7
123		2	max	.165	3	2.112	1	.015	2	0	3	0	3	.424	6
124			min	-.247	6	-.719	7	0	3	0	2	-.097	2	-.323	3
125		3	max	.165	3	.904	6	.015	2	0	3	.079	2	2.468	1
126			min	-.247	6	-2.536	1	0	3	0	2	0	3	-.816	7
127		4	max	.102	3	1.565	1	0	3	0	2	.003	2	3.132	7
128			min	-.304	6	-.546	7	-.015	2	0	3	-.003	6	-9.221	1
129		5	max	.102	3	1.077	6	0	3	0	2	0	3	.066	5
130			min	-.304	6	-3.082	1	-.015	2	0	3	-.176	2	-.258	6
131	M18	1	max	0	1	0	1	0	6	0	1	0	3	0	1
132			min	0	1	0	4	0	2	0	1	0	6	0	6
133		2	max	0	1	0	1	0	6	0	1	0	3	0	1
134			min	0	1	0	4	0	2	0	1	0	2	0	6
135		3	max	0	1	0	1	0	6	0	1	0	3	0	1
136			min	0	1	0	4	0	2	0	1	0	2	0	6
137		4	max	0	1	0	1	0	6	0	1	0	3	0	1
138			min	0	1	0	4	0	2	0	1	0	2	0	2
139		5	max	0	1	0	1	0	6	0	1	0	3	0	1
140			min	0	1	0	4	0	2	0	1	0	2	0	2
141	M19	1	max	6.65	1	-.083	1	.048	6	0	3	0	2	-.069	1
142			min	-2.245	7	-.215	6	0	3	-.042	2	0	3	-.18	6
143		2	max	6.65	1	-.083	1	.048	6	0	3	.011	6	-.052	1
144			min	-2.245	7	-.215	6	0	3	-.042	2	0	3	-.135	6
145		3	max	6.65	1	-.083	1	.048	6	0	3	.021	6	-.035	1
146			min	-2.245	7	-.215	6	0	3	-.042	2	0	3	-.09	6
147		4	max	6.65	1	-.083	1	.048	6	0	3	.03	6	-.017	1
148			min	-2.245	7	-.215	6	0	3	-.042	2	0	3	-.045	6
149		5	max	6.65	1	-.083	1	.048	6	0	3	.04	6	0	6
150			min	-2.245	7	-.215	6	0	3	-.042	2	0	3	0	5
151	M20	1	max	8.748	1	-.019	1	0	3	0	3	0	2	-.016	1
152			min	-3.043	7	-.096	7	-.037	2	-.023	6	0	3	-.08	7
153		2	max	8.748	1	-.019	1	0	3	0	3	0	3	-.012	1
154			min	-3.043	7	-.096	7	-.037	2	-.023	6	-.007	2	-.06	7
155		3	max	8.748	1	-.019	1	0	3	0	3	0	3	-.008	1
156			min	-3.043	7	-.096	7	-.037	2	-.023	6	-.015	2	-.04	7
157		4	max	8.748	1	-.019	1	0	3	0	3	0	3	-.004	1
158			min	-3.043	7	-.096	7	-.037	2	-.023	6	-.023	2	-.02	7
159		5	max	8.748	1	-.019	1	0	3	0	3	0	3	0	6
160			min	-3.043	7	-.096	7	-.037	2	-.023	6	-.031	2	0	1
161	M21	1	max	3.082	1	.308	6	.014	2	.176	2	0	3	.258	6
162			min	-1.077	6	-.079	5	0	3	0	3	0	2	-.066	5
163		2	max	3.082	1	.308	6	.014	2	.176	2	.003	2	.193	6
164			min	-1.077	6	-.079	5	0	3	0	3	0	3	-.05	5
165		3	max	3.082	1	.308	6	.014	2	.176	2	.006	2	.129	6
166			min	-1.077	6	-.079	5	0	3	0	3	0	3	-.033	5
167		4	max	3.082	1	.308	6	.014	2	.176	2	.009	2	.064	6
168			min	-1.077	6	-.079	5	0	3	0	3	0	3	-.017	5
169		5	max	3.082	1	.308	6	.014	2	.176	2	.012	2	0	2
170			min	-1.077	6	-.079	5	0	3	0	3	0	3	0	7

Envelope Member Section Deflections

	Member	Sec		x [in]	LC	y [in]	LC	z [in]	LC	x Rotate [r...	LC	(n) L/y Ratio	LC	(n) L/z Ratio	LC
1	M3	1	max	0	1	0	1	0	1	2.239e-3	2	NC	1	NC	1
2			min	0	1	0	1	0	1	-3.856e-4	7	NC	1	NC	1
3		2	max	0	6	.082	1	.039	3	2.239e-3	2	9372.911	1	2806.26	3
4			min	-.003	1	-.081	7	-.209	6	-3.856e-4	7	5612.072	7	1659.909	6
5		3	max	.002	6	.159	1	.059	3	2.239e-3	2	5858.317	1	1762.009	3
6			min	-.005	1	-.151	7	-.386	6	-3.856e-4	7	3610.673	7	1051.396	6
7		4	max	.003	6	.225	1	.042	3	2.239e-3	2	6696.108	1	2047.444	3
8			min	-.008	1	-.204	7	-.538	2	-3.856e-4	7	4292.885	7	3813.195	2
9		5	max	.004	6	.275	1	.01	7	2.39e-3	2	NC	1	NC	7
10			min	-.01	1	-.232	7	-.673	2	-3.494e-4	7	NC	7	NC	2
11	M4	1	max	0	1	0	1	0	1	3.856e-4	7	NC	1	NC	1
12			min	0	1	0	1	0	1	-7.993e-4	2	NC	1	NC	1
13		2	max	0	7	.065	1	.015	7	3.856e-4	7	NC	1	7385.052	7
14			min	-.003	1	-.081	7	-.274	2	-7.993e-4	2	5612.072	7	1070.819	2
15		3	max	.002	7	.127	1	.023	7	3.856e-4	7	8168.533	1	4636.523	7
16			min	-.006	1	-.151	7	-.498	2	-7.993e-4	2	3610.673	7	672.352	2
17		4	max	.002	7	.181	1	.016	7	3.856e-4	7	9335.698	1	5385.737	7
18			min	-.009	1	-.204	7	-.626	2	-7.993e-4	2	4292.885	7	781.273	2
19		5	max	.003	7	.222	1	.027	3	3.494e-4	7	NC	1	NC	3
20			min	-.011	1	-.232	7	-.616	2	-8.234e-4	2	NC	7	NC	2
21	M5	1	max	0	1	0	1	0	1	-4.504e-5	1	NC	1	NC	1
22			min	0	1	0	1	0	1	-5.453e-4	7	NC	1	NC	1
23		2	max	.001	6	.11	1	.052	3	-4.504e-5	1	3100.544	1	2109.024	3
24			min	-.003	1	-.085	7	-.23	6	-5.453e-4	7	4721.684	7	1456.138	6
25		3	max	.002	6	.204	1	.079	3	-4.504e-5	1	1937.857	1	1324.149	3
26			min	-.006	1	-.159	7	-.422	6	-5.453e-4	7	2951.073	7	921.463	6
27		4	max	.004	6	.264	1	.056	3	-4.504e-5	1	2214.724	1	1538.328	3
28			min	-.01	1	-.212	7	-.584	2	-5.453e-4	7	3372.678	7	5580.316	2
29		5	max	.005	6	.275	1	.014	7	-3.721e-5	1	NC	1	NC	7
30			min	-.012	1	-.231	7	-.749	2	-5.201e-4	7	NC	7	NC	2
31	M6	1	max	0	1	0	1	0	1	5.453e-4	7	NC	1	NC	1
32			min	0	1	0	1	0	1	-5.384e-4	2	NC	1	NC	1
33		2	max	0	7	.091	1	.02	7	5.453e-4	7	3573.968	1	5416.122	7
34			min	-.003	1	-.085	7	-.31	2	-5.384e-4	2	4721.684	7	902.784	2
35		3	max	.002	7	.169	1	.031	7	5.453e-4	7	2233.743	1	3400.694	7
36			min	-.007	1	-.159	7	-.563	2	-5.384e-4	2	2951.073	7	566.824	2
37		4	max	.003	7	.217	1	.022	7	5.453e-4	7	2552.856	1	3951.548	7
38			min	-.01	1	-.212	7	-.7	2	-5.384e-4	2	3372.678	7	658.558	2
39		5	max	.004	7	.223	1	.036	3	5.201e-4	7	NC	1	NC	3
40			min	-.013	1	-.231	7	-.674	2	-5.363e-4	2	NC	7	NC	2
41	M7	1	max	0	1	0	1	0	1	-4.229e-4	7	NC	1	NC	1
42			min	0	1	0	1	0	1	-7.531e-3	2	NC	1	NC	1
43		2	max	0	6	.036	2	.019	3	-4.229e-4	7	3594.845	2	5791.726	3
44			min	-.001	1	-.059	5	-.125	6	-7.531e-3	2	3092.859	5	2835.59	6
45		3	max	0	6	.083	2	.029	3	-4.229e-4	7	1548.445	2	3636.458	3
46			min	-.002	1	-.117	7	-.23	6	-7.531e-3	2	NC	7	1806.572	6
47		4	max	.001	6	.156	1	.021	3	-4.229e-4	7	822.83	1	4225.195	3
48			min	-.004	1	-.175	7	-.298	2	-7.531e-3	2	NC	7	5428.696	2
49		5	max	.002	6	.276	1	.005	7	-4.103e-4	7	463.579	1	NC	7
50			min	-.005	1	-.232	7	-.366	2	-7.829e-3	2	NC	7	NC	2
51	M8	1	max	0	1	0	1	0	1	1.162e-3	3	NC	1	NC	1
52			min	0	1	0	1	0	1	-1.237e-3	6	NC	1	NC	1
53		2	max	0	7	.014	1	.007	7	1.162e-3	3	8931.625	1	NC	7
54			min	-.001	1	-.059	5	-.147	2	-1.237e-3	6	3092.859	5	2063.787	2
55		3	max	0	7	.045	1	.01	7	1.162e-3	3	2828.553	1	NC	7
56			min	-.003	1	-.117	7	-.268	2	-1.237e-3	6	NC	7	1295.799	2

Envelope Member Section Deflections (Continued)

	Member	Sec		x [in]	LC	y [in]	LC	z [in]	LC	x Rotate [r...	LC	(n) L/y Ratio	LC	(n) L/z Ratio	LC
57		4	max	0	7	.109	1	.007	7	1.162e-3	3	1170.503	1	NC	7
58			min	-.004	1	-.175	7	-.339	2	-1.237e-3	6	NC	7	1505.615	2
59		5	max	.001	7	.223	1	.013	3	1.142e-3	3	573.422	1	NC	3
60			min	-.005	1	-.232	7	-.339	2	-1.242e-3	6	NC	7	NC	2
61	M9	1	max	.232	7	.104	7	0	3	3.682e-4	2	5614.196	7	NC	3
62			min	-.222	1	-.365	1	-.777	2	2.195e-5	7	1601.834	1	NC	2
63		2	max	.232	7	.016	6	.031	3	2.819e-3	3	NC	6	NC	3
64			min	-.223	1	-.047	3	-.601	2	-1.982e-3	6	NC	3	8584.889	2
65		3	max	.232	7	.021	7	.044	3	3.373e-3	1	NC	7	NC	3
66			min	-.223	1	-.055	1	-.678	2	-2.251e-3	6	NC	1	4817.933	2
67		4	max	.231	7	.091	7	.044	3	2.626e-3	3	6406.707	7	NC	3
68			min	-.223	1	-.296	1	-.554	2	-1.808e-3	6	1978.175	1	5448.182	2
69		5	max	.232	7	.001	7	.013	3	1.282e-3	3	NC	7	NC	3
70			min	-.223	1	-.005	1	-.339	2	-1.009e-3	6	NC	1	NC	2
71	M10	1	max	.232	7	.104	7	0	7	1.674e-4	6	5614.196	7	NC	7
72			min	-.275	1	-.378	1	-.777	2	-2.341e-4	3	1542.847	1	NC	2
73		2	max	.232	7	.024	6	.017	7	1.079e-3	7	NC	6	NC	7
74			min	-.275	1	-.047	3	-1.036	2	-4.211e-3	2	NC	3	1592.188	2
75		3	max	.232	7	.021	7	0	7	1.297e-3	7	NC	7	NC	7
76			min	-.275	1	-.054	1	-1.048	2	-4.821e-3	2	NC	1	1209.581	2
77		4	max	.231	7	.091	7	.019	7	1.001e-3	7	6406.707	7	NC	7
78			min	-.276	1	-.297	1	-1.414	2	-3.81e-3	2	1973.827	1	609.333	2
79		5	max	.232	7	.002	6	.005	7	4.476e-4	7	NC	6	NC	7
80			min	-.276	1	-.005	1	-.366	2	-1.987e-3	2	NC	1	NC	2
81	M11	1	max	.777	2	.104	7	.232	7	1.209e-3	7	NC	7	NC	7
82			min	0	7	-.378	1	-.275	1	-4.65e-3	1	NC	1	2733.477	1
83		2	max	.777	2	.103	7	.265	7	8.896e-4	7	NC	7	4338.099	7
84			min	0	7	-.382	1	-.259	1	-3.546e-3	1	NC	1	3895.529	1
85		3	max	.777	2	.103	7	.272	7	5.703e-4	7	NC	7	3561.507	7
86			min	0	3	-.382	1	-.244	1	-2.442e-3	1	NC	1	6607.149	1
87		4	max	.777	2	.103	7	.265	7	8.896e-4	7	NC	7	4338.099	7
88			min	0	3	-.375	1	-.236	1	-3.472e-3	1	NC	1	NC	1
89		5	max	.777	2	.104	7	.232	7	1.209e-3	7	NC	7	NC	7
90			min	0	3	-.365	1	-.222	1	-4.503e-3	1	NC	1	NC	1
91	M12	1	max	.346	2	.002	6	.214	7	1.773e-3	7	NC	6	NC	7
92			min	0	7	-.004	1	-.233	1	-4.068e-3	1	NC	1	2794.219	1
93		2	max	.346	2	.019	7	.233	7	1.773e-3	7	8142.29	7	7482.603	7
94			min	0	7	-.069	1	-.159	1	-4.025e-3	1	2249.181	1	6403.871	1
95		3	max	.346	2	.029	7	.245	7	1.773e-3	7	5250.369	7	4663.68	7
96			min	0	3	-.097	1	-.164	1	-3.982e-3	1	1564.503	1	8619.926	1
97		4	max	.346	2	.026	6	.233	7	1.773e-3	7	5849.716	6	7482.603	7
98			min	0	3	-.061	1	-.176	1	-3.939e-3	1	2585.54	1	NC	1
99		5	max	.346	2	.001	7	.214	7	1.773e-3	7	NC	7	NC	7
100			min	0	3	-.005	1	-.181	1	-3.896e-3	1	NC	1	NC	1
101	M13	1	max	.698	2	.005	6	.229	7	6.022e-4	3	NC	6	NC	7
102			min	0	7	-.012	1	-.278	1	-1.546e-4	6	NC	1	NC	1
103		2	max	.698	2	.058	7	.258	7	6.022e-4	3	2662.299	7	5044.042	7
104			min	0	7	-.186	1	-.272	1	-1.008e-4	6	825.349	1	NC	1
105		3	max	.697	2	.087	7	.277	7	6.022e-4	3	1722.351	7	3045.574	7
106			min	0	3	-.267	1	-.26	1	-4.705e-5	6	564.387	1	NC	1
107		4	max	.697	2	.068	6	.258	7	6.022e-4	3	2213.401	6	5044.042	7
108			min	0	3	-.17	1	-.243	1	6.704e-6	6	916.853	1	NC	1
109		5	max	.697	2	.004	7	.229	7	6.022e-4	3	NC	7	NC	7
110			min	0	3	-.013	1	-.226	1	6.046e-5	6	NC	1	NC	1
111	M14	1	max	.632	2	.004	6	.226	7	7.231e-4	7	NC	6	NC	7
112			min	0	7	-.01	1	-.262	1	-1.44e-3	1	NC	1	NC	1
113		2	max	.632	2	.042	7	.254	7	7.231e-4	7	3636.772	7	5169.412	7

Envelope Member Section Deflections (Continued)

	Member	Sec		x [in]	LC	y [in]	LC	z [in]	LC	x Rotate [r...	LC	(n) L/y Ratio	LC	(n) L/z Ratio	LC
114			min	0	7	-.144	1	-.272	1	-1.387e-3	1	1073.975	1	6190.136	1
115		3	max	.632	2	.064	7	.275	7	7.231e-4	7	2352.835	7	2952.51	7
116			min	0	3	-.205	1	-.247	1	-1.335e-3	1	740.735	1	NC	1
117		4	max	.632	2	.052	6	.254	7	7.231e-4	7	2932.763	6	5169.412	7
118			min	0	3	-.129	1	-.228	1	-1.282e-3	1	1215.159	1	NC	1
119		5	max	.632	2	.003	7	.226	7	7.231e-4	7	NC	7	NC	7
120			min	0	3	-.011	1	-.211	1	-1.229e-3	1	NC	1	NC	1
121	M15	1	max	.272	7	.103	7	0	3	1.803e-4	2	NC	7	NC	3
122			min	-.244	1	-.382	1	-.777	2	0	3	NC	1	NC	2
123		2	max	.272	7	.097	6	0	3	5.127e-4	2	NC	6	NC	3
124			min	-.244	1	-.281	1	-.6	2	0	3	NC	1	8351.548	2
125		3	max	.272	7	.097	7	0	3	5.49e-4	2	NC	7	NC	3
126			min	-.244	1	-.289	1	-.7	2	0	3	NC	1	4119.88	2
127		4	max	.272	7	.202	7	0	3	4.452e-4	2	3709.704	7	NC	3
128			min	-.244	1	-.608	1	-.526	2	0	3	1309.533	1	7743.591	2
129		5	max	.272	7	.029	7	0	3	2.713e-4	2	NC	7	NC	3
130			min	-.244	1	-.097	1	-.343	2	0	3	NC	1	NC	2
131	M18	1	max	.382	1	.244	1	.777	2	8.39e-4	2	NC	1	NC	2
132			min	-.103	7	-.272	7	0	3	0	3	NC	7	NC	3
133		2	max	.382	1	.238	1	.778	2	8.39e-4	2	NC	1	NC	2
134			min	-.103	7	-.271	7	0	3	0	3	NC	7	NC	3
135		3	max	.382	1	.232	1	.778	2	8.39e-4	2	NC	1	NC	2
136			min	-.103	7	-.269	7	0	3	0	3	NC	7	NC	3
137		4	max	.382	1	.226	1	.779	2	8.39e-4	2	NC	1	NC	2
138			min	-.103	7	-.268	7	0	3	0	3	NC	7	NC	3
139		5	max	.382	1	.22	1	.779	2	8.39e-4	2	NC	1	NC	2
140			min	-.103	7	-.267	7	0	3	0	3	NC	7	NC	3
141	M19	1	max	.205	1	.244	1	.627	2	1.309e-3	2	NC	1	NC	2
142			min	-.064	7	-.272	7	0	3	0	3	NC	7	NC	3
143		2	max	.205	1	.245	1	.628	2	1.309e-3	2	NC	1	NC	2
144			min	-.064	7	-.273	7	0	3	0	3	NC	7	NC	3
145		3	max	.205	1	.246	1	.629	2	1.309e-3	2	NC	1	NC	2
146			min	-.064	7	-.273	7	0	3	0	3	NC	7	NC	3
147		4	max	.205	1	.246	1	.631	2	1.309e-3	2	NC	1	NC	2
148			min	-.064	7	-.274	7	0	3	0	3	NC	7	NC	3
149		5	max	.205	1	.247	1	.632	2	1.309e-3	2	NC	1	NC	2
150			min	-.064	7	-.275	7	0	3	0	3	NC	7	NC	3
151	M20	1	max	.267	1	.244	1	.692	2	8.173e-4	2	NC	1	NC	2
152			min	-.087	7	-.272	7	0	3	0	3	NC	7	NC	3
153		2	max	.267	1	.248	1	.693	2	8.173e-4	2	NC	1	NC	2
154			min	-.087	7	-.273	7	0	3	0	3	NC	7	NC	3
155		3	max	.267	1	.252	1	.695	2	8.173e-4	2	NC	1	NC	2
156			min	-.087	7	-.274	7	0	3	0	3	NC	7	NC	3
157		4	max	.267	1	.256	1	.696	2	8.173e-4	2	NC	1	NC	2
158			min	-.087	7	-.275	7	0	3	0	3	NC	7	NC	3
159		5	max	.267	1	.26	1	.697	2	8.173e-4	2	NC	1	NC	2
160			min	-.087	7	-.277	7	0	3	0	3	NC	7	NC	3
161	M21	1	max	.097	1	.244	1	.343	2	0	3	NC	1	NC	2
162			min	-.029	7	-.272	7	0	3	-7.657e-4	6	NC	7	NC	3
163		2	max	.097	1	.224	1	.344	2	0	3	NC	1	NC	2
164			min	-.029	7	-.265	7	0	3	-7.657e-4	6	NC	7	NC	3
165		3	max	.097	1	.204	1	.344	2	0	3	NC	1	NC	2
166			min	-.029	7	-.258	7	0	3	-7.657e-4	6	NC	7	NC	3
167		4	max	.097	1	.184	1	.345	2	0	3	NC	1	NC	2
168			min	-.029	7	-.251	7	0	3	-7.657e-4	6	NC	7	NC	3
169		5	max	.097	1	.164	1	.346	2	0	3	NC	1	NC	2
170			min	-.029	7	-.245	7	0	3	-7.657e-4	6	NC	7	NC	3

ARCADIS

SUBJECT: TOPOCK
PARKING CANOPY
JOB NO.:

BY: CMW DATE: 12/2/14
CHKD: MSL DATE: 12/23/14

PAGE B20
SHEET 1

LRFD 3 → $\frac{wl^2}{2} = \frac{(0.369^{k}/_{FT})(8_{FT})^2}{2} = 11.81^{KIFT}$ — NEG M

$20_{FT}\ \frac{wl^2}{8} = 18.45^{KIFT}$ — POS MOMENT

1.0W → 44.7#/FT

$\frac{wl^2}{2} = \frac{[redacted](8_{FT})^2}{2} = 1.43^{KIFT}$

C10 × 15.3 ✓

DESIGN OF ROOF PURLINS:

AXIAL = ~~[illegible]~~ 0.497k (M10) ✓
y SHEAR = ~~3.[illegible] (M16)~~ 4.664k (M15) ✓
z SHEAR = ~~[illegible]~~ 0.529k (M10) ✓
yy MOMENT = ~~[illegible]~~ 1.833 K-FT (M10) ✓OK
zz MOMENT = ~~[illegible]~~ ~ (11.7K-FT CANTILEVER) 15.959 K-FT ✓OK (M10); ~~4.01~~ ✓OK (UPLIFT) M15 ✓

OR $\frac{wl^2}{8}\ 20_{FT}^2$ 2.24 KIFT

5.532 KIFT

$\frac{wl^2}{2}\ 8_{FT} = 4.74^{KIFT}$

SHEAR:

$V_N = \cancel{0.6} F_y A_w = \cancel{0.6} \times 36\ ksi \times [10'' \times 1/4''] = \cancel{54\ K}$ 48.4K

~~1.0.9~~ × 0.9 ← PER NOTE 2; 0.9 ×

~~8K~~ ~~54K~~ 48.4K > ~~3.528K~~ 4.664K OK ✓

0.148 k/FT D+L $\frac{wl^2}{8}\ 20_{FT} = 7.4^{KIFT}$ LRFD#6A

BENDING:

STRONG AXIS:

$L_b = 10^{FT}$ ✓ $L_p = 2.96^{FT}$ ✓ $L_r = 11.0^{FT}$ ✓

ZZ MOMENT = ~~14.69 K-FT~~ 15.959 K-FT ✓ (LC #1) — ↓ MOMENT ∴ $L_b = 1^{FT}$ ~ PURLIN BRACED BY ROOF DECK ✓

$L_p = 2.96 > L_b = 1.0^{FT}$ ∴

$M_{N_S} = 0.99 F_y S_x = 0.99 \times 36\ ksi \times 13.5\ in^3 = 481.2\ K\text{-}IN = 40.1\ K\text{-}FT$ ✓

$M_{N_S} = 40.1\ K\text{-}FT$ ✓ > ~~14.69~~ 15.959 K-FT OK ✓

WEAK AXIS:

yy MOMENT = ~~0.882~~ 1.833 K-FT

$M_{N_W} = 1.35 F_y S_y = 1.35 \times 36\ ksi \times 1.15\ in^3 = 55.89\ K\text{-}IN = 4.66\ K\text{-}FT$ ✓

$M_{NW} = 4.66\ K\text{-}FT > \cancel{0.882}$ 1.833 K-FT ✓

AXIAL IS MINIMAL & IGNORED

$\frac{\cancel{14.69} \ 15.959}{40.1\ K\text{-}FT} + \frac{\cancel{0.882}\ 1.833}{4.66\ K\text{-}FT} = \cancel{0.556} < 1.0$ OK ✓

0.791 < 1.0 OK ✓

ARCADIS

SUBJECT: [illegible]

JOB NO:

BY: CMW DATE: 12/10/14

CHKD: MSL DATE: 12/23/14

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SHEET 1

~~ZZ~~ = ~~[illegible]~~ = 5.532 K-FT

$L_b = 10FT$ $L_p = 2.96FT$ $L_R = 11FT$

$L_p < L_b < L_r$ [illegible]

$M_n = $ 10/11 [illegible] x(.36)

$M_n = $ ~~[illegible]~~ 0.675 $F_y S_x$ = ~~[illegible]~~ 0.675 [illegible]

$M_n = $ ~~[illegible]~~ 27.38 K-FT > 5.532 K-FT OK ✓

DEFLECTION:

$$\Delta = \sqrt{D_y^2 + D_z^2} = \sqrt{0.646"^2 + 1.475"^2} = 1.61" > \ell/240 = 1"$$

SINCE TOP FLANGE OF C10 x15.3 IS CONTINUALLY BRACED BY ROOF, & BOTTOM FLANGE IS LATERALLY BRACED, I_{C10} SHALL BE MULTIPLIED BY 3

$I_y = 3 \times 2.27 in^4 = 6.81 in^4$

$$\Delta_W = \frac{5w\ell^4}{384EI} = \frac{5 \times (50\#/FT)(20FT)^4}{384(29{,}000{,}000psi)(6.81 in^4)}$$

(44.7#/FT ← 1.0W)

$\Delta_W = 0.911" < 1"$ OK

STRONG AXIS DEFLECTION

- ASD LC#6A $D + 0.75L_r + 0.75(0.6W) \Rightarrow$ M10 = 0.233 K/FT; M15 = 0.239 K/FT ← USE

$$\Delta = \frac{5w\ell^4}{384EI} = 0.441^{IN} \approx \ell/544 << \ell/240 \ \& \ 1" \ \checkmark OK$$

(ℓ = 20FT, I = 67.3 IN^4)

$$\Delta_{8FT\,CANT} = \frac{w\ell^4}{8EI} = 0.188^{IN} \approx \ell/886 << \ell/240 \ \& \ 1" \ \checkmark OK$$

AGM Form 30 12-01

ARCADIS

SUBJECT: TOPOK – PARKING CANOPY

JOB NO:

BY: MSL DATE: 12/23/14

CHKD: DATE:

PAGE B20A1

SHEET /

WEAK AXIS DEFLECTION ~ 0.6W = 0.6 × 44.7#/FT (1.0W)

• $\Delta_{20FT} = \frac{5wl^4}{384EI} = 1.47^{IN}$ ← TOO MUCH ~ SINCE L3 ANGLE BRACES AT BOT FLANGE AT MIDSPAN & DECK AT TOP, ALL (3) C10 PURLINS TIED TOGETHER, ASSUME 2 C10'S RESIST LOADS

(I = 2.27 IN⁴)

Δ_{20FT} (2-C10's) = $0.735_{IN} \approx l/327 << l/240$ ✓OK

• $\Delta_{8FT} = \frac{5wl^4}{8EI} = 0.36^{IN} \approx l/266 < l/240$ ✓OK

Purlin Loads

$Axial = 0.497^{k}$ (M10 - LC2) ✓

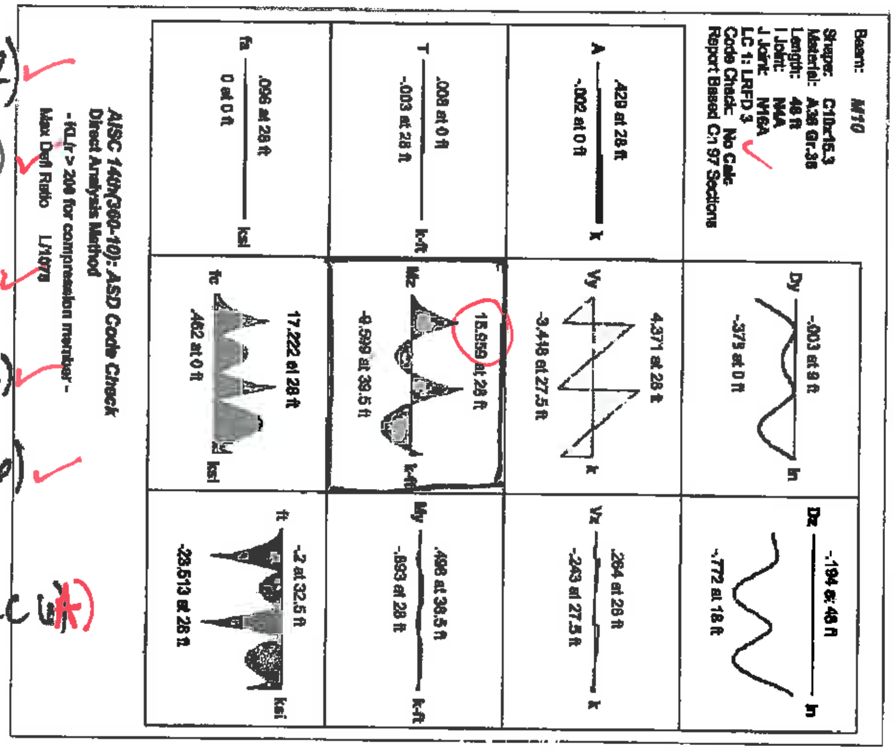
$V_y = 4.664^{k}$ (M15 LC1) ✓

$V_z = 0.529^{k}$ (M10 LC6) ✓

$M_z = 15.959^{k\text{-}ft}$ (M10 LC1) ✓

$M_y = 1.833^{k\text{-}ft}$ (M10 LC6) ✓

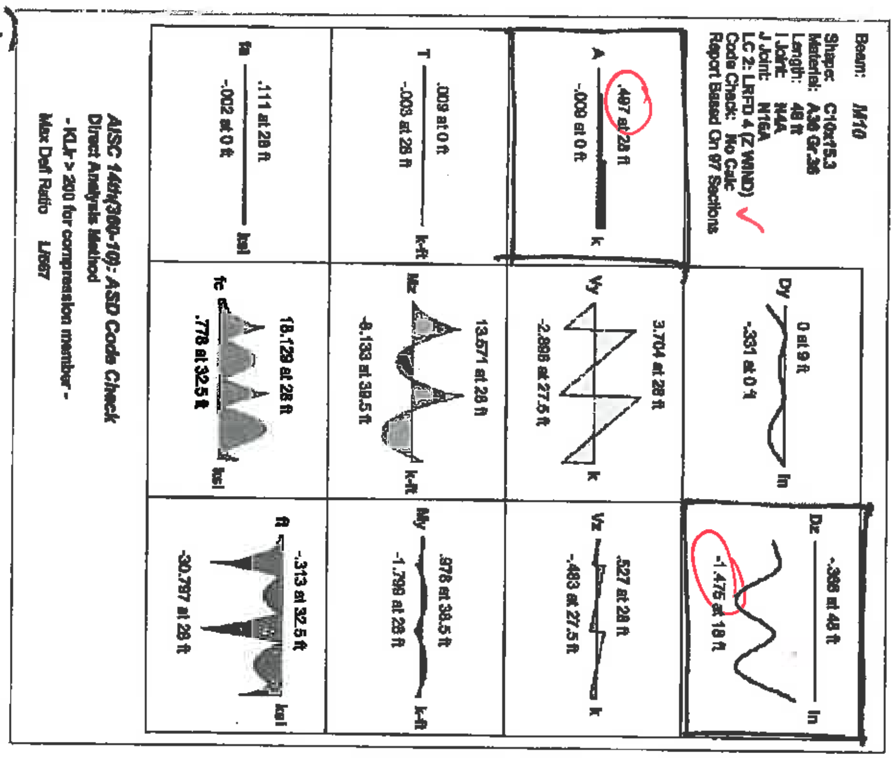
M_z uplift $=$ ~~$4.071^{k\text{-}ft}$~~ $5.532^{k\text{-}ft}$ (M10 LC 4)



Deflection: (LRFD LOADS)

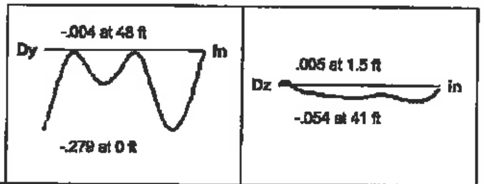
$D_y = 0.646''$ (M15 LC 1)
$0.373''$ (M10 LC#1)

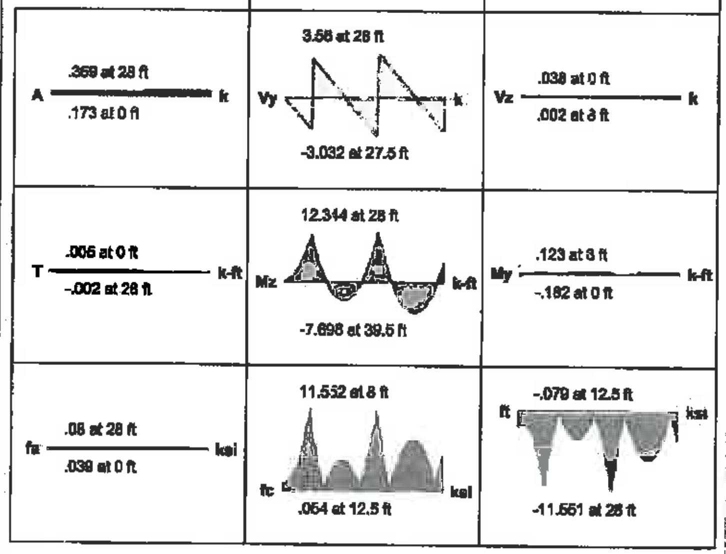
$D_z = 1.475''$ (M10 LC2)



Beam: *M10*

Shape: C10x15.3
Material: A36 Gr.36
Length: 48 ft
I Joint: N4A
J Joint: N16A
LC 3: LRFD 4 (X WIND) ✓
Code Check: No Calc
Report Based On 97 Sections





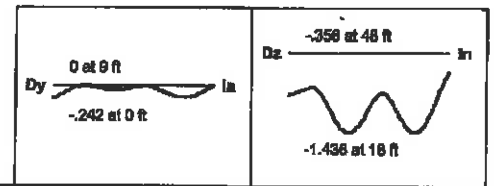
AISC 14th(360-10): ASD Code Check
Direct Analysis Method

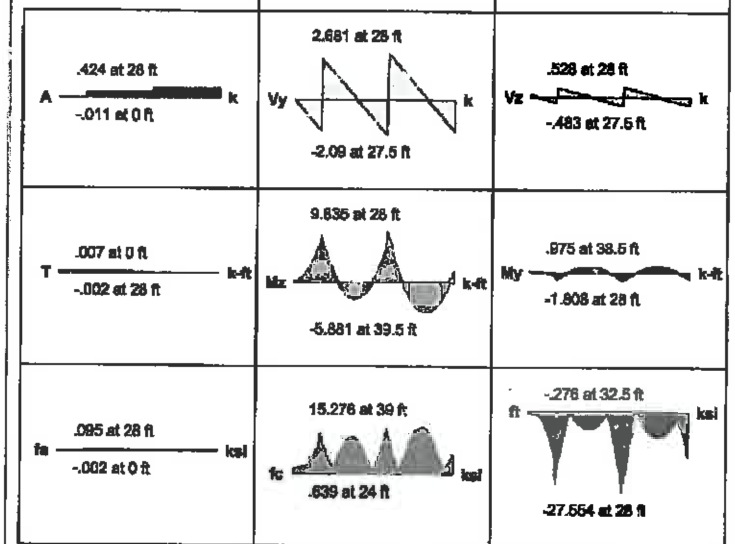
- KL/r > 200 for compression member -

Max Defl Ratio L/2094

Beam: *M10*

Shape: C10x15.3
Material: A36 Gr.36
Length: 48 ft
I Joint: N4A
J Joint: N16A
LC 4: LRFD 5 (Z WIND) ✓
Code Check: No Calc
Report Based On 97 Sections





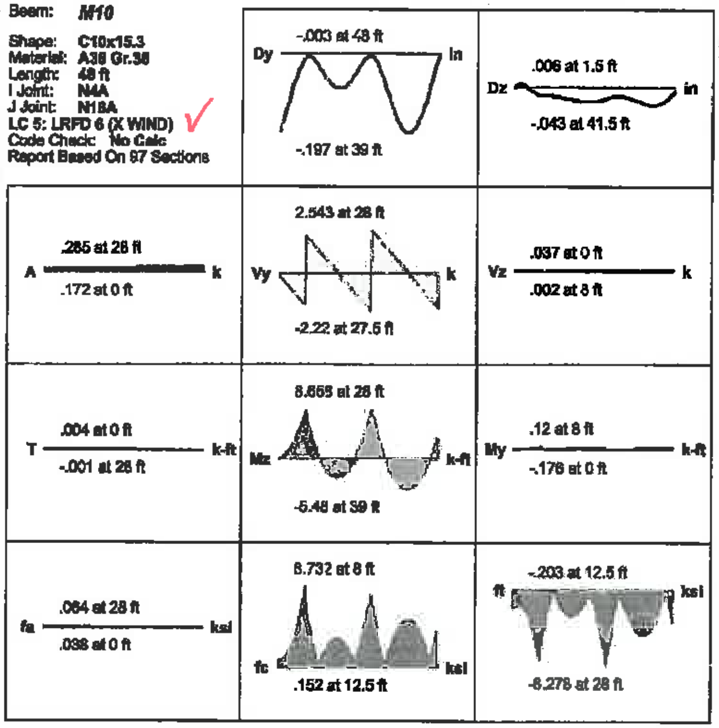
AISC 14th(360-10): ASD Code Check
Direct Analysis Method

- KL/r > 200 for compression member -

Max Defl Ratio L/577

Beam: *M10*

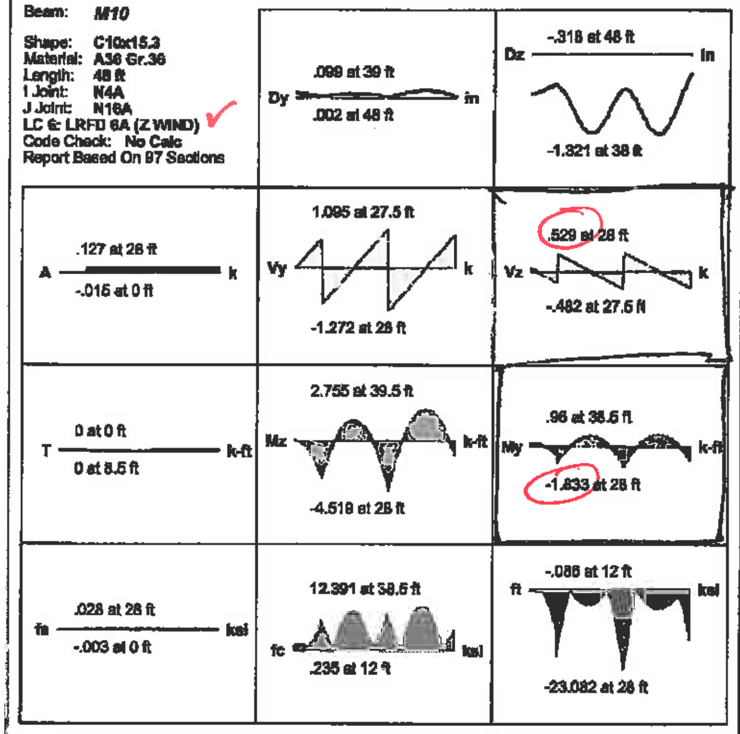
Shape: C10x15.3
Material: A36 Gr.36
Length: 48 ft
I Joint: N4A
J Joint: N18A
LC 5: LRFD 6 (X WIND) ✓
Code Check: No Calc
Report Based On 97 Sections



AISC 14th(360-10): ASD Code Check
Direct Analysis Method
- KL/r > 200 for compression member -
Max Defl Ratio L/2972

Beam: *M10*

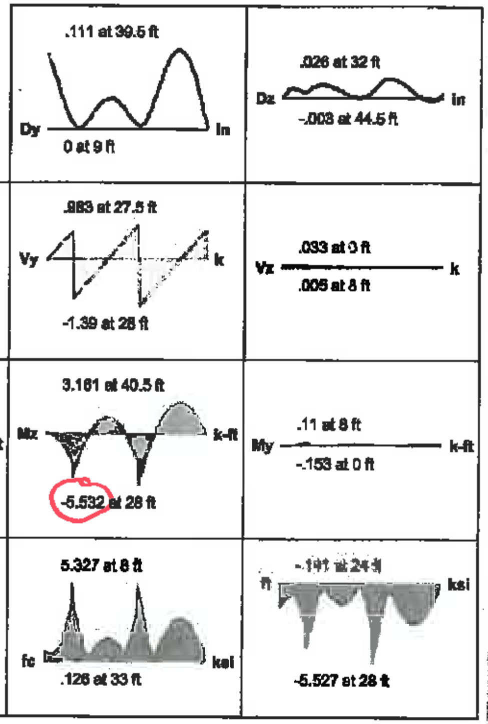
Shape: C10x15.3
Material: A36 Gr.36
Length: 48 ft
I Joint: N4A
J Joint: N16A
LC 6: LRFD 6A (Z WIND) ✓
Code Check: No Calc
Report Based On 97 Sections



AISC 14th(360-10): ASD Code Check
Direct Analysis Method
- KL/r > 200 for compression member -
Max Defl Ratio L/618

Beam: *M10*

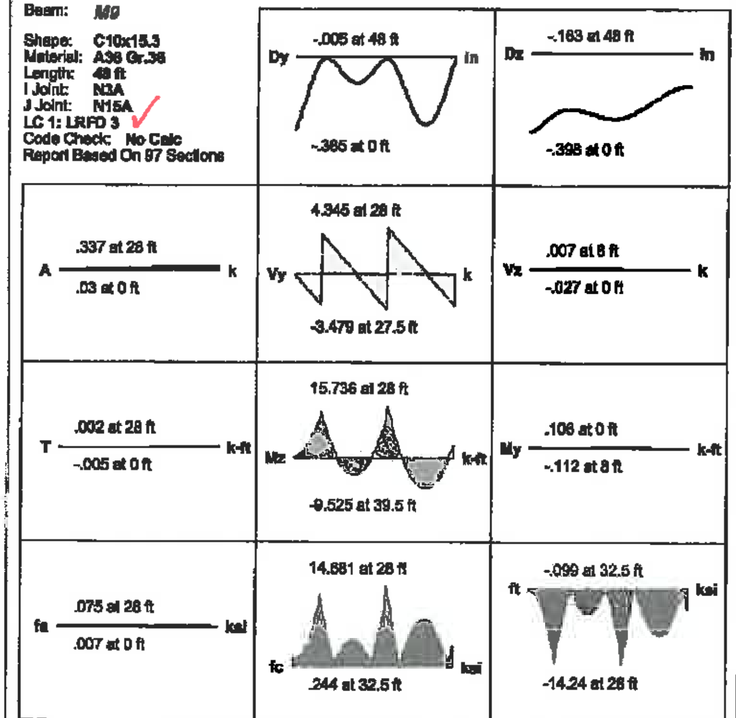
Shape: C10x15.3
Material: A36 Gr.36
Length: 48 ft
I Joint: N4A
J Joint: N16A
LC 7: LRFD 6A (X WIND) ✓
Code Check: No Calc
Report Based On 97 Sections



AISC 14th(360-10): ASD Code Check
Direct Analysis Method
- KL/r > 200 for compression member -
Max Defl Ratio L/5260

Beam: *M9*

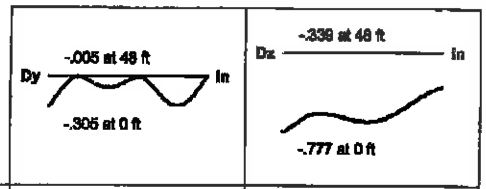
Shape: C10x15.3
Material: A36 Gr.36
Length: 48 ft
I Joint: N3A
J Joint: N15A
LC 1: LRFD 3 ✓
Code Check: No Calc
Report Based On 97 Sections

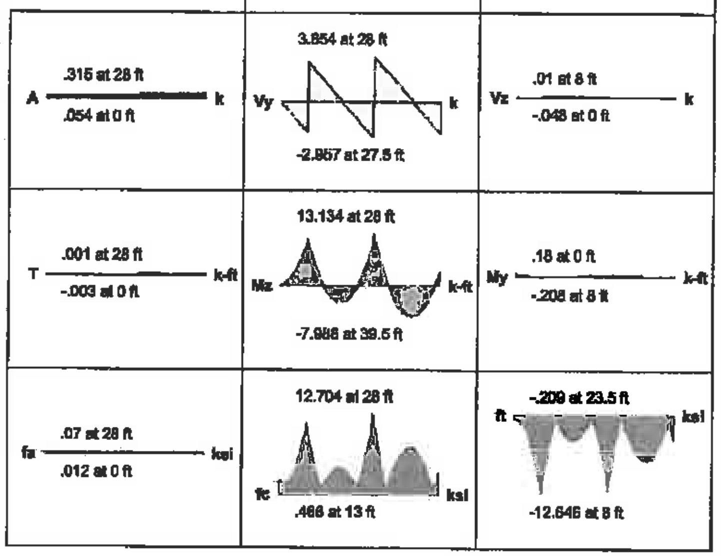


AISC 14th(360-10): ASD Code Check
Direct Analysis Method
- KL/r > 200 for compression member -
Max Defl Ratio L/1602

Beam: M9

Shape: C10x15.3
Material: A36 Gr.36
Length: 48 ft
I Joint: N3A
J Joint: N15A
LC 2: LRFD 4 (Z WIND)
Code Check: No Calc
Report Based On 97 Sections





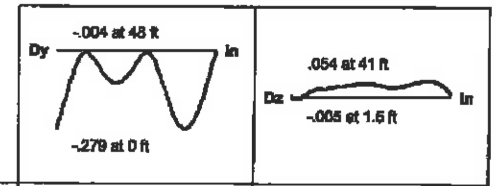
AISC 14th(360-10): ASD Code Check
Direct Analysis Method

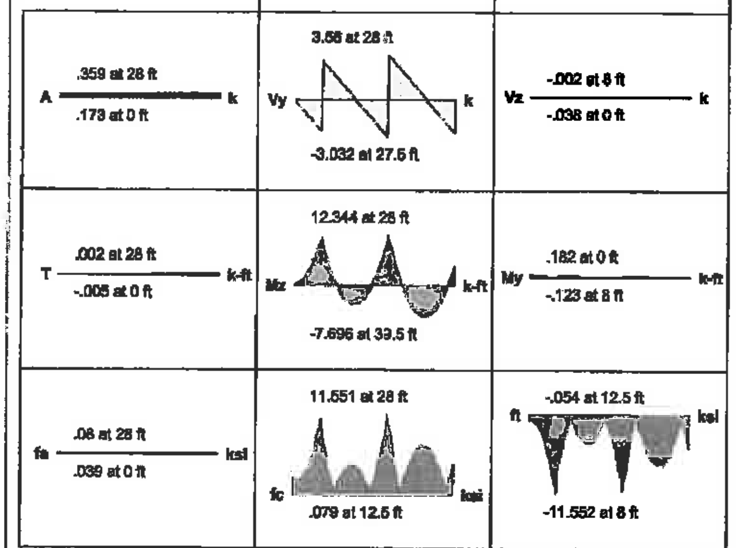
- KL/r > 200 for compression member -

Max Defl Ratio L/1920

Beam: M9

Shape: C10x15.3
Material: A36 Gr.36
Length: 48 ft
I Joint: N3A
J Joint: N15A
LC 3: LRFD 4 (X WIND)
Code Check: No Calc
Report Based On 97 Sections



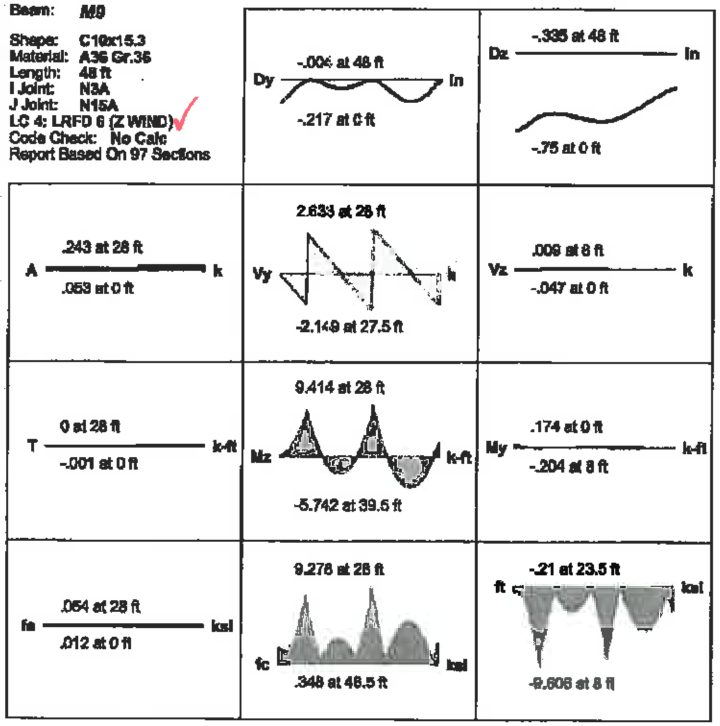


AISC 14th(360-10): ASD Code Check
Direct Analysis Method

- KL/r > 200 for compression member -

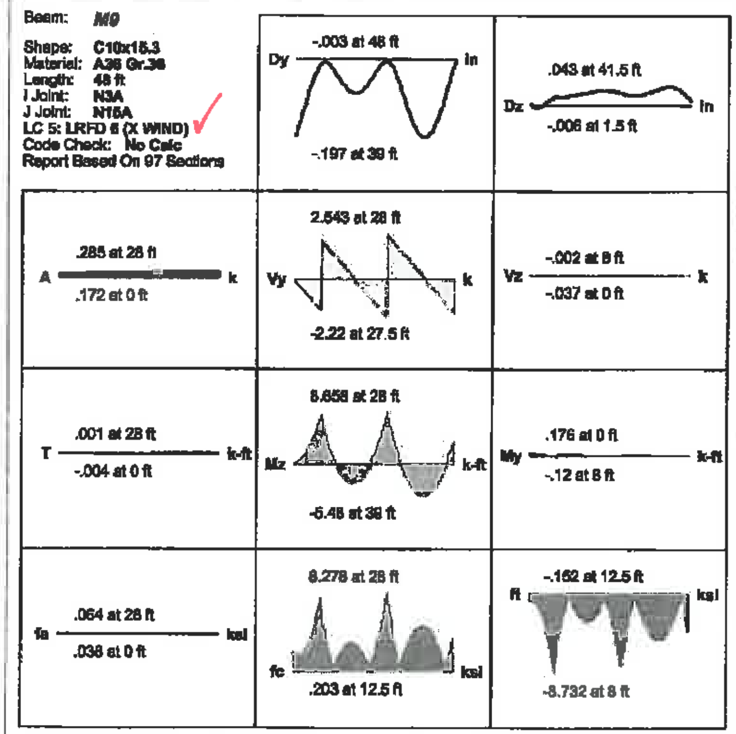
Max Def. Ratio L/2084

Beam: *M9*
Shape: C10x15.3
Material: A36 Gr.36
Length: 48 ft
I Joint: N3A
J Joint: N15A
LC 4: LRFD 6 (Z WIND)
Code Check: No Calc
Report Based On 97 Sections



AISC 14th(360-10): ASD Code Check
Direct Analysis Method
- KL/r > 200 for compression member -
Max Defl Ratio L/2701

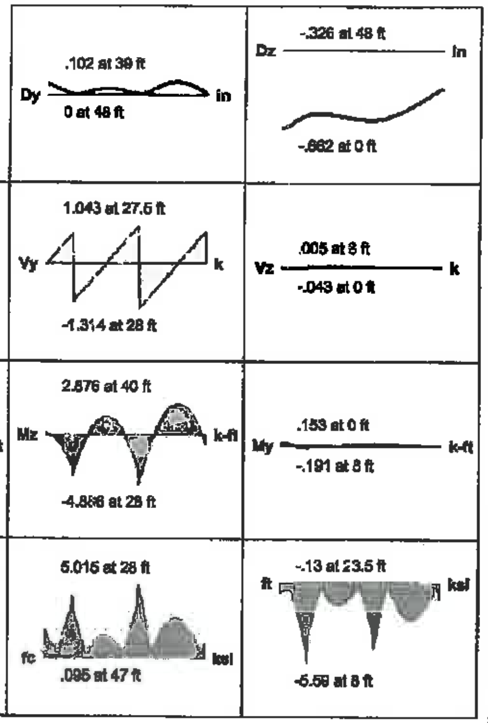
Beam: *M9*
Shape: C10x15.3
Material: A36 Gr.36
Length: 48 ft
I Joint: N3A
J Joint: N15A
LC 5: LRFD 6 (X WIND)
Code Check: No Calc
Report Based On 97 Sections



AISC 14th(360-10): ASD Code Check
Direct Analysis Method
- KL/r > 200 for compression member -
Max Defl Ratio L/2972

Beam: M9

Shape: C10x15.3
Material: A36 Gr.36
Length: 48 ft
I Joint: N3A
J Joint: N15A
LC 6: LRFD 6A (Z WIND) ✓
Code Check: No Calc
Report Based On 97 Sections



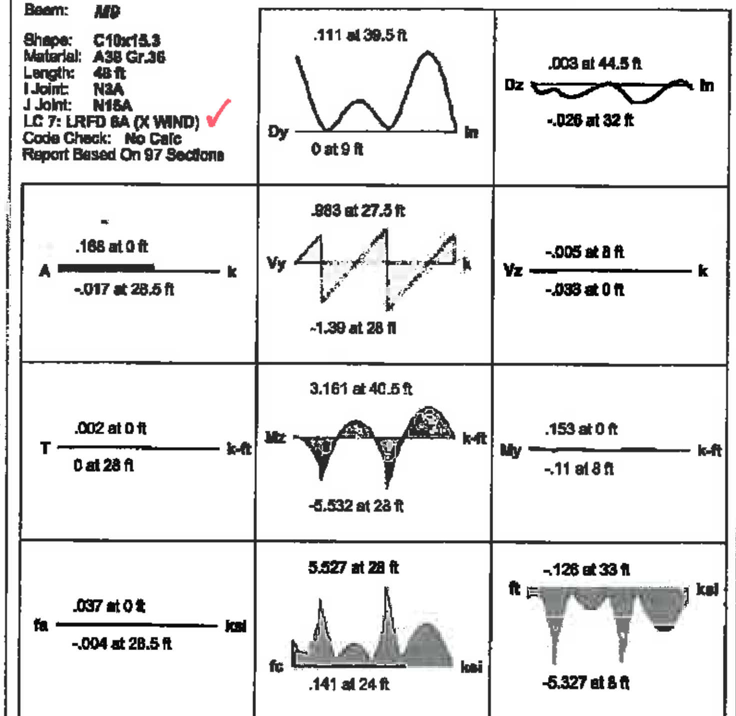
AISC 14th(360-10): ASD Code Check
Direct Analysis Method

- KL/r > 200 for compression member -

Max Defl Ratio L/4389

Beam: M9

Shape: C10x15.3
Material: A36 Gr.36
Length: 48 ft
I Joint: N3A
J Joint: N15A
LC 7: LRFD 6A (X WIND) ✓
Code Check: No Calc
Report Based On 97 Sections



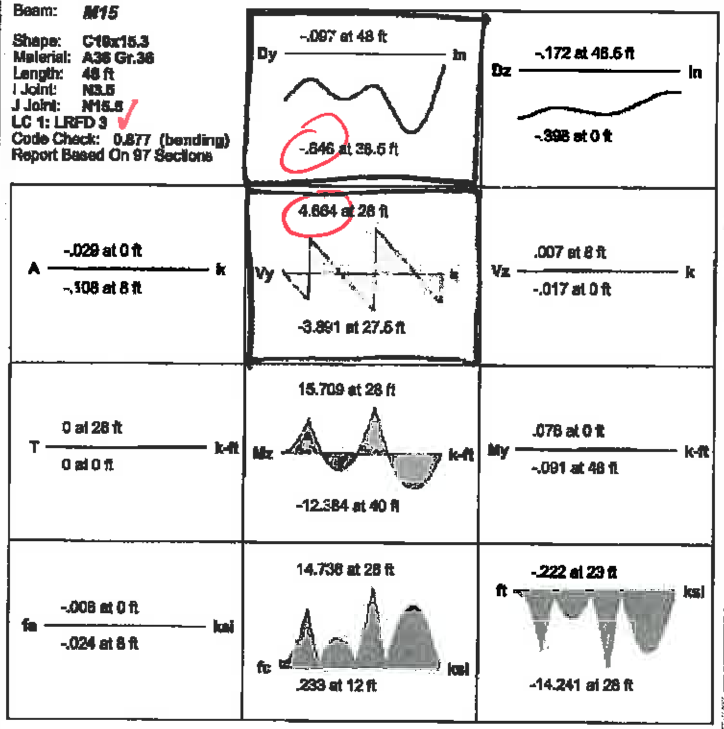
AISC 14th(360-10): ASD Code Check
Direct Analysis Method

- KL/r > 200 for compression member -

Max Defl Ratio L/5290

Beam: M15

Shape: C10x15.3
Material: A36 Gr.36
Length: 48 ft
I Joint: N3.5
J Joint: N15.5
LC 1: LRFD 3
Code Check: 0.877 (bending)
Report Based On 97 Sections



AISC 14th(360-10): ASD Code Check

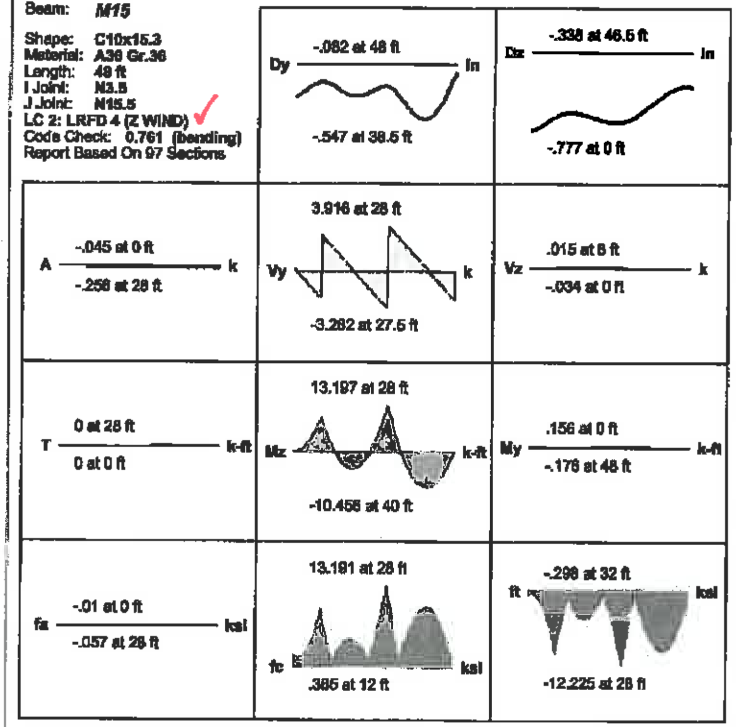
Direct Analysis Method

Max Bending Check	0.877	Max Shear Check	0.160 (y)
Location	28 ft	Location	28 ft
Equation	H1-1b	Max Defl Ratio	L/1167
Bending Flange	Compact	Compression Flange	Non-Slender
Bending Web	Compact	Compression Web	Non-Slender

Fy	36 ksi		y-y	z-z
Pnc/om	1.028 k	Lb	48 ft	48 ft
Pnt/om	96.575 k	KL/r	809.186	148.612
Mny/om	3.319 k-ft			
Mnz/om	18.373 k-ft	L Comp Flange	10 ft	
Vny/om	31.042 k	Warp Length	48 ft	
Vnz/om	29.324 k	L-torque	48 ft	
Cb	1	Tau_b	1	

Beam: M15

Shape: C10x15.3
Material: A36 Gr.36
Length: 48 ft
I Joint: N3.5
J Joint: N15.5
LC 2: LRFD 4 (Z WIND)
Code Check: 0.761 (bending)
Report Based On 97 Sections



AISC 14th(360-10): ASD Code Check

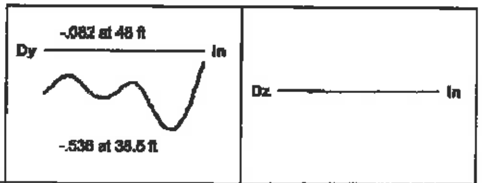
Direct Analysis Method

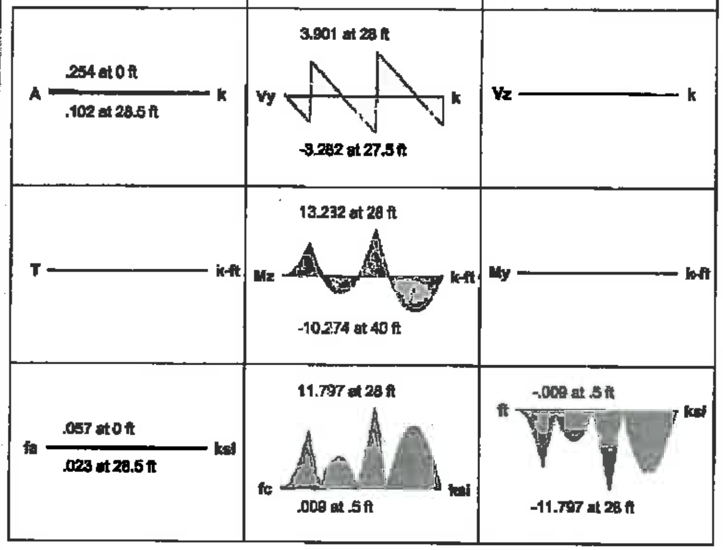
Max Bending Check	0.761	Max Shear Check	0.127 (y)
Location	28 ft	Location	28 ft
Equation	H1-1b	Max Defl Ratio	L/1361
Bending Flange	Compact	Compression Flange	Non-Slender
Bending Web	Compact	Compression Web	Non-Slender

Fy	36 ksi		y-y	z-z
Pnc/om	1.028 k	Lb	48 ft	48 ft
Pnt/om	96.575 k	KL/r	809.186	148.612
Mny/om	3.316 k-ft			
Mnz/om	18.373 k-ft	L Comp Flange	10 ft	
Vny/om	31.042 k	Warp Length	48 ft	
Vnz/om	29.324 k	L-torque	48 ft	
Cb	1	Tau_b	1	

Beam: *M15*

Shape: C10x15.3
Material: A36 Gr.36
Length: 48 ft
I Joint: N3.5
J Joint: N15.5
LC 3: LRFD 4 (X WIND)
Code Check: No Calc
Report Based On 97 Sections





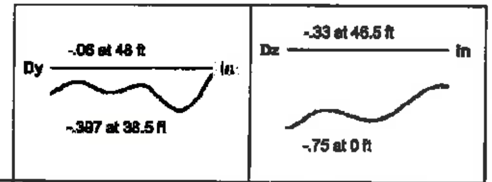
AISC 14th(360-10): ASD Code Check
Direct Analysis Method

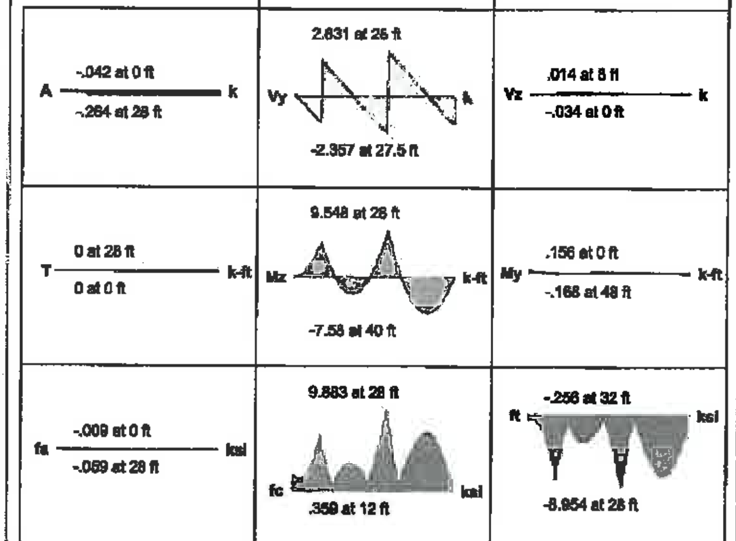
- KL/r > 200 for compression member -

Max Defl Ratio L/1393

Beam: *M15*

Shape: C10x15.3
Material: A36 Gr.36
Length: 48 ft
I Joint: N3.5
J Joint: N15.5
LC 4: LRFD 6 (Z WIND)
Code Check: 0.561 (bending)
Report Based On 97 Sections





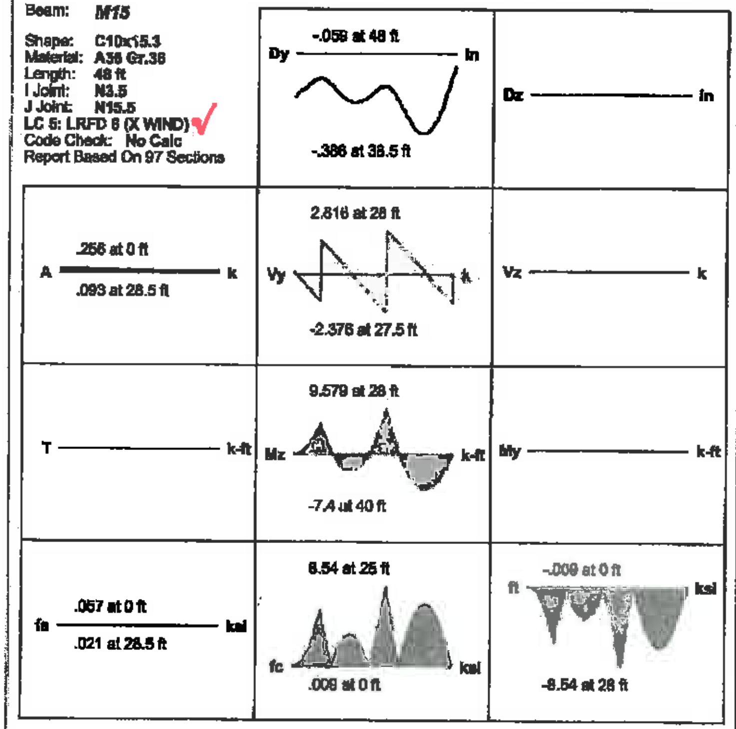
AISC 14th(360-10): ASD Code Check
Direct Analysis Method

Max Bending Check	0.561	Max Shear Check	0.082 (y)
Location	28 ft	Location	28 ft
Equation	H1-1b	Max Defl Ratio	L/1901
Bending Flange	Compact	Compression Flange	Non-Slender
Bending Web	Compact	Compression Web	Non-Slender

Fy	36 ksi		y-y	z-z
Pnc/om	1.028 k	Lb	48 ft	48 ft
Pnt/om	96.575 k	KL/r	809.186	146.512
Mny/om	3.319 k-ft			
Mnz/om	18.373 k-ft	L Comp Flange	10 ft	
Vny/om	31.042 k	Warp Length	48 ft	
Vnz/om	29.324 k	L-torque	48 ft	
Cb	1	Tau_b	1	

Beam: *M15*

Shape: C10x15.3
Material: A36 Gr.36
Length: 48 ft
I Joint: N3.5
J Joint: N15.5
LC 5: LRFD 6 (X WIND) ✓
Code Check: No Calc
Report Based On 97 Sections



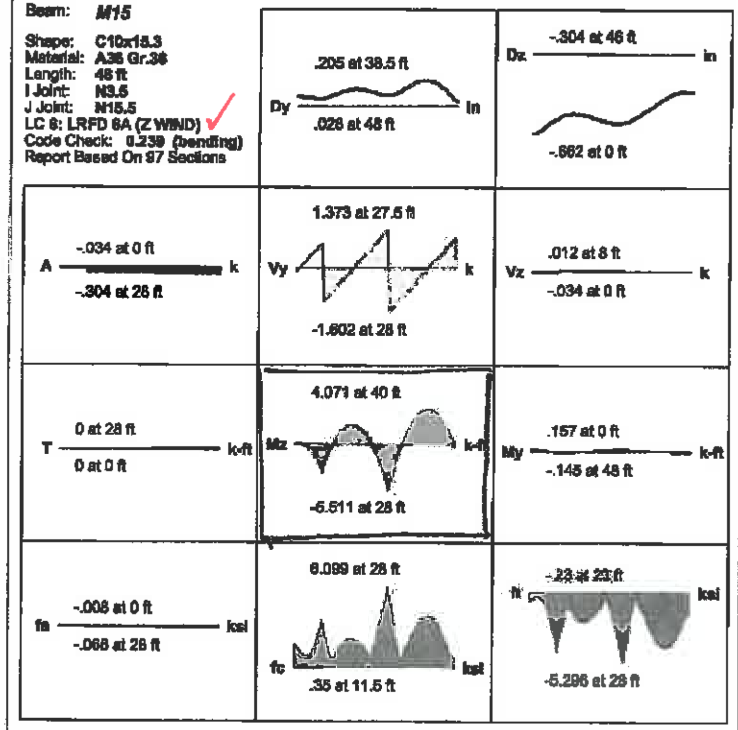
AISC 14th(360-10): ASD Code Check
Direct Analysis Method

- KL/r > 200 for compression member -

Max Defl Ratio L/1924

Beam: *M15*

Shape: C10x15.3
Material: A36 Gr.36
Length: 48 ft
I Joint: N3.5
J Joint: N15.5
LC 6: LRFD 6A (Z WIND) ✓
Code Check: 0.239 (bending)
Report Based On 97 Sections



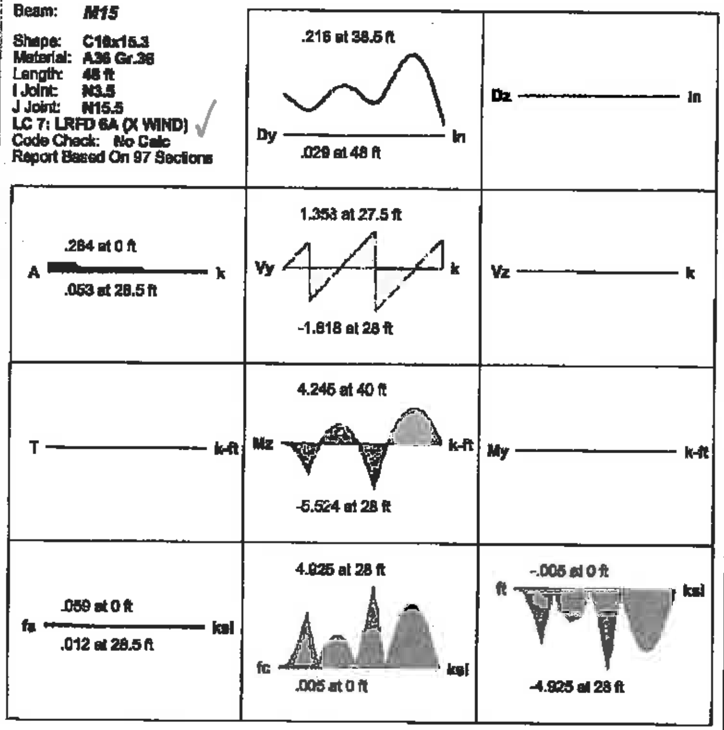
AISC 14th(360-10): ASD Code Check
Direct Analysis Method

Max Bending Check	0.239	Max Shear Check	0.052 (y)
Location	40.5 ft	Location	28 ft
Equation	H1-1b	Max Defl Ratio	L/3420
Bending Flange	Compact	Compression Flange	Non-Slender
Bending Web	Compact	Compression Web	Non-Slender

Fy	36 ksi		y-y	z-z
Pnc/om	1.028 k	Lb	48 ft	48 ft
Pnt/om	98.578 k	KL/r	909.186	146.812
Mny/om	3.319 k-ft			
Mnz/om	18.373 k-ft	L Comp Flange	10 ft	
Vny/om	31.042 k	Warp Length	48 ft	
Vnz/om	29.324 k	L-torque	48 ft	
Cb	1	Tau_b	1	

Beam: ***M15***

Shape: C18x15.3
Material: A36 Gr.36
Length: 48 ft
I Joint: N3.5
J Joint: N15.5
LC 7: LRFD 6A (X WIND)
Code Check: No Calc
Report Based On 97 Sections



AISC 14th(360-10): ASD Code Check
Direct Analysis Method

- KL/r > 200 for compression member -

Max Defl Ratio L/3339

ROOF BEAMS: (M11, M12, M13, & M14)

AXIAL =	1.108K ✓	MODEL ASSUMES THESE MEMBERS REPRESENT 2 C10x15.3 BEAMS (÷2) =	=	0.554K ✓
y SHEAR =	~~5.028K~~ 5.07K ✓		=	~~2.514K~~ 2.54 ✓
z SHEAR =	0.272K ✓		=	0.136K ✓
yy MOMENT =	1.264K-FT ✓		=	0.632K-FT ✓
zz MOMENT =	~~20.895~~ K-FT 20.91 ✓		=	10.5K-FT ✓

* ALL LOADS ARE ≤ TO PURLIN LOADS ✓ THEREFORE C10x15.3 OK FOR BEAM DESIGN.

** FOR ALL FRAMING CONNECTIONS, SEE "SECTION BD".

COLUMN DESIGN:

MEMBER SIZE = HSS 6x6x1/4

AXIAL = ~~13.298K~~ 13.303K (LC1 - M6) ✓

y SHEAR = 0.489K (M7) ✓

z SHEAR = ~~1.129K~~ (M6) 1.169K

yy MOMENT = ~~9.031K-FT~~ (M6 - LC 2) 11.04

zz MOMENT = 1.349K-FT ~~(M8 - LC3)~~ OK

COMPRESSION:

$$Kl/r = \frac{1.0 \times 10.67FT \times 12"/FT}{2.34"} = 54.72 ✓$$

$$800/\sqrt{F_y} = 117.95 ✓ > 54.72 ✓ \therefore P_u = 0.9 F_y A_g \times 0.658^P ✓$$

$$P = F_y \, (Kl/r)^2 / 286{,}000 = 0.482 ✓$$

Envelope Member Section Forces

	Member	Sec		Axial[k]	LC	y Shear[k]	LC	z Shear[k]	LC	Torque[k...	LC	y-y Mom...	LC	z-z Mom...	LC
1	M12	1	max	.468	2	1.405	3	.272	6	0	3	.084	3	1.791	3
2			min	-.069	7	-.965	6	-.051	3	0	2	-1.264	6	-3.734	6
3		2	max	.468	2	1.351	3	.272	6	0	3	-.026	7	.787	7
4			min	-.069	7	-1.006	6	-.051	3	0	2	-.496	2	-3.996	2
5		3	max	.482	2	.531	7	.272	6	0	3	.366	6	2.318	7
6			min	-.069	7	-1.826	2	-.009	4	0	2	-.225	3	-7.501	1
7		4	max	.482	2	.49	7	.051	3	0	3	.123	6	2.262	6
8			min	-.069	7	-1.881	2	-.032	6	0	2	-.071	3	-2.343	3
9		5	max	.482	2	.448	7	.051	3	0	3	.084	3	4.943	2
10			min	-.069	7	-1.936	2	-.032	6	0	2	.026	6	-.62	7
11	M13	1	max	1.108	2	3.948	1	-.004	1	0	3	.138	6	4.89	3
12			min	-.194	7	-2.378	6	-.047	7	0	2	.035	1	-7.758	6
13		2	max	1.108	2	3.893	1	-.004	1	0	3	.031	2	2.457	7
14			min	-.194	7	-2.419	6	-.047	7	0	2	-.033	7	-9.767	2
15		3	max	1.108	2	1.521	7	.047	7	0	3	.019	1	6.959	7
16			min	-.194	7	-4.918	1	-.04	6	0	2	-.173	7	-20.895	1
17		4	max	1.08	2	1.48	7	.047	7	0	3	-.001	1	5.092	6
18			min	-.194	7	-4.973	1	-.007	1	0	2	-.033	7	-6.378	3
19		5	max	1.08	2	1.439	7	.047	7	0	3	.107	7	11.072	2
20			min	-.194	7	-5.028	1	-.007	1	0	2	-.021	1	-1.921	7
21	M14	1	max	.797	2	2.942	1	-.045	3	0	3	.642	6	3.715	3
22			min	-.171	7	-1.878	6	-.151	6	0	2	.134	3	-6.672	6
23		2	max	.797	2	2.887	1	-.045	3	0	3	.215	2	1.798	7
24			min	-.171	7	-1.919	6	-.151	6	0	2	-.024	7	-7.888	2
25		3	max	.845	2	2.757	3	.049	4	0	3	-.069	1	5.105	7
26			min	-.171	7	-3.815	1	-.151	6	0	2	-.263	6	-15.904	1
27		4	max	.845	2	1.082	7	.063	6	0	3	0	3	4.189	6
28			min	-.171	7	-3.87	1	.016	1	0	2	-.053	6	-4.803	3
29		5	max	.845	2	1.041	7	.063	6	0	3	.153	7	9.406	2
30			min	-.171	7	-3.925	1	.016	1	0	2	.044	1	-1.386	7

Envelope Member Section Forces

	Member	Sec		Axial[k]	LC	y Shear[k]	LC	z Shear[k]	LC	Torque[k...	LC	y-y Mom...	LC	z-z Mom...	LC
1	M3	1	max	10.154	1	.235	7	.691	6	0	1	0	1	0	1
2			min	-3.651	6	-.098	1	-.376	3	0	1	0	1	0	1
3		2	max	10.097	1	.19	7	.646	6	0	1	1.784	6	.261	1
4			min	-3.694	6	-.098	1	-.376	3	0	1	-1.002	3	-.566	7
5		3	max	10.04	1	.144	7	.602	6	0	1	3.449	6	.522	1
6			min	-3.736	6	-.098	1	-.376	3	0	1	-2.004	3	-1.011	7
7		4	max	9.983	1	.099	7	.557	6	0	1	4.994	6	.783	1
8			min	-3.779	6	-.098	1	-.376	3	0	1	-3.006	3	-1.336	7
9		5	max	6.986	1	0	7	.833	2	-.134	3	.008	2	1.097	2
10			min	-2.035	7	-.223	2	-.027	5	-.642	6	-.002	7	-1.494	7
11	M4	1	max	11.108	1	.235	7	.952	2	0	1	0	1	0	1
12			min	-2.904	7	-.068	1	-.143	7	0	1	0	1	0	1
13		2	max	11.051	1	.19	7	.952	2	0	1	2.54	2	.183	1
14			min	-2.947	7	-.068	1	-.143	7	0	1	-.381	7	-.566	7
15		3	max	10.994	1	.144	7	.952	2	0	1	5.08	2	.365	1
16			min	-2.99	7	-.068	1	-.143	7	0	1	-.763	7	-1.011	7
17		4	max	10.937	1	.099	7	.952	2	0	1	7.621	2	.548	1
18			min	-3.033	7	-.068	1	-.143	7	0	1	-1.144	7	-1.336	7
19		5	max	6.957	1	.004	6	.052	4	.153	7	.004	6	.736	1
20			min	-2.035	7	-.082	3	.015	1	.044	1	-.005	3	-1.494	7
21	M5	1	max	12.178	1	.223	7	.783	6	0	1	0	1	0	1
22			min	-4.629	6	-.317	1	-.499	3	0	1	0	1	0	1
23		2	max	12.121	1	.223	7	.738	6	0	1	2.028	6	.847	1
24			min	-4.671	6	-.317	1	-.499	3	0	1	-1.332	3	-.595	7
25		3	max	12.064	1	.223	7	.693	6	0	1	3.937	6	1.694	1
26			min	-4.714	6	-.317	1	-.499	3	0	1	-2.665	3	-1.189	7
27		4	max	12.007	1	.223	7	.648	6	0	1	5.726	6	2.541	1
28			min	-4.757	6	-.317	1	-.499	3	0	1	-3.997	3	-1.784	7
29		5	max	8.005	1	.183	7	1.071	2	-.035	1	.004	1	3.366	1
30			min	-2.429	7	-.292	1	.004	7	-.138	6	-.001	7	-2.345	7
31	M6	1	max	13.263	1	.223	7	1.129	2	0	1	0	1	0	1
32			min	-3.697	7	-.276	1	-.195	7	0	1	0	1	0	1
33		2	max	13.206	1	.223	7	1.129	2	0	1	3.01	2	.736	1
34			min	-3.739	7	-.276	1	-.195	7	0	1	-.52	7	-.595	7
35		3	max	13.149	1	.223	7	1.129	2	0	1	6.021	2	1.472	1
36			min	-3.782	7	-.276	1	-.195	7	0	1	-1.04	7	-1.189	7
37		4	max	13.091	1	.223	7	1.129	2	0	1	9.031	2	2.208	1
38			min	-3.825	7	-.276	1	-.195	7	0	1	-1.559	7	-1.784	7
39		5	max	8.01	1	.183	7	-.004	7	.107	7	.002	6	2.917	1
40			min	-2.429	7	-.243	1	-.039	1	-.021	1	-.003	1	-2.345	7
41	M7	1	max	4.722	1	.412	3	.422	6	0	1	0	1	0	1
42			min	-1.745	6	-.145	6	-.182	3	0	1	0	1	0	1
43		2	max	4.664	1	.412	3	.377	6	0	1	1.065	6	.386	6
44			min	-1.788	6	-.145	6	-.182	3	0	1	-.486	3	-1.099	3
45		3	max	4.607	1	.412	3	.332	6	0	1	2.01	6	.772	6
46			min	-1.831	6	-.145	6	-.182	3	0	1	-.971	3	-2.197	3
47		4	max	4.55	1	.412	3	.287	6	0	1	2.836	6	1.158	6
48			min	-1.873	6	-.145	6	-.182	3	0	1	-1.457	3	-3.296	3
49		5	max	3.113	1	.489	2	.477	2	1.264	6	0	7	1.316	6
50			min	-.952	6	-.018	7	-.005	7	-.084	3	-.003	1	-4.344	3
51	M8	1	max	5.287	1	.412	3	.502	2	0	1	0	1	0	1
52			min	-1.108	7	-.081	6	-.064	7	0	1	0	1	0	1
53		2	max	5.23	1	.412	3	.502	2	0	1	1.34	2	.215	6
54			min	-1.151	7	-.081	6	-.064	7	0	1	-.169	7	-1.099	3
55		3	max	5.173	1	.412	3	.502	2	0	1	2.68	2	.43	6
56			min	-1.194	7	-.081	6	-.064	7	0	1	-.339	7	-2.197	3

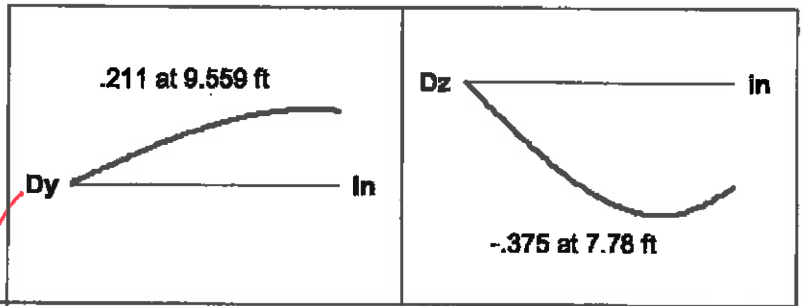
Envelope Member Section Forces (Continued)

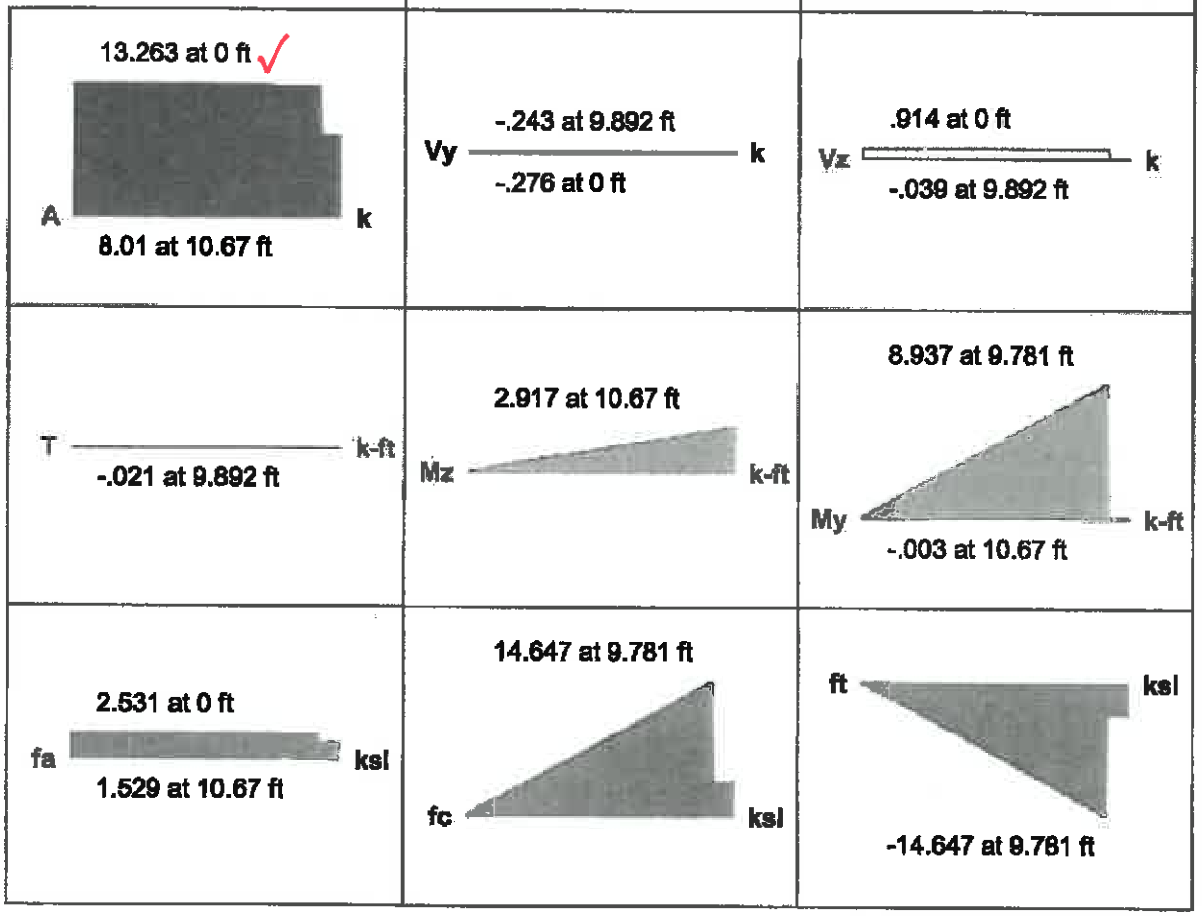
	Member	Sec		Axial[k]	LC	y Shear[k]	LC	z Shear[k]	LC	Torque[k...	LC	y-y Mom...	LC	z-z Mom...	LC
57		4	max	5.116	1	.412	3	.502	2	0	1	4.02	2	.646	6
58			min	-1.237	7	-.081	6	-.064	7	0	1	-.508	7	-3.296	3
59		5	max	3.137	1	.351	3	.006	4	.084	3	.002	1	.835	6
60			min	-.909	6	-.049	6	0	1	.026	6	-.001	6	-4.344	3

B21C

Column: *M6*

Shape: HSS6x6x4
Material: A500 Gr.B Rect
Length: 10.67 ft
I Joint: N9
J Joint: N11A
LC 1: LRFD 3
Code Check: 0.338 (bending) ✓
Report Based On 97 Sections





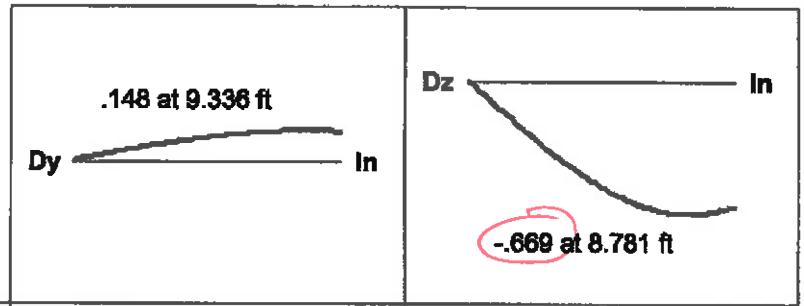
AISC 14th(360-10): LRFD Code Check
Direct Analysis Method

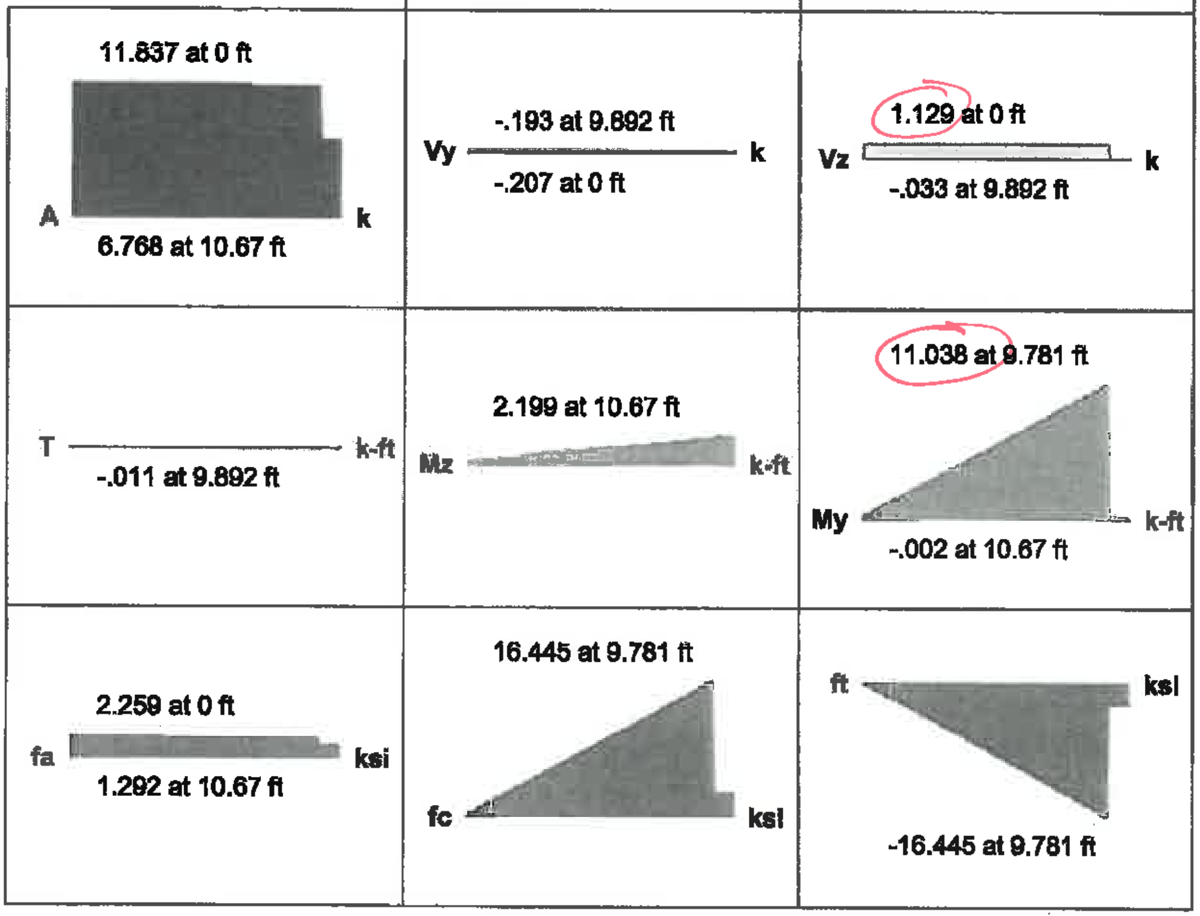
Max Bending Check	0.338	Max Shear Check	0.015 (z)
Location	9.781 ft	Location	0 ft
Equation	H1-1b	Max Defl Ratio	L/708
Bending Flange	Compact	Compression Flange	Non-Slender
Bending Web	Compact	Compression Web	Non-Slender

Fy	46 ksi		y-y	z-z
phi*Pnc	177.248 k	Lb	10.67 ft	10.67 ft
phi*Pnt	216.936 k	KL/r	54.806	54.806
phi*Mny	38.64 k-ft			
phi*Mnz	38.64 k-ft	L Comp Flange	10.67 ft	
phi*Vny	61.361 k	Warp Length	NC	
phi*Vnz	61.361 k	L-torque	10.67 ft	
phi*Tn	31.98 k-ft	Tau_b	1	
Cb	1.656			

Column: *M6*

Shape: HSS6x6x4
Material: A500 Gr.B Rect
Length: 10.67 ft
I Joint: N9
J Joint: N11A
LC 2: LRFD 4 (Z WIND)
Code Check: 0.371 (bending)
Report Based On 97 Sections





AISC 14th(360-10): LRFD Code Check

Direct Analysis Method

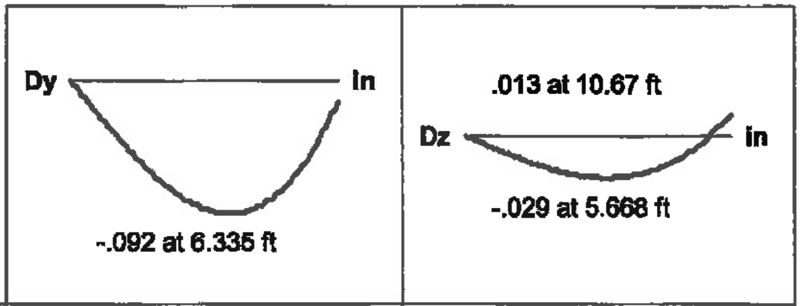
Max Bending Check	0.371	Max Shear Check	0.018 (z)
Location	9.781 ft	Location	0 ft
Equation	H1-1b	Max Defl Ratio	L/573
Bending Flange	Compact	Compression Flange	Non-Slender
Bending Web	Compact	Compression Web	Non-Slender

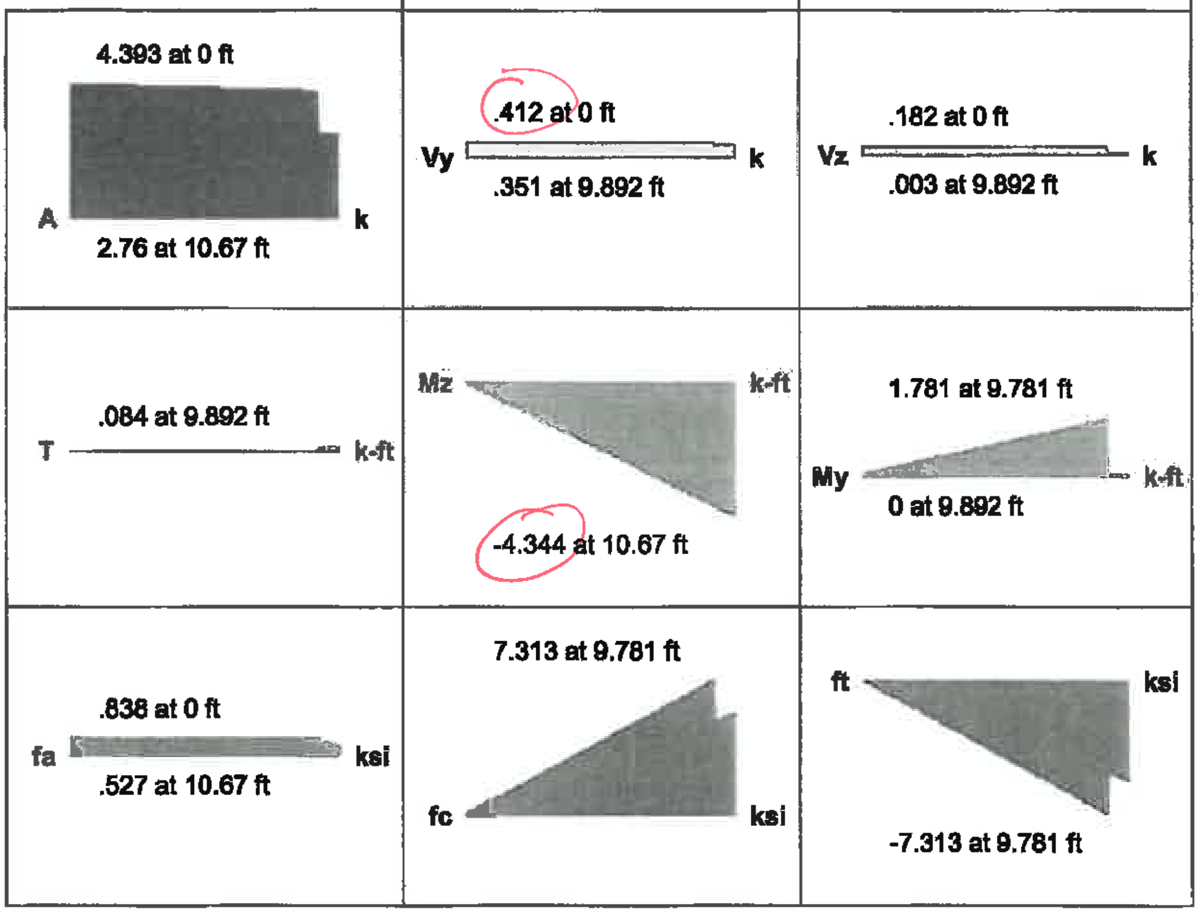
Fy	46 ksi		y-y	z-z
phi*Pnc	177.248 k	Lb	10.67 ft	10.67 ft
phi*Pnt	216.936 k	KL/r	54.806	54.806
phi*Mny	38.64 k-ft			
phi*Mnz	38.64 k-ft	L Comp Flange	10.67 ft	
phi*Vny	61.361 k	Warp Length	NC	
phi*Vnz	61.361 k	L-torque	10.67 ft	
phi*Tn	31.98 k-ft	Tau_b	1	
Cb	1.661			

Column: ***M8***

Shape:	**HSS6x6x4**
Material:	**A500 Gr.B Rect**
Length:	**10.67 ft**
I Joint:	**N13**
J Joint:	**N15A**

LC 3: LRFD 4 (X WIND)
Code Check: **0.162 (bending)**
Report Based On 97 Sections





AISC 14th(360-10): LRFD Code Check

Direct Analysis Method

Max Bending Check	**0.162**	Max Shear Check	**0.008 (y)**
Location	**9.781 ft**	Location	**9.892 ft**
Equation	**H1-1b**	Max Defl Ratio	**L/1532**
Bending Flange	**Compact**	Compression Flange	**Non-Slender**
Bending Web	**Compact**	Compression Web	**Non-Slender**

Fy	**46 ksi**
phi*Pnc	**177.248 k**
phi*Pnt	**216.936 k**
phi*Mny	**38.64 k-ft**
phi*Mnz	**38.64 k-ft**
phi*Vny	**61.361 k**
phi*Vnz	**61.361 k**
phi*Tn	**31.98 k-ft**
Cb	**1.654**

	y-y	z-z
Lb	**10.67 ft**	**10.67 ft**
KL/r	**54.806**	**54.806**

L Comp Flange	**10.67 ft**
Warp Length	**NC**
L-torque	**10.67 ft**
Tau_b	**1**

ARCADIS

SUBJECT: TOPDR
PARKING CANOPY
JOB NO:

BY: CMW DATE: 12/18/14
CHKD: MSC DATE: 12/23/14

PAGE B210
SHEET 1

Δ = 0.406 IN ... LC 9 (ASD 5) - MEMBER 5 ✓
LSHT B21E

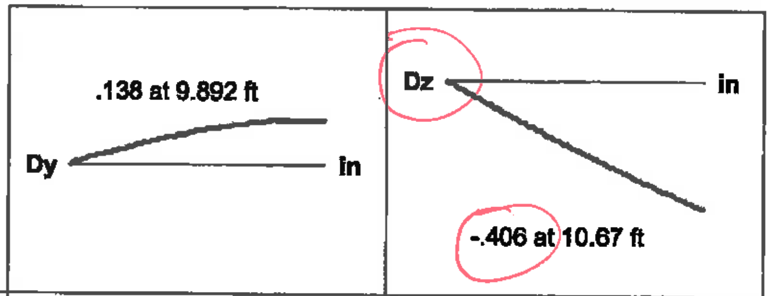
$\ell/240$ = $10.64^{FT} \times 12^{IN/FT} / 240$ = 0.53 IN ✓

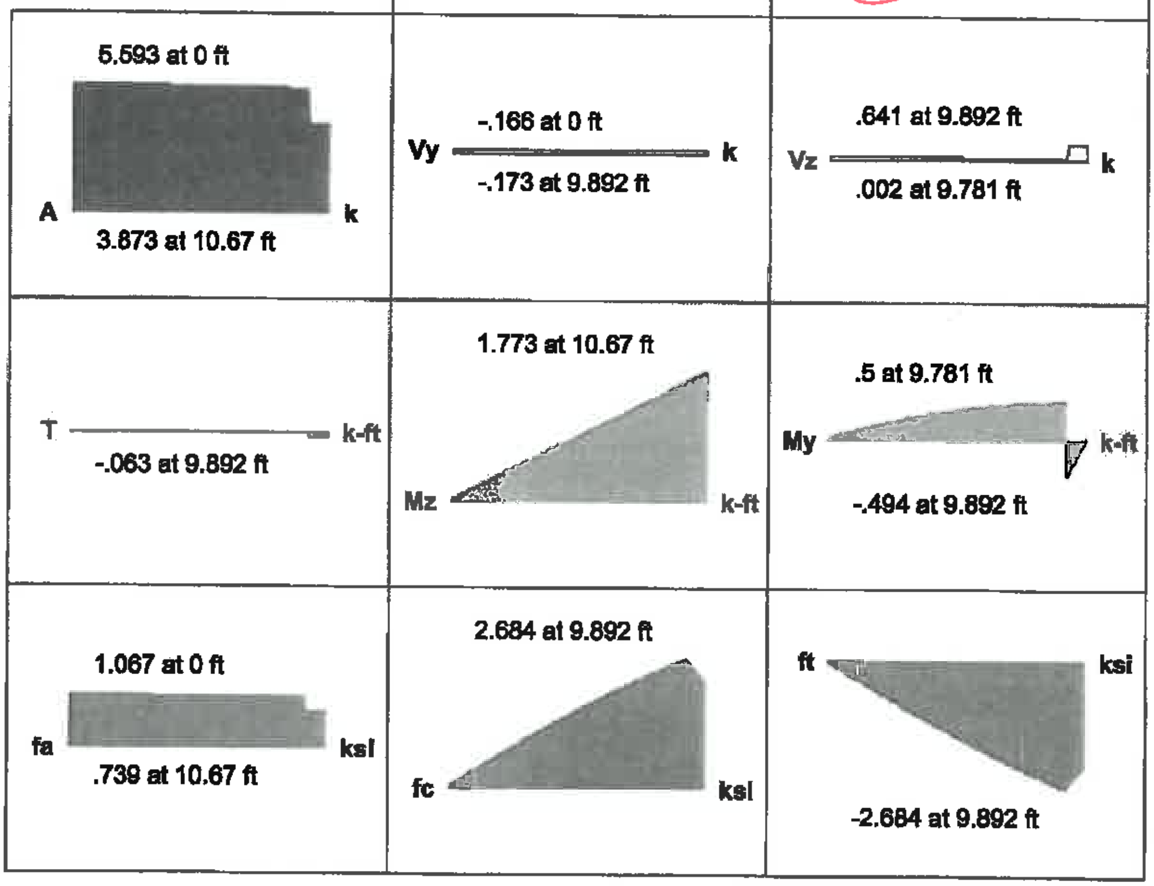
$\Delta < \ell/240$ OK ✓

B21E

Column: *M5*

Shape: HSS6x6x4
Material: A500 Gr.B Rect
Length: 10.67 ft
I Joint: N10
J Joint: N12A
LC 9: ASD 5
Code Check: 0.070 (bending)
Report Based On 97 Sections





AISC 14th(360-10): LRFD Code Check

Direct Analysis Method

Max Bending Check	0.070	Max Shear Check	0.012 (z)
Location	9.781 ft	Location	9.892 ft
Equation	H1-1b	Max Defl Ratio	L/3810
Bending Flange	Compact	Compression Flange	Non-Slender
Bending Web	Compact	Compression Web	Non-Slender

Fy	46 ksi
phi*Pnc	177.248 k
phi*Pnt	216.936 k
phi*Mny	38.64 k-ft
phi*Mnz	38.64 k-ft
phi*Vny	61.361 k
phi*Vnz	61.361 k
phi*Tn	31.98 k-ft
Cb	1.67

	y-y	z-z
Lb	10.67 ft	10.67 ft
KL/r	54.806	54.806

L Comp Flange	10.67 ft
Warp Length	NC
L-torque	10.67 ft
Tau_b	1

ARCADIS

SUBJECT: TOPOK – PARKING CANOPY

BY: MSL DATE: 12/23/14

CHKD: DATE:

JOB NO:

B-21F

SHEET 1

Column Deflection – Quick Check

- TRIB WIND LOAD ON C10 PURLIN = 0.6W × [(20FT/2 + 20FT/2) TRIB × 16.0IN] @ 10.67FT (33.5 psf)

& 0.6W × 6IN HSS × 10.67FT @ (10.67FT/2)

= (20.1#/FT × 20FT LONG TRIB × 1.33FT TALL) @ 10.67FT HIGH &

= 536# @ 10.67FT & 10.1#/FT UP 10.67FT HEIGHT

$$= \left[\frac{P\ell^3}{3EI} = \frac{(536^{\#})(10.67^{FT} \times 12^{IN/FT})^3}{(3 \times 29E^6 \times 28.6 IN^4)}\right] + \left[\frac{w\ell^4}{8EI} = \frac{(10.1^{\#/FT} \div 12^{IN/FT})(10.67^{FT} \times 12^{IN/FT})^4}{8 \times 29E^6 \times 28.6 IN^4}\right]$$

$$= 0.452^{IN} + 0.034^{IN} \Rightarrow 0.486^{IN} \approx \ell/263 < \ell/240 \;\&\; 1''$$

FYI – THIS IS CONSERVATIVE B/C 2 COLUMNS IN EACH BAY, SO YOU COULD ARGUE FRAME ONLY SEE'S 1/2 OF THIS DEFLECTION ≈ 1/4"

ALSO IGNORE THE 1ST 2'-0" OF 10.67FT TALL HSS COLUMN IS A CONCRETE PIER IS CONSERVATIVE

$P_N = 0.9 \times 46ksi \times 5.24 in^2 \times 0.658^{(0.482)} = 177.3^k$ ✓

$P_N >$ ~~13.263^k~~ 13.303^k OK ✓

BENDING:

$M_N = 0.99 F_y S = 0.99 \times 46KSI \times 9.54 in^3 = 434.5^{K-IN} = 36.2^{K-FT}$

$M_N >$ ~~9.031 K-FT~~ ~~ϕ~~ 4.344 K-FT WEAK AXIS OK ✓ → COMBINED STRESSES = 0.365 + 0.12 + 0.01 = 0.495 < 1.0 ✓ OK (AXIAL, M_{yy}, M_{zz})

11.04

BASEPLATE DESIGN:

REACTIONS:

NODE N9 → F_x = ~~0.215^k~~ 0.252^k / 0.129^k F_y = ~~11.02^k~~ 13.263^k F_z = ~~0.61^k~~ 0.914^k LC1 ✓

NODE N9 → F_x = ~~0.169^k~~ -0.034^k F_y = 10.233^k -4.629^k F_z = 0.846^k LC2

NODE N10 → F_x = -0.029^k F_y = -4.366^k F_z = 0.737^k

FOLLOWING AISC DESIGN GUIDE 1:

P_u = ~~11.02^k~~ 13.263^k ↓ ✓

$M_u = 0^k$ ✓

$N = 11^{IN}$ $B = 11^{IN}$ ✓

$e = 0/11.02^k$ (13.263^k) $= 0^{IN}$ ✓

$f_{P(MAX)} = \phi_c (0.85 f'_c)\sqrt{A_2/A_1} = 0.65 \times 0.85 \times 4000 PSI \times \sqrt{1} = 2.21^{KSI}$ ✓

$q_{MAX} = f_{P_{MAX}} \times B = 2.21^{KSI} \times 11^{IN} = 24.31 K/IN$ ✓

$e_{CRIT} = N/2 - P_u/2q_{MAX} = 11^{IN}/2 - 11.02^k$ (13.263^k) $/ 2 \times 24.31^{K/IN}$

$=$ ~~5.27^{IN}~~ 5.23^{IN}

$e < e_{crit}$, ∴ SMALL MOMENT DESIGN CONTROLS ✓

BEARING LENGTH (Y) = $N - 2e$ = 11 IN − 2.0 = <u>11 IN</u>

$q = P_u / Y = 11.02^K / 11^{IN} = 1.01^K/IN < q_{MAX}$ OK ✓

MINIMUM PLATE THICKNESS:

$f_p = P_u / BY = $ ~~11.02K~~ 13.263K $/ 11^{IN} \times 11^{IN} =$ ~~0.091~~ KSI

$m = \frac{N - 0.95d}{2} = \frac{11^{IN} - 0.95(6^{IN})}{2} = 2.65^{IN}$ ✓ ← CONTROLS

$t_{P(REQ'D)} = 1.49 m \sqrt{f_P / F_y} = 1.49(2.65^{IN}) \sqrt{\frac{0.091 KSI}{36 KSI}} = 0.199^{IN}$

$n = \frac{B - 0.8 b_f}{2}$ (0.8 → 0.95) $= \frac{11^{IN} - 0.8(6^{IN})}{2}$ (0.8 → 0.95) $= 3.1^{IN}$ ✓

$t_{P(REQ'D)} = 1.44(3.1^{IN}) \sqrt{\frac{0.091 KSI}{36 KSI}} = 0.232^{IN}$

$n' = 1.5''$, $X = 0.032$, $\lambda = 0.18$

USE 11 IN × 11 IN × ~~1/2 IN~~ 3/8" BASEPLATE → ✓ OK

FOR ANCHORAGE, SEE HILTI PRINTOUTS ON SHT B24

LRFD → $t_{MIN} = \ell \sqrt{\frac{2P_u}{0.9 F_y BN}} = 2.65'' \sqrt{\frac{(2 \times 13.263^K)}{(0.9 \times 36 KSI \times 11 IN \times 11 IN)}}$

$= 0.218 IN$

Company:	ARCADIS	Page:	1
Specifier:	CMW	Project:	Topok Parking Canopy
Address:		Sub-Project I Pos. No.:	
Phone I Fax:	|	Date:	12/18/2014
E-Mail:			

Specifier's comments: LC 2 NODE N9

LC#1 LRFD 3

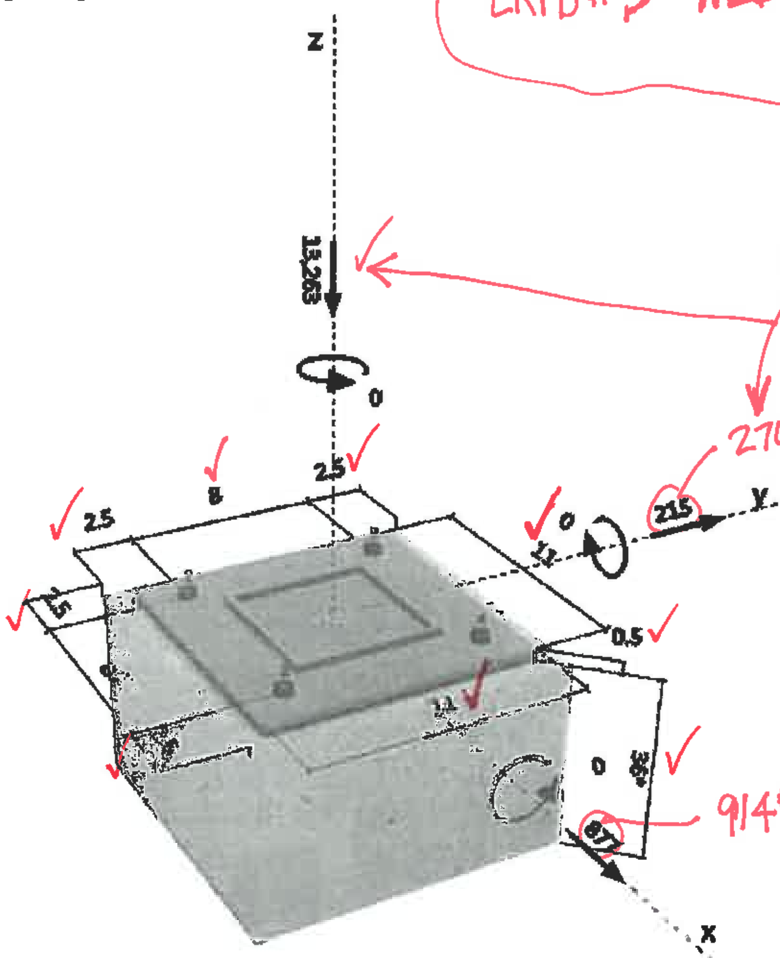
1 Input data

Anchor type and diameter:	**Hex Head ASTM F 1554 GR. 36 3/4**
Effective embedment depth:	h_{ef} = 12.000 in.
Material:	ASTM F 1554
Proof:	design method ACI 318-08 / CIP
Stand-off installation:	e_b = 0.000 in. (no stand-off); t = 0.500 in.
Anchor plate:	l_x x l_y x t = 11.000 in. x 11.000 in. x 0.500 in.; (Recommended plate thickness: not calculated)
Profile:	Square HSS (AISC); (L x W x T) = 6.000 in. x 6.000 in. x 0.250 in.
Base material:	cracked concrete, 4000, f_c' = 4000 psi; h = 36.000 in.
Reinforcement:	tension: condition B, shear: condition B; edge reinforcement: none or < No. 4 bar
Seismic loads (cat. C, D, E, or F)	no

CONSERV

LRFD #3 1.2D+1.6L$_R$+0.5W↓ +0.5W→ Z DIR

Geometry [in.] & Loading [lb, in.lb]



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Address:		Sub-Project I Pos. No.:	
Phone I Fax:	|	Date:	12/18/2014
E-Mail:			

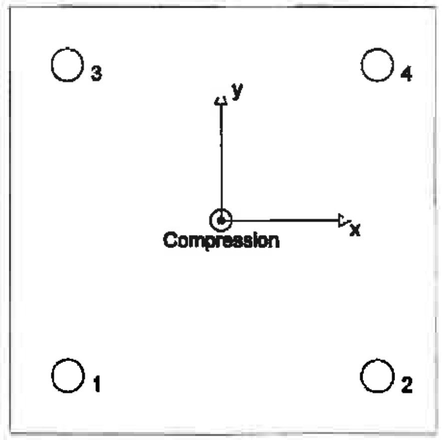
2 Load case/Resulting anchor forces

Load case: Design loads

Anchor reactions [lb]
Tension force: (+Tension, -Compression)

Anchor	Tension force	Shear force	Shear force x	Shear force y
1	0	226	219	54
2	0	226	219	54
3	0	226	219	54
4	0	226	219	54

max. concrete compressive strain: 0.03 [‰]
max. concrete compressive stress: 110 [psi]
resulting tension force in (x/y)=(0.000/0.000): 0 [lb]
resulting compression force in (x/y)=(0.000/0.000): 13263 [lb]



3 Tension load

	Load N_{ua} [lb]	Capacity ϕN_n [lb]	Utilization $\beta_N = N_{ua}/\phi N_n$	Status
Steel Strength*	N/A	N/A	N/A	N/A
Pullout Strength*	N/A	N/A	N/A	N/A
Concrete Breakout Strength**	N/A	N/A	N/A	N/A
Concrete Side-Face Blowout, direction **	N/A	N/A	N/A	N/A

* anchor having the highest loading **anchor group (anchors in tension)

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4 Shear load

	Load V_{ua} [lb]	Capacity ϕV_n [lb]	Utilization $\beta_V = V_{ua}/\phi V_n$	Status
Steel Strength*	226	7555	3	OK
Steel failure (with lever arm)*	N/A	N/A	N/A	N/A
Pryout Strength**	903	21687	5	OK
Concrete edge failure in direction x+**	903	2412	38	OK

* anchor having the highest loading **anchor group (relevant anchors)

4.1 Steel Strength

$V_{sa} = n\ 0.6\ A_{se,V}\ f_{uta}$ ACI 318-08 Eq. (D-20)

$\phi\ V_{steel} \geq V_{ua}$ ACI 318-08 Eq. (D-2)

Variables

n	$A_{se,V}$ [in.^{2}]	f_{uta} [psi]
1	0.33	58000

Calculations

V_{sa} [lb]
11623

Results

V_{sa} [lb]	ϕ_{steel}	$\phi\ V_{sa}$ [lb]	V_{ua} [lb]
11623	0.650	7555	226

4.2 Pryout Strength

$V_{cpg} = k_{cp}\left[\left(\frac{A_{Nc}}{A_{Nc0}}\right)\psi_{ec,N}\ \psi_{ed,N}\ \psi_{c,N}\ \psi_{cp,N}\ N_b\right]$ ACI 318-08 Eq. (D-31)

$\phi\ V_{cpg} \geq V_{ua}$ ACI 318-08 Eq. (D-2)

A_{Nc} see ACI 318-08, Part D.5.2.1, Fig. RD.5.2.1(b)

$A_{Nc0} = 9\ h_{ef}^2$ ACI 318-08 Eq. (D-6)

$\psi_{ec,N} = \left(\frac{1}{1+\frac{2\ e_N'}{3\ h_{ef}}}\right) \leq 1.0$ ACI 318-08 Eq. (D-9)

$\psi_{ed,N} = 0.7 + 0.3\left(\frac{c_{a,min}}{1.5h_{ef}}\right) \leq 1.0$ ACI 318-08 Eq. (D-11)

$\psi_{cp,N} = \text{MAX}\left(\frac{c_{a,min}}{c_{ac}}, \frac{1.5h_{ef}}{c_{ac}}\right) \leq 1.0$ ACI 318-08 Eq. (D-13)

$N_b = k_c\ \lambda\ \sqrt{f'_c}\ h_{ef}^{1.5}$ ACI 318-08 Eq. (D-7)

Variables

k_{cp}	h_{ef} [in.]	$e_{c1,N}$ [in.]	$e_{c2,N}$ [in.]	$c_{a,min}$ [in.]
2	2.667	0.000	0.000	2.500

$\psi_{c,N}$	c_{ac} [in.]	k_c	λ	f'_c [psi]
1.000	-	24	1	4000

Calculations

A_{Nc} [in.^{2}]	A_{Nc0} [in.^{2}]	$\psi_{ec1,N}$	$\psi_{ec2,N}$	$\psi_{ed,N}$	$\psi_{cp,N}$	N_b [lb]
169.00	64.00	1.000	1.000	0.888	1.000	6610

Results

V_{cpg} [lb]	$\phi_{concrete}$	$\phi\ V_{cpg}$ [lb]	V_{ua} [lb]
30981	0.700	21687	903

Input data and results must be checked for agreement with the existing conditions and for plausibility!
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4.3 Concrete edge failure in direction x+

$V_{cbg} = \left(\frac{A_{Vc}}{A_{Vc0}}\right) \psi_{ec,V}\ \psi_{ed,V}\ \psi_{c,V}\ \psi_{h,V}\ \psi_{parallel,V}\ V_b$ — ACI 318-08 Eq. (D-22)

$\phi\ V_{cbg} \geq V_{ua}$ — ACI 318-08 Eq. (D-2)

A_{Vc} see ACI 318-08, Part D.6.2.1, Fig. RD.6.2.1(b)

$A_{Vc0} = 4.5\ c_{a1}^2$ — ACI 318-08 Eq. (D-23)

$\psi_{ec,V} = \left(\frac{1}{1 + \frac{2e_V}{3c_{a1}}}\right) \leq 1.0$ — ACI 318-08 Eq. (D-26)

$\psi_{ed,V} = 0.7 + 0.3\left(\frac{c_{a2}}{1.5c_{a1}}\right) \leq 1.0$ — ACI 318-08 Eq. (D-28)

$\psi_{h,V} = \sqrt{\frac{1.5c_{a1}}{h_a}} \geq 1.0$ — ACI 318-08 Eq. (D-29)

$V_b = \left(7 \left(\frac{l_e}{d_a}\right)^{0.2} \sqrt{d_a}\right) \lambda \sqrt{f'_c}\ c_{a1}^{1.5}$ — ACI 318-08 Eq. (D-24)

Variables

c_{a1} [in.]	c_{a2} [in.]	e_{cV} [in.]	$\psi_{c,V}$	h_a [in.]
2.500	2.500	0.000	1.000	36.000

l_e [in.]	λ	d_a [in.]	f'_c [psi]	$\psi_{parallel,V}$
6.000	1.000	0.750	4000	1.000

Calculations

A_{Vc} [in.^{2}]	A_{Vc0} [in.^{2}]	$\psi_{ec,V}$	$\psi_{ed,V}$	$\psi_{h,V}$	V_b [lb]
46.88	28.13	1.000	0.900	1.000	2297

Results

V_{cbg} [lb]	$\phi_{concrete}$	$\phi\ V_{cbg}$ [lb]	V_{ua} [lb]
3446	0.700	2412	903

5 Warnings

- Load re-distributions on the anchors due to elastic deformations of the anchor plate are not considered. The anchor plate is assumed to be sufficiently stiff, in order not to be deformed when subjected to the loading!
- Condition A applies when supplementary reinforcement is used. The Φ factor is increased for non-steel Design Strengths except Pullout Strength and Pryout strength. Condition B applies when supplementary reinforcement is not used and for Pullout Strength and Pryout Strength. Refer to your local standard.
- Checking the transfer of loads into the base material and the shear resistance are required in accordance with ACI 318 or the relevant standard!

Fastening meets the design criteria! √

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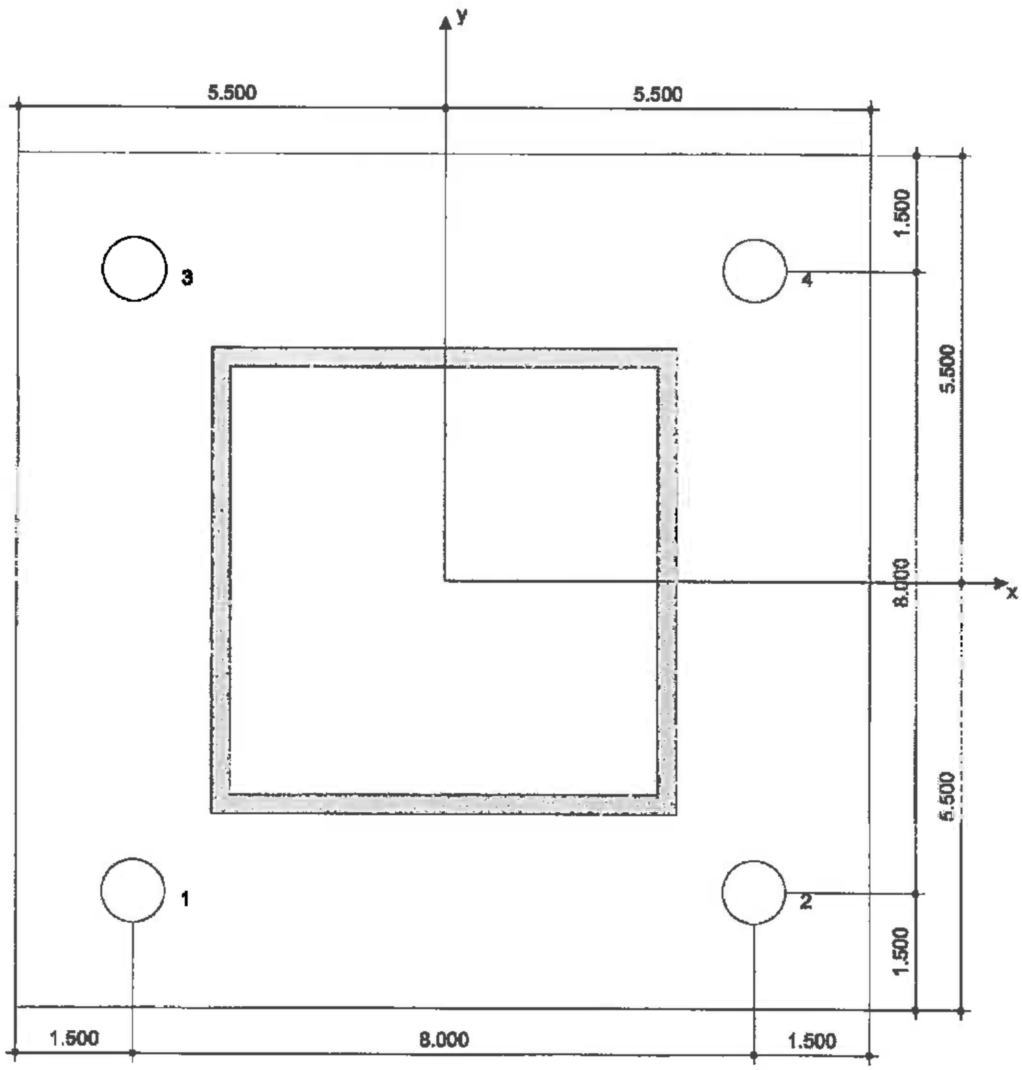
Specifier:	CMW	Project:	Topok Parking Canopy
Address:		Sub-Project I Pos. No.:	
Phone I Fax:	|	Date:	12/18/2014
E-Mail:			

6 Installation data

Anchor plate, steel: -
Profile: Square HSS (AISC); 6.000 x 6.000 x 0.250 in.
Hole diameter in the fixture: d_f = 0.813 in.
Plate thickness (input): 0.500 in.
Recommended plate thickness: not calculated
Cleaning: No cleaning of the drilled hole is required

Anchor type and diameter: Hex Head ASTM F 1554 GR. 36 3/4
Installation torque: -0.009 in.lb
Hole diameter in the base material: - in.
Hole depth in the base material: 12.000 in.
Minimum thickness of the base material: 14.000 in.



Coordinates Anchor in.

Anchor	x	y	c_{-x}	c_{+x}	c_{-y}	c_{+y}
1	-4.000	-4.000	2.500	10.500	2.500	10.500
2	4.000	-4.000	10.500	2.500	2.500	10.500
3	-4.000	4.000	2.500	10.500	10.500	2.500
4	4.000	4.000	10.500	2.500	10.500	2.500

Input data and results must be checked for agreement with the existing conditions and for plausibility!
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Profis Anchor 2.4.9

Company:	ARCADIS	Page:	1
Specifier:	CMW	Project:	Topok Parking Canopy
Address:		Sub-Project I Pos. No.:	
Phone I Fax:	|	Date:	12/18/2014
E-Mail:			

Specifier's comments: ~~LC 3~~ NODE N9
LC#4 – LRFD 6

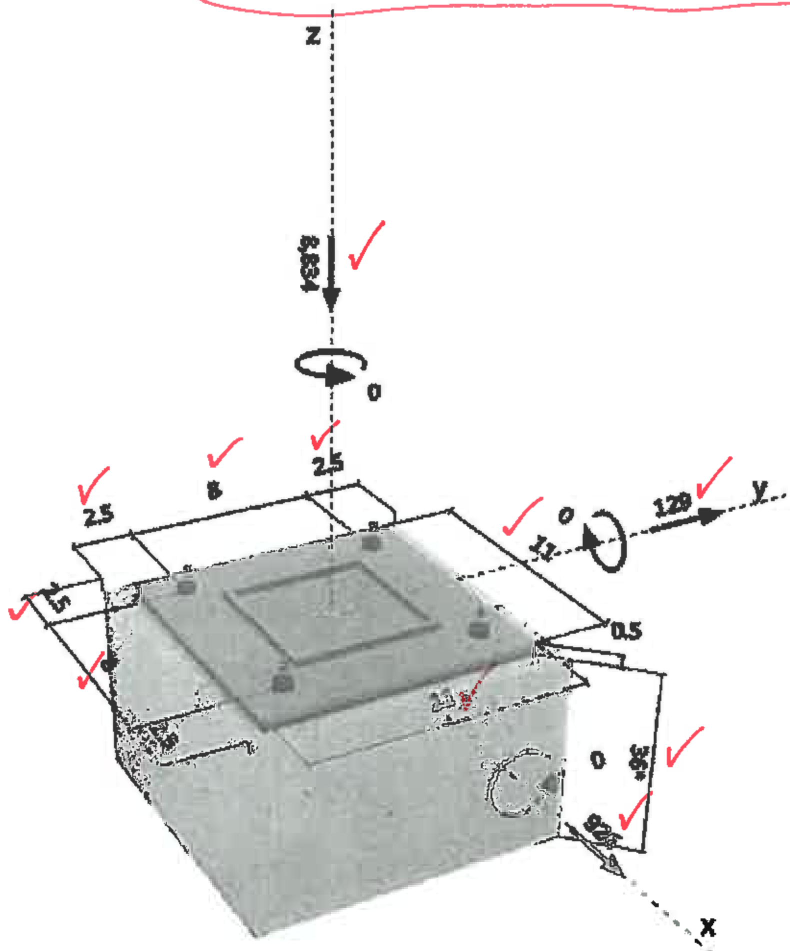
1 Input data

Anchor type and diameter:	Hex Head ASTM F 1554 GR. 36 3/4
Effective embedment depth:	h_{ef} = 12.000 in.
Material:	ASTM F 1554
Proof:	design method ACI 318-08 / CIP
Stand-off installation:	e_b = 0.000 in. (no stand-off); t = 0.500 in.
Anchor plate:	l_x x l_y x t = 11.000 in. x 11.000 in. x 0.500 in.; (Recommended plate thickness: not calculated)
Profile:	Square HSS (AISC); (L x W x T) = 6.000 in. x 6.000 in. x 0.250 in.
Base material:	cracked concrete, 4000, f_c' = 4000 psi; h = 36.000 in.
Reinforcement:	tension: condition B, shear: condition B; edge reinforcement: none or < No. 4 bar
Seismic loads (cat. C, D, E, or F)	no

CONSERVATIVE

LRFD 6 = 0.9D + 1.0W ↓ + 1.0W → Z DIR

Geometry [in.] & Loading [lb, in.lb]



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Phone I Fax:	|	Date:	12/18/2014
E-Mail:			

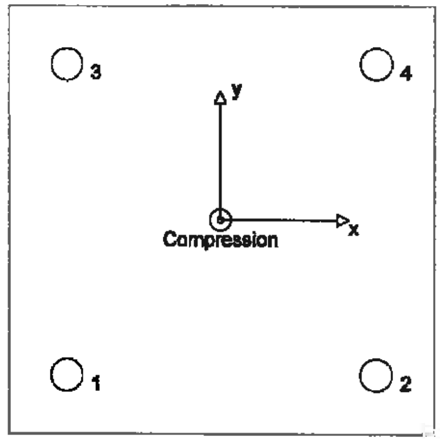
2 Load case/Resulting anchor forces

Load case: Design loads

Anchor reactions [lb]
Tension force: (+Tension, -Compression)

Anchor	Tension force	Shear force	Shear force x	Shear force y
1	0	234	232	32
2	0	234	232	32
3	0	234	232	32
4	0	234	232	32

max. concrete compressive strain: 0.02 [‰]
max. concrete compressive stress: 73 [psi]
resulting tension force in (x/y)=(0.000/0.000): 0 [lb]
resulting compression force in (x/y)=(0.000/0.000): 8834 [lb]



3 Tension load

	Load N_{ua} [lb]	Capacity ϕN_n [lb]	Utilization $\beta_N = N_{ua}/\phi N_n$	Status
Steel Strength*	N/A	N/A	N/A	N/A
Pullout Strength*	N/A	N/A	N/A	N/A
Concrete Breakout Strength**	N/A	N/A	N/A	N/A
Concrete Side-Face Blowout, direction **	N/A	N/A	N/A	N/A

* anchor having the highest loading **anchor group (anchors in tension)

Input data and results must be checked for agreement with the existing conditions and for plausibility!
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Phone I Fax:	|	Date:	12/16/2014
E-Mail:			

4 Shear load

	Load V_{ua} [lb]	Capacity ϕV_n [lb]	Utilization $\beta_V = V_{ua}/\phi V_n$	Status
Steel Strength*	234	7555	4	OK
Steel failure (with lever arm)*	N/A	N/A	N/A	N/A
Pryout Strength**	935	21687	5	OK
Concrete edge failure in direction x+**	935	2412	39 ✓	OK

* anchor having the highest loading **anchor group (relevant anchors)

4.1 Steel Strength

$V_{sa} = n\ 0.6\ A_{se,V}\ f_{uta}$ ACI 318-08 Eq. (D-20)
$\phi\ V_{steel} \geq V_{ua}$ ACI 318-08 Eq. (D-2)

Variables

n	$A_{se,V}$ [in.²]	f_{uta} [psi]
1	0.33	58000

Calculations

V_{sa} [lb]
11623

Results

V_{sa} [lb]	ϕ_{steel}	$\phi\ V_{sa}$ [lb]	V_{ua} [lb]
11623	0.650	7555	234

4.2 Pryout Strength

$V_{cpg} = k_{cp}\left[\left(\frac{A_{Nc}}{A_{Nc0}}\right)\psi_{ec,N}\ \psi_{ed,N}\ \psi_{c,N}\ \psi_{cp,N}\ N_b\right]$ ACI 318-08 Eq. (D-31)
$\phi\ V_{cpg} \geq V_{ua}$ ACI 318-08 Eq. (D-2)
A_{Nc} see ACI 318-08, Part D.5.2.1, Fig. RD.5.2.1(b)
$A_{Nc0} = 9\ h_{ef}^2$ ACI 318-08 Eq. (D-6)
$\psi_{ec,N} = \left(\frac{1}{1+\frac{2\ e_N}{3\ h_{ef}}}\right) \leq 1.0$ ACI 318-08 Eq. (D-9)
$\psi_{ed,N} = 0.7 + 0.3\left(\frac{c_{a,min}}{1.5h_{ef}}\right) \leq 1.0$ ACI 318-08 Eq. (D-11)
$\psi_{cp,N} = \text{MAX}\left(\frac{c_{a,min}}{c_{ac}}, \frac{1.5h_{ef}}{c_{ac}}\right) \leq 1.0$ ACI 318-08 Eq. (D-13)
$N_b = k_c\ \lambda\ \sqrt{f'_c}\ h_{ef}^{1.5}$ ACI 318-08 Eq. (D-7)

Variables

k_{cp}	h_{ef} [in.]	$e_{c1,N}$ [in.]	$e_{c2,N}$ [in.]	$c_{a,min}$ [in.]
2	2.667	0.000	0.000	2.500

$\psi_{c,N}$	c_{ac} [in.]	k_c	λ	f'_c [psi]
1.000	-	24	1	4000

Calculations

A_{Nc} [in.²]	A_{Nc0} [in.²]	$\psi_{ec1,N}$	$\psi_{ec2,N}$	$\psi_{ed,N}$	$\psi_{cp,N}$	N_b [lb]
169.00	64.00	1.000	1.000	0.888	1.000	6610

Results

V_{cpg} [lb]	$\phi_{concrete}$	$\phi\ V_{cpg}$ [lb]	V_{ua} [lb]
30981	0.700	21687	935

Input data and results must be checked for agreement with the existing conditions and for plausibility!
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4.3 Concrete edge failure in direction x+

$V_{cbg} = \left(\frac{A_{Vc}}{A_{Vc0}}\right) \psi_{ec,V}\ \psi_{ed,V}\ \psi_{c,V}\ \psi_{h,V}\ \psi_{parallel,V}\ V_b$ ACI 318-08 Eq. (D-22)

$\phi\ V_{cbg} \geq V_{ua}$ ACI 318-08 Eq. (D-2)

A_{Vc} see ACI 318-08, Part D.6.2.1, Fig. RD.6.2.1(b)

$A_{Vc0} = 4.5\ c_{a1}^2$ ACI 318-08 Eq. (D-23)

$\psi_{ec,V} = \left(\frac{1}{1 + \frac{2e_V}{3c_{a1}}}\right) \leq 1.0$ ACI 318-08 Eq. (D-26)

$\psi_{ed,V} = 0.7 + 0.3\left(\frac{c_{a2}}{1.5c_{a1}}\right) \leq 1.0$ ACI 318-08 Eq. (D-28)

$\psi_{h,V} = \sqrt{\frac{1.5c_{a1}}{h_a}} \geq 1.0$ ACI 318-08 Eq. (D-29)

$V_b = \left(7\left(\frac{l_e}{d_a}\right)^{0.2} \sqrt{d_a}\right) \lambda \sqrt{f'_c}\ c_{a1}^{1.5}$ ACI 318-08 Eq. (D-24)

Variables

c_{a1} [in.]	c_{a2} [in.]	e_{cV} [in.]	$\psi_{c,V}$	h_a [in.]
2.500	2.500	0.000	1.000	36.000

l_e [in.]	λ	d_a [in.]	f'_c [psi]	$\psi_{parallel,V}$
6.000	1.000	0.750	4000	1.000

Calculations

A_{Vc} [in.^{2}]	A_{Vc0} [in.^{2}]	$\psi_{ec,V}$	$\psi_{ed,V}$	$\psi_{h,V}$	V_b [lb]
46.88	28.13	1.000	0.900	1.000	2297

Results

V_{cbg} [lb]	$\phi_{concrete}$	$\phi\ V_{cbg}$ [lb]	V_{ua} [lb]
3446	0.700	2412	935

5 Warnings

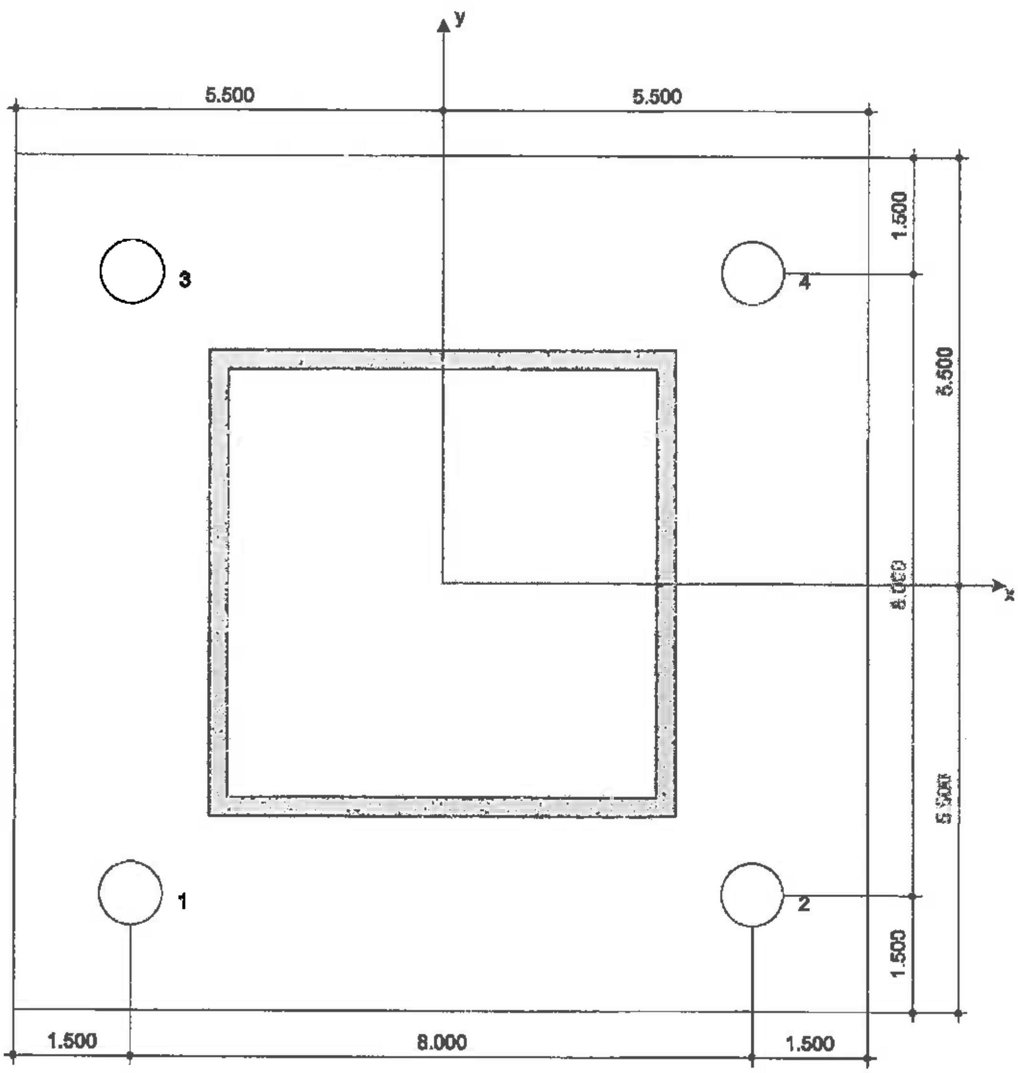
- Load re-distributions on the anchors due to elastic deformations of the anchor plate are not considered. The anchor plate is assumed to be sufficiently stiff, in order not to be deformed when subjected to the loading!
- Condition A applies when supplementary reinforcement is used. The Φ factor is increased for non-steel Design Strengths except Pullout Strength and Pryout strength. Condition B applies when supplementary reinforcement is not used and for Pullout Strength and Pryout Strength. Refer to your local standard.
- Checking the transfer of loads into the base material and the shear resistance are required in accordance with ACI 318 or the relevant standard!

Fastening meets the design criteria! ✓

6 Installation data

Anchor plate, steel: -
Profile: Square HSS (AISC); 6.000 x 6.000 x 0.250 in.
Hole diameter in the fixture: d_f = 0.813 in.
Plate thickness (input): 0.500 in.
Recommended plate thickness: not calculated
Cleaning: No cleaning of the drilled hole is required

Anchor type and diameter: Hex Head ASTM F 1554 GR. 36 3/4
Installation torque: -0.009 in.lb
Hole diameter in the base material: - in.
Hole depth in the base material: 12.000 in.
Minimum thickness of the base material: 14.000 in.



Coordinates Anchor in.

Anchor	x	y	c_{-x}	c_{+x}	c_{-y}	c_{+y}
1	-4.000	-4.000	2.500	10.500	2.500	10.500
2	4.000	-4.000	10.500	2.500	2.500	10.500
3	-4.000	4.000	2.500	10.500	10.500	2.500
4	4.000	4.000	10.500	2.500	10.500	2.500

Input data and results must be checked for agreement with the existing conditions and for plausibility!
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Company:	ARCADIS	Page:	1
Specifier:	CMW	Project:	Topok Parking Canopy
Address:		Sub-Project I Pos. No.:	
Phone I Fax:	|	Date:	12/18/2014
E-Mail:			

Specifier's comments: LC 6 NODE N10

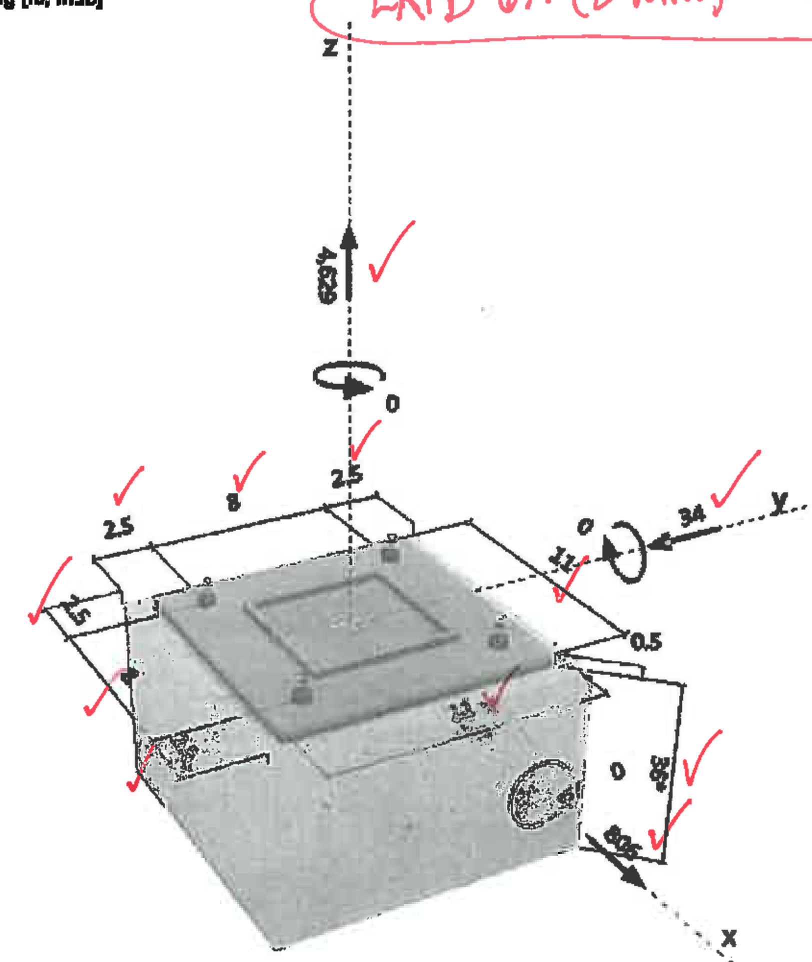
1 Input data

Anchor type and diameter:	Hex Head ASTM F 1554 GR. 36 3/4
Effective embedment depth:	h_{ef} = 12.000 in.
Material:	ASTM F 1554
Proof:	design method ACI 318-08 / CIP
Stand-off installation:	e_b = 0.000 in. (no stand-off); t = 0.500 in.
Anchor plate:	l_x x l_y x t = 11.000 in. x 11.000 in. x 0.500 in.; (Recommended plate thickness: not calculated)
Profile:	Square HSS (AISC); (L x W x T) = 6.000 in. x 6.000 in. x 0.250 in.
Base material:	cracked concrete, 4000, f_c' = 4000 psi; h = 36.000 in.
Reinforcement:	tension: condition B, shear: condition B;
	edge reinforcement: none or < No. 4 bar
Seismic loads (cat. C, D, E, or F)	no

CONSERVATIVE

LRFD 6A (Z WIND) = 0.9D MIN + 1.0W↑ + 1.0W→

Geometry [in.] & Loading [lb, in.lb]



Input data and results must be checked for agreement with the existing conditions and for plausibility!
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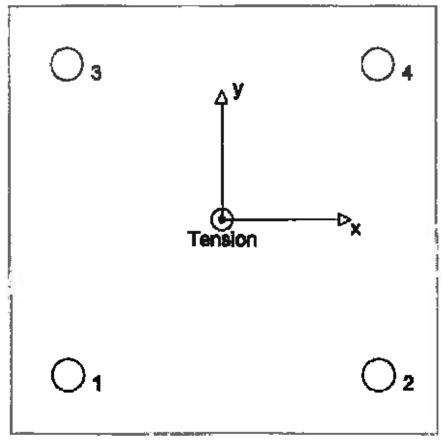
2 Load case/Resulting anchor forces

Load case: Design loads

Anchor reactions [lb]
Tension force: (+Tension, -Compression)

Anchor	Tension force	Shear force	Shear force x	Shear force y
1	1157	202	202	-9
2	1157	202	202	-9
3	1157	202	202	-9
4	1157	202	202	-9

max. concrete compressive strain: - [‰]
max. concrete compressive stress: - [psi]
resulting tension force in (x/y)=(0.000/0.000): 4629 [lb]
resulting compression force in (x/y)=(0.000/0.000): 0 [lb]



3 Tension load

	Load N_{ua} [lb]	Capacity ϕN_n [lb]	Utilization $\beta_N = N_{ua}/\phi N_n$	Status
Steel Strength*	1157	14529	8	OK
Pullout Strength*	1157	14650	8	OK
Concrete Breakout Strength**	4629	10843	43	OK
Concrete Side-Face Blowout, direction x+**	2315	21959	11	OK

* anchor having the highest loading **anchor group (anchors in tension)

3.1 Steel Strength

$N_{sa} = n\, A_{se,N}\, f_{uta}$ ACI 318-08 Eq. (D-3)
$\phi\, N_{steel} \geq N_{ua}$ ACI 318-08 Eq. (D-1)

Variables

n	$A_{se,N}$ [in.^{2}]	f_{uta} [psi]
1	0.33	58000

Calculations

N_{sa} [lb]
19372

Results

N_{sa} [lb]	ϕ_{steel}	$\phi\, N_{sa}$ [lb]	N_{ua} [lb]
19372	0.750	14529	1157

Input data and results must be checked for agreement with the existing conditions and for plausibility!
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3.2 Pullout Strength

$N_{pN} = \psi_{c,p} N_p$ ACI 318-08 Eq. (D-14)

$N_p = 8 A_{brg} f'_c$ ACI 318-08 Eq. (D-15)

$\phi N_{pN} \geq N_{ua}$ ACI 318-08 Eq. (D-1)

Variables

$\psi_{c,p}$	A_{brg} [in.^{2}]	f'_c [psi]
1.000	0.65	4000

Calculations

N_p [lb]
20928

Results

N_{pn} [lb]	$\phi_{concrete}$	ϕN_{pn} [lb]	N_{ua} [lb]
20928	0.700	14650	1157

3.3 Concrete Breakout Strength

$N_{cbg} = \left(\frac{A_{Nc}}{A_{Nc0}}\right) \psi_{ec,N} \psi_{ed,N} \psi_{c,N} \psi_{cp,N} N_b$ ACI 318-08 Eq. (D-5)

$\phi N_{cbg} \geq N_{ua}$ ACI 318-08 Eq. (D-1)

A_{Nc} see ACI 318-08, Part D.5.2.1, Fig. RD.5.2.1(b)

$A_{Nc0} = 9 h_{ef}^2$ ACI 318-08 Eq. (D-6)

$\psi_{ec,N} = \left(\frac{1}{1 + \frac{2 e_N}{3 h_{ef}}}\right) \leq 1.0$ ACI 318-08 Eq. (D-9)

$\psi_{ed,N} = 0.7 + 0.3 \left(\frac{c_{a,min}}{1.5h_{ef}}\right) \leq 1.0$ ACI 318-08 Eq. (D-11)

$\psi_{cp,N} = \text{MAX}\left(\frac{c_{a,min}}{c_{ac}}, \frac{1.5h_{ef}}{c_{ac}}\right) \leq 1.0$ ACI 318-08 Eq. (D-13)

$N_b = k_c \lambda \sqrt{f'_c} h_{ef}^{1.5}$ ACI 318-08 Eq. (D-7)

Variables

h_{ef} [in.]	$e_{c1,N}$ [in.]	$e_{c2,N}$ [in.]	$c_{a,min}$ [in.]	$\psi_{c,N}$
2.667	0.000	0.000	2.500	1.000

c_{ac} [in.]	k_c	λ	f'_c [psi]
0.000	24	1	4000

Calculations

A_{Nc} [in.^{2}]	A_{Nc0} [in.^{2}]	$\psi_{ec1,N}$	$\psi_{ec2,N}$	$\psi_{ed,N}$	$\psi_{cp,N}$	N_b [lb]
169.00	64.00	1.000	1.000	0.888	1.000	6610

Results

N_{cbg} [lb]	$\phi_{concrete}$	ϕN_{cbg} [lb]	N_{ua} [lb]
15491	0.700	10843	4629

Input data and results must be checked for agreement with the existing conditions and for plausibility!
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3.4 Concrete Side-Face Blowout, direction x+

$N_{sb} = 160\ c_{a1} \sqrt{A_{brg}}\ \lambda \sqrt{f'_c}$ ACI 318-08 Eq. (D-17)

$N_{sbg} = \alpha_{group}\ N_{sb}$ ACI 318-08 Eq. (D-18)

$\phi\ N_{sbg} \geq N_{ua}$ ACI 318-08 Eq. (D-1)

$\alpha_{group} = \left(1 + \frac{s}{6\ c_{a1}}\right)$ see ACI 318-08, Part D.5.4.2 Eq. (D-18)

Variables

c_{a1} [in.]	c_{a2} [in.]	A_{brg} [in.^{2}]	λ	f'_c [psi]	s [in.]
2.500	2.500	0.65	1.000	4000	8.000

Calculations

α_{group}	N_{sb} [lb]
1.533	20459

Results

N_{sbg} [lb]	$\phi_{concrete}$	$\phi\ N_{sbg}$ [lb]	$N_{ua,edge}$ [lb]
31370	0.700	21959	2315

4 Shear load

	Load V_{ua} [lb]	Capacity ϕV_n [lb]	Utilization $\beta_V = V_{ua}/\phi V_n$	Status
Steel Strength*	202	7555	3	OK
Steel failure (with lever arm)*	N/A	N/A	N/A	N/A
Pryout Strength**	807	21687	4	OK
Concrete edge failure in direction x+**	807	2412	34	OK

* anchor having the highest loading **anchor group (relevant anchors)

4.1 Steel Strength

$V_{sa} = n\ 0.6\ A_{se,V}\ f_{uta}$ ACI 318-08 Eq. (D-20)
$\phi\ V_{steel} \geq V_{ua}$ ACI 318-08 Eq. (D-2)

Variables

n	$A_{se,V}$ [in.^{2}]	f_{uta} [psi]
1	0.33	58000

Calculations

V_{sa} [lb]
11623

Results

V_{sa} [lb]	ϕ_{steel}	$\phi\ V_{sa}$ [lb]	V_{ua} [lb]
11623	0.650	7555	202

4.2 Pryout Strength

$$V_{cpg} = k_{cp}\left[\left(\frac{A_{Nc}}{A_{Nc0}}\right)\psi_{ec,N}\ \psi_{ed,N}\ \psi_{c,N}\ \psi_{cp,N}\ N_b\right]$$ ACI 318-08 Eq. (D-31)

$\phi\ V_{cpg} \geq V_{ua}$ ACI 318-08 Eq. (D-2)

A_{Nc} see ACI 318-08, Part D.5.2.1, Fig. RD.5.2.1(b)

$A_{Nc0} = 9\ h_{ef}^2$ ACI 318-08 Eq. (D-6)

$$\psi_{ec,N} = \left(\frac{1}{1+\frac{2\ e_N}{3\ h_{ef}}}\right) \leq 1.0$$ ACI 318-08 Eq. (D-9)

$$\psi_{ed,N} = 0.7 + 0.3\left(\frac{c_{a,min}}{1.5h_{ef}}\right) \leq 1.0$$ ACI 318-08 Eq. (D-11)

$$\psi_{cp,N} = \text{MAX}\left(\frac{c_{a,min}}{c_{ac}}, \frac{1.5h_{ef}}{c_{ac}}\right) \leq 1.0$$ ACI 318-08 Eq. (D-13)

$N_b = k_c\ \lambda\ \sqrt{f'_c}\ h_{ef}^{1.5}$ ACI 318-08 Eq. (D-7)

Variables

k_{cp}	h_{ef} [in.]	$e_{c1,N}$ [in.]	$e_{c2,N}$ [in.]	$c_{a,min}$ [in.]
2	2.667	0.000	0.000	2.500

$\psi_{c,N}$	c_{ac} [in.]	k_c	λ	f'_c [psi]
1.000	-	24	1	4000

Calculations

A_{Nc} [in.^{2}]	A_{Nc0} [in.^{2}]	$\psi_{ec1,N}$	$\psi_{ec2,N}$	$\psi_{ed,N}$	$\psi_{cp,N}$	N_b [lb]
169.00	64.00	1.000	1.000	0.888	1.000	6610

Results

V_{cpg} [lb]	$\phi_{concrete}$	$\phi\ V_{cpg}$ [lb]	V_{ua} [lb]
30981	0.700	21687	807

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4.3 Concrete edge failure in direction x+

$V_{cbg} = \left(\frac{A_{Vc}}{A_{Vc0}}\right) \psi_{ec,V}\ \psi_{ed,V}\ \psi_{c,V}\ \psi_{h,V}\ \psi_{parallel,V}\ V_b$ ACI 318-08 Eq. (D-22)

$\phi\ V_{cbg} \geq V_{ua}$ ACI 318-08 Eq. (D-2)

A_{Vc} see ACI 318-08, Part D.6.2.1, Fig. RD.6.2.1(b)

$A_{Vc0} = 4.5\ c_{a1}^2$ ACI 318-08 Eq. (D-23)

$\psi_{ec,V} = \left(\frac{1}{1 + \frac{2e_V}{3c_{a1}}}\right) \leq 1.0$ ACI 318-08 Eq. (D-26)

$\psi_{ed,V} = 0.7 + 0.3\left(\frac{c_{a2}}{1.5c_{a1}}\right) \leq 1.0$ ACI 318-08 Eq. (D-28)

$\psi_{h,V} = \sqrt{\frac{1.5c_{a1}}{h_a}} \geq 1.0$ ACI 318-08 Eq. (D-29)

$V_b = \left(7\left(\frac{l_e}{d_a}\right)^{0.2}\sqrt{d_a}\right)\lambda\ \sqrt{f'_c}\ c_{a1}^{1.5}$ ACI 318-08 Eq. (D-24)

Variables

c_{a1} [in.]	c_{a2} [in.]	e_{cV} [in.]	$\psi_{c,V}$	h_a [in.]
2.500	2.500	0.000	1.000	36.000

l_e [in.]	λ	d_a [in.]	f'_c [psi]	$\psi_{parallel,V}$
6.000	1.000	0.750	4000	1.000

Calculations

A_{Vc} [in.^{2}]	A_{Vc0} [in.^{2}]	$\psi_{ec,V}$	$\psi_{ed,V}$	$\psi_{h,V}$	V_b [lb]
46.88	28.13	1.000	0.900	1.000	2297

Results

V_{cbg} [lb]	$\phi_{concrete}$	$\phi\ V_{cbg}$ [lb]	V_{ua} [lb]
3446	0.700	2412	807

5 Combined tension and shear loads

β_N	β_V	ζ	Utilization $\beta_{N,V}$ [%]	Status
0.427	0.334	5/3	41	OK

$\beta_{NV} = \beta_N^{\zeta} + \beta_V^{\zeta} <= 1$

6 Warnings

- Load re-distributions on the anchors due to elastic deformations of the anchor plate are not considered. The anchor plate is assumed to be sufficiently stiff, in order not to be deformed when subjected to the loading!
- Condition A applies when supplementary reinforcement is used. The Φ factor is increased for non-steel Design Strengths except Pullout Strength and Pryout strength. Condition B applies when supplementary reinforcement is not used and for Pullout Strength and Pryout Strength. Refer to your local standard.
- Checking the transfer of loads into the base material and the shear resistance are required in accordance with ACI 318 or the relevant standard!

Fastening meets the design criteria!

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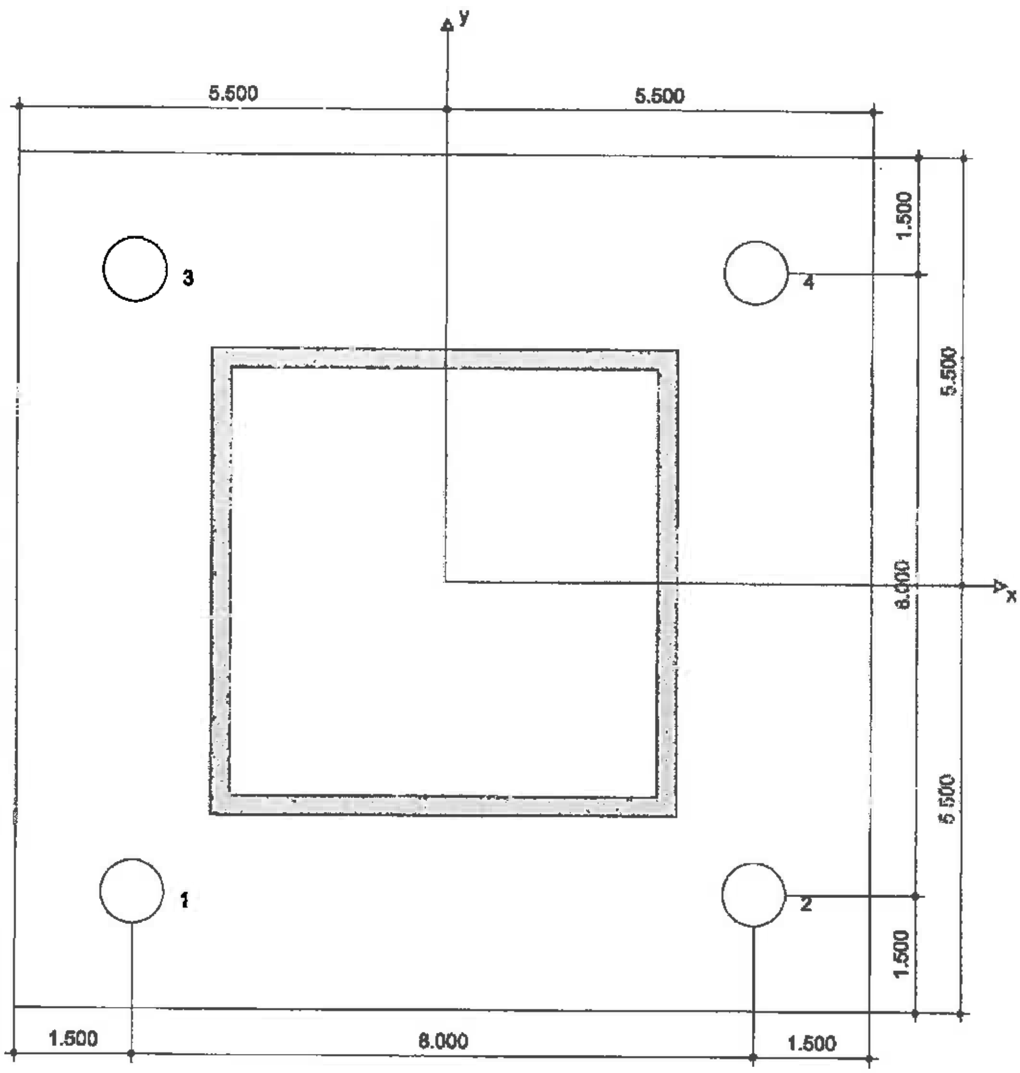
7 Installation data

Anchor plate, steel: -
Profile: Square HSS (AISC); 6.000 x 6.000 x 0.250 in.
Hole diameter in the fixture: d_f = 0.813 in.
Plate thickness (input): 0.500 in.
Recommended plate thickness: not calculated
Cleaning: No cleaning of the drilled hole is required

Anchor type and diameter: Hex Head ASTM F 1554 GR. 36 3/4
Installation torque: -0.009 in.lb
Hole diameter in the base material: - in.
Hole depth in the base material: 12.000 in.
Minimum thickness of the base material: 14.000 in.



Coordinates Anchor in.

Anchor	x	y	c_{-x}	c_{+x}	c_{-y}	c_{+y}
1	-4.000	-4.000	2.500	10.500	2.500	10.500
2	4.000	-4.000	10.500	2.500	2.500	10.500
3	-4.000	4.000	2.500	10.500	10.500	2.500
4	4.000	4.000	10.500	2.500	10.500	2.500

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→ SEE B22 FOR REACTIONS @ T/PIER

FOUNDATION DESIGN:

LOADS @ T/PIER = F_x = ~~0.183~~ K 0.252K F_y = 2.412 K ↓ 13.263K F_y = ~~2.55~~ K ↑ -4.629K↑

F_z = ~~0.461~~ K 0.914K

(CONSERVATIVE 3'-1 3/8")

PIER DESIGN:

$F_{LATERAL} = \sqrt{215\#^2 + 848\#^2}$ = ~~874.8~~# 948#

(252#, 914#)

M_u = ~~875#~~ 912.5 948 × 3.75 FT = ~~3.3~~ K-FT 3.56 K-FT

T_c = 60 KSI × 6 × 0.44 in² × 0.9 = ~~158K~~ 142.6K > 4.~~366~~ K↑ 4.629 ✓OK

$A_{PIER} = (\pi \times (18\text{ in})^2)/4 = 254.5\text{ in}^2$ ✓

PER ACI 318-08,

$$A_{S_{MIN}} = \frac{3\sqrt{f'_c}}{f_y} \times b_w d \quad \text{(Eq 10-3)}$$

d_{AVG} = 12 1/8" + 3 1/4"/2 = 13.7 in

$$= \frac{3\sqrt{4000\text{ PSI}}}{60{,}000\text{ PSI}} \times 12\text{ in} \times 13.7\text{ in} = 0.52\text{ in}^2 \text{ (3 BARS)}$$

= 0.18 in²/BAR (#4)

10.9.1 — $A_{ST_{MIN}}$ = $0.01A_g$ = 0.01 × 254.5 in² = 2.545 in² ✓

6 BARS ~ USE 6 #6 BARS VERTICALLY

(A_s = 2.65 IN²/ft) ✓OK

ACI 10.9.1 CONTROLS MINIMUM STEEL

$$M_u/\phi bd^2 = \frac{\sout{3.3}\ 3.56\text{ K-FT}\ (12{,}000\text{ \#-in}/\text{K-FT})}{0.9 \times 12\text{ in} \times (13.7\text{ in})^2} = \sout{19.5}\ 21.1 \rightarrow \rho = 0.00036$$

EQUIVALENT TO 18" Ø — 15.1 IN TO WORST CASE BAR — $A_{S REQ}$ = 4/3 ρbd = 0.08 in²/ft

BY INSPECTION, REQ'D A_{ST} IS MUCH LESS THAN CODE REQUIRED MINIMUM.

USE (6) #6 BARS HOOKED IN FOOTING

3#6 (A_s = 1.32 IN²/ft) >> ✓OK

ARCADIS

SUBJECT: TOPOK
PARKING CANOPY
JOB NO:

BY: CMW DATE: 12/3/14
CHKD: MSL DATE: 12/23/14

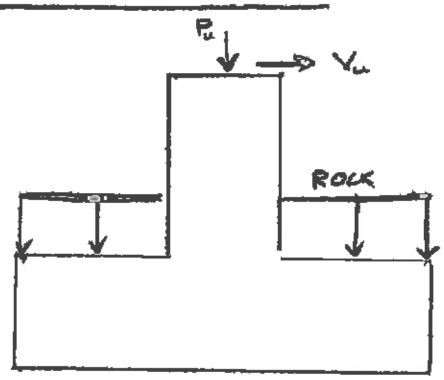
DESIGN OF TIES:

7.10.5.1 ~ #6 BAR → #3 TIE ✓

7.10.5.2 ~
- $16\,d_b = 16 \times 0.750^{in} = 12^{in}$ ✓ ← CONTROLS
- $48\,d_{b_{TIE}} = 48 \times 0.375^{in} = 18^{in}$ ✓
- LEAST DIM. 18in ✓

USE #3 TIES @ 12" c/c w/ (3) #3 TIES @ TOP OF PIER ✓

FOOTING DESIGN:



W_T PIER = $0.150^{KCF} \times 3^{FT} \times (\pi \times 1.5^2 / 4)$ ✓
$= 795^{\#}$ ✓

W_T FOOTING = $0.150^{KCF} \times 4^{FT} \times 4^{FT} \times 1.5^{FT}$
$= 3600^{\#}$ ✓

GRAVEL = $0.107^{KCF} \times 1^{FT} \times (16^{SF} - 1.78^{SF})$
$= 1.53^{K}$ ✓

$(0.795^{K} + 3.6^{K} + 1.53^{K})$
$= 5.925^{K}$ ✓

SLIDING:

$F_S = V_u = 1^{K}$ 0.622K ✓

$F_{S_R} = 0.3 \times (5.925^{K} + 7.12^{K}) = 3.92^{K} > F_S$ ✓ OK
(corrections: 7.12K → 6.82K; 3.92K → 3.82K)

$FoS_{SLIDING} = 3.92^{K} / 1.00^{K} = 3.91 > 1.5$ OK ✓
(correction: 6.18)

C2A
B-29

Company :
Designer :
Job Number :

Dec 18, 2014
2:56 PM
Checked By:_____

ASD LOAD COMBINATIONS

Joint Reactions (By Combination)

	LC	Joint Label	X [k]	Y [k]	Z [k]	MX [k-ft]	MY [k-ft]	MZ [k-ft]
1	8	N6	.034	6.152	-.257	0	0	0
2	8	N5	.034	6.152	.257	0	0	0
3	8	N10	.16	7.28	-.332	0	0	0
4	8	N9	.16	7.28	.332	0	0	0
5	8	N14	-.193	2.93	-.123	0	0	0
6	8	N13	-.193	2.93	.123	0	0	0
7	8	Totals:	0	32.724	0			
8	8	COG (ft):	X: 24.072	Y: 10.47	Z: 6			
9	9	N6	.041	4.73	.124	0	0	0
10	9	N5	.009	5.816	.531	0	0	0
11	9	N10	.159	5.593	.083	0	0	0
12	9	N9	.113	6.821	.622	0	0	0
13	9	N14	-.141	2.195	.114	0	0	0
14	9	N13	-.182	2.856	.289	0	0	0
15	9	Totals:	0	28.011	1.763			
16	9	COG (ft):	X: 24.085	Y: 10.436	Z: 6			
17	10	N6	-.011	-1.636	.406	0	0	0
18	10	N5	-.043	-.611	.248	0	0	0
19	10	N10	-.005	-2.22	.464	0	0	0
20	10	N9	-.05	-1.069	.243	0	0	0
21	10	N14	.074	-.746	.246	0	0	0
22	10	N13	.035	-.105	.155	0	0	0
23	10	Totals:	0	-6.386	1.763			
24	10	COG (ft):	X: 23.629	Y: 11.696	Z: 6			
25	11	N6	.052	6.691	-.042	0	0	0
26	11	N5	.028	7.52	.534	0	0	0
27	11	N10	.2	7.983	-.118	0	0	0
28	11	N9	.166	8.923	.646	0	0	0
29	11	N14	-.208	3.118	.021	0	0	0
30	11	N13	-.238	3.618	.281	0	0	0
31	11	Totals:	0	37.853	1.322			
32	11	COG (ft):	X: 24.063	Y: 10.497	Z: 6			
33	12	N6	.01	1.484	.188	0	0	0
34	12	N5	-.014	2.274	.303	0	0	0
35	12	N10	.067	1.596	.194	0	0	0
36	12	N9	.033	2.486	.336	0	0	0
37	12	N14	-.034	.718	.129	0	0	0
38	12	N13	-.063	1.205	.172	0	0	0
39	12	Totals:	0	9.764	1.322			
40	12	COG (ft):	X: 24.243	Y: 9.999	Z: 6			
41	13	N6	.038	3.563	.17	0	0	0
42	13	N5	.006	4.639	.485	0	0	0
43	13	N10	.128	4.27	.139	0	0	0
44	13	N9	.083	5.485	.566	0	0	0
45	13	N14	-.108	1.619	.136	0	0	0
46	13	N13	-.148	2.276	.266	0	0	0
47	13	Totals:	0	21.852	1.763			
48	13	COG (ft):	X: 24.065	Y: 10.49	Z: 6			
49	14	N6	-.008	-2.123	.422	0	0	0
50	14	N5	-.04	-1.102	.232	0	0	0
51	14	N10	-.019	-2.71	.48	0	0	0
52	14	N9	-.064	-1.563	.228	0	0	0
53	14	N14	.085	-1.009	.255	0	0	0
54	14	N13	.046	-.37	.146	0	0	0
55	14	Totals:	0	-8.877	1.763			
56	14	COG (ft):	X: 23.84	Y: 11.113	Z: 6			

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BY: CMW DATE: 2/3/14
CHKD: MSL DATE: 12/23/14

PAGE ~~2~~ C3 (B-29)
SHEET 1

OVERTURNING:

M_{OT} = ~~1.00~~ 0.622K × (3 FT + 1.5 FT) = ~~4.50~~ K-FT 2.80K·FT

M_R = ~~13.05~~ K 12.74K × 2 FT = ~~26.1~~ K-FT 25.49K·FT

M_R > 1.5 M_{OT} OK ✓

CHECK FOOTING FOR UPLIFT SCENARIO (LCL):

P = ~~2.55~~ K ↑ 2.11K F_{RES} = ~~0.44~~ K 0.46

SLIDING 2:

F_R = 0.3 × ~~7.11~~ K 5.925K = ~~2.133~~ K 1.778K > 0.44K OK ✓

OVERTURNING 2:

M_{OT_2} = ~~0.44~~ K 0.48K × 4.5 FT + ~~2.55~~ K × 2 FT = ~~7.08~~ K-FT 2.16K·FT

M_{R_2} = ~~7.11~~ K 5.925K − 2.71K × 2 FT = ~~11.92~~ 8.532 6.43K·FT FT-K > ~~7.08~~ 2.16K·FT OK ✓

FoS = ~~1.21~~ = ~~1.25~~ OK ✓
2.98 ~~1.5~~ > 1.5

BEARING PRESSURE:

e_1 = M/Q ~~4.50~~ 2.8K K-FT / ~~13.05~~ K 12.75 = ~~0.345~~ FT 0.219 FT

B/6 = 4 FT / 6 = 0.67 FT > e_1

$q_{MAX} = \frac{Q}{BL}(1 + 6e/B)$ = $\frac{13.05^K}{16 SF}$ (1 + $\frac{6 × 0.345^{FT}}{4^{FT}}$) = 1238 PSF < 1500 PSF OK ✓

$q_{MIN} = \frac{Q}{BL}(1 - 6e/B)$ = $\frac{13.05^K}{16 SF}$ (1 − $\frac{6 × 0.345^{FT}}{4^{FT}}$) = 394 PSF

$A = 16 Ft^2$, $y = 2 Ft$, $I = \frac{bh^3}{12} = 21.33 Ft^4$, $q = P/A \pm My/I = 0.797 ksf \pm 0.263 ksf$
= 1060 psf OR 534 psf < 1500 psf ✓ ok

AGM Form 30 12-01

CHECK BEARING PRESSURE FOR UPLIFT CASE:

$e_z = \frac{~~7.08~~\ 2.16\ ^{K-FT}}{~~7.11~~\ 3.215^K} = ~~0.99~~\ 0.672\ ^{FT} > B/6 \therefore$

$q = P/A \pm My/I = 201psf \pm 202psf = 403psf$ or $0psf < 1500psf$ ✓ok

OR 403psf to 0psf over 3.98ft

$q_{MAX} = \frac{4Q}{3L(B-2e)} = \frac{4 \times 7.11^K}{3 \times 4^{FT}(4^{FT} - 2 \times 0.99^{FT})} = 1173$ PSF < 1500 PSF ✓ok

5.625^K

1438 PSF OK ✓

FOOTING REINFORCEMENT:

$M_{FOOTING} = ~~1250~~\ 1500\ \#/FT \times 2^{FT} = 2.5^{K-FT}$ ✓

$M_u/\phi bd^2 = \frac{2.5^{K-FT} \times 12^{IN}/FT \times 1000\#/K}{0.9 \times 12^{IN} \times (~~15.5~~\ 14.5_{IN})^2} = 11.56$ ← SMALL ρ VALUE = ρ = 0.00027 ✓

$A_s = 4/3\rho bd = 0.06\ IN^2/ft$

PROVIDE MIN REINFORCEMENT:

$A_{ST_{MIN}} = ~~0.002~~\ 0.0018 \times b \times ~~d~~\ h = ~~0.002~~\ 0.0018 \times (12^{IN}) \times (~~15.5~~\ 18^{IN}) = ~~0.372~~\ 0.389\ IN^2 / 2$ FACES

$= ~~0.186~~\ 0.194\ IN^2$ → #4 @ ~~10~~ 12 c/c EW TOP & BOTTOM

($A_s = 0.20\ IN^2/ft$) ✓OK

CONNECTION DESIGN:

C10x15.3 (BEAMS) TO (HSS) COLUMN:

MOMENT CONNECTION → (2)-3/4" ∅ THRU-BOLTS TO HANDLE SHEAR, WELD TOP/BOT FLANGE OF C10 TO HSS 6x6x1/4 FOR MOMENT

(CONSERVATIVELY PROVIDING (4)-3/4" ∅ BOLTS)

*ALL LOADS ARE FACTORED

$5.08^K < 15.9^K \times 2 = 31.8^K$ ✓OK

SHEAR = $\sqrt{(4.2^K)^2 + (0.914^K)^2}$ = ~~4.2~~^{K} (NOT CUT IN HALF B/C THRU-BOLTS PICK UP LOAD FROM 2 C10x15.)

5.07^K 0.272^K ← SHT B19

PER AISC CHAPTER 7: (THRU-BOLTS TO HSS)

$\phi R_N = 0.75 \times 1.8 n F_y d t = 0.75 \times 1.8 \times 2 \times 36 KSI \times 0.25^{IN} \times 0.75^{IN}$ (46 ksi ← HSS A500 GR B)

$\phi R_N =$ ~~18.23~~^{K} 23.29^K > ~~4.2~~^{K} 5.08^K OK✓

TABLE 7-1 A325 (2) 3/4" ∅ $= 15.9^K \times 2 = 31.8^K$ ✓OK > 5.08^K

M = ~~10.44~~ ~~11.47~~ 11.457^K-FT /2 (2 BEAMS) = ~~5.22~~ ~~5.46~~ 5.73^K-FT ÷ $(10^{IN}/12^{IN/FT})$ = ~~6.26~~^{K} 5.73 (TENSION / COMPRESSION)

DESIGN OF WELD:

$\phi R_N =$ ~~0.75~~ $\times (1.392 \times D \times l)$ = ~~0.75~~ $\times 1.392 \times 3 \times 4^{IN}$ = ~~12.53~~^{K} 5.73^K (AISC 13TH ED 8-8; 3/16"; LONG)

~~12.53~~^{K} 16.70^K > ~~6.26~~^{K} 5.73^K OK. PROVIDE 3/16" x 4" LONG FILLET WELD TOP BOTTOM OF C10x15.3

$\phi R_N = SHEAR = 0.6 F_y A_g = 0.6(36 KSI)(0.25")(0.75")(2 BOLTS) = 8.1^K > 5.08^K$ (CHANNEL; C10 WEB; BOLT)

→ FYI ACTUALLY HAVE 4 BOLTS

DIA
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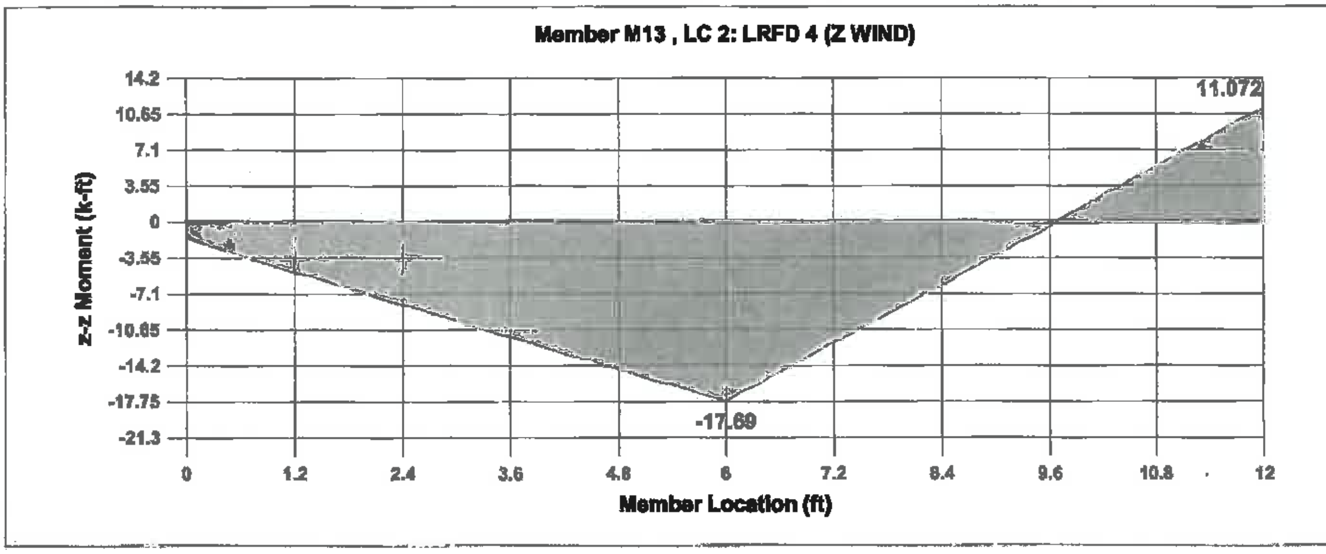

Member M13 , LC 2: LRFD 4 (Z WIND)
z-z Moment (k-ft)
14.2
10.65
7.1
3.55
0
-3.55
-7.1
-10.65
-14.2
-17.75
-21.3
11.072
-17.69
0
1.2
2.4
3.6
4.8
6
7.2
8.4
9.6
10.8
12
Member Location (ft)

DIB
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Member Section Forces (By Combination) FACTORED LOADS

	LC	Member Label	Sec	Axial[k]	y Shear[k]	z Shear[k]	Torque[k-ft]	y-y Mo...	z-z Mo...
1	1	M12	1	.358	1.381	.114	0	-.613	.459
2			2	.358	1.326	.114	0	-.269	-3.6
3			3	.365	-1.813	.01	0	.074	-7.501
4			4	.365	-1.867	.01	0	.02	-1.981
5			5	.365	-1.922	.01	0	.05	3.704
6	1	M13	1	.901	3.948	-.004	0	.035	2.466
7			2	.901	3.893	-.004	0	.023	-9.297
8			3	.901	-4.918	-.007	0	.019	-20.895
9			4	.887	-4.973	-.007	0	-.001	-6.045
10			5	.887	-5.028	-.007	0	-.021	8.955
11	1	M14	1	.657	2.942	-.063	0	.309	1.438
12			2	.657	2.887	-.063	0	.12	-7.306
13			3	.681	-3.815	.016	0	-.069	-15.904
14			4	.681	-3.87	.016	0	-.003	-4.377
15			5	.681	-3.925	.016	0	.044	7.315
16	2	M12	1	.468	.861	.251	0	-1.25	-1.496
17			2	.468	.806	.251	0	-.496	-3.996
18			3	.482	-1.826	-.003	0	.257	-6.343
19			4	.482	-1.881	-.003	0	.081	-.783
20			5	.482	-1.936	-.003	0	.071	4.943
21	2	M13	1	1.108	2.723	-.024	0	.103	-1.679
22			2	1.108	2.668	-.024	0	.031	-9.767
23			3	1.108	-4.734	.002	0	-.041	-17.69
24			4	1.08	-4.789	.002	0	-.017	-3.378
25			5	1.08	-4.844	.002	0	-.011	11.072
26	2	M14	1	.797	1.936	-.139	0	.633	-2.164
27			2	.797	1.881	-.139	0	.215	-7.888
28			3	.845	-3.761	.046	0	-.202	-13.486
29			4	.845	-3.815	.046	0	-.03	-2.122
30			5	.845	-3.87	.046	0	.106	9.406
31	3	M12	1	.175	1.405	-.051	0	.084	1.791
32			2	.175	1.351	-.051	0	-.071	-2.343
33			3	.175	-1.296	.051	0	-.225	-6.312
34			4	.175	-1.351	.051	0	-.071	-2.343
35			5	.175	-1.405	.051	0	.084	1.791
36	3	M13	1	.505	3.784	-.032	0	.076	4.89
37			2	.505	3.729	-.032	0	-.019	-6.378
38			3	.505	-3.674	.032	0	-.113	-17.482
39			4	.505	-3.729	.032	0	-.019	-6.378
40			5	.505	-3.784	.032	0	.076	4.89
41	3	M14	1	.339	2.867	-.045	0	.134	3.715
42			2	.339	2.812	-.045	0	0	-4.803
43			3	.339	2.757	-.045	0	-.133	-13.158
44			4	.339	-2.812	.045	0	0	-4.803
45			5	.339	-2.867	.045	0	.134	3.715
46	4	M12	1	.418	.48	.255	0	-1.252	-1.952
47			2	.418	.438	.255	0	-.487	-3.329
48			3	.431	-1.459	-.009	0	.277	-4.593
49			4	.431	-1.501	-.009	0	.089	-.153
50			5	.431	-1.542	-.009	0	.062	4.41
51	4	M13	1	.969	1.704	-.027	0	.11	-2.866
52			2	.969	1.663	-.027	0	.028	-7.917
53			3	.969	-3.688	.005	0	-.054	-12.844
54			4	.941	-3.729	.005	0	-.02	-1.693
55			5	.941	-3.77	.005	0	-.005	9.555
56	4	M14	1	.693	1.154	-.141	0	.634	-3.065

Member Section Forces (By Combination) (Continued)

	LC	Member Label	Sec	Axial[k]	y Shear[k]	z Shear[k]	Torque[k-ft]	y-y Mo...	z-z Mo...
57			2	.693	1.113	-.141	0	.21	-6.467
58			3	.741	-2.961	.049	0	-.213	-9.783
59			4	.741	-3.003	.049	0	-.035	-.837
60			5	.741	-3.044	.049	0	.112	8.232
61	5	M12	1	.125	1.018	-.047	0	.078	1.297
62			2	.125	.977	-.047	0	-.062	-1.695
63			3	.125	-.936	.047	0	-.203	-4.563
64			4	.125	-.977	.047	0	-.062	-1.695
65			5	.125	-1.018	.047	0	.078	1.297
66	5	M13	1	.365	2.737	-.035	0	.082	3.538
67			2	.365	2.696	-.035	0	-.022	-4.611
68			3	.365	-2.655	.035	0	-.126	-12.637
69			4	.365	-2.696	.035	0	-.022	-4.611
70			5	.365	-2.737	.035	0	.082	3.538
71	5	M14	1	.235	2.065	-.047	0	.137	2.68
72			2	.235	2.023	-.047	0	-.004	-3.452
73			3	.235	1.982	-.047	0	-.145	-9.461
74			4	.235	-2.023	.047	0	-.004	-3.452
75			5	.235	-2.065	.047	0	.137	2.68
76	6	M12	1	.224	-.965	.272	0	-1.264	-3.734
77			2	.224	-1.006	.272	0	-.449	-.778
78			3	.237	-1.047	.272	0	.366	2.302
79			4	.237	-.011	-.032	0	.123	2.262
80			5	.237	-.052	-.032	0	.026	2.357
81	6	M13	1	.409	-2.378	-.04	0	.138	-7.758
82			2	.409	-2.419	-.04	0	.017	-.562
83			3	.409	-2.46	-.04	0	-.104	6.777
84			4	.384	.541	.016	0	-.032	5.092
85			5	.384	.5	.016	0	.017	3.529
86	6	M14	1	.287	-1.878	-.151	0	.642	-6.672
87			2	.287	-1.919	-.151	0	.189	-.976
88			3	.334	-1.961	-.151	0	-.263	4.845
89			4	.334	.185	.063	0	-.053	4.189
90			5	.334	.143	.063	0	.135	3.697
91	7	M12	1	-.069	-.448	-.026	0	.053	-.62
92			2	-.069	-.49	-.026	0	-.026	.787
93			3	-.069	.531	.026	0	-.105	2.318
94			4	-.069	.49	.026	0	-.026	.787
95			5	-.069	.448	.026	0	.053	-.62
96	7	M13	1	-.194	-1.439	-.047	0	.107	-1.921
97			2	-.194	-1.48	-.047	0	-.033	2.457
98			3	-.194	1.521	.047	0	-.173	6.959
99			4	-.194	1.48	.047	0	-.033	2.457
100			5	-.194	1.439	.047	0	.107	-1.921
101	7	M14	1	-.171	-1.041	-.059	0	.153	-1.386
102			2	-.171	-1.082	-.059	0	-.024	1.798
103			3	-.171	-1.123	-.059	0	-.2	5.105
104			4	-.171	1.082	.059	0	-.024	1.798
105			5	-.171	1.041	.059	0	.153	-1.386

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ARCADIS

SUBJECT: TOPOK
PARKING CANOPY
JOB NO:

BY: CMW DATE: 12/4/14
CHKD: MSL DATE: 12/24/14

PAGE D2
SHEET 1

CONNECTION OF C10x15.3 PURLIN TO C10x15.3 BEAM:

SHEAR = ~~325#~~ 894# TENSION = ~~2285#~~ ← 369#/FT x 20 FT C/C TRIB = 7380# FACT (LRFD)

1.0W = 44.7#/FT x 20 FT C/C TRIB = 894#

C10 WEB SHEAR → ϕR_n = ~~0.75 x 1.8~~ (0.6) x 2 x 36 KSI x 0.25 x 0.5" = ~~12.15K~~ 5.4K > ~~0.325K~~ 894# OK ✓ TABLE 7-1

ϕR_T = 0.9 x 36 KSI x 2 x 0.20 in² = 12.96K > ~~2.29K~~ 7.38K OK ✓

TABLE 7-2 ~ (2) 1/2" Ø BOLTS = 13.25K >

TABLE 7-1 = 7.03K x 2 (2) 1/2" Ø BOLTS = 14.06K ✓

✓OK USE (2) - 1/2" Ø BOLTS W/ L3x3x1/4" CLIP ANGLE
(1/2" Ø BOLTS USED FOR CLEARANCE / EDGE [illegible] REQUIREMENTS) ✓

CONNECTION OF ROOF PURLIN TO HSS COLUMN:

REACTION = 4.664 + 3.891

REACTION = 0.529K + 0.482K

SHEAR = $\sqrt{\cancel{4.1K}^2 + \cancel{0.529K}^2}$ = ~~4.2K~~ ~~1.064K~~ 8.62K
1.07K, 8.56K², 0.483K, 1.011K x 2

(2) - 3/4" BOLTS - SC - 22.1K > ~~4.2K~~ OK ✓
([illegible] PROVIDE (4) - 3/4" DIA [illegible])

→ CONNECTION HSS = 46.58K
C10 WEB = 16.2K
23.29K (B32) x 2
8.1K (B32) x 2
> 8.62K ✓OK

T = M/y 4.4K-FT ~~14.938~~ FT-K ÷ (10 in / 12 in/FT) = ~~17.93K~~ 5.28K ✓

ϕR_n = ~~0.75~~ x 1.392 x ~~4~~ 3 x ~~4 in~~ 5 in = ~~25.06K~~ ~~15.66K~~ 20.88K OK ✓

PROVIDE ~~3/8"~~ x ~~4~~ WELD
3/16" x 5"

~ FYI ~ IF MAX M_{ZZ} MOMENT = 15,959 K-FT / (10 in / 12 in/FT) = 19.15K < 20.88K ✓OK
CONSERVATIVE (NEGATIVE MOMENT FROM WORST CASE GRAVITY LOADS)
2.12 in

~ ALSO HAVE (4) 3/4" Ø BOLTS → M_{CAP} = 4 L (V_{CAP}) = 116.6 K-IN − BOLTS NET CAPACITY
[45.9K LRFD − (8.62K / 4 BOLTS)]
+ 20.88K x 10 in − WELD
325.35 K-IN ≈ 27.11 K-FT > 15,959 ✓OK

3"

Envelope Member Section Forces FACTORED

	Member	Sec		Axial[k]	LC	y Shear[k]	LC	z Shear[k]	LC	Torque[k...	LC	y-y Mom...	LC	z-z Mom...	LC
1	M3	1	max	10.154	1	.235	7	.691	6	0	1	0	1	0	1
2			min	-3.651	6	-.098	1	-.376	3	0	1	0	1	0	1
3		2	max	10.097	1	.19	7	.646	6	0	1	1.784	6	.261	1
4			min	-3.694	6	-.098	1	-.376	3	0	1	-1.002	3	-.566	7
5		3	max	10.04	1	.144	7	.602	6	0	1	3.449	6	.522	1
6			min	-3.736	6	-.098	1	-.376	3	0	1	-2.004	3	-1.011	7
7		4	max	9.983	1	.099	7	.557	6	0	1	4.994	6	.783	1
8			min	-3.779	6	-.098	1	-.376	3	0	1	-3.006	3	-1.336	7
9		5	max	6.986	1	0	7	.833	2	-.134	3	.008	2	1.097	2
10			min	-2.035	7	-.223	2	-.027	5	-.642	6	-.002	7	-1.494	7
11	M4	1	max	11.108	1	.235	7	.952	2	0	1	0	1	0	1
12			min	-2.904	7	-.068	1	-.143	7	0	1	0	1	0	1
13		2	max	11.051	1	.19	7	.952	2	0	1	2.54	2	.183	1
14			min	-2.947	7	-.068	1	-.143	7	0	1	-.381	7	-.566	7
15		3	max	10.994	1	.144	7	.952	2	0	1	5.08	2	.365	1
16			min	-2.99	7	-.068	1	-.143	7	0	1	-.763	7	-1.011	7
17		4	max	10.937	1	.099	7	.952	2	0	1	7.621	2	.548	1
18			min	-3.033	7	-.068	1	-.143	7	0	1	-1.144	7	-1.336	7
19		5	max	6.957	1	.004	6	.052	4	.153	7	.004	6	.736	1
20			min	-2.035	7	-.082	3	.015	1	.044	1	-.005	3	-1.494	7
21	M5	1	max	12.178	1	.223	7	.783	6	0	1	0	1	0	1
22			min	-4.629	6	-.317	1	-.499	3	0	1	0	1	0	1
23		2	max	12.121	1	.223	7	.738	6	0	1	2.028	6	.847	1
24			min	-4.671	6	-.317	1	-.499	3	0	1	-1.332	3	-.595	7
25		3	max	12.064	1	.223	7	.693	6	0	1	3.937	6	1.694	1
26			min	-4.714	6	-.317	1	-.499	3	0	1	-2.665	3	-1.189	7
27		4	max	12.007	1	.223	7	.648	6	0	1	5.726	6	2.541	1
28			min	-4.757	6	-.317	1	-.499	3	0	1	-3.997	3	-1.784	7
29		5	max	8.005	1	.183	7	1.071	2	-.035	1	.004	1	3.366	1
30			min	-2.429	7	-.292	1	.004	7	-.138	6	-.001	7	-2.345	7
31	M6	1	max	13.263	1	.223	7	1.129	2	0	1	0	1	0	1
32			min	-3.697	7	-.276	1	-.195	7	0	1	0	1	0	1
33		2	max	13.206	1	.223	7	1.129	2	0	1	3.01	2	.736	1
34			min	-3.739	7	-.276	1	-.195	7	0	1	-.52	7	-.595	7
35		3	max	13.149	1	.223	7	1.129	2	0	1	6.021	2	1.472	1
36			min	-3.782	7	-.276	1	-.195	7	0	1	-1.04	7	-1.189	7
37		4	max	13.091	1	.223	7	1.129	2	0	1	9.031	2	2.208	1
38			min	-3.825	7	-.276	1	-.195	7	0	1	-1.559	7	-1.784	7
39		5	max	8.01	1	.183	7	-.004	7	.107	7	.002	6	2.917	1
40			min	-2.429	7	-.243	1	-.039	1	-.021	1	-.003	1	-2.345	7
41	M7	1	max	4.722	1	.412	3	.422	6	0	1	0	1	0	1
42			min	-1.745	6	-.145	6	-.182	3	0	1	0	1	0	1
43		2	max	4.664	1	.412	3	.377	6	0	1	1.065	6	.386	6
44			min	-1.788	6	-.145	6	-.182	3	0	1	-.486	3	-1.099	3
45		3	max	4.607	1	.412	3	.332	6	0	1	2.01	6	.772	6
46			min	-1.831	6	-.145	6	-.182	3	0	1	-.971	3	-2.197	3
47		4	max	4.55	1	.412	3	.287	6	0	1	2.836	6	1.158	6
48			min	-1.873	6	-.145	6	-.182	3	0	1	-1.457	3	-3.296	3
49		5	max	3.113	1	.489	2	.477	2	1.264	6	0	7	1.316	6
50			min	-.952	6	-.018	7	-.005	7	-.084	3	-.003	1	-4.344	3
51	M8	1	max	5.287	1	.412	3	.502	2	0	1	0	1	0	1
52			min	-1.108	7	-.081	6	-.064	7	0	1	0	1	0	1
53		2	max	5.23	1	.412	3	.502	2	0	1	1.34	2	.215	6
54			min	-1.151	7	-.081	6	-.064	7	0	1	-.169	7	-1.099	3
55		3	max	5.173	1	.412	3	.502	2	0	1	2.68	2	.43	6
56			min	-1.194	7	-.081	6	-.064	7	0	1	-.339	7	-2.197	3

Envelope Member Section Forces (Continued)

	Member	Sec		Axial[k]	LC	y Shear[k]	LC	z Shear[k]	LC	Torque[k...	LC	y-y Mom...	LC	z-z Mom...	LC
57		4	max	5.116	1	.412	3	.502	2	0	1	4.02	2	.646	6
58			min	-1.237	7	-.081	6	-.064	7	0	1	-.508	7	-3.296	3
59		5	max	3.137	1	.351	3	.006	4	.084	3	.002	1	.835	6
60			min	-.909	6	-.049	6	0	1	.026	6	-.001	6	-4.344	3

Lotycz, Matt • TANK FOR TOPAK — IF WALKWAY C-1

MSL 6/18/14

From: Baxter, Jonathan
Sent: Thursday, March 29, 2012 11:57 AM
To: Lotycz, Matt
Subject: PG&E Topock Info
Attachments: supervault-information.pdf

Information is starting to come in now and I'll have more for you later. We are to proceed with the shipping container buildings for the time being, however a final decision has not yet been made.

(IRZ CARBON SUBSTRATE ← i.e.)

Tank information is attached – the MW-20 bench will use the 15,000 gallon version, while the TW bench will have the 3,000 gallon model. The ethanol blend we purchase has a density of ~6.557 lbs/gal.

The shipping containers: 40' containers: ~7,200 lbs empty, 20' containers: ~6,000 lbs empty. I'm not too sure of the weight and quantity of equipment being added to the containers at this point.

Jonathan Baxter, PE | Staff Environmental Engineer | jonathan.baxter@arcadis-us.com

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ARCADIS, Imagine the result

Professional Registration/PE-WI
Please consider the environment before printing this email.

WELL VAULT - TOP SLAB DESIGN

- 4'-0" CLEAR SPAN PER DRAWING S-00-05
  (8', 6', 5', & 8'-6" IN OTHER DIRECTION)
- DESIGN FOR HS-20 (LC#1) & 300psf (LC#2) UNIFORM LOAD (NOT SIMULT)

~ LC#1 ~ 16K WHEEL LOAD UNF

(EQ 3-1) $I = \frac{50}{L+125} = 0.39 > 0.3$ MAX
USE 30%

- $S = 4^{F}$ CLEAR + 6" = 4.5 FT c/c
- MAIN REINF ⊥ TO TRAFFIC = $\left(\frac{S+2}{32}\right) P_{20} \times 1.3_{IMP} \times 1.6_{ACI}$
  $= 6.76$ K-FT ACI
- MAIN REINF ‖ TO TRAFFIC = 900 S = 4.05 K-FT × 1.3 IMP × 1.6 ACI
  = 8.42 K-FT ACI
- LC#2 300psf → $M_{ACI} = \frac{wl^2}{8} = \frac{(300psf \times 1.6_{ACI})(4.5^{ft})^2}{8}$
  = 1.22 K-FT ACI
- SLAB DL = 150psf → $\frac{wl^2}{8}$ = 0.38 K-FT UNF, 0.46 K-FT ACI

→ TRY 12" THICK w/ 2" COVER BOT ~ d = 12" - 2" COVER - 4/16" = 9.7"

8.42 K-FT + 0.46 → $M_u/\phi bd^2$
- R = 104.9 → ρ = 0.0018 → $A_{S\,REQ'D} = \frac{4}{3}\rho bd = 0.28$ IN²/FT

~ USE #4 @ 8" c/c (A_s = 0.29 IN²/FT)

- NO NEED TO CHECK ACI 318 10.6.4 SINCE 4/3ρ USED
  & $A_{S\,PROV'D} > A_{S\,REQ'D}$

- DIST REINF

  - MAIN REINF ∥ TO TRAFFIC $= \frac{100}{\sqrt{S}} = 47.1\% < 50\%$ MAX

  - MAIN REINF ⊥ TO TRAFFIC $= \frac{220}{\sqrt{S}} = 103.7\% > 67\%$ MAX ← USE

    $5.64^{K/FT}$ ⇐ × $8.42^{K/FT}$ ACI (SHT F-1)
    +0.46

    → $d = 12'' - 2''_{COVER} - 4/8'' - 4/16'' = 9.20^{IN}$

  - $R = 80.1 \rightarrow \rho = 0.0013 \rightarrow A_s = 4/3 \rho b d = 0.20 \, IN^2/FT$

    ~ USE #4 @ 12" o/c ($A_s = 0.20 \, IN^2/FT$)

- AT OPENING ~ MAX OPENING 2'-0" ϕ

  ∴ 1^F SECTION EACH SIDE OF OPENING MUST HANDLE 2'-0" TRIB

  ~ ~~ADD #3 @ 12" o/c 4N B/W TRP #3 @ 12" o/c~~

  2 #4 EACH SIDE OF OPENING

- CHECK SHEAR

  - LC#1 ⇒ $E = 0.8X + 3.75 \rightarrow$ USE 4^F (CASE A) (/6")

    $E = 0.35X + 3.2 \rightarrow \underline{3.4^F}$ USE

  - $(16^K \times 1.3_{IMP} \times 1.6_{ACI}) / 3.4^F = 9.79^K$ (1FT SECTION)

  - $V_{ACI} = P$ (LOAD W/IN INCHES OF SUPPORT) $= 9.79^K$ LC#1 ← USE

  - LC#2 $V_{ACI} = \frac{wl}{2} = \frac{300psf \times 1.6_{ACI} \times 4.5^F}{2} = 1.08^K$

- $V_{ACI \, DL} = 150pcf \times 1.2_{ACI} \times 4.5ft^2 = 0.41^K$

(CON'T SHEAR)

• $\phi V_c = 2\phi\sqrt{f'_c}\,bd = 10.81^K > V_{ACI} = (9.79^K + 0.41^K)$ ✓OK ($d = 9.5^{IN}$)

BEAM A AT OPENING

• BEAM SPAN = 3^{FT} c/c

• BEAM LOAD = $5^{FT}/(2\times2) = 1.25^{FT} \times 300psf = 375psf_{LL}$
  " $\times$ 150psf 188psf DL
  563psf UNF; 826psf ACI

• $V_{ACI} = 1.24^K$

• $M_{ACI} = \frac{wl^2}{8} = 0.93^{K\cdot FT}$

~ BY INSPECTION, 12" thick w/ #4 @ 12" o/c IS SUFFICIENT

BEAM B AT OPENING

• $M_{ACI} = (8.42 + 0.46)^{K/FT} \times 2.5^{FT} = 22.2^{K\cdot FT}$

• SPREAD OVER 18" WIDE SLAB SECTION = b = 18"; d = 9.7 IN

~ $R = M_u/\phi bd^2 = 174.8 \rightarrow \rho = 0.0030 \rightarrow A_s = \rho_{min} bd$
$A_{S\,REQ'D} = 0.58\ IN^2/FT$ ~ ADD (2) #4 IN E/W TYP #4 @ 8" o/c
~ 2 + 2 ⇒ 4 #4 $A_s = 0.78\ IN^2/FT$ ✓OK

• $\phi V_c = 18.52^K > V_{ACI}$ @ FACE = $\frac{660psf_{ACI} \times 4^{FT}}{2} \times 2.5^{FT}_{TRIB} = 3.30^K$ ✓OK

CHECK REMOVABLE TOP SLAB

- LOAD SPANS IN 5FT WIDTH % ~ DL = 150psf × $\frac{5FT}{2}$ = 375 psf UNF
  450 psf ACI
- MAX SPAN = 8'-6" CLEAR − 3" − 3" = 8'-0" CLEAR w/ 9" OVERHANG EACH END
  - $V_{ACI} = \frac{450 plf \times 8FT}{2} = 1.8^K$
  - $M_{ACI} = \frac{450 psf \times 8FT^2}{8} = 3.6^{K \cdot FT}$
- ~18" WIDTH OF SLAB WORKING w/ d = 9.2 IN
- $\phi V_C = 17.56^K > V_{ACI}$ √OK
- $R = M_u/\phi b d^2 = 31.5 \rightarrow \rho = 0.0005 \rightarrow A_s = 4/3 \rho b d = 0.12^{IN^2}/FT$
- → #4 @ 12" o/c TYP = ($A_s = 0.30^{IN^2}/FT$) OVER 18" √OK

ARCADIS

SUBJECT: PG&E – TOPOCK, CA
WELL VAULTS – TOP SLAB
JOB NO:

BY: MSL DATE: 8/4/14
CHKD: DATE:

PAGE F-5
SHEET 1

BOUYANCY CALC

- ASSUME GW 1FT BELOW GRADE – ULTRA-CONSERVATIVE FOR DESERT
- UPLIFT = (4FT DEEP + 8" BASE SLAB) × (9'-6" × 5'-0") % WALLS × 62.4pcf
  = 13.34K
- DEAD LOAD =
  - WALLS = (0.5' THICK × 4FT TALL) × [(9.5FT × 2) + (4' × 2)] (27FT) × 150pcf
    = 8.1K
  - BASE SLAB = 9.5' × 5' × 150pcf × 0.5' = 3.56K
  - SOIL ON TOES = (4FT DEEP + 6" + 6") × [(10.0' × 2) + (5.5FT × 2)] (31FT)
    × (110pcf – 62.4pcf)
    = 7.38K

TOTAL = 19.04K ~ FS = 1.43 ≈ 1.5 B/C SOIL 3Δ OFF TOES WOULD GIVE FS = 1.5 ✓ OK

AGM Form 30 12-01

C-2

SuperVault MH
Multi-Hazard Rated
Protected Aboveground Fuel Storage Tanks

SuperVault MH

The SuperVault MH is the first **MULTI-HAZARD RATED Insulated and Protected Aboveground Fuel Storage Tank** available in the World and it is the first tank to pass the stringent safety requirements of Uniform Fire Code Standard A-II-F-1 (formerly known as 79-7) and Southwest Research Institute Standard 95-03 and 93-01. The Multi-Hazard Rating allows the SuperVault MH to be recertified for use after exposure to a fire, puncture or impact. The SuperVault MH provides safe aboveground storage with the highest insulation value available in a lightweight concrete design. The unique design provides unsurpassed fire protection and puncture resistance while also making handling and installation much easier than tanks encased in normal weight concrete. Since the tanks are relatively lightweight they can be shipped anywhere in the world. The insulating concrete is also protected from deterioration and damage by an additional outer steel tank. The SuperVault MH is available in two styles, cylindrical and rectangular.

***SuperVault MH* Cylindrical Tanks** - Available from 250 Gallons to 20,000 Gallons

The Cylindrical line of the SuperVault MH offers two advantages to the fleet fueling operation: larger capacities available and less unusable capacity. Because of their height these tanks generally require either a ground level fill or an access platform for filling. Special plumbing and valves are included in the equipment packages for these tanks because the pumping unit is mounted on the end of the tank for convenience.

***SuperVault MH* Rectangular Tanks** - Available from 250 Gallons to 2,000 Gallons

The Rectangular line of the SuperVault MH offers two advantages to the smaller fuel user: less visual impact and the simplicity of tank top equipment. Because the rectangular tanks are lower profile than their cylindrical counterparts, pumping equipment may be conveniently located on the top of the tank and still be accessible from the ground.

Advantages of the *SuperVault MH*

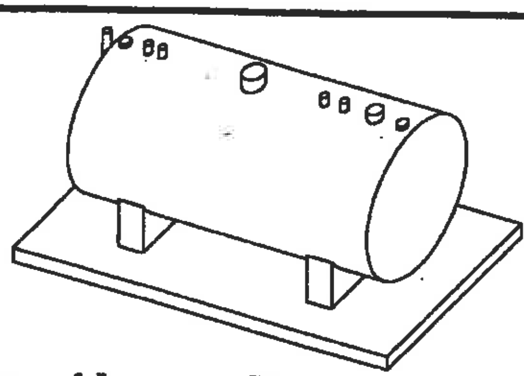
C-3

- **30-YEAR WARRANTY:** (see actual warranty for details)
- **ATTRACTIVE:** Both styles have been designed to make an aesthetically pleasing fueling facility.
- **EASILY MONITORED:** Monitoring is easily accomplished by checking the monitor tube.
- **FULLY LISTED TANK ASSEMBLY:** All SuperVault MH tanks are Multi-Hazard Rated, Insulated and Protected Aboveground Fuel Storage Tanks listed to UL 2085 Protected Tank, SwRI 95-03 and 93-01 and UFC Standard A-II-F-1 (formerly known as UFC Standard 79-7) with a 4-Hour Fire Rating.
- **BEST INSULATION:**

  1. MADE OF LIGHTWEIGHT CONCRETE
     Lighter tanks make transportation and installation easier and less costly.
  2. SOLID CONCRETE INSULATION
     Cannot slough, settle, or compact away from the inner tank during normal use or during a fire event insuring maximum protection of fuel and property. The Special Insulation Formula also helps guard against corrosion of the Steel Primary and Secondary Tanks.
  3. HEAT TRANSFER TO THE PRIMARY TANK AT AN ABSOLUTE MINIMUM
     No other tank provides a higher level of insulation and fuel security. Prevents large fuel losses due to evaporation in hot climates.
  4. MULTI-HAZARD RATED!

- **4-HOUR FIRE RATING:** The SuperVault MH is the first tank on the market to pass the SwRI 95-03 multi-hazard test, the toughest test for aboveground fuel tanks by a nationally certified testing lab. Most tanks are single-hazard rated which means they can withstand a hazard (Fire, Bullet, Impact) one time, but then have to be disposed of carefully. The SuperVault MH has been tested for multiple exposure to fires and other hazards and an extended element exposure test. This means that if the SuperVault MH experiences a hazard, it may be recertified and kept in service rather than having to be replaced. No down time. No fuel loss. No replacement cost. The SuperVault MH. Built to last.
- **PUNCTURE RESISTANCE (BALLISTICS):** The integrity of the primary tank is not endangered by the many bumps and bruises encountered in equipment fueling operations and meets UFC requirements for bullet resistance.
- **HIGH IMPACT RESISTANCE:** The SuperVault MH meets the crash test requirements of UFC Standard A-II-F-1 (also called 79-7). To meet the requirement the tank must be able to withstand the impact of a 12,000 pound battering ram traveling at 10 mph.
- **ADDITIONAL SEISMIC RESTRAINTS NOT REQUIRED:** Built-in supports offer integral anchoring capability.
- **EXTERNAL DIKING NOT REQUIRED BY UFC:** The SuperVault MH outer tank provides 110% of secondary containment.
- **GUARD POSTS NOT REQUIRED BY UFC:** The SuperVault MH tanks meet the impact resistance testing of the Uniform Fire Code.
- **AVAILABLE IN TWO STYLES:** Fuel efficient cylindrical or low profile rectangular.

C-4

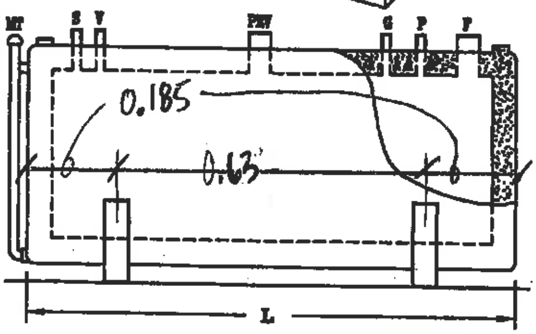


LEGEND

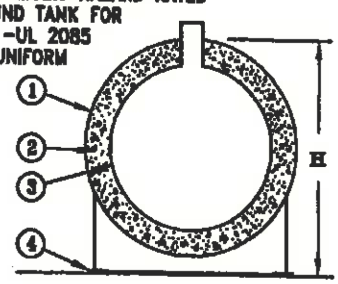
P	Pump
G	Level Gage
V	Normal Vent
PEV	Primary Emer. Vent
F	Fill
MT	Monitor Tube
S	Spare

FEATURES

1. Fully Listed Double Wall Tank Assembly Multi-Hazard-4 Hour Fire Rated
2. 6" Thick, Lightweight, Impact and Projectile Resistant Insulating Concrete
3. UL 142 Steel Primary & Secondary Containment Tanks
4. Integral Supports and Seismic Restraints



- ENTIRE TANK ASSEMBLY IS LISTED AS A MULTI-HAZARD RATED INSULATED AND PROTECTED ABOVEGROUND TANK FOR FLAMMABLE AND COMBUSTIBLE LIQUIDS -UL 2085 PROTECTED, SwRI 95038 93-01, and UNIFORM FIRE CODE STANDARD A-II-F-1.*
- Outer steel tank protects the insulation from the harmful effects of the weather and from damage during normal use.
- Lightweight design makes delivery and installation much easier than normal weight concrete tanks.
- Outer steel tank capacity is greater than 110% of the capacity of the primary tank.



MODEL NO.	MINIMUM CAPACITY	PRIMARY TANK DIAMETER	PRIMARY TANK LENGTH	OVERALL LENGTH	OVERALL HEIGHT	APPROX. WEIGHT
MH-D1-250	250	37 1/4	60	6' 3"	4' 7"	3,700
MH-D1-500	500	37 1/4	107	10' 2"	4' 7"	5,400
MH-D1-750	750	37 1/4	160	14' 7"	4' 7"	7,400
MH-D2-500	500	50 5/8	60	6' 3"	5' 9"	5,100
MH-D2-750	750	50 5/8	87	8' 6"	5' 9"	6,500
MH-D2-1000	1,000	50 5/8	116	10' 11"	5' 9"	7,800
MH-D2-1500	1,500	50 5/8	173	15' 8"	5' 9"	10,600
MH-D2-2000	2,000	50 5/8	231	20' 6"	5' 9"	13,500
MH-D3-1000	1,000	64	73	7' 4"	6' 10"	7,600
MH-D3-1500	1,500	64	109	10' 4"	6' 10"	9,700
MH-D3-2000	2,000	64	145	13' 4"	6' 10"	12,000
MH-D3-3000	3,000	64	216	19' 3"	6' 10"	16,400
MH-D3-4000	4,000	64	288	25' 3"	6' 10"	22,600
MH-D4-2000	2,000	82 5/8	87	8' 6"	8' 5"	12,900
MH-D4-3000	3,000	82 5/8	130	12' 1"	8' 5"	16,700
MH-D4-4000	4,000	82 5/8	174	15' 9"	8' 5"	22,160
MH-D4-5000	5,000	82 5/8	216	19' 3"	8' 5"	26,000
MH-D4-6000	6,000	82 5/8	259	22' 10"	8' 5"	29,400
MH-D4-8000	8,000	82 5/8	348	30' 3"	8' 5"	37,300
MH-D4-10000	10,000	82 5/8	440	37' 11"	8' 5"	44,000
MH-D5-6000	6,000	114 5/8	145	13' 4"	11' 1"	28,800
MH-D5-8000	8,000	114 5/8	180	16' 3"	11' 1"	34,800
MH-D5-10000	10,000	114 5/8	230	20' 5"	11' 1"	41,500
MH-D5-12000	12,000	114 5/8	273	24' 0"	11' 1"	48,000
MH-D5-15000	15,000	114 5/8	338	29' 5"	11' 1"	55,600
MH-D5-20000	20,000	114 5/8	449	38' 8"	11' 1"	69,500

Note: – Height minus 4 inches = outside width.

TW BENCH → MH-D4-3000

MW20 BENCH → MH-D5-15000

HAZ CARBON SUBSTRATE

3000 GAL × 6.55#/gal
F = 19,671# ETHANOL
(@8.34#/gal = 25,020#)

15,000 GAL × 6.55#/gal
F = 98,355# ETHANOL
(@8.34#/gal = 125,100#)

- Proprietary design and insulating concrete provide fire protection exceeding the requirements of Uniform Fire Code Test Standard A-II-F-1* for Fire Protected Above Ground Storage Tanks.
- Specially engineered construction protects the insulated primary steel tank from ballistic impact in accordance with Section 77.203(d)(2) of the Uniform Fire Code.
- Outer steel tank is protected from the elements with a high performance industrial epoxy and urethane coating system.
- Integral supports provide 4" ground clearance and seismic anchoring capability.
- All fittings are steel pipe couplings (F.P.T.).
- The monitor tube allows physical monitoring of the outer steel secondary containment tank.
- Dispensing & Storage: Gasoline, Diesel, Ethanol, Methanol, Jet Fuels, Lube Oils
- Waste product storage: Oil, Solvents, Anti-freeze
- Optional fuel dispensing and waste oil equipment packages available
- Optional UL Listed spill containment system available.
- Optional access platform available.
- Meets requirements of NFPA 30 for above ground storage tanks.
- Electronic monitoring capability.
- Environmentally safe.
- No underground storage tank liability insurance required.
- Designed to withstand natural disasters including earthquakes and fires.
- Can be easily relocated.

GENERAL INFORMATION for *SUPERVAULT* MH SERIES MODEL D

* UFC Standard A-II-F-1 was formerly known as UFC Standard 79-7.

Specifications subject to change without notice.

modern custom fabrication

SUPERVAULT™ MH
MULTI-HAZARD RATED, PROTECTED TANK

DATE:	REVISION No.:	REVISION DATE:	DRAWING NUMBER
4/12/96	0	6/26/96	8.101

ARCADIS

SUBJECT: PG&E-TOPOCK, CA
MW20 & TW BENCH STORAGE TANK
JOB NO:

BY: MSL DATE: 4/16/12
CHKD: DATE:

PAGE C-5
SHEET 1

TW BENCH STORAGE TANK ~ (REFER TO SHT C-1 & C-4)

- 3000 GAL TANK ~ 3000 GAL × 6.557 #/GAL = F = 19,671 # ETHANOL
  OR × 8.34 #/GAL = F = 25,020 # WATER ← USE TO BE CONSERVATIVE
- TANK DEAD LOAD ~ 16,700 # (SHT C-4)
  ~ HAND-SKETCH ~ 82 5/8" D ≈ 6.885 FT
  - STEEL PL ~ $490\,pcf \times \frac{3/16''\,THICK}{12\,IN/FT} \times (\pi \times 7.885\,FT) \times \frac{130\,IN + 12\,IN}{12\,IN/FT}$
    = 2245 #
  - CONCRETE ~ $\left[90\,pcf \times \left(\frac{\pi \times 7.885\,FT^2}{4} - \frac{\pi \times 6.885\,FT^2}{4}\right) \times \frac{130\,IN}{12\,IN/FT}\right]$ (48.83 FT², 37.23 FT², 125.66 CF)
    $+ \left[\frac{6''}{12\,IN/FT} \times 2 \times \frac{\pi \times 7.885\,FT^2}{4} \times 90\,pcf\right]$ (48.83 FT², 48.83 CF)
    = 2245 # + 15,705 # = 17,949 #
  ~ TOTAL TANK DL = 17,949 # ≈ 16,700 # LISTED ON C-4 ← USE

- TOTAL TANK GRAVITY LOAD

$$DL + F = 16,700\# + 25,020\# = 41,720\#$$

$$\sim \left(\frac{6.885\,FT^2 \times \pi}{4}\right) \times \frac{130\,IN}{12\,IN/FT} \times 7.48\,\frac{FT^3}{GAL} = 3017\ GALLONS \approx 3000\ GALLON\ CAPACITY$$

(6.885 FT = ID OF CONCRETE TANK; 130 IN = CLEAR LENGTH OF CONCRETE TANK)

AGM Form 30 12-01

ARCADIS

SUBJECT: PG&E TOPOK
TW BENCH STORAGE TANK
JOB NO:

BY: MSL DATE: 6/19/14
CHKD: DATE:

PAGE C-5A
SHEET 1

WIND LOAD (CHAPTER 29 - ASCE 7-10)

- $q_z = 0.00256 K_z K_{zt} K_d V^2 = 32.8$ psf
  - K_z = 0.85 (EXP C<15ft) — TABLE 29.3-1
  - V = 115 mph (FIG 26.5-1A) ULTIMATE ~ ARIZONA SIDE (CONSERV)
  - K_d = 0.95 (ROUND TANK — TABLE 26.6-1)
  - K_{zt} = 1.2 (CONSERVATIVE — FIG 26.8-1)
- $F = q_z G C_f A_f = (32.8\,psf)(0.85)(0.7)(12'\text{-}4''\ \text{LONG} \times 8'\text{-}5''\ \text{TALL})$
  - G = 0.85 (SECT 26.9.1)
  - C_f: ($D\sqrt{q_z} = 48.2 > 2.5$, $h/d = 9'\text{-}5''/8'\text{-}5'' = 1.12$, ROUGH) = 0.7
  - = 1985# (1.0W)

SEISMIC LOAD (CHAPTER 15 ASCE 7-10 ~ SEISMIC DESIGN REQ'S FOR NON-BUILDING STRUCTURES)

- $I_e = 1.5$ (SECTION 15.4.1.1)
- $V = 0.30 S_{ds} W I_e$ (EQ 15.4-5 ~ SECTION 15.4.2)
  - $= (0.30)(0.245)(41{,}720\#)(1.5)$
  - = 4600# (1.0E)

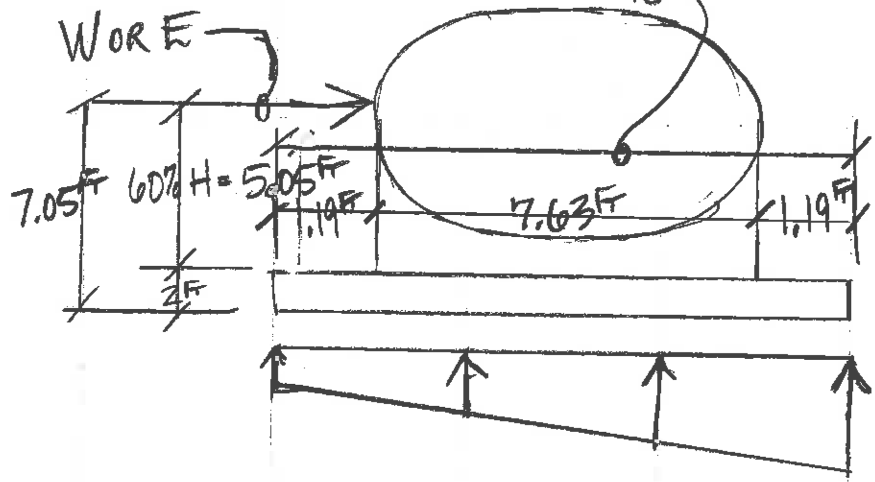
LOAD COMBINATIONS (ASCE 7-10 - SECTION 2.4.1 & 12.4.3.2)

- ARCADIS NOT RESPONSIBLE FOR TANK OR TANK ANCHORAGE DESIGN ($\Omega = 2.5$ REQ'D, SECTION 15.7.3)
- THEREFORE ARCADIS ONLY RESPONSIBLE FOR FOUNDATION $\Rightarrow \Omega = 1.0$
- LC#5 $D + 0.6W =$ 41,720# ↓ & 1191# →
- LC#5A $D + 0.7E = (1.0 + 0.14 S_{ds}) D + 0.7 \Omega Q_E$ = 43,151# ↓ & 3220# → (Ω = 1.0, Q_E = 1.0E)
- LC#7 $0.6D + 0.6W$ = 10,020# ↓ & 1191# → (16,700)
- ~~LC#8 $0.6D + 0.7E = (0.6 - 0.14 S_{ds}) D + 0.7 \Omega Q_E$ = 23,601# ↓ & 3220#~~ (0.566; Ω = 1.0, Q_E = 1.0E)

D INCLUDES FLUID (TANK FULL) WEIGHT

SEISMIC IN SHORT DIRECTION (8'-0" DIRECTION)

- O/O SADDLE APPROX = 82 5/8" + (4 1/2" × 2) = 7.63 FT
- O/O PAD IN SHORT DIRECTION = 10 FT



~ ASSUME 3 FT OF SLAB DISTRIBUTION EACH SIDE OF BOTH SADDLES

- MAX/MIN BEARING PRESSURE ~ LC#5A & LC#8
  - OVERTURNING MOMENT$_{UNF}$ = (3220#)(7.05 FT) = 22.70 K·FT
  - RESISTING MOMENT$_{UNF}$ = [(43151#)(5 FT)] + [3 FT × 2 SLABS × 2 SADDLES × 10 FT WIDE × 15…
    36 K DL × 2 FT THICK × 10 FT / 2 ARM

    LC#5A = 215.76 K + 180 K·FT = 395.8 K·FT >> ✓OK

    LC#8 = 219.8 K·FT >>

- q_{UNF} = P/A +/- My/I = 0.66 KSF +/- 0.114 KSF → 0.774 KSF OR 0.546 KSF (LC#5A)

  0.367 KSF +/- 0.114 KSF → 0.48 KSF OR 0.253 KSF (LC#8)

  ~ LC#5A → ΣP = 79.15 K, A = 3 FT × 2 × 2 × 10 = 120 FT², y = 5 FT, I = bh³/12 = 1000 FT⁴ (12 FT, 10 FT)

  ~ LC#8A → ΣP = 43.98 K, [A, y, I & M SAME) ; ΣM$_{ℓ}$ = 22.7 K·FT

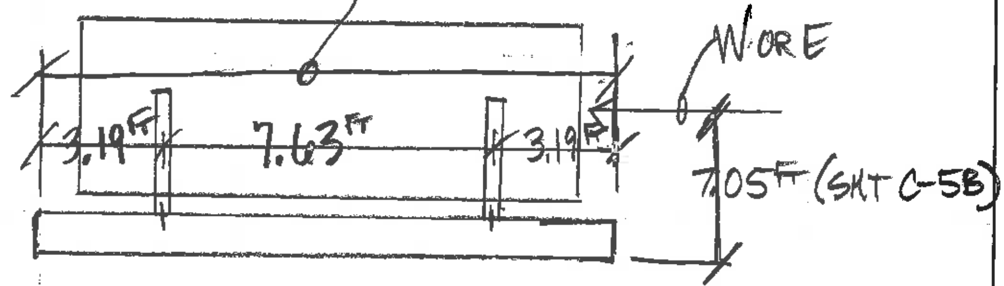
  << 1500 psf NET ALLOW ✓OK

~ BY INSPECTION LC#5 & #7 DO NOT CONTROL

- SLIDING RESISTANCE = LC#8A = (0.25 × 43.98 K) = 11 K >> 3.22 K ✓OK
  (μ = 0.25)

SEISMIC IN LONG DIRECTION (7.6FT C/C SADDLES IN LONG DIR)

- O/O PAD IN LONG DIR = 14FT



- ASSUME LOAD DISTRIBUTION INTO ALL 10FT OF PAD WIDTH
- MAX/MIN PRESSURE ~ LC#5A & 8
  - OVERTURNING MOMENT$_{UNF}$ = 22.7 KIFT (SHT C-5B)
  - RESISTING MOMENT$_{UNF}$ = $(43151^{\#} \times \frac{14FT}{2}) + (36^{K}_{PAD\,DL} \times \frac{14FT}{2})$ = 554.0 KIFT LC#5A MAX

    LC#8 MIN = 307.8 KIFT √OK

- $q_{UNF} = P/A + My/I$ = 0.565 KSF +/- 0.069 KSF → 0.634 KSF OR 0.496 KSF (LC#5A)

  0.314 KSF +/- 0.069 KSF → 0.383 KSF OR 0.245 KSF (LC#8)

  ~LC#5A → ΣP = 79.15K (SHT C-5C), A = 14FT × 10FT = 140SF, $y = \frac{14FT}{2} = 7FT$

  $I = bh^3/12 = 2287\ FT^4$

  ~LC#8 → ΣP = 43.98K (SHT C-5C), A, y, I SAME

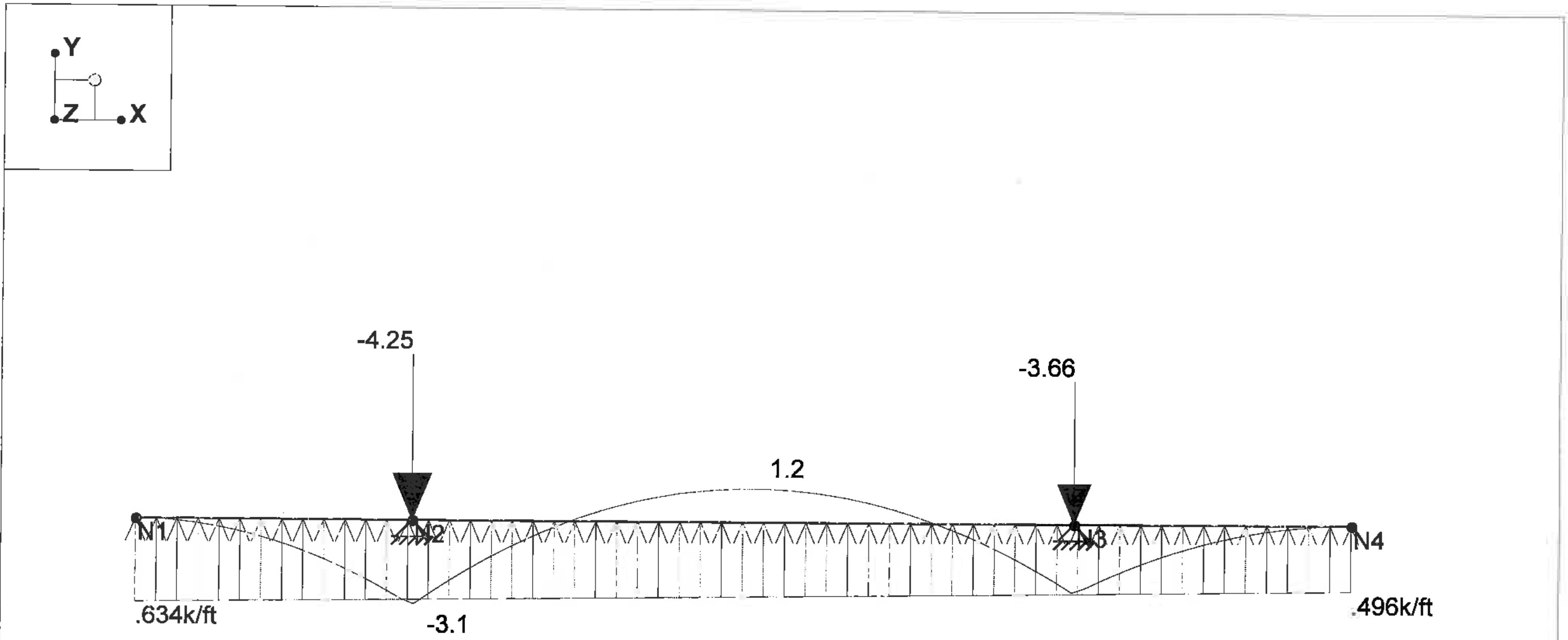
→ BY INSPECTION LC#5 & 7 (WIND) DOES NOT CONTROL

V_{UNF} = 2.3K (3.68K ACI) < 5.79K 2' SLAB DESIGN (ON SHT C-9) √OK

& M_{UNF} = 3.1 KIFT (4.96 KIFT ACI) ← SEE RISA-2D DESIGN ON SHT C-5D

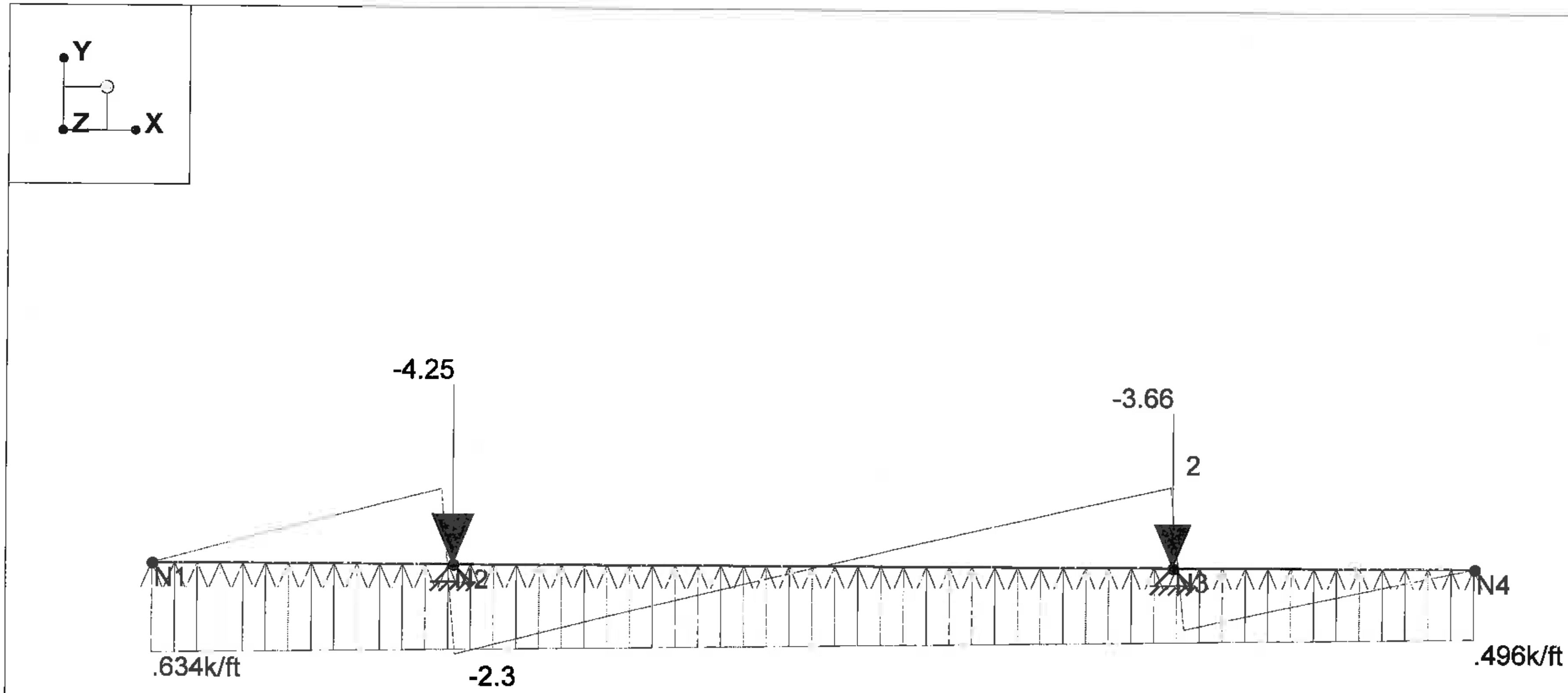
< 8.67 KIFT ACI FOR 2'-0" SLAB W/ #5@12" C/C EF/EW (ON SHT C-9) √OK

C-5D



Loads: LC 1, unf
Results for LC 1, unf
Member Bending Moments (k-ft)
Y-direction Reaction units are k and k-ft

ARCADIS	RG&E - Topok, CA - TW Bench	SK - 1
Matt Lotycz		June 19, 2014 at 2:58 PM
3000 Gal Storage Tank		3000 gal TW Bench Tank.r2d



Loads: LC 1, unf
Results for LC 1, unf
Member Shear Forces (k)
Y-direction Reaction units are k and k-ft

ARCADIS	RG&E - Topok, CA - TW Bench	SK - 2
Matt Lotycz		June 19, 2014 at 3:00 PM
3000 Gal Storage Tank		3000 gal TW Bench Tank.r2d

Joint Coordinates and Temperatures

	Label	X [ft]	Y [ft]	Temp [F]
1	N1	0	0	0
2	N2	3.185	0	0
3	N3	10.815	0	0
4	N4	14	0	0

Member Primary Data

	Label	I Joint	J Joint	Rotate(deg)	Section/Shape	Type	Design List	Material	Design Rules
1	M1	N1	N4		HR1A	Beam	Wide Flange	A36 Gr.36	Typical

Joint Boundary Conditions

	Joint Label	X [k/in]	Y [k/in]	Rotation[k-ft/rad]	Footing
1	N2	Reaction	Reaction		
2	N3	Reaction	Reaction		

Member Distributed Loads (BLC 1 : unf)

	Member Label	Direction	Start Magnitude[k/ft,deg]	End Magnitude[k/ft,deg]	Start Location[f...	End Location[ft...
1	M1	Y	.634	.496	0	%100

Basic Load Cases

	BLC Description	Category	X Gravity	Y Gravity	Joint	Point	Distributed
1	unf	None					1

Load Combinations

	Description	Sol...	PD...	SR...	BLC	Fact...	BLC	Fact...	BLC	Fact...	BLC	Fact...	BLC	Fact...	BLC	Fact...	BLC	Fact...	BLC	Fact...
1	unf	Yes			1	1														

Joint Reactions

	LC	Joint Label	X [k]	Y [k]	MZ [k-ft]
1	1	N2	0	-4.25	0
2	1	N3	0	-3.66	0
3	1	Totals:	0	-7.91	
4	1	COG (ft):	X: 6.715	Y: 0	

Member Section Forces

	LC	Member Label	Sec	Axial[k]	Shear[k]	Moment[k-ft]
1	1	M1	1	0	0	0
2			2	0	-2.092	-2.474
3			3	0	-.054	1.246
4			4	0	1.863	-1.956
5			5	0	0	0

Member Section Stresses

	LC	Member Label	Sec	Axial[ksi]	Shear[ksi]	Top Bending[ksi]	Bot Bending[ksi]
1	1	M1	1	0	0	0	0
2			2	0	-1.56	3.803	-3.803

Member Section Stresses (Continued)

	LC	Member Label	Sec	Axial[ksi]	Shear[ksi]	Top Bending[ksi]	Bot Bending[ksi]
3			3	0	-.04	-1.915	1.915
4			4	0	1.389	3.006	-3.006
5			5	0	0	0	0

ARCADIS

SUBJECT: PG&E – TOPOCK, CA
TW BENCH STORAGE TANK

JOB NO:

BY: MSL DATE: 4/19/12
CHKD: DATE:

PAGE C-6
SHEET 1

TW BENCH STORAGE TANK ~ FOUNDATION DESIGN

- ASSUME NET ALLOWABLE BEARING PRESSURE = 1500 psf (MINIMUM PER CODE WHEN NO SOIL INFORMATION AVAILABLE)
- TOTAL LOAD = 41,720#

$$\frac{41{,}720\#}{1500\,psf - 75\,psf} \leftarrow 6'' \text{ CONC SLAB ABOVE EX. GRADE}$$

= 29.28 SQ FT

→ USE 14'-0" LONG × 10'-0" WIDE (11½ IN EACH SIDE OF 12'-4" LONG TANK) × (12⅝" EACH SIDE OF 7'-11" WIDE)

130" CLEAR + 6" + 6" = 11'-10"

82⅝" CLEAR + 6" + 6" = 7.885 FT

→ = 140 SF ≈ 298 psf BEARING PRESSURE OK

→ TOO CONSERVATIVE TO ASSUME TANK SADDLE LEGS BEAR ON ENTIRE CONCRETE PAD AREA, LOOK AT ½ TANK LOAD ON 4 FT WIDE (2 FT EACH SIDE OF SADDLE ℄ × 7.885 FT SADDLE LENGTH

∴ (41,720#/2)/(4 FT WIDE × 7.885 FT) = 661 psf < 1200 psf ✓OK

↑ 2'-0" THICK PAD @ THIS LOCATION [1500 psf ALLOW − (2' × 150 pcf) SLAB DL]

ARCADIS

SUBJECT: PG&E – TOPOCK, CA
MW-20 & TW BENCH STORAGE TANK
JOB NO:

BY: MSL DATE: 4/16/12
CHKD: MSL DATE: 6/18/14

PAGE C-7
SHEET 1

IRZ CARBON SUBSTRATE

MW-20 BENCH STORAGE TANK ~ (REFER TO SHT C-1 & C-4)

- 15,000 GAL TANK ~ 15,000 GAL × 6.557 #/GAL = F = 98,355 # ETHANOL
  OR × 8.34 #/GAL = F = 125,100 # WATER
  (USE TO BE CONSERVATIVE)
- TANK DEAD LOAD ~ 55,600 # (SHT C-4)
  ~ HAND-SKETCH ~ 114 5/8" OD ≈ 9.552 FT
  - STEEL PL ~ 490 pcf × $\frac{3/16" \text{ THICK}}{12 \text{ IN/FT}}$ × (π × 10.552 FT) × $\frac{338 \text{ IN}}{12 \text{ IN/FT}}$ = 7,149 #
  - CONCRETE ~ $\left[90 \text{ pcf} \times \left(\frac{\pi \times 10.552 \text{ FT}^2}{4} - \frac{\pi \times 9.552 \text{ FT}^2}{4}\right) \times \frac{338 \text{ IN}}{12 \text{ IN/FT}}\right]$ (87.45, 71.66 FT², 40.027K)
    + $\left[\frac{6"}{12 \text{ IN/FT}} \times 2 \times \frac{\pi \times 10.552 \text{ FT}^2}{4} \times 90 \text{ pcf}\right]$ (87.45, 7.871K)
    = 7,149 # + 47,898 # = 55,047 #
  ~ TOTAL TANK DL = 55,047 # ≈ 55,600 # LISTED ON C-4 (USE)

- TOTAL TANK GRAVITY LOAD

DL + F = 55,600 # + 125,100 # = 180,700 #

ID OF CONCRETE TANK

~ $\left(\frac{9.552 \text{ FT}^2 \times \pi}{4}\right) \times \frac{338 \text{ IN}}{12 \text{ IN/FT}} \times 7.48 \frac{\text{FT}^3}{\text{GAL}}$ = 15,098 GAL ≈ 15,000 GALLON CAPACITY

ARCADIS

SUBJECT: PG&E – TOPOCK, CA
MW-20 BENCH STORAGE TANK

JOB NO:

BY: MSL DATE: 4/19/12
CHKD: MSL DATE: 6/18/14

PAGE C-8
SHEET 1

MW-20 BENCH STORAGE TANK ~ FOUNDATION DESIGN

(IRZ CARBON SUBSTRATE)

- ASSUME NET ALLOWABLE BEARING PRESSURE = 1500 psf (MINIMUM PER CODE WHEN NO SOIL INFORMATION AVAILABLE)
- TOTAL LOAD = 180,700#

1500 psf – 75 psf ← 6" CONC SLAB ABOVE EX. GRADE

= 126.81 SQ FT

→ USE 31'-6" LONG × 12'-6" WIDE (12½ IN CLEAR EACH SIDE OF 29'-5" LONG TANK) × (11½ IN CLEAR EACH SIDE OF 10'-7" WIDE)

28'-2" + 6" + 6" = 29'-2"

114 5/8" + 6" + 6" = 10.55 FT

→ = 394 SF ≈ 459 psf BEARING PRESSURE OK

→ TOO CONSERVATIVE TO ASSUME TANK SADDLE LEGS BEAR ON ENTIRE CONCRETE PAD AREA, LOOK AT ½ TANK LOAD ON 4 FT WIDE (2 FT EACH SIDE OF SADDLE ℄ × 10.552 FT SADDLE LENGTH

∴ (180,700#/2)/(4 FT WIDE × 10.55 FT) = 2140 psf > 1425 psf NO GOOD

~ TRY 6 FT WIDTH × (10.55 FT SADDLE LENGTH + 1 FT SLAB EACH END) 12 FT

∴ (180,700#/2)/(6 FT WIDE × 12.5 FT) = 1205 psf ≈ 1200 psf ✓ OK
℄ (3 FT EACH SIDE)

• 2'-0" THICK PAD @ THIS LOCATION

[1500 psf ALLOW – (2' × 150 pcf) SLAB DL]

AGM Form 30 12-01

ARCADIS

SUBJECT: PG&E TOPOK
1RZ CARBON STORAGE TANK
JOB NO:

BY: MSL DATE: 6/19/14
CHKD: DATE:

PAGE C-8A
SHEET 1

WIND LOAD (CHAPTER 29 – ASCE 7-10)

• $q_z = 0.00256 K_z K_{zt} K_d V^2 = 32.8\,psf$
- K_z: 0.85 (EXP C < 15 FT) – TABLE 29.3-1
- V: 115 mph (FIG 26.5-1A) ULTIMATE ~ ARIZONA SIDE (CONSERV)
- K_d: 0.95 (ROUND TANK – TABLE 26.6-1)
- K_{zt}: 1.2 (CONSERVATIVE – FIG 26.8-1)

• $F = q_z G C_f A_f = (32.8\,psf)(0.85)(0.7)(29'5''\ LONG \times 10.55'\ TALL)$
- G: 0.85 (SECT 26.9.1)
- C_f: ($D\sqrt{q_z} = 48.2 > 2.5$, $h/d = 9'5''/8'5'' = 1.12$, ROUGH) = 0.7

$= 6057\#\ (1.0W)$

SEISMIC LOAD (CHAPTER 15 ASCE 7-10 ~ SEISMIC DESIGN REQ'S FOR NON-BUILDING STRUCTURES)

• $I_e = 1.5$ (SECTION 15.4.1.1)

• $V = 0.30 S_{ds} W I_e$ (EQ 15.4-5 ~ SECTION 15.4.2)

$= (0.30)(0.245)(180{,}700\#)(1.5)$

$= 19{,}922\#\ (1.0E)$

LOAD COMBINATIONS (ASCE 7-10 – SECTION 2.4.1 & 12.4.3.2)

$\Omega = 2.5$ REQ'D (SECTION 15.7.3)

• ARCADIS NOT RESPONSIBLE FOR TANK OR TANK ANCHORAGE DESIGN

• THEREFORE ARCADIS ONLY RESPONSIBLE FOR FOUNDATION ⟹ $\Omega = 1.0$

• LC#5 $D + 0.6W = 180{,}700\#\downarrow$ & $3634\#\rightarrow$

• LC#5A $D + 0.7E = (1.0 + 0.14 S_{ds})D + 0.7\,\Omega Q_E = 186{,}898\#\downarrow$ & $13{,}945\#\rightarrow$ [$(1.0+0.14S_{ds}) = 1.034$; $\Omega = 1.0$; $Q_E = 1.0E$]

• LC#7 $0.6D + 0.6W = 33{,}360\#\downarrow$ & $3634\#\rightarrow$ [$0.6D$ = 55,600#]

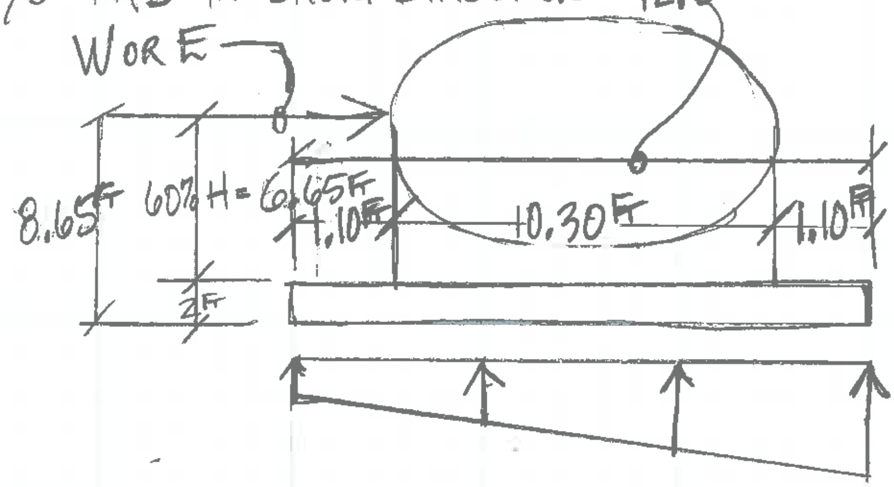
• LC#8 $0.6D + 0.7E = (0.6 - 0.14 S_{ds})D + 0.7\,\Omega Q_E = 102{,}222\#\downarrow$ & $13{,}945\#$ [$(0.6-0.14S_{ds}) = 0.566$; $\Omega = 1.0$; $Q_E = 1.0E$]

D INCLUDES FLUID (TANK FULL) WEIGHT

AGM Form 30-12-01

SEISMIC IN SHORT DIRECTION (10.3 FT DIRECTION)

- O/O SADDLE → APPROX = 114 5/8" + (4½" × 2) = 10.30 FT
- O/O PAD IN SHORT DIRECTION = 12.5 FT



~ ASSUME 3 FT OF SLAB DISTRIBUTION EACH SIDE OF BOTH SADDLES

- MAX/MIN BEARING PRESSURE ~ LC#5A & LC#8
  - OVERTURNING MOMENT (UNF) = (13,945#)(8.65 FT) = 120.62 K·FT
  - RESISTING MOMENT = [(186,898#)(12.5 FT / 2)] + [3 FT × 2 SIDES × 2 SADDLES × 12.5 FT × 150 pcf × 2 FT THICK × 12.5 FT / 2 ARM] (45K DL, WIDE)

  LC#5A = 1168.1 K·FT + 281.25 K·FT = 1449.4 K·FT >> ✓OK

  LC#8 = 798.4 K·FT >>

- $q = P/A \pm My/I$ = 1.545 KSF ± 0.772 KSF → 2.32 KSF OR 0.77 KSF (LC#5A) (NO GOOD)

  0.852 KSF ± 0.772 KSF → 1.62 KSF OR 0.08 KSF (LC#8) (NO GOOD)

  ~ LC#5A → ΣP = 231.9K, A = 3 FT × 2 × 2 × 12.5 FT = 150 FT², y = 6.25 FT, $I = \frac{bh^3}{12}$ = 976 FT⁴

  ΣM℄ = 120.6 K·FT

  ~ LC#8A → ΣP = 127.75K, [A, y, I & M SAME)

  << 1500 psf NET ALLOW ✓OK

~ BY INSPECTION LC#5 & #7 DO NOT CONTROL

TRY 4^{FT} EACH SIDE OF SADDLE

- LC#5A ~ $\Sigma P = 246.9^K$, $A = 200\,SF$, $y = 6.25^{IN}$, $I = 1302.1\,FT^4$
  $\circlearrowright \Sigma M_{\mathbb{C}} = 120.62^{KIFT}$
  - $q = P/A +/- My/I = 1.235\,KSF \pm 0.579\,KSF \rightarrow 1.814\,KSF$ OR $0.656\,KSF$
    ↳ > 1500psf NO GOOD

TRY 4.25^{FT} EACH SIDE OF SADDLE

- LC#5A ~ $\Sigma P = 250.6^K$, $A = 4.25^{FT} \times 2 \times 2 \times 12.5' = 212.5\,SF$, $y = 6.25\,FT$
  $I = 1383.5\,FT^4$, $\circlearrowright \Sigma M_{\mathbb{C}} = 120.62^{KIFT}$
  - $q = P/A +/- My/I = 1.179\,KSF +/- 0.545 \rightarrow 1.72\,KSF$ & $0.634\,KSF$
    ↳ > 1.5KSF NO GOOD

TRY 4.25FT EACH SIDE × 12'-8" LONG

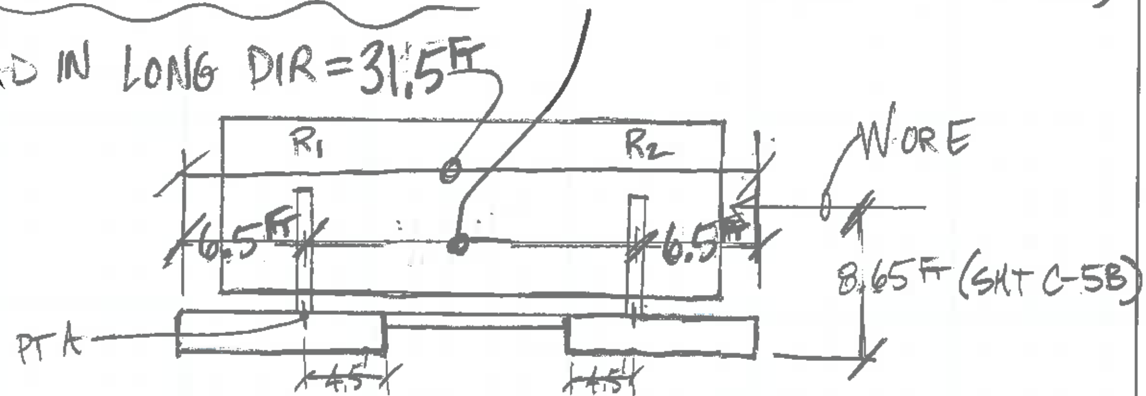
- LC#5A ~ $\Sigma P = 251.5^K$, $A = 215.3^{FT^4}$, $y = 6.33\,FT$
  $I = 1439.6\,FT^4$, $\circlearrowright \Sigma M_{\mathbb{C}} = 120.62^{KIFT}$
  - $q = P/A +/- My/I = 1.168\,KSF +/- 0.531\,KSF$

TRY 4.5^{FT} ~~EACH SIDE~~ × 12'-8" LONG

- LC#5A - $\Sigma P = 255.3^K$, $A = 228\,SF$, $y = 6.33\,FT$, $I = 1524.3\,FT^4$
  - $q = 1.12\,KSF +/- 0.50\,KSF \rightarrow 1.62\,KSF$ OR $0.62\,KSF$
    ↳ < 1500psf NET ALLOW + ($1.5^{FT} \times 110\,pcf$) OVERBURDEN
    = 1.67KSF GROSS ✓OK

SEISMIC IN LONG DIRECTION (18.5FT c/c SADDLES IN LONG DIR)

- O/O PAD IN LONG DIR = 31.5FT



- ASSUME LOAD DISTRIBUTION INTO ALL 10FT OF PAD WIDTH
- MAX/MIN PRESSURE ~ LC#5A & 8
  - OVERTURNING MOMENT = 120.6 KIF (SHT C-8B)
  - RESISTING MOMENT = (186,898#/2)(18.5FT/2) = 1728.8 KIF >> ✓OK
    SLAB DL IGNORED
    LC#8 MIN = 945.6 KIF ✓OK
- $q = P/A + My/I$ = 1.177 KSF +/- LC#5A ← TAKES INTO ACCOUNT INCREASED FTG PRESSURE DUE TO LATERAL LOAD
  <1500 psf ✓OK ✓OK
  0.391 KSF +/- LC#8 MIN
  ~ LC#5A → ΣP = 134.17K (SHT C-5C), A = 9FT × 12.67FT = 114 SF, y = 9F/2 = 4.5F
  ↑ 4.5FT × 2 ← CONSERV HAVE 6'-6" ON 1 SIDE
  $I = bh^3/12 = 769.5$ F4 (12.67#, 9FT)
  ~ LC#8 → ΣP =   K (SHT C-5C), A, y, I SAME

→ BY INSPECTION LC#5 & 7 (WIND) DOES NOT CONTROL

- ↺ ΣM_PTA = 0, LC#5A; −(186,898# × 18.5F/2) + 120.6 KIF + (R2↑ × 18.5F) = 0
  R2 = 86.93K GRAVITY DOWN
  R1 = 186.898K TOTAL − R2 ⇒ R1 = 99.97K GRAVITY DOWN
- ↺ ΣM_PTA = 0, LC#8; R2 = 44.59K GRAVITY DOWN & R1 = 57.63K GRAVITY DOWN

SLAB-ON-GRADE FOUNDATION DESIGN

- REF SHT C-10 FOR WORST CASE IRZ CARBON SUBSTRATE LOADING
  - → GROSS BEARING PRESSURE = 1505 psf ≈ 1500 psf NET ALLOWABLE PER CODE
  - → $V_{MAX\,UNF} = 3.61^K$
  - → $M_{MAX\,UNF} = 5.42^{K\text{-}FT}$

(SAME AS SHT C-10 IF USE 3^{FT} EACH SIDE)
(UPDATED 6/20/14 4.5^{FT} EACH SIDE OF SADDLE)

- IF ANALYZED AS CANTILEVER SUPPORT w/ 4.5^{FT} SPAN (C/C) EACH SIDE OF SUPPORT w/ 1320 psf NET UNF LOADING (1.62 ksf – 0.3 ksf SLAB DL)
  - $V_{UNF} = wl = (1320\ psf_{NET})(4.5\ FT) = 5.94^K,\ (\times 1.6_{ACI}) = 9.50^K_{ACI}$
  - $M_{UNF} = \frac{wl^2}{2} = \frac{(1320\ psf_{NET})(4.5\ FT)^2}{2} = 13.37^{K\text{-}FT},\ (\times 1.6_{ACI}) = 21.38^{K\text{-}FT}_{ACI}$

~ USE 2^{FT} THICK PAD

- $d = 24'' - 3''_{COVER} - 8/16'' = 20.5''$ (WORST CASE BOTTOM)
- $\phi V_c = 2\phi\sqrt{f'_c}\,bd = 2(0.75)\sqrt{4000}(12)(20.5'') = 23.3^K >> V_{ACI}$ ✓OK
- $R = M_u/\phi bd^2 = 56.53 \rightarrow \rho = 0.0010 \rightarrow A_{S\,REQ'D} = 4/3\rho bd$ (M_u = 8.67 K-FT ACI)
- $A_{S\,REQ'D} = 0.31\ IN^2/FT$
  - ~ USE #5 @ 12" C/C ($A_S = 0.31\ IN^2/FT$) >
- ACI 318 T&S REQ'S $= \frac{0.0018bh}{2\ FACES} = 0.26\ IN^2/FT$

BEAM ON ELASTIC FOUNDATION ANALYSIS

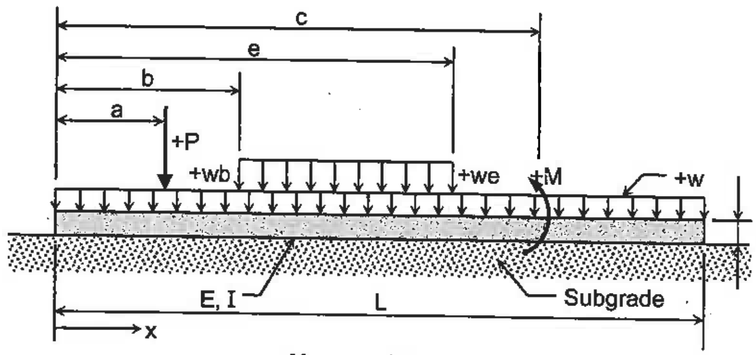
For Soil Supported Beam, Combined Footing, Slab Strip or Mat Strip of Assumed Finite Length with Both Ends Free

Job Name:	RG&E - Topok, CA - TW-20 & IRZ Storage Ta	Subject:	Slab-on-Grade		
Job Number:	RC000753.0008	Originator:	MSL	Checker:	

Input Data:

Beam Data:

Length, L =	6.0000	ft.
Width, B =	1.0000	ft.
Thickness, T =	24.0000	ft.
Modulus, E =	3600	ksi
Subgrade, K =	100	pci



Beam Loadings:

Full Uniform:

w = 0.3000 kips/ft.

Distributed:

	Start: b (ft.)	Wb (kips/ft.)	End: e (ft.)	We (kips/ft.)
#1:				
#2:				
#3:				
#4:				
#5:				
#6:				

Point Loads:

	a (ft.)	P (kips)
#1:	3.0000	7.23
#2:		
#3:		
#4:		
#5:		
#6:		
#7:		
#8:		
#9:		
#10:		
#11:		
#12:		

Moments:

	c (ft.)	M (ft-kips)
#1:		
#2:		
#3:		
#4:		

Nomenclature

Results:

Beam Flexiblity Criteria:

for β*L <= π/4	beam is rigid
for π/4 < β*L < π	beam is semi-rigid
for β*L >= π	beam is flexible
for β*L >= 6	beam is semi-infinite long

Inertia, I =	####### ft.^4	I = B*T^3/12
β =	0.016	β = ((K*B)/(4*E*I))^(1/4)
β*L =	0.098	β*L = Flexibility Factor

Beam is rigid

Max. Shears and Locations:

+V(max) =	3.61 k	@ x =	3.00 ft.
-V(max) =	-3.61 k	@ x =	3.00 ft.

Max. Moments and Locations:

+M(max) =	5.42 ft-k	@ x =	3.00 ft.
-M(max) =	0.00 ft-k	@ x =	0.00 ft.

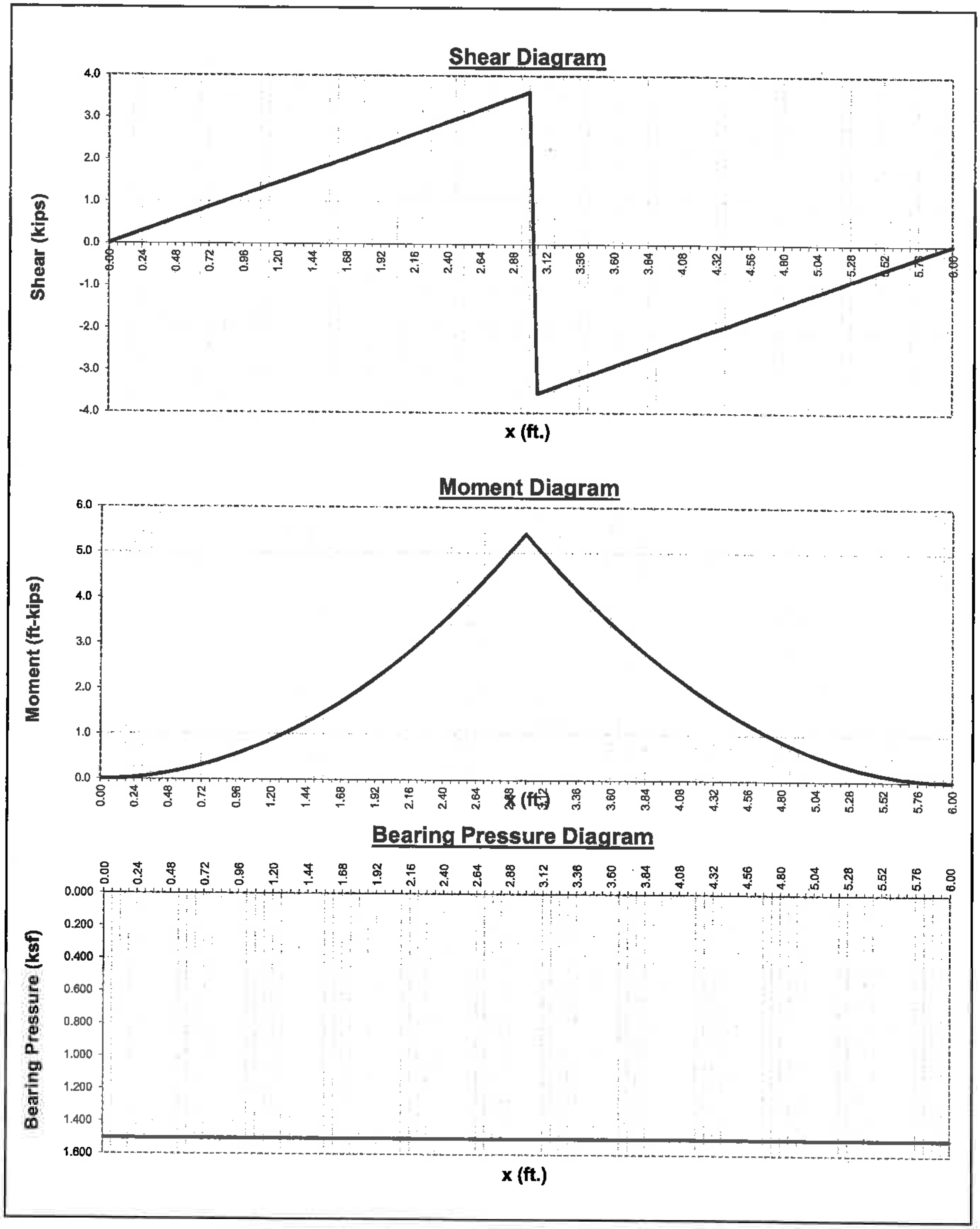
Max. Deflection and Location:

Δ(max) = -0.104 in. @ x = 0.00 ft.

Max. Soil Pressure and Location:

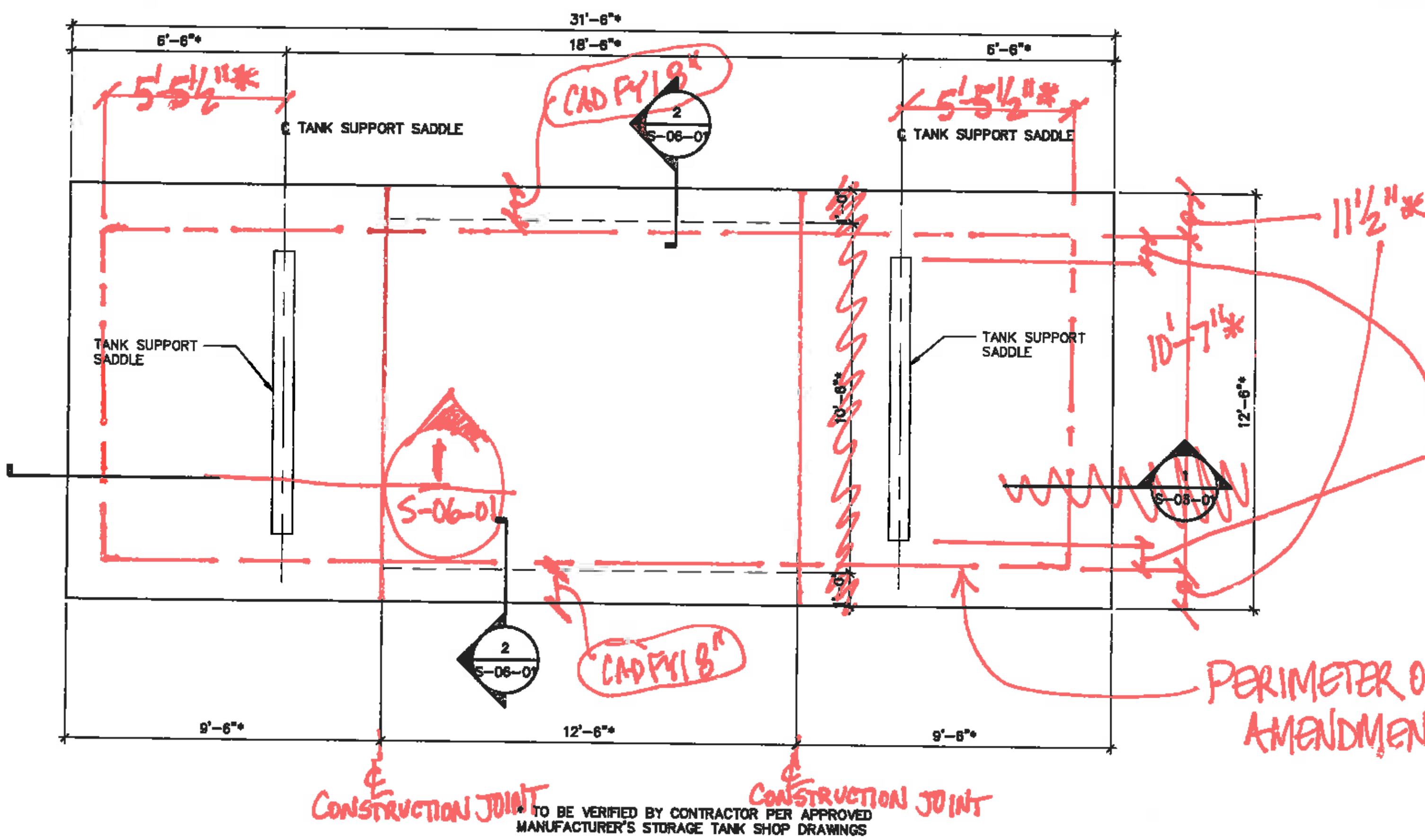
Q(max) = 1.505 ksf @ x = 0.00 ft.

Comments:


Shear Diagram
Shear (kips)
x (ft.)
Moment Diagram
Moment (ft-kips)
x (ft.)
Bearing Pressure Diagram
Bearing Pressure (ksf)
x (ft.)

Tabulation of Beam Shear, Moment, Deflection, and Bearing Pressure for 100 Equal Segments					
Point #	x (ft.)	Shear (k)	Moment (ft-k)	Deflection (in.)	Bearing Pressure (ksf)
1	0.0000	0.00	0.00	-0.1045	1.505
2	0.0600	0.07	0.00	-0.1045	1.505
3	0.1200	0.14	0.01	-0.1045	1.505
4	0.1800	0.22	0.02	-0.1045	1.505
5	0.2400	0.29	0.03	-0.1045	1.505
6	0.3000	0.36	0.05	-0.1045	1.505
7	0.3600	0.43	0.08	-0.1045	1.505
8	0.4200	0.51	0.11	-0.1045	1.505
9	0.4800	0.58	0.14	-0.1045	1.505
10	0.5400	0.65	0.18	-0.1045	1.505
11	0.6000	0.72	0.22	-0.1045	1.505
12	0.6600	0.80	0.26	-0.1045	1.505
13	0.7200	0.87	0.31	-0.1045	1.505
14	0.7800	0.94	0.37	-0.1045	1.505
15	0.8400	1.01	0.43	-0.1045	1.505
16	0.9000	1.08	0.49	-0.1045	1.505
17	0.9600	1.16	0.56	-0.1045	1.505
18	1.0200	1.23	0.63	-0.1045	1.505
19	1.0800	1.30	0.70	-0.1045	1.505
20	1.1400	1.37	0.78	-0.1045	1.505
21	1.2000	1.45	0.87	-0.1045	1.505
22	1.2600	1.52	0.96	-0.1045	1.505
23	1.3200	1.59	1.05	-0.1045	1.505
24	1.3800	1.66	1.15	-0.1045	1.505
25	1.4400	1.73	1.25	-0.1045	1.505
26	1.5000	1.81	1.36	-0.1045	1.505
27	1.5600	1.88	1.47	-0.1045	1.505
28	1.6200	1.95	1.58	-0.1045	1.505
29	1.6800	2.02	1.70	-0.1045	1.505
30	1.7400	2.10	1.82	-0.1045	1.505
31	1.8000	2.17	1.95	-0.1045	1.505
32	1.8600	2.24	2.08	-0.1045	1.505
33	1.9200	2.31	2.22	-0.1045	1.505
34	1.9800	2.39	2.36	-0.1045	1.505
35	2.0400	2.46	2.51	-0.1045	1.505
36	2.1000	2.53	2.66	-0.1045	1.505
37	2.1600	2.60	2.81	-0.1045	1.505
38	2.2200	2.67	2.97	-0.1045	1.505
39	2.2800	2.75	3.13	-0.1045	1.505
40	2.3400	2.82	3.30	-0.1045	1.505
41	2.4000	2.89	3.47	-0.1045	1.505
42	2.4600	2.96	3.65	-0.1045	1.505
43	2.5200	3.04	3.83	-0.1045	1.505
44	2.5800	3.11	4.01	-0.1045	1.505
45	2.6400	3.18	4.20	-0.1045	1.505
46	2.7000	3.25	4.39	-0.1045	1.505
47	2.7600	3.32	4.59	-0.1045	1.505
48	2.8200	3.40	4.79	-0.1045	1.505
49	2.8800	3.47	5.00	-0.1045	1.505
50	2.9400	3.54	5.21	-0.1045	1.505
51	3.0000	3.61	5.42	-0.1045	1.505
52	3.0600	-3.54	5.21	-0.1045	1.505

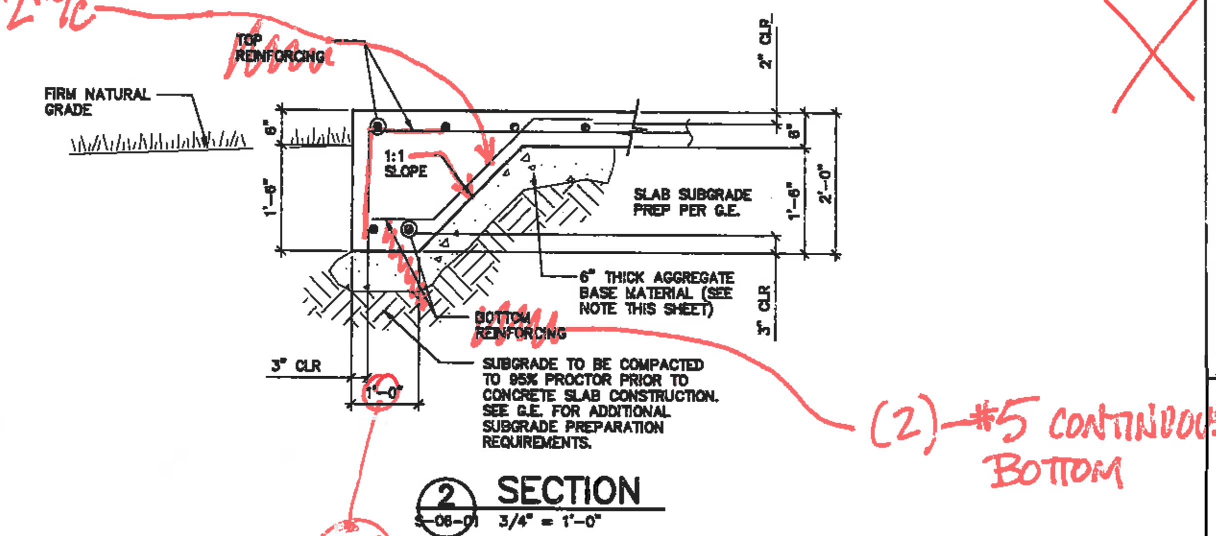
53	3.1200	-3.47	5.00	-0.1045	1.505
54	3.1800	-3.40	4.79	-0.1045	1.505
55	3.2400	-3.32	4.59	-0.1045	1.505
56	3.3000	-3.25	4.39	-0.1045	1.505
57	3.3600	-3.18	4.20	-0.1045	1.505
58	3.4200	-3.11	4.01	-0.1045	1.505
59	3.4800	-3.04	3.83	-0.1045	1.505
60	3.5400	-2.96	3.65	-0.1045	1.505
61	3.6000	-2.89	3.47	-0.1045	1.505
62	3.6600	-2.82	3.30	-0.1045	1.505
63	3.7200	-2.75	3.13	-0.1045	1.505
64	3.7800	-2.67	2.97	-0.1045	1.505
65	3.8400	-2.60	2.81	-0.1045	1.505
66	3.9000	-2.53	2.66	-0.1045	1.505
67	3.9600	-2.46	2.51	-0.1045	1.505
68	4.0200	-2.39	2.36	-0.1045	1.505
69	4.0800	-2.31	2.22	-0.1045	1.505
70	4.1400	-2.24	2.08	-0.1045	1.505
71	4.2000	-2.17	1.95	-0.1045	1.505
72	4.2600	-2.10	1.82	-0.1045	1.505
73	4.3200	-2.02	1.70	-0.1045	1.505
74	4.3800	-1.95	1.58	-0.1045	1.505
75	4.4400	-1.88	1.47	-0.1045	1.505
76	4.5000	-1.81	1.36	-0.1045	1.505
77	4.5600	-1.73	1.25	-0.1045	1.505
78	4.6200	-1.66	1.15	-0.1045	1.505
79	4.6800	-1.59	1.05	-0.1045	1.505
80	4.7400	-1.52	0.96	-0.1045	1.505
81	4.8000	-1.45	0.87	-0.1045	1.505
82	4.8600	-1.37	0.78	-0.1045	1.505
83	4.9200	-1.30	0.70	-0.1045	1.505
84	4.9800	-1.23	0.63	-0.1045	1.505
85	5.0400	-1.16	0.56	-0.1045	1.505
86	5.1000	-1.08	0.49	-0.1045	1.505
87	5.1600	-1.01	0.43	-0.1045	1.505
88	5.2200	-0.94	0.37	-0.1045	1.505
89	5.2800	-0.87	0.31	-0.1045	1.505
90	5.3400	-0.80	0.26	-0.1045	1.505
91	5.4000	-0.72	0.22	-0.1045	1.505
92	5.4600	-0.65	0.18	-0.1045	1.505
93	5.5200	-0.58	0.14	-0.1045	1.505
94	5.5800	-0.51	0.11	-0.1045	1.505
95	5.6400	-0.43	0.08	-0.1045	1.505
96	5.7000	-0.36	0.05	-0.1045	1.505
97	5.7600	-0.29	0.03	-0.1045	1.505
98	5.8200	-0.22	0.02	-0.1045	1.505
99	5.8800	-0.14	0.01	-0.1045	1.505
100	5.9400	-0.07	0.00	-0.1045	1.505
101	6.0000	0.00	0.00	-0.1045	1.505



* TO BE VERIFIED BY CONTRACTOR PER APPROVED MANUFACTURER'S STORAGE TANK SHOP DRAWINGS

IRZ CARBON SUBSTRATE STORAGE TANK: FOUNDATION PLAN

3/8" = 1'-0"



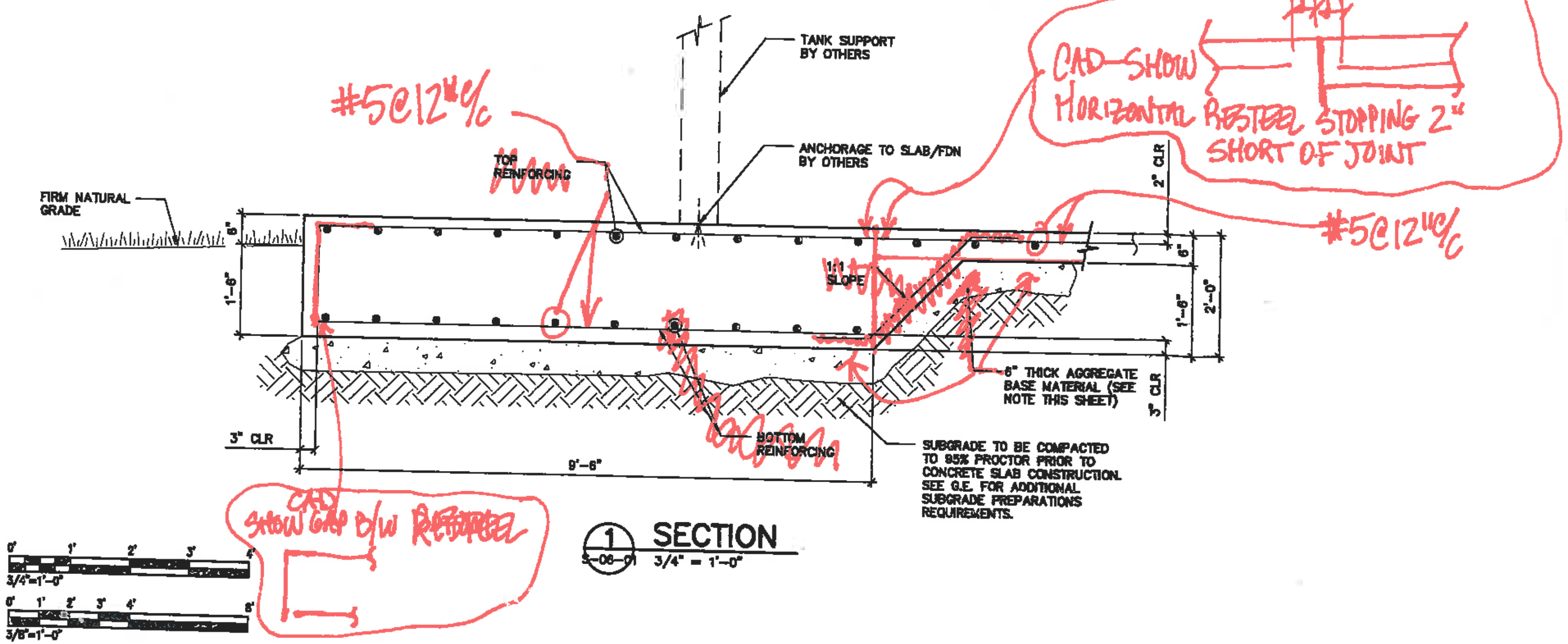
2 SECTION

S-06-01 3/4" = 1'-0"

FOUNDATION NOTES:

- CARBON AMENDMENT TANK SUPPORTS/SADDLES ARE BY OTHERS, ATTACHMENT OF CARBON AMENDMENT TANK TO SUPPORTS/SADDLES IS BY OTHERS; ANCHORAGE OF CARBON AMENDMENT TANK OR SUPPORTS/SADDLES TO THE CONCRETE SLAB/FOUNDATION IS BY OTHERS.
- FOUNDATION DESIGN IS BASED UPON 1500 psf ALLOWABLE BEARING PRESSURE, IN CONFORMANCE WITH CBC TABLE 18-1-C FOR CLASSIFICATION(S) SW, SP, SM, SC, GM, AND/OR GC. A LICENSED GEOTECHNICAL ENGINEER SHALL PROVIDE SUBGRADE COMPACTION AND PREPARATION REQUIREMENTS, AND SHALL INSPECT THE EXCAVATIONS AND CONFIRM THAT 1500 psf BEARING IS ALLOWED FOR THE FOUNDATIONS DELINEATED HEREIN, AS WELL AS 0.40 FRICTION FOR THE CARBON AMENDMENT TANK FOUNDATION. WHEN ENGINEERED FILL IS REQUIRED BY THE GEOTECHNICAL ENGINEER, IT SHALL BE TESTED AND INSPECTED BY THE GEOTECHNICAL ENGINEER.
- IF THE BUILDING OFFICIAL OR GEOTECHNICAL ENGINEER DETERMINES THAT EXPANSIVE SOILS OR OTHER GEOLOGIC ISSUES OF CONCERN MAY BE PRESENT, THEN HE/SHE MAY REQUIRE THAT SPECIAL PROVISIONS BE MADE TO THE FOUNDATION DESIGN TO SAFEGUARD AGAINST DAMAGE DUE TO THE EXPANSIVENESS OR OTHER GEOLOGIC ISSUES. IF THIS BECOMES THE SITUATION THEN ALL FOUNDATION CONSTRUCTION MUST BE HALTED AND THE GEOTECHNICAL ENGINEER SHALL PROVIDE A GEOTECHNICAL REPORT WITH RECOMMENDATIONS IN CONSIDERATION OF THE CONDITIONS.
- GROSS WEIGHT OF CARBON AMENDMENT STORAGE TANK (INCLUDING CONTENTS (FUEL) AND SUPPORT SADDLES) SHALL NOT EXCEED 181,000 lbs. THIS PARAMETER SHALL BE POSTED IN PLAIN SIGHT WITH PERMANENT LETTERING.
- REFER TO THE GENERAL NOTES AND STRUCTURAL SPECIFICATIONS FOR ADDITIONAL REQUIREMENTS.
- STRUCTURAL OBSERVATIONS OF CONSTRUCTION ARE RECOMMENDED (PER CBC SECTION 1702), SO AS TO OBSERVE THE PROGRESS AND QUALITY OF THE CONTRACTOR'S WORK AND TO DETERMINE IF THE WORK IS PROCEEDING IN GENERAL ACCORDANCE WITH THE CONSTRUCTION DOCUMENTS.
- REINFORCING STEEL: ASTM A615, 60KSI YIELD GRADE, DEFORMED BILLET STEEL BARS, UNFINISHED
- PLACE, SUPPORT AND SECURE REINFORCEMENT AGAINST DISPLACEMENT. DO NOT DEVIATE FROM REQUIRED POSITION.
- AGGREGATE BASE MATERIAL: TO BE CRUSHED GRAVEL MEETING THE FOLLOWING GRADATION AND COMPACTED TO 95% MAXIMUM DRY DENSITY OF MODIFIED PROCTOR.

SIEVE SIZE	TOTAL PERCENT PASSING
2 INCH	100
1 INCH	70 TO 100
3/4 INCH	50 TO 90
NO. 4	30 TO 60
NO. 30	9 TO 33
NO. 200	0 TO 15



1 SECTION

S-06-01 3/4" = 1'-0"

3/4"=1'-0"

3/8"=1'-0"

-DRAFT-
NOT FOR CONSTRUCTION

ARCADIS

NO.	DATE	DESCRIPTION	GM/SPEC	DWN	CHKD	SUPV	APVD BY
0	9/12/12	INTERMEDIATE (60%) DESIGN SUBMITTAL	GWE	MSL	JPB	JEF	

REVISIONS

APPROVED BY: JEF
SUPV: JPB
DSGN: MSL
DWN: GWE
CHKD: JPB
DE: JEF
DATE: 9/12/12
SCALES: AS SHOWN

TOPOCK GROUNDWATER REMEDIATION PROJECT

IRZ CARBON SUBSTRATE STORAGE TANK FOUNDATION

GAS TRANSMISSION & DISTRIBUTION
PACIFIC GAS AND ELECTRIC COMPANY
SAN FRANCISCO, CALIFORNIA

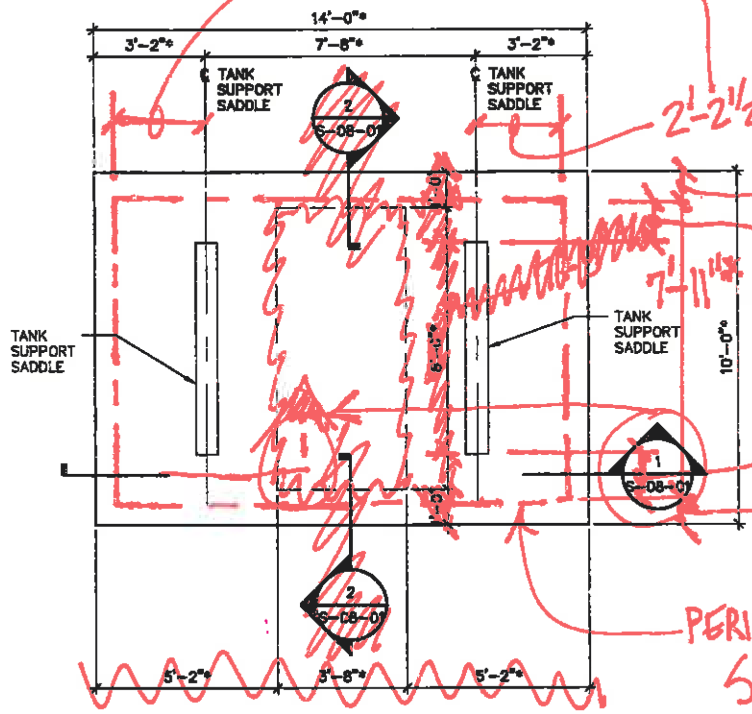
MICROFILM
BILL OF MAT'L
DWG LIST
SUPSDS
SUPSD BY
SHEET NO. of SHEETS

S-06-01

C-11

C-12

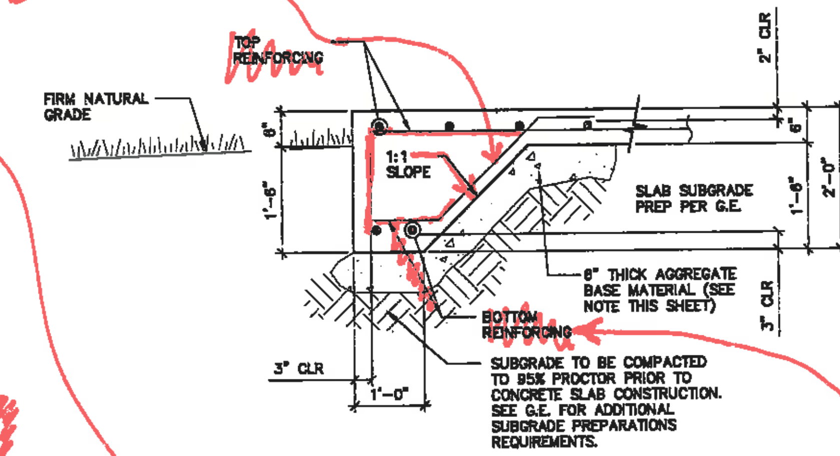
CAD - PULL OFF PAGE, THIS SECTION IS NO LONGER NEEDED



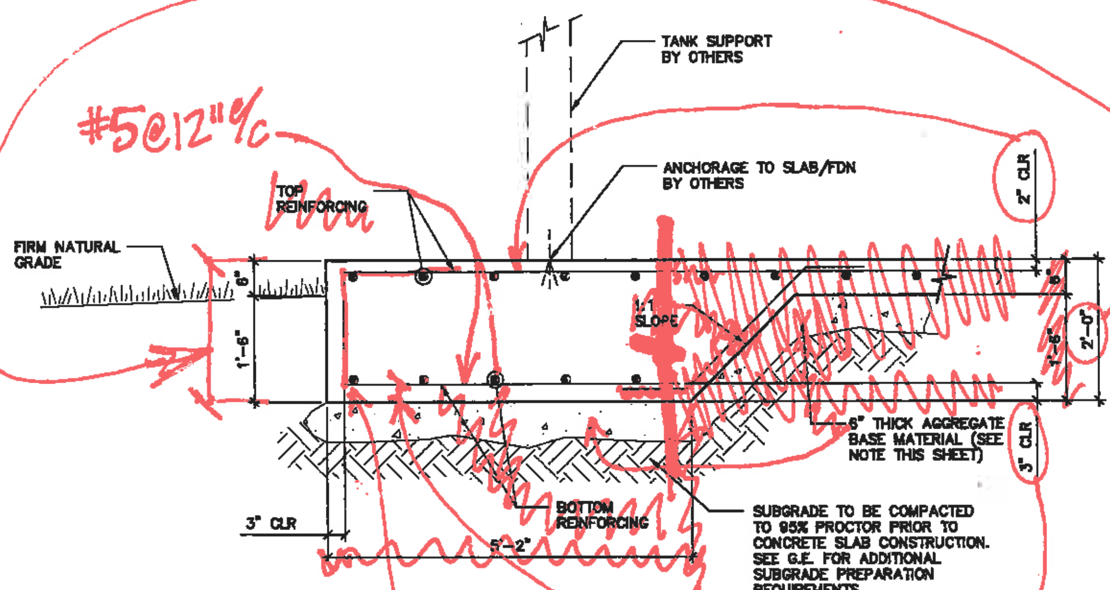
* TO BE VERIFIED BY CONTRACTOR PER APPROVED MANUFACTURER'S STORAGE TANK SHOP DRAWINGS

TW BENCH STORAGE TANK: FOUNDATION PLAN

3/8" = 1'-0"



2 SECTION S-08-01 3/4" = 1'-0"



1 SECTION S-08-01 3/4" = 1'-0"

SHOW GAP B/W REBAR (CAD)

3/4"=1'-0"

3/8"=1'-0"

FOUNDATION NOTES:

- CARBON AMENDMENT TANK SUPPORTS/SADDLES ARE BY OTHERS, ATTACHMENT OF CARBON AMENDMENT TANK TO SUPPORTS/SADDLES IS BY OTHERS; ANCHORAGE OF CARBON AMENDMENT TANK OR SUPPORTS/SADDLES TO THE CONCRETE SLAB/FOUNDATION IS BY OTHERS.
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- IF THE BUILDING OFFICIAL OR GEOTECHNICAL ENGINEER DETERMINES THAT EXPANSIVE SOILS OR OTHER GEOLOGIC ISSUES OF CONCERN MAY BE PRESENT, THEN HE/SHE MAY REQUIRE THAT SPECIAL PROVISIONS BE MADE TO THE FOUNDATION DESIGN TO SAFEGUARD AGAINST DAMAGE DUE TO THE EXPANSIVENESS OR OTHER GEOLOGIC ISSUES. IF THIS BECOMES THE SITUATION THEN ALL FOUNDATION CONSTRUCTION MUST BE HALTED AND THE GEOTECHNICAL ENGINEER SHALL PROVIDE A GEOTECHNICAL REPORT WITH RECOMMENDATIONS IN CONSIDERATION OF THE CONDITIONS.
- GROSS WEIGHT OF CARBON AMENDMENT STORAGE TANK (INCLUDING CONTENTS (FUEL) AND SUPPORT SADDLES) SHALL NOT EXCEED 42,000 lbs. THIS PARAMETER SHALL BE POSTED IN PLAIN SIGHT WITH PERMANENT LETTERING.
- REFER TO THE GENERAL NOTES AND STRUCTURAL SPECIFICATIONS FOR ADDITIONAL REQUIREMENTS.
- STRUCTURAL OBSERVATIONS OF CONSTRUCTION ARE RECOMMENDED (PER CBC SECTION 1702), SO AS TO OBSERVE THE PROGRESS AND QUALITY OF THE CONTRACTOR'S WORK AND TO DETERMINE IF THE WORK IS PROCEEDING IN GENERAL ACCORDANCE WITH THE CONSTRUCTION DOCUMENTS.
- REINFORCING STEEL: ASTM A615, 60KSI YIELD GRADE, DEFORMED BILLET STEEL BARS, UNFINISHED
- PLACE, SUPPORT AND SECURE REINFORCEMENT AGAINST DISPLACEMENT. DO NOT DEVIATE FROM REQUIRED POSITION.
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SIEVE SIZE	TOTAL PERCENT PASSING
2 INCH	100
1 INCH	70 TO 100
3/4 INCH	50 TO 90
NO. 4	30 TO 60
NO. 30	9 TO 33
NO. 200	0 TO 15

-DRAFT- NOT FOR CONSTRUCTION

ARCADIS

NO.	DATE	DESCRIPTION	GM/SPEC	DWN	CHKD	SUPV	APVD BY
0	9/12/12	INTERMEDIATE (60%) DESIGN SUBMITTAL	GWE	MSL	JPB	JEF	

REVISIONS

APPROVED BY: JEF
SD
SUPV JPB
DSGN MSL
DWN GWE
CHKD JPB
OK JEF
DATE 9/12/12
SCALES AS SHOWN

TOPOCK GROUNDWATER REMEDIATION PROJECT

TW BENCH STORAGE TANK FOUNDATION

GAS TRANSMISSION & DISTRIBUTION
PACIFIC GAS AND ELECTRIC COMPANY
SAN FRANCISCO, CALIFORNIA

MICROFILM / BILL OF MAT'L / DWG LIST / SUPSDS / SUPSD BY / SHEET NO. of SHEETS / REV

S-08-01

ARCADIS

SUBJECT: PG&E – TOPOK, CA
MW-20 BENCH UNLOADING PAD
JOB NO:

BY: MSL DATE: 4/20/12
CHKD: MSL DATE: 6/18/14

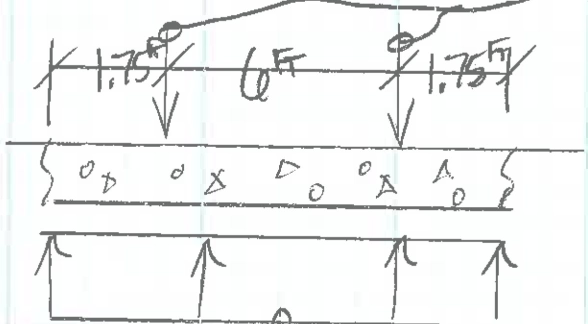
PAGE D-1
SHEET 1

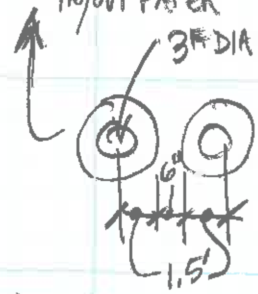
ALSO KNOWN AS "IRZ"

(MW-20 BENCH) UNLOADING PAD

- REF SHT D-2 FOR TYPICAL TRACTOR TRAILER TRUCK DIMENSIONS
- REF SHT D-3 FOR AASHTO GUIDELINES
  - ~ 4FT WIDE ON EACH SIDE OF 8FT TRUCK WIDTH = 16FT TOTAL WIDTH
  - ∴ USE 2FT EACH SIDE = 12FT TOTAL WIDTH (PER JON B 6/18/14)
- HS-20 TRAFFIC RATED
  - ASSUME 3.5FT WHEEL LOAD DISTRIBUTION ∥ TO TRAFFIC & 1.75FT ⊥ TO WHEEL (EACH SIDE)
  - IMPACT FACTOR = 1.3
  - ANALYZE 1FT STRIP OF SLAB

$P = \dfrac{16^K \times 1.3_{IMPACT}}{3.5^{FT}_{IN/OUT\ PAPER}} = 5.94^K_{UNF}$





$\dfrac{5.94^K \times 2\ \text{WHEEL LOCATIONS}}{(3.5^{FT} + 6^{FT})} = 1.25\ KSF_{UNF}$

- REFERENCE SHT D-6 FOR SLAB-ON-GRADE DESIGN FOR POINT LOADS — $M_{UNF} = 3.71$ K-FT $V_{UNF} = 3.75^K$

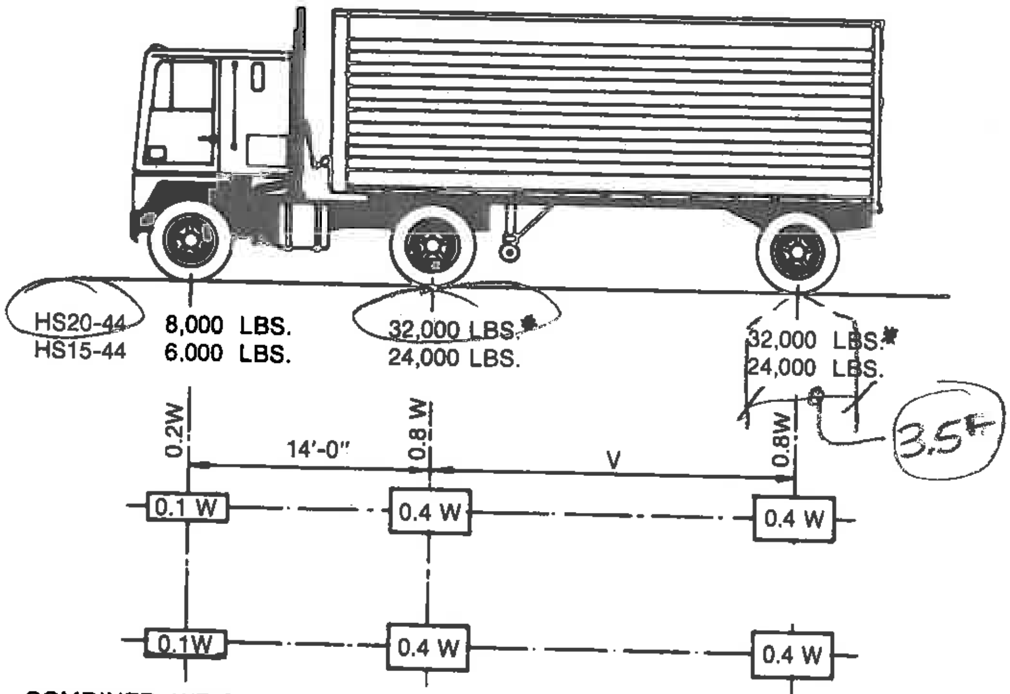
→ TRY 8" SOG W/ RESTEEL CENTERED ΔMAX = 0.10 IN ✓OK (SHT D-6) ← TO CONSERVATIVE

- $d = 8''/2 - 6/16'' = 3.63$ IN
- $\phi V_c = 2\phi\sqrt{f'_c}\,bd = 4.13^K > V_{ACI} = 3.75^K \times 1.6_{ACI} = 6^K$ ← NO GOOD

SEE SHT D-7

AGM Form 30 12-01

D-1A



W = COMBINED WEIGHT ON THE FIRST TWO AXLES WHICH IS THE SAME AS FOR THE CORRESPONDING H TRUCK.

V = VARIABLE SPACING — 14 FEET TO 30 FEET INCLUSIVE. SPACING TO BE USED IS THAT WHICH PRODUCES MAXIMUM STRESSES.

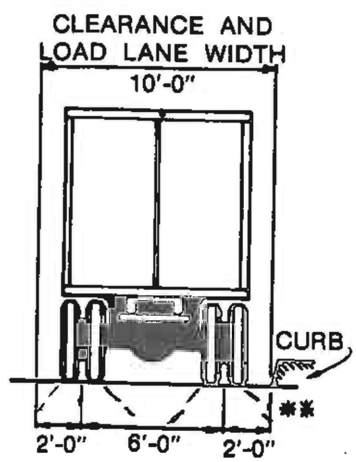


FIGURE 3.7.7A Standard HS Trucks

*In the design of timber floors and orthotropic steel decks (excluding transverse beams) for H 20 Loading, one axle load of 24,000 pounds or two axle loads of 16,000 pounds each, spaced 4 feet apart may be used, whichever produces the greater stress, instead of the 32,000-pound axle shown.

**For slab design, the center line of wheels shall be assumed to be 1 foot from face of curb. (See Article 3.24.2.)

D-2

Lotycz, Matt

From: Baxter, Jonathan
Sent: Monday, April 16, 2012 2:31 PM
To: Lotycz, Matt
Subject: FW: Ethanol Delivery Tank Dimensions

Ethanol Tanker info. Didn't include total weight, so I'll check on that.

From: Kurapati, Madhavi
Sent: Monday, April 16, 2012 1:10 PM
To: Baxter, Jonathan
Subject: FW: Ethanol Delivery Tank Dimensions

Hi Jon,

Below are the ethanol trucks dimensions. Let me know if you need anything else. My week is pretty open at this point.
Thanks,
M

Madhavi Kurapati | Environmental Specialist II | [illegible]
T. 612.373.0211

From: Tom Lowe [mailto:Tom.Lowe@univarusa.com]
Sent: Monday, April 16, 2012 1:08 PM
To: Kurapati, Madhavi
Subject: RE: Ethanol Delivery Tank Dimensions

Hi Madhavi,

Our Tractor Trailer Trucks dimensions are as follows:

Width: 8 ft
Height: 12 ft 4 in
Length: 60 to 65 ft depending on trailer used.

Please contact me if you have any other questions.

Tom Lowe
Account Manager
Univar
M + 1 [illegible] 3595

From: Kurapati, Madhavi [mailto:Madhavi.Kurapati@arcadis-us.com]
Sent: Monday, April 16, 2012 5:47 AM
To: Tom Lowe
Subject: RE: Ethanol Delivery Tank Dimensions

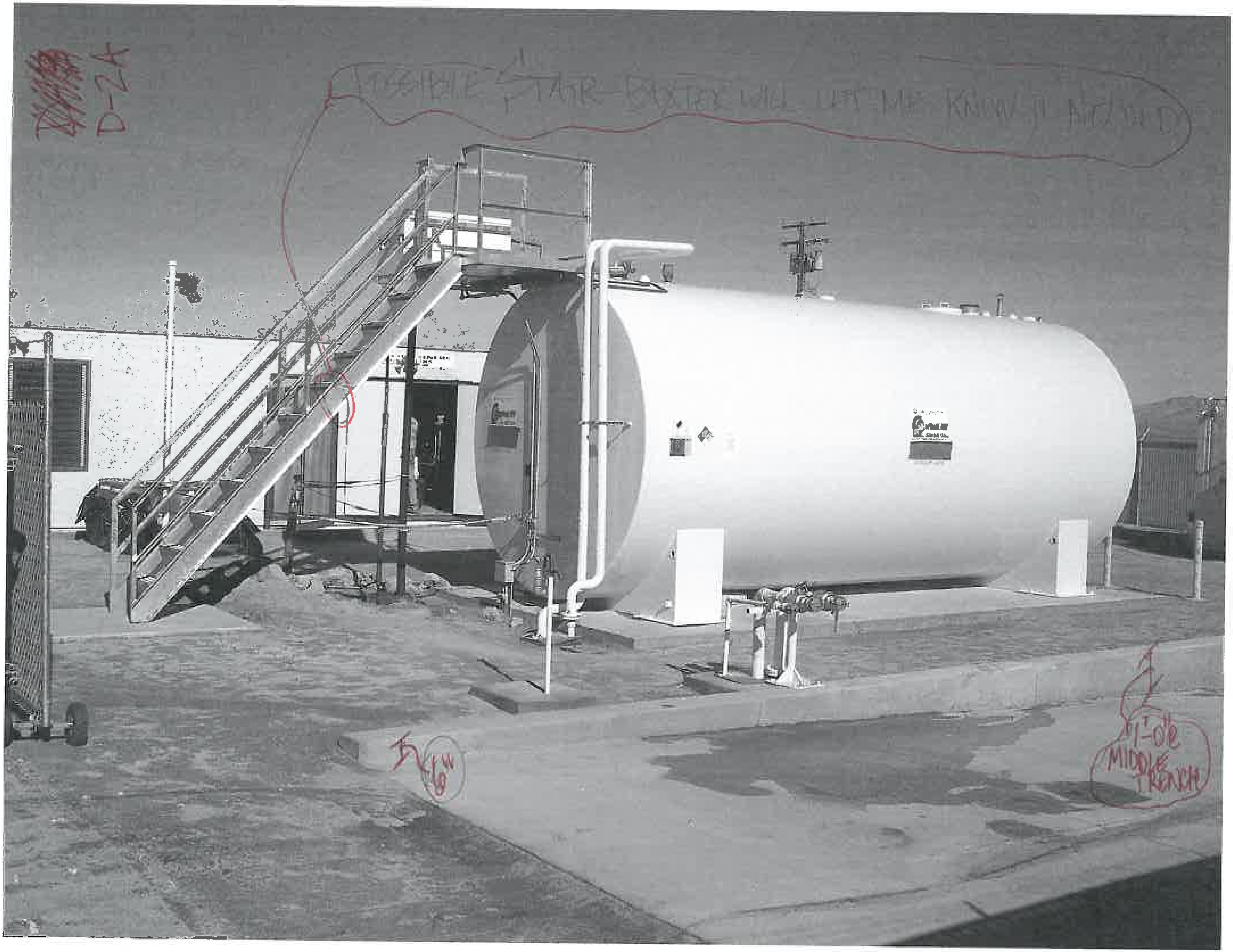
Hi Tom,

Just checking to see if you were able to get the dimensions of the trucks for me. Thanks, Madhavi

D-1B

3.30 TIRE CONTACT AREA

The tire contact area for the Alternate Military Loading or HS 20-44 shall be assumed as a rectangle with a length in the direction of traffic of 10 inches, and a width of tire of 20 inches. For other design vehicles, the tire contact should be determined by the engineer.


D-2A
1'-0" MIDDLE TRENCH

Lotycz, Matt

To: Baxter, Jonathan
Subject: RE: Hinkley Tank Install Pic

Lotycz, Matt [1:14 PM]:
in that photo you just sent, is that a "similar tanker offload containmnet slab" I see in front of the tank?
Baxter, Jonathan [1:18 PM]:
that's a deeper basin type containment slab than what we would want for topock
i think jon f is thinking the topock one would be drive through, this hinkley one is over 3' deep at the base
Lotycz, Matt [1:24 PM]:
ok, yeah, when we talked we were thinking 8" or so deep at the base (the middle) so that you could drive thru
Baxter, Jonathan [1:24 PM]:
yeah, i think that's pretty good

From: Baxter, Jonathan
Sent: Tuesday, April 03, 2012 1:16 PM
To: Lotycz, Matt
Subject: RE: Hinkley Tank Install Pic

Then I'm glad I sent it! They shipped the stairs to us completely assembled we just had to bolt to tabs at the top of the tank and anchor bolts in the concrete pad. Looking at the picture you can see where there are vents at the far end of the tank (and instruments added after the picture was taken) that became the problem for accessing from that stair.

From: Lotycz, Matt
Sent: Tuesday, April 03, 2012 12:14 PM
To: Baxter, Jonathan
Subject: RE: Hinkley Tank Install Pic

Whoa, now that is a stair! Much more than I was initially thinking.

From: Baxter, Jonathan
Sent: Tuesday, April 03, 2012 1:11 PM
To: Lotycz, Matt
Subject: Hinkley Tank Install Pic

| Staff Environmental Engineer |

| 126 N Jefferson St., Suite 400 | Milwaukee, WI 53202
T: 414 277 6256 | M: 414 477 9243 | F: 414 276 7603
www.arcadis-us.com

ARCADIS, Imagine the result

Professional Registration/PE-WI

Lotycz, Matt

From: Baxter, Jonathan
Sent: Tuesday, April 03, 2012 1:11 PM
To: Lotycz, Matt
Subject: Hinkley Tank Install Pic
Attachments: 100_1005.jpg

Jonathan Baxter, PE | Staff Environmental Engineer | [illegible]

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www.arcadis-us.com

ARCADIS, Imagine the result

Professional Registration/PE-WI
[illegible]

D-3

Interstate Highway standards

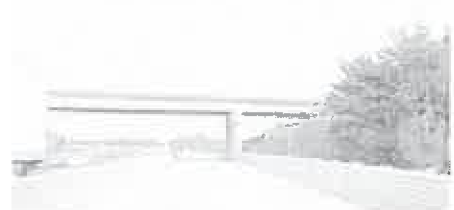
rom Wikipedia, the free encyclopedia

Standards for Interstate Highways in the United States are defined by the American Association of State Highway and Transportation Officials (AASHTO) in the publication *A Policy on Design Standards - Interstate System*. For a certain highway to be considered an Interstate, it must meet these construction requirements or obtain a waiver from the Federal Highway Administration.

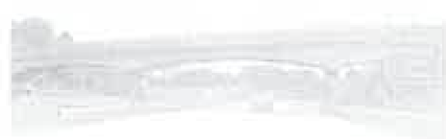
Contents

Standards

These standards are, as of July 2007, as follows:



An Interstate Highway under construction, with both directions of traffic moved to one side of the roadway



- **Controlled access:** All access onto and off the roadway is to be controlled with interchanges and grade separations (including railroad crossings). See List of gaps in Interstate Highways for the few cases that violate this rule. Interchanges should provide full access; ramps are to be designed with the appropriate standards in mind. Minimum interchange spacing should be 1 mi (1.6 km) in urban areas and 3 mi (4.8 km) in rural areas; collector/distributor roads or other configurations that reduce weaving can be used in urban areas to shorten this distance.
  - Access control (from adjacent properties) should extend at least 100 feet (30 m) in urban areas and 300 feet (91 m) in rural areas in each direction along the crossroad from the ramps.
- **Minimum design speed:** Minimum design speed of 75 mph (121 km/h) in rural areas, with 65 mph (105 km/h) acceptable in rolling terrain, and as low as 50 mph (80 km/h) allowed in mountainous and urban areas.[citation needed] However, speed limits as low as 40 mph (64 km/h) are occasionally encountered, generally on pre-existing freeways that were grandfathered into the system.
  - Sight distance, curvature and superelevation according to the current edition of AASHTO's *A Policy on Geometric Design of Highways and Streets* for the design speed.
- **Maximum grade:** Maximum grade is determined by a table, with up to 6% allowed in mountainous areas and hilly urban areas.
- **Minimum number of lanes:** At least two lanes in each direction, and more if necessary for an acceptable level of service in the design year, according to the current edition of AASHTO's *A Policy on Geometric Design of Highways and Streets*. Climbing lanes and emergency escape ramps should be provided where appropriate.
- **Minimum lane width:** Minimum lane width of 12 feet (3.66 m). Also for most U.S. and state highways.

- **Shoulder width:** Minimum outside paved shoulder width of 10 feet (3.05 m) and inside shoulder width of 4 feet (1.22 m). With three or more lanes in each direction, the inside paved shoulder should be at least 10 feet (3.05 m) wide. If truck traffic is over 250 Directional Design Hour Volume, shoulders at least 12 feet (3.66 m) wide should be considered. In mountainous terrain, 8 feet (2.44 m) outside and 4 feet (1.22 m) inside shoulders are acceptable, except when there are at least four lanes in each direction, in which case the inside shoulders should also be 8 feet (2.44 m) wide.
- **Pavement sloping:** Pavement cross slope of at least 1.5% and preferably 2% to ensure proper drainage on flat sections. This can be increased to 2.5% in areas of heavy rainfall. Shoulder cross slope should be between 2% and 6% but not less than the main lanes.
  - Land slopes within the clear zone should be at most 4:1 and preferably 6:1 or flatter. Roadside barriers should be used for slopes of 3:1 or steeper, in accordance with the current edition of AASHTO's *Roadside Design Guide*.
- **Median width:** Minimum median width of 36 feet (11 m) in rural areas, and 10 feet (3.0 m) in urban or mountainous areas. To prevent median-crossing accidents, guard rail or Jersey barrier should be installed in medians in accordance with the current edition of AASHTO's *Roadside Design Guide*, based on traffic, median width and crash history. When possible, median openings between parallel bridges less than 30 feet (9.14 m) in width should be decked over; otherwise barriers or guard rails should be installed to exclude vehicles from the gap.
- **Recovery areas:** No fixed objects should be in the clear recovery area, determined by the design speed in accordance with the current edition of AASHTO's *Roadside Design Guide*. When this is not possible, breakaway supports or barriers guarding the objects shall be used.
- **Curb slope:** Vertical curbs are prohibited. Sloping curbs are to be at the edge of the paved shoulder, with a maximum height of 100 millimetres (3.9 in). The combination of curbs and guard rail is discouraged; in this case the guard rail should be closer to the road than the curb.
- **Vertical clearance:** Minimum vertical clearance under overhead structures (including over the paved shoulders) of 16 feet (4.88 m) in rural areas and 14 feet (4.27 m) in urban areas, with allowance for extra layers of pavement. Through urban areas at least one routing should have 16 feet (4.88 m) clearances. Sign supports and pedestrian overpasses must be at least 17 feet (5.18 m) above the road, except on urban routes with lesser clearance, where they should be at least 1 ft (0.3 m) higher than other objects.
- **Horizontal clearance:** under or along a bridge shall be the full paved width of the rest of the road. Bridges longer than 200 feet (61 m) can be narrower, with a minimum of 4 feet (1.22 m) on both sides of the travel lanes.
- **Bridge strength:** New bridges are to have at least MS 18 (HS-20) structural capacity. Weaker bridges that can continue to serve the route for 20 more years are allowed to remain.
  - Additionally, existing bridges can remain if they have at least 12 feet (3.66 m) lanes with 10 feet (3.05 m) outside and 3.5 feet (1.07 m) inside shoulders. Long bridges are to have at least 3.5 feet (1.07 m) on each side of the travel lanes; bridge railing should be upgraded to current standards if necessary.
- **Tunnel clearance:** Tunnels should in theory be equivalent to long overcrossings, but because of cost the standards can be reduced. Vertical clearance is the same as under bridges, including the provision for alternate routing. Widtl should be at least 44 feet (13.41 m), which consists of two 12 feet (3.66 m) lanes, 10 feet (3.05 m) outside and 5 feet (1.52 m) inside shoulders, and 2.5 feet (0.76 m) safety walkways on each side. If necessary to meet the dimensions of the approach, this can be shifted left or right. A reduced width is acceptable due to high cost. In this case, the minimum width is 30 feet (9.14 m), with at least 2 feet (0.61 m) more than the approach for the sum of th

I-94 in Michigan, showing examples of non-interchange overpass signage in median, upcoming exit signage on right shoulder, a 1950s overpass with height restriction signage, newly installed cable median barrier, and parallel grooved pavement with shoulder rumble strips

An Interstate Highway bridge with an asphalt overlay

I-70 entering the Twin Tunnel west of Denver shoulder widths, but at least 24 feet (7.32 m) total, and at least 1.5 feet (0.46 m) on each side for a safety walkway. If there is no safety walkway, a 3-foot (0.91 m) offset with a "safety shape" in the wall is acceptable.

Exceptions

A narrow older "grandfathered" section of Interstate 94/69 after entering Michigan from Sarnia, Ontario

The standards have been changed over the years, resulting in many older Interstates not conforming to the current standards, and yet others are not built to standards because to do so would be too costly or environmentally unsound.

Some roads were grandfathered into the system. Most of these were toll roads that were built before the Interstate system came into existence or were under construction at the time President Dwight D. Eisenhower signed the Federal Aid Highway Act of 1956. The most notable example is the Pennsylvania Turnpike, which originally had a very narrow median that later required the installation of a Jersey barrier due to heavy traffic loads.

Interstate 93 super-2 through Franconia Notch, New Hampshire

Interstate 93 through Franconia Notch, Jew Hampshire is also a notable exception being a super two parkway with a peed limit of 45 miles per hour.

nterstate 35E through Saint Paul, Minnesota is an example of a freeway that was not grandfathered into the system that i ,onetheless an exception to standards. The freeway was not opened until 1990, has a speed limit of 45 MPH, and does ot allow vehicles weighing over 9,000 pounds GVW. This is due to a number of lawsuits from wealthy surrounding omeowners, which heavily delayed and modified the project dating to the 1960s.

nterstate 75 on the Mackinac Bridge between St. Ignace and Mackinaw City, Michigan, is undivided. The bridge was esigned before the start of the Interstate Highway System, and it was grandfathered into the system.[1]

References

1. ^ Rubin, Lawrence A. (1985). *Bridging the Straits: The Story of Mighty Mac*. Detroit: Wayne State University Press. ISBN 9780814317891.

- "Interstate standards" (http://groups.google.com/group/misc.transport.road/msg/4dd88f22052fe94d) , John Lansford, employee North Carolina Department of Transportation, misc.transport.road newsgroup November 2, 1999

External links

- AASHTO Bookstore - A Policy on Design Standards - Interstate System (https://bookstore.transportation.org/item_details.aspx?ID=1175) (ISBN 1560512911)

Retrieved from "http://en.wikipedia.org/w/index.php?title=Interstate_Highway_standards&oldid=482781916"
Categories: Interstate Highway System Lists of standards

- This page was last modified on 19 March 2012 at 20:40.

D-4

TRENCH CASTINGS: HEAVY DUTY

Neenah Foundry offers a variety of heavy duty cast iron trench castings. Select from the list below to find the trench castings that fit your needs.

DEFINITION → PER STEVE OKKLA 4/20/12 2PM EST → HS-20 RATED ~ OIL TANKER ~ 16,000# WHEEL

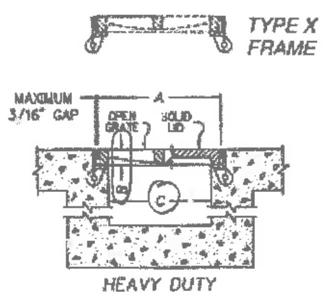
R-4990 and R-4999 Series

PRINT THIS PRODUCT

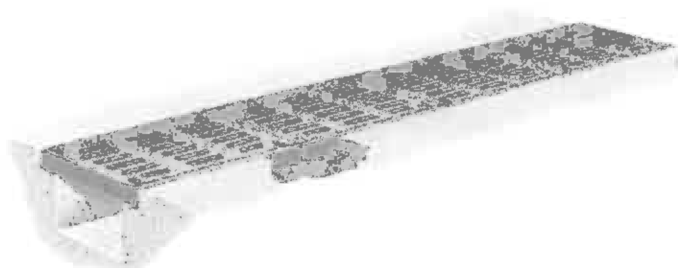
R-4990 AND R-4999 SERIES

HEAVY DUTY TRENCH

Materials: All frames and grates/lids are furnished standard in Gray Iron, Class 35-B for heavy-duty use. For extra heavy-duty use or superior durability requirements, see our Airport and Port Grating Series and our R-4993 & R-4994 Series.



General schematic shown may not apply to all designs. Bar and rib depths, plate thicknesses, and seating widths vary on different sizes and styles. If your project has design restrictions, contact your sales representative or product engineering.



Illustrating Type C bolted trench. Bolted trench sections are furnished in 24" standard lengths. When bolted trench is furnished, they are shipped assembled – AT NO TIME should the units be disassembled during installation. When removing covers, do not mix or rotate 180 degrees as bolt holes may lose alignment and improper bearing may occur.

Un-bolted Catalog No.	Bolted Catalog No.	A	B	C	Type A	Type C	Type D	Type E	Type P	Type Q
R-4990-AX	R-4999-AX	8	1-1/2	6	x	x	x	x	x	
R-4990-BX	R-4999-BX	10	1-1/2	8	x	x	x	x	x	
R-4990-CX	R-4999-CX	12	1-1/2	10	x	x	x	x	x	x
R-4990-DX	R-4999-DX	14	1-1/2	12	x	x	x	x	x	x

x – indicates availability

41,600# ULTIMATE LOAD CAPACITY ~ WHEEL LOAD

Un-bolted Catalog No.	Bolted Catalog No.	A	B	C	Type A	Type C	Type D	Type E	Type P	Type Q
R-4990-EX	R-4999-EX	17	1-1/2	15	x	x	x	x	x	
R-4990-FX	R-4999-FX	20	1-1/2	18	x	x	x	x	x	
R-4990-GX	R-4999-GX	23	1-1/2	21	x	x	x			
R-4990-HX	R-4999-HX	26	1-1/2	24	x	x	x	x		x
R-4990-JX	R-4999-JX	30	2	27	x	x	x			
R-4990-KX	R-4999-KX	33	2	30	x	x	x	x		
R-4990-LX	R-4999-LX	36	2	33	x	x	x			
R-4990-MX	R-4999-MX	39	2	36	x	x	x			
R-4990-NX	R-4999-NX	45	2	42	x	x	x			
R-4990-OX	R-4999-OX	51	2	48	x		x			

x – Indicates availability

40,700# ULTIMATE LOAD CAPACITY-WHEEL LOAD

TRENCH CASTINGS

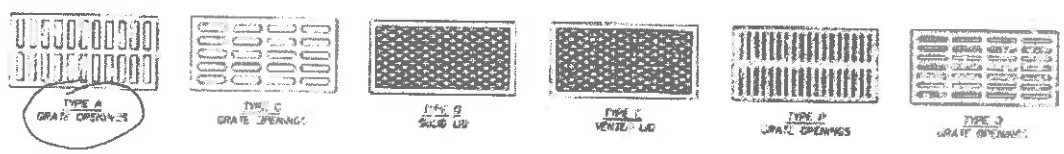
Read Carefully Before Ordering

The various standard trench drains are available with a number of alternatives. It is important to examine all of the variables carefully and specify your requirements fully. Your order will be entered correctly and promptly if includes the following information:

STEVE OKALA

- Complete catalog number
- Frame and pieces, when required
- Type of lid or grate: A, C, D, E, P or Q
- Length of trench sections
- Angles and intersections *
- Load requirements

* Trenches with angles, intersections, size changes, or other special requirements require detail drawings prior to ordering. Contact your sales representative or product engineering for assistance.



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All dimensions are listed in inches unless otherwise noted.

To order Neenah Foundry products, please call **800.558.5075**.

NEENAH ENTERPRISES - INDUSTRIAL

Neenah Enterprises Inc. is a leader in producing construction/municipal castings and manufactures products to a host of other industrial industries through our Industrial Division NEI.

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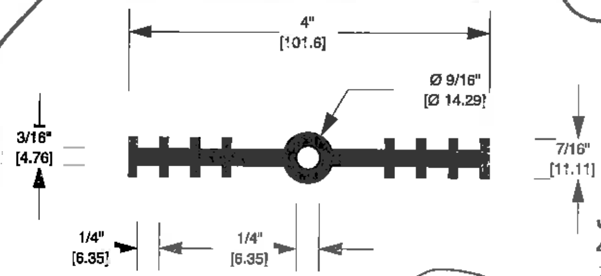
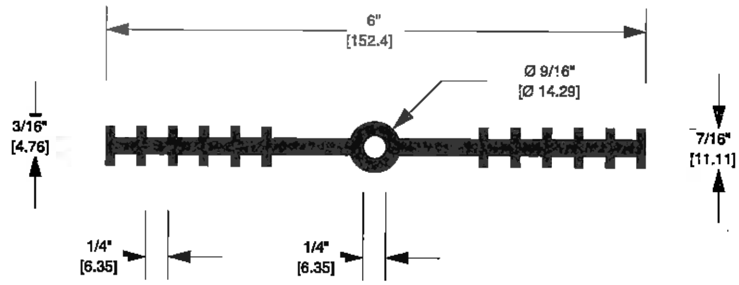
Trench Castings
LiftMate

ENGINEERING TOOLS & CALCULATORS
Modified Manning Calculators

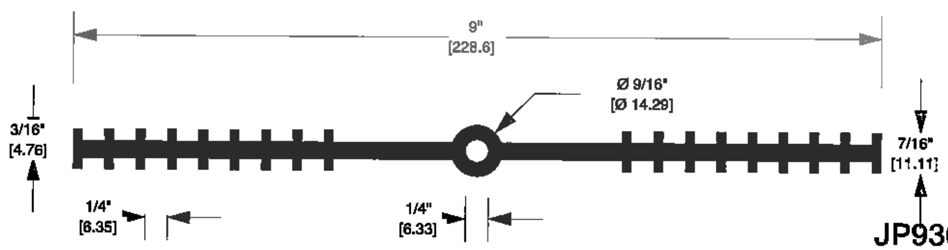
D-5



JP436 (with eyelets: EYJP436)
4" Ribbed Centerbulb Waterstop
75 ft Head of H_2O

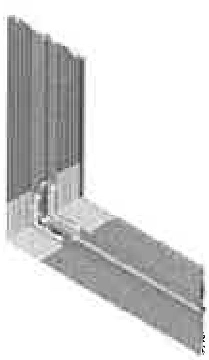


JP636 (with eyelets: EYJP636)
6" Ribbed Centerbulb Waterstop
125 ft Head of H_2O



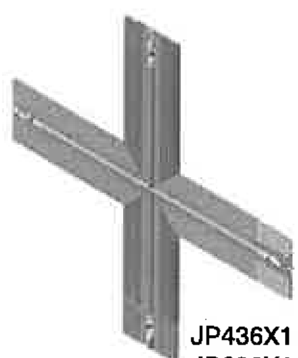
JP936 (with eyelets: EYJP936)
9" Ribbed Centerbulb Waterstop
175 ft Head of H_2O

Standard Fabrications



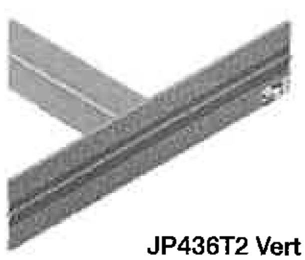
JP436L1 Flat Ell
JP636L1 Flat Ell
JP936L1 Flat Ell

JP436T1 Flat Tee
JP636T1 Flat Tee
JP936T1 Flat Tee

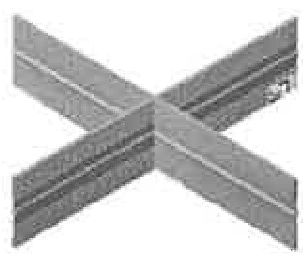


JP436X1 Flat Cross
JP636X1 Flat Cross
JP936X1 Flat Cross

JP436L2 Vert Ell
JP636L2 Vert Ell
JP936L2 Vert Ell



JP436T2 Vert Tee
JP636T2 Vert Tee
JP936T2 Vert Tee



JP436X2 Vert Cross
JP636X2 Vert Cross
JP936X2 Vert Cross

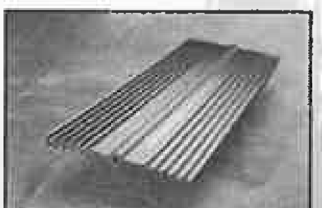
EARTH SHIELD®

Waterstops for Chemical, Industrial, & Environmental Applications

All ribbed Earth Shield® Waterstop profiles are available with factory installed brass eyelets. The eyelets provide for a convenient and durable tie-off point for wire tying the waterstop to the steel reinforcement prior to the concrete pour.

Earth Shield® Retrofit Column and Pipe Fitting (part number JP320LC1.XX* [*XX is diameter in inches]) is manufactured with a flexible, chemical-resistant polymer and includes all stainless steel anchoring hardware.

See page 14 for more info



Earth Shield® JP636 TPV Ribbed Centerbulb (6" width) is the industry standard, utilized on most jobs for its proven fluid-sealing properties.

See page 4 for more info

Waterstops play a critical role in the integrity of concrete structures. They provide a fluid-tight diaphragm when embedded in, and running through concrete joints. Earth Shield® Thermoplastic Vulcanizate Waterstop (TPV), by JP Specialties, Inc., greatly expands the scope of conventional waterstop by offering unmatched chemical resistance to a broad spectrum of aggressive chemicals, solvents, and hot petroleum oils. Manufactured NSF certified, EPA-compliant waterstop profiles are available for new construction and retrofit, as well as the tools and accessories for proper field installation.

JP Specialties, Inc. is the leading manufacturer of chemical resistant waterstop and related concrete accessories. Our NSF 61 certified Earth Shield® line of chemical resistant waterstop is used throughout the world by major engineering firms and project owners for primary and secondary containment applications, as well as industrial wastewater treatment and ozone contactor structures. We invented and hold the patent on the technology used to mechanically weld thermoplastic waterstops.

Services offered include free blueprint take-off and shop drawings, on-site welding certification, and individual corrosion resistance certification for the project owner.

Earth Shield® Chemical Resistant Waterstop
Phone: 800-821-3859; 951-763-7077
Fax: 951-763-7074
www.earthshield.com
J.P. SPECIALTIES, INC.

Earth Shield® Thermoplastic Vulcanizate (TPV / TPER) Waterstop Basic Use

Earth Shield® Thermoplastic Vulcanizate Waterstop is used as a fluid-tight diaphragm, embedded in concrete, across and along the joint, for primary and secondary containment structures. Earth Shield® Chemical Resistant Waterstops are resistant to a wide range of oils, solvents, and aggressive chemicals. Alcohol, ketones, glycols, esters, and aqueous solutions of acids, salts, and bases have little effect on Earth Shield® Thermoplastic Vulcanizate Waterstop.

Unlike polyvinyl chloride (PVC) waterstop, **Earth Shield® waterstop contains no plasticizer, stabilizer, or filler to leech out when exposed to chemicals, fuels, and aggressive industrial fluids.** Also, unlike PVC waterstop, Earth Shield® can withstand prolonged exposure to high and low temperatures (-78°F to 275°F long term) without detrimental effect.

Earth Shield® TPV Waterstop is NSF Standard 61 Certified for use in drinking water and is made of a recyclable polymer, so it's good for health and the environment.
http://www.earthshield.com/earth_shield_waterstop/waterstop_tpv/waterstop_tpv.html

The superior chemical resistance of Earth Shield® Thermoplastic Vulcanizate Waterstop is enhanced by the use of a ribbed centerbulb configuration, which is available in a 4, 6, and 9-inch width. This provides for greater mechanical bonding with the concrete and a barrier against migration of liquid flow around the waterstop. The ribbed centerbulb style also allows for joint movement and may be used in above or below grade applications. Additional shapes are available for retrofit, extreme expansion, stainless steel and base seal applications.

Different varieties and grades of thermoplastic elastomers (TPE) are commercially available. On the low-end there is thermoplastic polyolefin (TPO), which has a rubber phase that is not cross-linked. On the high-end there is thermoplastic vulcanizate (TPV)... Earth Shield® has chosen a fully cross-linked TPV as our standard elastomer compound, which provides superior mechanical properties, retention, and chemical resistance. In fact, when compared side-by-side, no competitive product is even close to achieving the physical properties of Earth Shield®.

Typical Applications

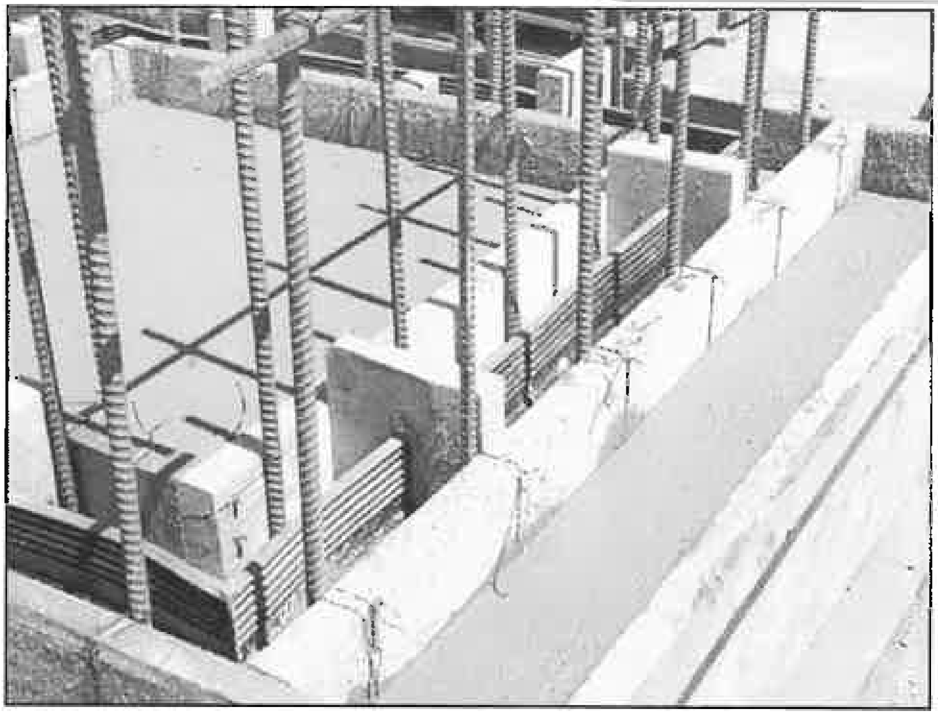
- *Primary and secondary containment*
- *Waste water treatment plants*
- *Refineries*
- *Ozone contactor structures*
- *Mining facilities*
- *Fueling areas*
- *Chemical factories*
- *Manure pits*

Earth Shield® Advantages

- *Outstanding fluid resistance to a wide range of aqueous-based fluids, oils, and hydrocarbons*
- *Excellent retention of physical properties at elevated temperatures*
- *Superior ozone and weather resistance*

Installation

Install Earth Shield® TPV Waterstop in all concrete joints. Waterstop should be centered in, and run the extent of the joint. All changes of directions should be prefabricated (see Shop Made Fittings), leaving only butt-welding for the field. If installing in an expansion joint, keep center bulb unembedded to allow it to accommodate movement as designed. Use optional factory installed brass eyelets (or #3 hog rings) and tie wire to secure waterstop to reinforcing steel to avoid displacement during the concrete pour. Splice straight lengths of waterstop, and Shop Made Fittings to straight lengths, with an ST-10® In Line Waterstop Splicer with the iron temperature set to 410°F to 430°F.
More detailed installation instructions can be found in our Standard 3-part Specifications.



Technical Assistance

Qualified technical assistance is available during any phase of your construction project.

Specifications

Standard 3-part Specifications are available at our website in Microsoft® Word and Adobe® PDF format, and upon request in printed and a variety of computer word processor formats. Call our Technical Sales Staff for additional help with your specification.
http://www.earthshield.com/earth_shield_waterstop/waterstop_tpv/waterstop_tpv.html

NSF

NON-TOXIC PLASTIC · NO BISPHENOL A · NO PHTHALATES · BPA FREE

Suggested Proprietary Short Form Guide Specification Section 03150 (Master Format 2004 — 03 15 13)

TPV Chemical Resistant Waterstop

Waterstop indicated in drawings and specifications for contraction (control), expansion and construction joints shall be Earth Shield® TPV Chemical Resistant Waterstop Part No. <u>####</u> [Designer insert appropriate part number here] as manufactured by JP Specialties, Inc.; Murrieta, CA 92562; Phone 951-763-7077

1. *Thermoplastic Vulcanizate (TPV) Waterstop shall conform to EPA Title 40 CFR Section 265.193. The suitability of the waterstop for a specific application should be determined by specific testing for that particular requirement per ASTM D471. Project-specific certification to be provided by the manufacturer.*
2. *Thermoplastic Vulcanizate (TPV) Waterstop shall be independently certified for use in potable water per NSF/ANSI Standard 61. Third-party certified documentation to be provided by the manufacturer.*
3. *No equals or substitutions allowed.*

Property	Test Method	Required Results
Specific Gravity	ASTM D792	.96
Shore A Hardness (5 sec.)	ASTM D2240	90±3 at 25°C (77°F)
Tensile Strength	ASTM D412	2,300 psi
Ultimate Elongation	ASTM D412	530%
100% Modulus	ASTM D746	1,000 psi
Tear Strength	ASTM D624	278 pli at 25°C (77°F)
Compression Set	ASTM D395	29% at 25°C (77°F)
Brittle Point	ASTM D746	-61°C (-78°F)
Drinking Water Safe	NSF/ANSI 61	Waterstop certified by NSF for use in potable water
Ozone Resistance	ASTM D1171	Passed, no cracking at 500 pphm
Chemical Resistance	ASTM D471	Meet or exceed specific testing standards for contained fluids as required by Owner and certified by Manufacturer
Green Certification	GreenSpec	Approved

Ribbed Centerbulb

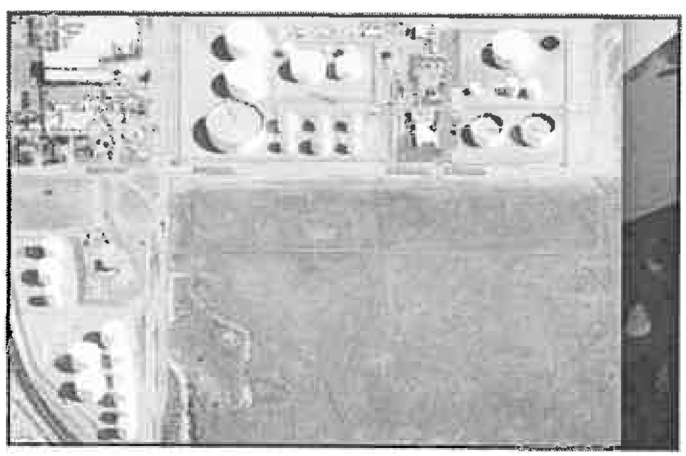
for Moving and Non-Moving Joints

Ribbed centerbulb is the most versatile type of waterstop available. The centerbulb accommodates lateral, transverse, and shear movement. Ribbed centerbulb can be used in expansion, construction, and control joints.

Ribbed centerbulb waterstops provide superior anchoring abilities and a long fluid-flow path because of the multiple ribs on the exterior flanges. Under stress, the multiple ribs will distort less than a dumbbell type waterstop. This is because the stress is first applied to the inward-most anchoring rib, and decreases to the subsequent ribs.

The centerbulb allows for joint movement beyond the ultimate elongation of the material (530%), without causing distortion to anchoring ribs. All of our ribbed centerbulb waterstops are manufactured with a 9/16" outer diameter centerbulb, which is the largest in the industry. This centerbulb, coupled with the outstanding mechanical properties of our proprietary TPV elastomer (ultimate elongation, tensile strength, etc.), provides for unsurpassed joint movement and sealing abilities.

Like all our thermoplastic vulcanizate waterstops, ribbed centerbulb can be heat-welded using a standard waterstop splicing iron. This allows for easy field fabrications, and allows the waterstop to function as a continuous, homogeneous, fluid-tight diaphragm. Waterstop change of directions (fittings) can be purchased along with straight roll stock, and custom, fit-to-print waterstop modules are produced to order.



F. Misalignment of waterstop splice resulting in misalignment of waterstop in excess of 1/2 inch in 10 feet.
G. Visible porosity in the weld.
H. Charred or burnt material.
I. Bubbles or inadequate bonding.
J. Visible signs of splice separation when cooled splice (24 hours or greater) is bent by hand at sharp angle.

APPENDIX A

Earth Shield® Thermoplastic Vulcanizate Waterstop (TPV) — Effect of 166 hour immersion (ASTM D-471) on properties of Earth Shield® Thermoplastic Vulcanizate Waterstop

Fluids	Temp., °C	Ultimate Elongation Percent Retention	Ultimate Tensile Strength Percent Retention	100% Modulus Percent Retention	Hardness, Change, Shore A Units	Weight Change Percent
98% Sulfuric Acid	23	77	82	108	-1	2.1
10% Hydrochloric Acid	23	88	87	85	6	0.3
50% Sodium Hydroxide	23	101	107	104	-4	-0.1
10% Potassium Hydroxide	23	101	101	106	-1	0.1
Water	100	84	94	106	4	2.9
10% Zinc Chloride	23	89	87	83	5	0
Sea Water	23	98	107	99	4	0.3
15% Sodium Chloride	23	93	90	94	5	0.7
18% Calcium Chloride/14% Calcium	150	71	86	110	-2	-0.1
Bromide, 2.5% Detergent (Tide®)	23	103	103	103	0	-0.1
Acetic Acid	23	103	102	102	-2	3.2
Acrylonitrile	23	102	104	110	-4	0.9
Aniline	23	99	94	99	-2	1.5
Bromobenzene	23	94	91	88	-3	41.9
n-Butyl Acetate	23	95	92	80	5	0.3
Carbon Disulfide	23	94	68	82	-19	60.4
Cyclohexane	23	63	58	62	-6	45.3
Diethyl Ether	23	98	97	95	-7	-1.8

Fluids	Temp., °C	Ultimate Elongation Percent Retention	Ultimate Tensile Strength Percent Retention	100% Modulus Percent Retention	Hardness, Change, Shore A Units	Weight Change Percent
Dimethylformamide	23	96	105	100	6	0
Dioctyl Phthalate	23	101	97	103	-1	-0.2
1,4-Dioxane	23	98	94	95	-3	1.1
95% Ethanol	23	106	98	99	0	-1.7
Glycerol	23	102	101	103	-2	-0.2
n-Hexane	23	90	92	94	-10	5.7
Isophorone Diisocyanate	23	101	92	105	7.2	.30
Methylethylketone	23	95	94	79	6	-4.8
Nitrobenzene	23	100	98	102	-2	-1.5
Piperidene	23	98	105	94	6	-1.9
1-Propanol	23	93	98	100	6	-4.3
Toluene Diisocyanate	23	88	98	103	7.2	4.93
Pyridine	23	98	105	94	6	-1.9

Fluids	Temp., °C	Ultimate Elongation Percent Retention	Ultimate Tensile Strength Percent Retention	100% Modulus Percent Retention	Hardness, Change, Shore A Units	Weight Change Percent
Trichloroethylene	23	101	105	85	-13	97.2
Turpentine	23	80	75	85	-10	34.8
Xylene	23	84	85	90	-11	24.9
ASTM #1 Oil	100	88	91	99	1	13.5
ASTM #1 Oil	125	70	78	91	-1	21.6
ASTM #2 Oil	100	82	86	93	-2	27.1
ASTM #2 Oil	125	65	79	93	-6	40.1
ASTM #3 Oil	100	72	75	80	-6	41.6
ASTM #3 Oil	125	60	71	83	-13	59.8
IRM 902	100	85	86	100	-5	20.8
IRM 902[2]	125	71	79	97	-7	29.3
IRM 903	100	76	78	91	-9	35.4
IRM 903[2]	125	60	69	84	-15	50.6
Reference Fuel A (Isooctane)	23	86	85	82	-1	13.2
Reference Fuel B (Isooctane/ Toluene, 70/30)	23	82	84	81	-7	24.5
Reference Fuel C (Isooctane/ Toluene, 50/50)	23	67	68	75	-4	29.4
Diesel	23	89	81	87	-11	17
JP4 Jet Fuel	23	100	71	79	-11	17
JP8 Jet Fuel	23	100	93	95	-7	8
Kerosene	23	92	85	88	-10	15
Automatic Transmission Fluid	125	63	77	82	-11	43.4
Hydraulic Brake Fluid	23	95	102	95	5	-1.8
Hydraulic Brake Fluid 2	100	89	94	97	6	-12.8
Lithium Grease	23	93	98	92	5	3.5
Lithium Grease	100	88	88	92	-7	18.8

Fluids	Temp., °C	Ultimate Elongation Percent Retention	Ultimate Tensile Strength Percent Retention	100% Modulus Percent Retention	Hardness, Change, Shore A Units	Weight Change Percent
Power Steering Fluid	125	54	59	68	-12	52.2
Antifreeze, 50/50 Ethylene Glycol (Prestone®)/water	125	84	99	96	2	3.1
Pydraul® 312	125	79	85	90	0	17.6
Skydrol® 500 B4	125	93	104	101	4	-4.2
Sunvis® 706 Fluid	125	67	77	84	-8	39.9
Ucon® CC732	125	91	99	96	2	5.3
Ucon® 50HB5100	125	91	99	96	2	5.3
Freon® 11	5	92	88	88	-9	32.3

All solution concentrations by weight.

VOID TOO CONSERVATIVE

BEAM ON ELASTIC FOUNDATION ANALYSIS

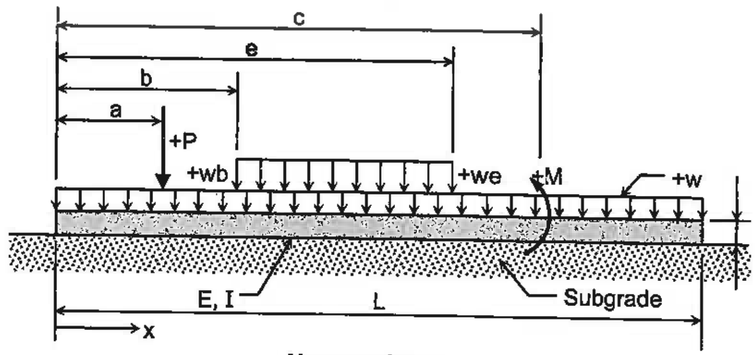
For Soil Supported Beam, Combined Footing, Slab Strip or Mat Strip of Assumed Finite Length with Both Ends Free

Job Name:	RG&E - Topok, CA - IRZ Unloading Pads	Subject:	Slab-on-Grade		
Job Number:	RC000753.0008	Originator:	MSL	Checker:	

Input Data:

Beam Data:

Length, L = 9.5000 ft.
Width, B = 1.0000 ft.
Thickness, T = 8.0000 ft.
Modulus, E = 3600 ksi
Subgrade, K = 100 pci



Nomenclature

Beam Loadings:

Full Uniform:
w = 0.1000 kips/ft.

Distributed:

	Start b (ft.)	Start Wb (kips/ft.)	End e (ft.)	End We (kips/ft.)
#1:				
#2:				
#3:				
#4:				
#5:				
#6:				

Point Loads:

	a (ft.)	P (kips)
#1:	1.7500	5.94
#2:	7.7500	5.94
#3:		
#4:		
#5:		
#6:		
#7:		
#8:		
#9:		
#10:		
#11:		
#12:		

Moments:

	c (ft.)	M (ft-kips)
#1:		
#2:		
#3:		
#4:		

Results:

Beam Flexiblity Criteria:

for β*L <= π/4	beam is rigid
for π/4 < β*L < π	beam is semi-rigid
for β*L >= π	beam is flexible
for β*L >= 6	beam is semi-infinite long

Inertia, I = 42.6667 ft.^4 I = B*T^3/12
β = 0.037 β = ((K*B)/(4*E*I))^(1/4)
β*L = 0.355 β*L = Flexibility Factor

Beam is rigid

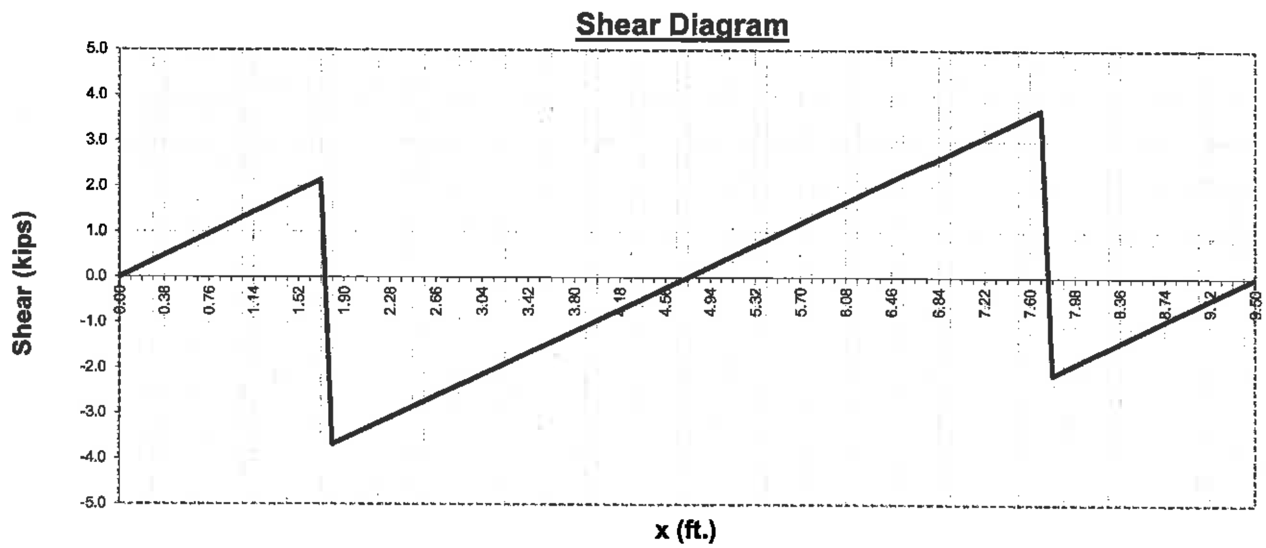
Max. Shears and Locations:
+V(max) = 3.75 k @ x = 7.75 ft.
-V(max) = -3.75 k @ x = 1.75 ft.

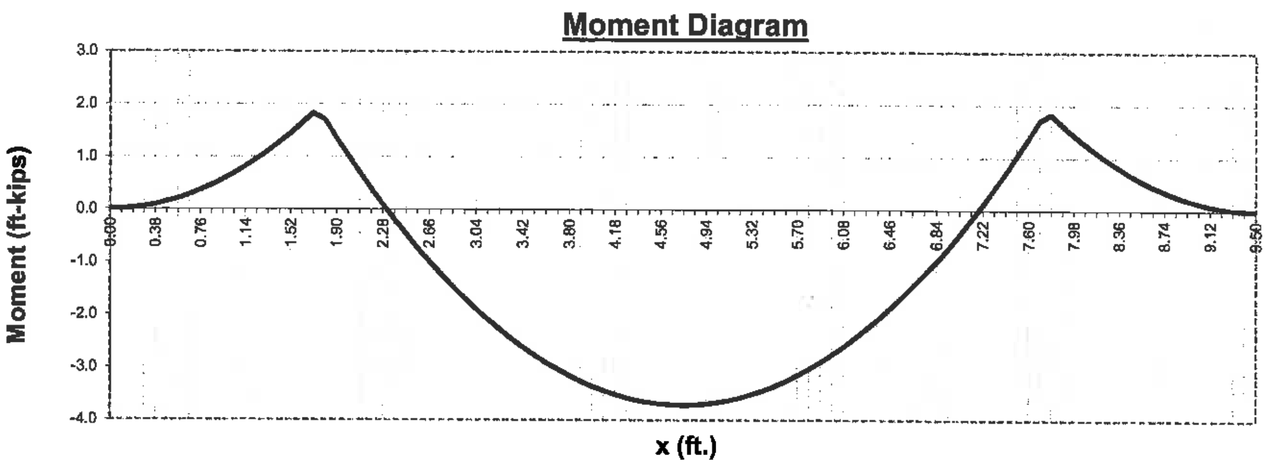
Max. Moments and Locations:
+M(max) = 1.91 ft-k @ x = 1.75 ft.
-M(max) = -3.71 ft-k @ x = 4.75 ft.

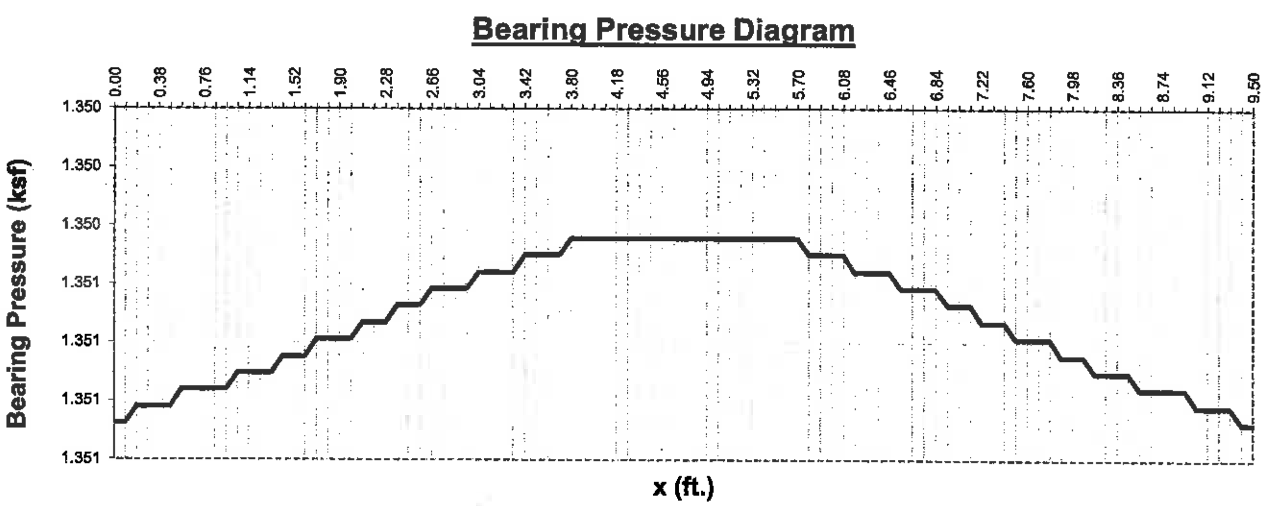
Max. Deflection and Location:
Δ(max) = -0.094 in. @ x = 0.00 ft.

Max. Soil Pressure and Location:
Q(max) = 1.351 ksf @ x = 0.00 ft.

Comments:


Shear Diagram
Shear (kips)
5.0
4.0
3.0
2.0
1.0
0.0
-1.0
-2.0
-3.0
-4.0
-5.0
0.38 0.76 1.14 1.52 1.90 2.28 2.66 3.04 3.42 3.80 4.18 4.56 4.94 5.32 5.70 6.08 6.46 6.84 7.22 7.60 7.98 8.36 8.74 9.12 9.50
x (ft.)


Moment Diagram
Moment (ft-kips)
3.0
2.0
1.0
0.0
-1.0
-2.0
-3.0
-4.0
0.38 0.76 1.14 1.52 1.90 2.28 2.66 3.04 3.42 3.80 4.18 4.56 4.94 5.32 5.70 6.08 6.46 6.84 7.22 7.60 7.98 8.36 8.74 9.12 9.50
x (ft.)


Bearing Pressure Diagram
Bearing Pressure (ksf)
0.00 0.38 0.76 1.14 1.52 1.90 2.28 2.66 3.04 3.42 3.80 4.18 4.56 4.94 5.32 5.70 6.08 6.46 6.84 7.22 7.60 7.98 8.36 8.74 9.12 9.50
1.350
1.350
1.350
1.351
1.351
1.351
1.351
x (ft.)

Tabulation of Beam Shear, Moment, Deflection, and Bearing Pressure for 100 Equal Segments					
Point #	x (ft)	Shear (k)	Moment (ft-k)	Deflection (in.)	Bearing Pressure (ksf)
1	0.0000	0.00	0.00	-0.0938	1.351
2	0.0950	0.12	0.01	-0.0938	1.351
3	0.1900	0.24	0.02	-0.0938	1.351
4	0.2850	0.36	0.05	-0.0938	1.351
5	0.3800	0.48	0.09	-0.0938	1.351
6	0.4750	0.59	0.14	-0.0938	1.351
7	0.5700	0.71	0.20	-0.0938	1.351
8	0.6650	0.83	0.28	-0.0938	1.351
9	0.7600	0.95	0.36	-0.0938	1.351
10	0.8550	1.07	0.46	-0.0938	1.351
11	0.9500	1.19	0.56	-0.0938	1.351
12	1.0450	1.31	0.68	-0.0938	1.351
13	1.1400	1.43	0.81	-0.0938	1.351
14	1.2350	1.54	0.95	-0.0938	1.351
15	1.3300	1.66	1.11	-0.0938	1.351
16	1.4250	1.78	1.27	-0.0938	1.351
17	1.5200	1.90	1.44	-0.0938	1.351
18	1.6150	2.02	1.63	-0.0938	1.351
19	1.7100	2.14	1.83	-0.0938	1.351
20	1.8050	-3.68	1.71	-0.0938	1.351
21	1.9000	-3.56	1.37	-0.0938	1.351
22	1.9950	-3.45	1.03	-0.0938	1.351
23	2.0900	-3.33	0.71	-0.0938	1.351
24	2.1850	-3.21	0.40	-0.0938	1.351
25	2.2800	-3.09	0.10	-0.0938	1.351
26	2.3750	-2.97	-0.19	-0.0938	1.351
27	2.4700	-2.85	-0.46	-0.0938	1.351
28	2.5650	-2.73	-0.73	-0.0938	1.351
29	2.6600	-2.61	-0.98	-0.0938	1.351
30	2.7550	-2.49	-1.22	-0.0938	1.351
31	2.8500	-2.38	-1.46	-0.0938	1.351
32	2.9450	-2.26	-1.68	-0.0938	1.351
33	3.0400	-2.14	-1.88	-0.0938	1.350
34	3.1350	-2.02	-2.08	-0.0938	1.350
35	3.2300	-1.90	-2.27	-0.0938	1.350
36	3.3250	-1.78	-2.44	-0.0938	1.350
37	3.4200	-1.66	-2.61	-0.0938	1.350
38	3.5150	-1.54	-2.76	-0.0938	1.350
39	3.6100	-1.43	-2.90	-0.0938	1.350
40	3.7050	-1.31	-3.03	-0.0938	1.350
41	3.8000	-1.19	-3.15	-0.0938	1.350
42	3.8950	-1.07	-3.26	-0.0938	1.350
43	3.9900	-0.95	-3.35	-0.0938	1.350
44	4.0850	-0.83	-3.44	-0.0938	1.350
45	4.1800	-0.71	-3.51	-0.0938	1.350
46	4.2750	-0.59	-3.57	-0.0938	1.350
47	4.3700	-0.48	-3.62	-0.0938	1.350
48	4.4650	-0.36	-3.66	-0.0938	1.350
49	4.5600	-0.24	-3.69	-0.0938	1.350
50	4.6550	-0.12	-3.71	-0.0938	1.350
51	4.7500	0.00	-3.71	-0.0938	1.350
52	4.8450	0.12	-3.71	-0.0938	1.350

53	4.9400	0.24	-3.69	-0.0938	1.350
54	5.0350	0.36	-3.66	-0.0938	1.350
55	5.1300	0.48	-3.62	-0.0938	1.350
56	5.2250	0.59	-3.57	-0.0938	1.350
57	5.3200	0.71	-3.51	-0.0938	1.350
58	5.4150	0.83	-3.44	-0.0938	1.350
59	5.5100	0.95	-3.35	-0.0938	1.350
60	5.6050	1.07	-3.26	-0.0938	1.350
61	5.7000	1.19	-3.15	-0.0938	1.350
62	5.7950	1.31	-3.03	-0.0938	1.350
63	5.8900	1.43	-2.90	-0.0938	1.350
64	5.9850	1.54	-2.76	-0.0938	1.350
65	6.0800	1.66	-2.61	-0.0938	1.350
66	6.1750	1.78	-2.44	-0.0938	1.350
67	6.2700	1.90	-2.27	-0.0938	1.350
68	6.3650	2.02	-2.08	-0.0938	1.350
69	6.4600	2.14	-1.88	-0.0938	1.350
70	6.5550	2.26	-1.68	-0.0938	1.351
71	6.6500	2.38	-1.46	-0.0938	1.351
72	6.7450	2.49	-1.22	-0.0938	1.351
73	6.8400	2.61	-0.98	-0.0938	1.351
74	6.9350	2.73	-0.73	-0.0938	1.351
75	7.0300	2.85	-0.46	-0.0938	1.351
76	7.1250	2.97	-0.19	-0.0938	1.351
77	7.2200	3.09	0.10	-0.0938	1.351
78	7.3150	3.21	0.40	-0.0938	1.351
79	7.4100	3.33	0.71	-0.0938	1.351
80	7.5050	3.45	1.03	-0.0938	1.351
81	7.6000	3.56	1.37	-0.0938	1.351
82	7.6950	3.68	1.71	-0.0938	1.351
83	7.7900	-2.14	1.83	-0.0938	1.351
84	7.8850	-2.02	1.63	-0.0938	1.351
85	7.9800	-1.90	1.44	-0.0938	1.351
86	8.0750	-1.78	1.27	-0.0938	1.351
87	8.1700	-1.66	1.11	-0.0938	1.351
88	8.2650	-1.54	0.95	-0.0938	1.351
89	8.3600	-1.43	0.81	-0.0938	1.351
90	8.4550	-1.31	0.68	-0.0938	1.351
91	8.5500	-1.19	0.56	-0.0938	1.351
92	8.6450	-1.07	0.46	-0.0938	1.351
93	8.7400	-0.95	0.36	-0.0938	1.351
94	8.8350	-0.83	0.28	-0.0938	1.351
95	8.9300	-0.71	0.20	-0.0938	1.351
96	9.0250	-0.59	0.14	-0.0938	1.351
97	9.1200	-0.48	0.09	-0.0938	1.351
98	9.2150	-0.36	0.05	-0.0938	1.351
99	9.3100	-0.24	0.02	-0.0938	1.351
100	9.4050	-0.12	0.01	-0.0938	1.351
101	9.5000	0.00	0.00	-0.0938	1.351

ARCADIS

SUBJECT: TOPOCK GA – PG&E
IRZ UNLOADING PAD
JOB NO:

BY: MSL DATE: 6/20/14
CHKD: DATE:

PAGE D-7
SHEET 1

~ USE 20" (⊥ TO TRAFFIC) TIRE CONTACT AREA PER AASHTO (SHT D-1B)

- SEE SHT D-8 FOR SLAB-ON-GRADE DESIGN FOR TIRE POINT LOAD:
  - $V_{UNF} = 2.67^K$ (x1.6 ACI) = 4.27^K_{ACI}
  - $M_{UNF} = 3.71^{KIFT}$ ↓ = 5.94^{KIFT}_{ACI} ← NO NEED TO MULTIPLY BY ACI 350 Sd SINCE 1.3 IMPACT FACTOR USED 4 DYNAMIC
- USE 8" SOG w/ STEEL CENTERED ~ $d = 8''/2 - 4/16'' = 3.75''$
  - $\phi V_C = 4.27^K \approx V_{ACI} = 2.67^K \times 1.6_{ACI} = 4.27^K$ ✓OK (CONSERV B/C 4500 SPECIFIED)
  - $R = M_U / \phi b d^2 = 469.0 \rightarrow \rho = 0.00845 \rightarrow A_S = 0.38 \, in^2/ft$

→ USE #5 @ 8" o/c EW CENTERED IN SLAB ($A_S = 0.46 \, in^2/ft$) ✓OK

→ REF SHT D-7A FOR ACI 350 DESIGN (INCL 1.3 IMPACT FACTOR)
  ~ #5 @ 9" o/c ~ $\phi M_N / M_U = 0.98$
  ~ #5 @ 8" o/c – " = 1.19 ✓OK

~ USE 2" COVER MAX SINCE $ PENALIZED FOR EXCESSIVE COVER

→ ACI 318 10.6.4 SPACING REQ'S = $S = 15\left(\frac{40{,}000}{f_s}\right) - 2.5 C_c$
  - $f_s = \frac{M_{UNF}}{A_s d \times 7/8} = 29.9 \, ksi < 2/3 f_y$ $S = 11.6^{IN} > 8''$ PROV'D ✓OK ($\angle 3\,3/8''$)

- ACI 350 T&S STL
  - SHORT DIR (13'-4" POUR) ~ $A_{S\,REQ'D} = 0.0036 b h$ (12", 8") $= 0.29 \, in^2/ft$ ← ✓OK
  - LONG DIR (80 FT > 40 FT) — $A_{S\,REQ'D} = 0.005 b h = 0.48 \, in^2/ft$ ← ✓OK

→ PROVIDE CONSTRUCTION JOINTS BREAKING 80 FT DIRECTION INTO MAX 16 FT POURS

ACI 350-06- One Way Slab Design

d_b =	0.625	in	bar dia
s =	8	in	center to center spacing of bars
c_c =	2	in	Clear Cover
h =	8	in	Total Thickness of Section
f'c =	4000	psi	28 day conc strength
fy =	60000	psi	restl yield
Ma =	3,710.0	ft lbs	unfactored bending moment

R =	319.2
ρ =	0.0056
ρ used =	0.0056
As Req =	0.382 in²

As trial =	0.46	sq.in/ft	
d =	5.69	in	effective section depth
ρ =	0.0067		steel ratio
n =	8.06		Es/Ec
k =	0.28		
j =	0.9067		

@ 3 3/8" COVER AS INSTALLED SO INCREASES TO 2.29 & φMn/Mu = 0.61 (TOO CONSERVATIVE)

at Service Loading

k*d =	1.59	in	compression block depth
c =	1.87	in	neutral axis location
j*d =	5.16	in	internal moment arm
β =	1.61		strain gradient amp. Factor EQ 10-6
fs max =	21.56	ksi	max steel stress EQ 10-4

at Factored Loading

γ = u =	1.60		ACI factor
S_d =	1.57		environmental durability factor
Mu =	9,293.0	ft lbs	factored moment
a =	0.68	in	compression block depth
c =	0.796	in	neutral axis location
jd =	5.35	in	internal moment arm
φMn =	11,077.4	ft lbs	nominal moment capacity

φMn/Mu = 1.192

					Strength Check	Steel Check
#	5	@	8	c/c	Pass	Pass

Hook Length

As req =	0.382	sq in	
As prov =	0.46	sq in	
β =	1	Epoxy coating, 1.2 Epoxy coating	
λ =	1	Lightweight Concrete 1.3	
Side Cover =	0.7	Cover pependicular to hook >2.5", 2" bar extention	
d_b =	0.625	(in) bar size	
l_{dh} =	6.9	in	

ACI 350-06- One Way Slab Design

d_b =	0.625	in	bar dia
s =	9	in	center to center spacing of bars
c_c =	2	in	Clear Cover
h =	8	in	Total Thickness of Section
f'c =	4000	psi	28 day conc strength
fy =	60000	psi	restl yield
Ma =	3,710.0	ft lbs	unfactored bending moment

R =	347.3
ρ =	0.0061
ρ used =	0.0061
As Req =	0.418 in^2

As trial =	0.41	sq.in/ft	
d =	5.69	in	effective section depth
ρ =	0.0060		steel ratio
n =	8.06		Es/Ec
k =	0.27		
j =	0.9100		

at Service Loading

k*d =	1.54	in	compression block depth
c =	1.81	in	neutral axis location
j*d =	5.18	in	internal moment arm
β =	1.60		strain gradient amp. Factor EQ 10-6
fs max =	19.82	ksi	max steel stress EQ 10-4

at Factored Loading

γ = u =	1.60		ACI factor
S_d =	1.70		environmental durability factor
Mu =	10,109.9	ft lbs	factored moment
a =	0.60	in	compression block depth
c =	0.708	in	neutral axis location
jd =	5.39	in	internal moment arm
φMn =	9,915.7	ft lbs	nominal moment capacity

φMn/Mu = 0.981

						Strength Check	Steel Check
#	5	@	9	c/c		FAIL	FAIL

Hook Length

As req =	0.418	sq in
As prov =	0.41	sq in
β =	1	Epoxy coating, 1.2 Epoxy coating
λ =	1	Lightweight Concrete 1.3
Side Cover =	0.7	Cover pependicular to hook >2.5", 2" bar extention
d_b =	0.625	(in) bar size
l_{dh} =	8.5	in

D-8

"BOEF.xls" Program
Version 1.4

BEAM ON ELASTIC FOUNDATION ANALYSIS

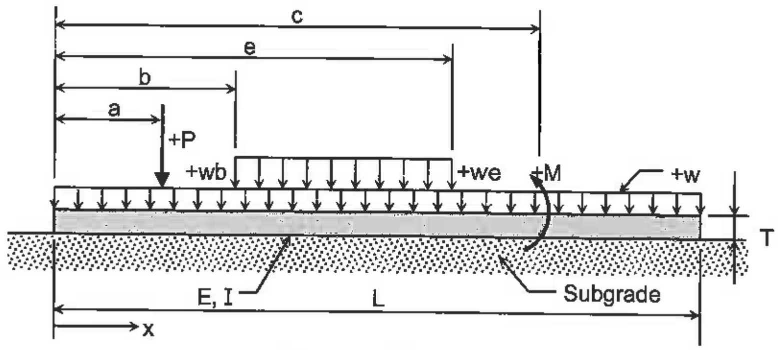
For Soil Supported Beam, Combined Footing, Slab Strip or Mat Strip of Assumed Finite Length with Both Ends Free

Job Name:	RG&E - Topok, CA - IRZ Unloading Pads	Subject:	Slab-on-Grade
Job Number:	RC000753.0008	Originator:	MSL	Checker:

Input Data:

Beam Data:

Length, L =	9.5000	ft.
Width, B =	1.0000	ft.
Thickness, T =	8.0000	ft.
Modulus, E =	3600	ksi
Subgrade, K =	100	pci



Nomenclature

Beam Loadings:

Full Uniform:
w = 0.0000 kips/ft.

Distributed:

	Start		End	
	b (ft.)	Wb (kips/ft.)	e (ft.)	We (kips/ft.)
#1:	0.9167	3.5640	2.5830	3.5640
#2:	6.9167	3.5640	8.5830	3.5640
#3:				
#4:				
#5:				
#6:				

10IN EACH SIDE OF 1.75FT & 7.75FT WHEEL LOAD LOCATION
20" CONTACT AREA

Point Loads:

	a (ft.)	P (kips)
#1:		
#2:		
#3:		
#4:		
#5:		
#6:		
#7:		
#8:		
#9:		
#10:		
#11:		
#12:		

Moments:

	c (ft.)	M (ft-kips)
#1:		
#2:		
#3:		
#4:		

Results:

Beam Flexiblity Criteria:

for $\beta*L <= \pi/4$ beam is rigid
for $\pi/4 < \beta*L < \pi$ beam is semi-rigid
for $\beta*L >= \pi$ beam is flexible
for $\beta*L >= 6$ beam is semi-infinite long

Inertia, I =	42.6667	ft.^4	I = B*T^3/12
β =	0.037		β = ((K*B)/(4*E*I))^(1/4)
β*L =	0.355		β*L = Flexibility Factor

Beam is rigid

Max. Shears and Locations:

+V(max) =	2.67 ✓	k	@ x =	6.94	ft.
-V(max) =	-2.67	k	@ x =	2.57	ft.

Max. Moments and Locations:

+M(max) =	0.81	ft-k	@ x =	8.08	ft.
-M(max) =	-3.71 ✓	ft-k	@ x =	4.75	ft.

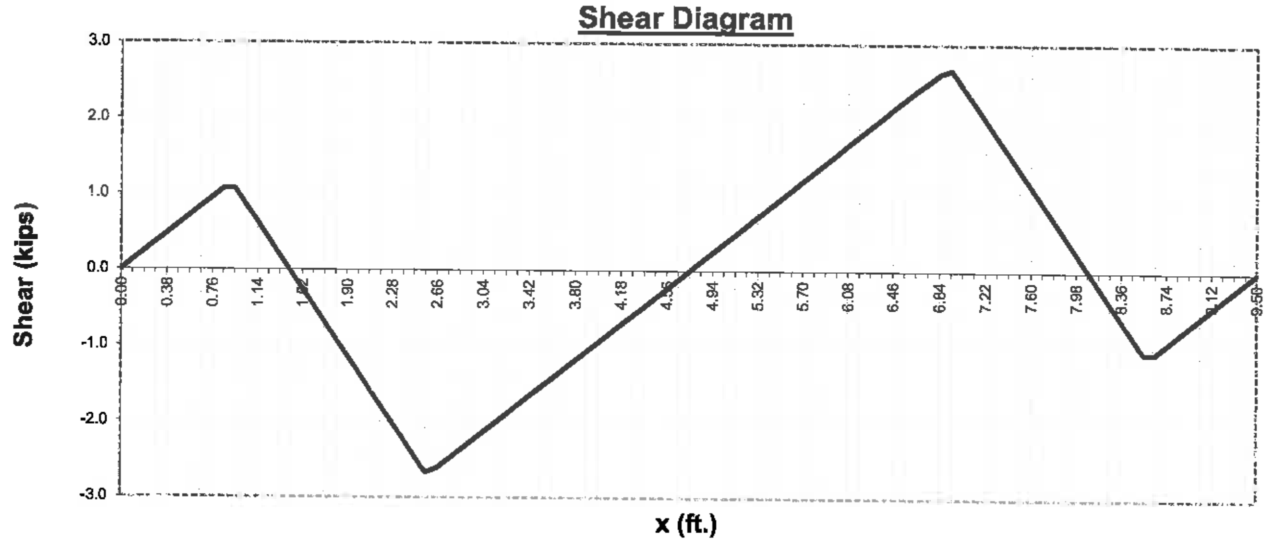
Max. Deflection and Location:

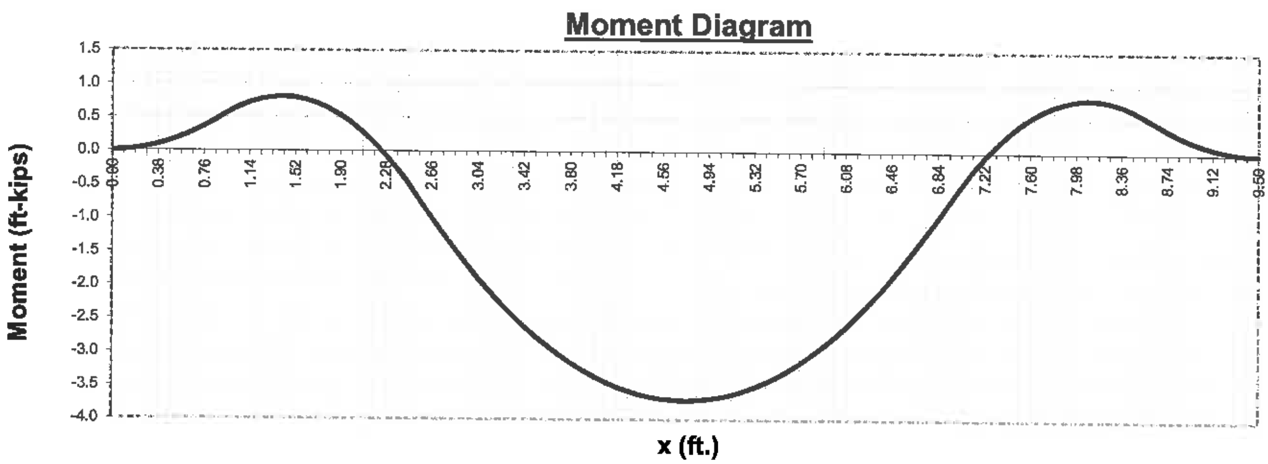
Δ(max) =	-0.087 ✓	in.	@ x =	0.00	ft.

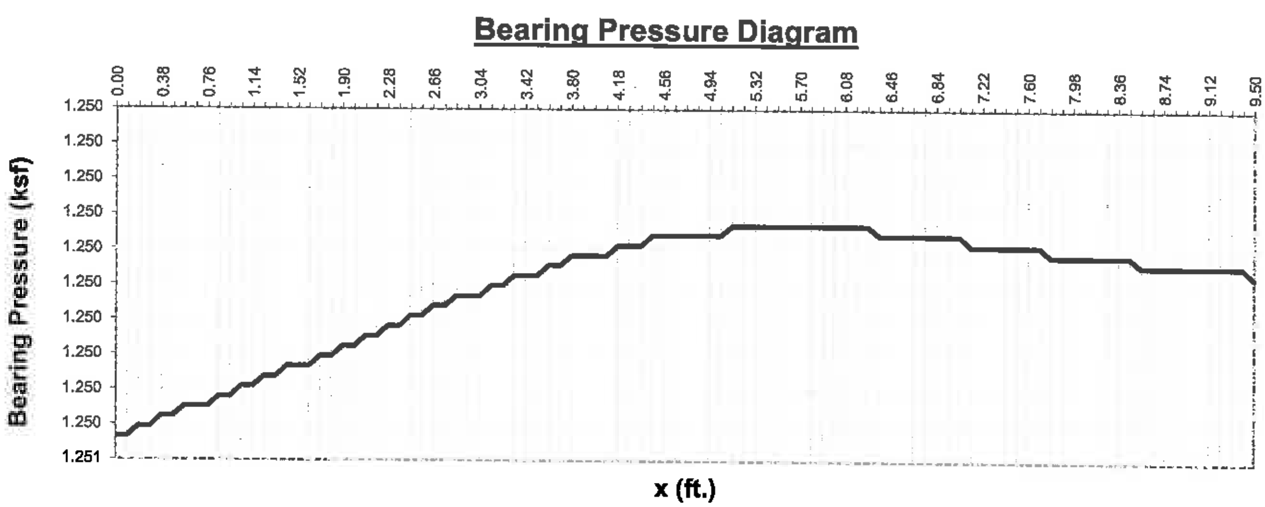
Max. Soil Pressure and Location:

Q(max) =	1.250 ✓	ksf	@ x =	0.00	ft.

Comments:


Shear Diagram
Shear (kips)
3.0
2.0
1.0
0.0
-1.0
-2.0
-3.0
0.00
0.38
0.76
1.14
1.52
1.90
2.28
2.66
3.04
3.42
3.80
4.18
4.56
4.94
5.32
5.70
6.08
6.46
6.84
7.22
7.60
7.98
8.36
8.74
9.12
9.50
x (ft.)


Moment Diagram
Moment (ft-kips)
1.5
1.0
0.5
0.0
-0.5
-1.0
-1.5
-2.0
-2.5
-3.0
-3.5
-4.0
0.00
0.38
0.76
1.14
1.52
1.90
2.28
2.66
3.04
3.42
3.80
4.18
4.56
4.94
5.32
5.70
6.08
6.46
6.84
7.22
7.60
7.98
8.36
8.74
9.12
9.50
x (ft.)


Bearing Pressure Diagram
Bearing Pressure (ksf)
0.00
0.38
0.76
1.14
1.52
1.90
2.28
2.66
3.04
3.42
3.80
4.18
4.56
4.94
5.32
5.70
6.08
6.46
6.84
7.22
7.60
7.98
8.36
8.74
9.12
9.50
1.250
1.250
1.250
1.250
1.250
1.250
1.250
1.250
1.250
1.250
1.251
x (ft.)

Tabulation of Beam Shear, Moment, Deflection, and Bearing Pressure for 100 Equal Segments					
Point #	x (ft.)	Shear (k)	Moment (ft-k)	Deflection (in.)	Bearing Pressure (ksf)
1	0.0000	0.00	0.00	-0.0868	1.250
2	0.0950	0.12	0.01	-0.0868	1.250
3	0.1900	0.24	0.02	-0.0868	1.250
4	0.2850	0.36	0.05	-0.0868	1.250
5	0.3800	0.48	0.09	-0.0868	1.250
6	0.4750	0.59	0.14	-0.0868	1.250
7	0.5700	0.71	0.20	-0.0868	1.250
8	0.6650	0.83	0.28	-0.0868	1.250
9	0.7600	0.95	0.36	-0.0868	1.250
10	0.8550	1.07	0.46	-0.0868	1.250
11	0.9500	1.07	0.56	-0.0868	1.250
12	1.0450	0.85	0.65	-0.0868	1.250
13	1.1400	0.63	0.72	-0.0868	1.250
14	1.2350	0.41	0.77	-0.0868	1.250
15	1.3300	0.19	0.80	-0.0868	1.250
16	1.4250	-0.03	0.81	-0.0868	1.250
17	1.5200	-0.25	0.80	-0.0868	1.250
18	1.6150	-0.47	0.76	-0.0868	1.250
19	1.7100	-0.69	0.71	-0.0868	1.250
20	1.8050	-0.91	0.63	-0.0868	1.250
21	1.9000	-1.13	0.53	-0.0868	1.250
22	1.9950	-1.35	0.42	-0.0868	1.250
23	2.0900	-1.57	0.28	-0.0868	1.250
24	2.1850	-1.79	0.12	-0.0868	1.250
25	2.2800	-2.01	-0.06	-0.0868	1.250
26	2.3750	-2.23	-0.26	-0.0868	1.250
27	2.4700	-2.45	-0.49	-0.0868	1.250
28	2.5650	-2.67	-0.73	-0.0868	1.250
29	2.6600	-2.61	-0.98	-0.0868	1.250
30	2.7550	-2.49	-1.22	-0.0868	1.250
31	2.8500	-2.38	-1.46	-0.0868	1.250
32	2.9450	-2.26	-1.68	-0.0868	1.250
33	3.0400	-2.14	-1.88	-0.0868	1.250
34	3.1350	-2.02	-2.08	-0.0868	1.250
35	3.2300	-1.90	-2.27	-0.0868	1.250
36	3.3250	-1.78	-2.44	-0.0868	1.250
37	3.4200	-1.66	-2.61	-0.0868	1.250
38	3.5150	-1.54	-2.76	-0.0868	1.250
39	3.6100	-1.42	-2.90	-0.0868	1.250
40	3.7050	-1.31	-3.03	-0.0868	1.250
41	3.8000	-1.19	-3.15	-0.0868	1.250
42	3.8950	-1.07	-3.25	-0.0868	1.250
43	3.9900	-0.95	-3.35	-0.0868	1.250
44	4.0850	-0.83	-3.44	-0.0868	1.250
45	4.1800	-0.71	-3.51	-0.0868	1.250
46	4.2750	-0.59	-3.57	-0.0868	1.250
47	4.3700	-0.47	-3.62	-0.0868	1.250
48	4.4650	-0.36	-3.66	-0.0868	1.250
49	4.5600	-0.24	-3.69	-0.0868	1.250
50	4.6550	-0.12	-3.71	-0.0868	1.250
51	4.7500	0.00	-3.71	-0.0868	1.250
52	4.8450	0.12	-3.71	-0.0868	1.250

53	4.9400	0.24	-3.69	-0.0868	1.250
54	5.0350	0.36	-3.66	-0.0868	1.250
55	5.1300	0.48	-3.62	-0.0868	1.250
56	5.2250	0.59	-3.57	-0.0868	1.250
57	5.3200	0.71	-3.51	-0.0868	1.250
58	5.4150	0.83	-3.43	-0.0868	1.250
59	5.5100	0.95	-3.35	-0.0868	1.250
60	5.6050	1.07	-3.25	-0.0868	1.250
61	5.7000	1.19	-3.15	-0.0868	1.250
62	5.7950	1.31	-3.03	-0.0868	1.250
63	5.8900	1.43	-2.90	-0.0868	1.250
64	5.9850	1.54	-2.76	-0.0868	1.250
65	6.0800	1.66	-2.61	-0.0868	1.250
66	6.1750	1.78	-2.44	-0.0868	1.250
67	6.2700	1.90	-2.27	-0.0868	1.250
68	6.3650	2.02	-2.08	-0.0868	1.250
69	6.4600	2.14	-1.88	-0.0868	1.250
70	6.5550	2.26	-1.67	-0.0868	1.250
71	6.6500	2.38	-1.45	-0.0868	1.250
72	6.7450	2.49	-1.22	-0.0868	1.250
73	6.8400	2.61	-0.98	-0.0868	1.250
74	6.9350	2.67	-0.73	-0.0868	1.250
75	7.0300	2.45	-0.48	-0.0868	1.250
76	7.1250	2.23	-0.26	-0.0868	1.250
77	7.2200	2.01	-0.06	-0.0868	1.250
78	7.3150	1.79	0.12	-0.0868	1.250
79	7.4100	1.57	0.28	-0.0868	1.250
80	7.5050	1.35	0.42	-0.0868	1.250
81	7.6000	1.13	0.53	-0.0868	1.250
82	7.6950	0.91	0.63	-0.0868	1.250
83	7.7900	0.69	0.71	-0.0868	1.250
84	7.8850	0.47	0.76	-0.0868	1.250
85	7.9800	0.25	0.80	-0.0868	1.250
86	8.0750	0.03	0.81	-0.0868	1.250
87	8.1700	-0.19	0.80	-0.0868	1.250
88	8.2650	-0.41	0.77	-0.0868	1.250
89	8.3600	-0.63	0.72	-0.0868	1.250
90	8.4550	-0.85	0.65	-0.0868	1.250
91	8.5500	-1.07	0.56	-0.0868	1.250
92	8.6450	-1.07	0.46	-0.0868	1.250
93	8.7400	-0.95	0.36	-0.0868	1.250
94	8.8350	-0.83	0.28	-0.0868	1.250
95	8.9300	-0.71	0.20	-0.0868	1.250
96	9.0250	-0.59	0.14	-0.0868	1.250
97	9.1200	-0.48	0.09	-0.0868	1.250
98	9.2150	-0.36	0.05	-0.0868	1.250
99	9.3100	-0.24	0.02	-0.0868	1.250
100	9.4050	-0.12	0.01	-0.0868	1.250
101	9.5000	0.00	0.00	-0.0868	1.250

CURB WALL DESIGN

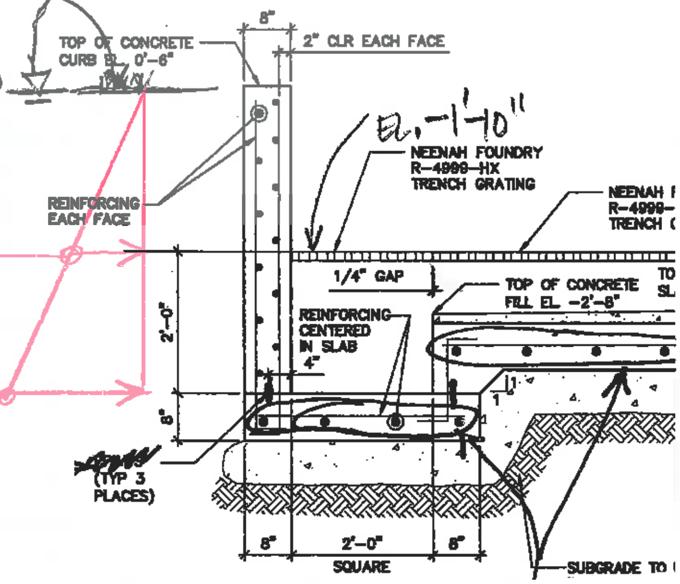
- WORST CASE WALL IS @ SUMP BUT THAT IS TOO CONSERVATIVE TO DESIGN AS VERTICAL CANTILEVER @ THAT LOCATION
  ~ WILL DESIGN THAT PORTION TO SPAN HORIZONTALLY 2 FT CLEAR TO SHORTER "MORE STOUT" VERTICAL CANTILEVERS.

GRADE @ GW @ TOP OF WALL CONSERVATIVE

$[130-62.4 \times K_a=0.5]+62.4\,pcf_{HYDRO}$
$=96.2\,psf$ PER 1 FT DEPTH

$(6''+1'\text{-}10'')\times 96.2\,psf = 225\#/FT$

$(6''+1'\text{-}10''+2^{FT})\times '' = 417\#/FT$



~ HORIZ STEEL IN 8" DISTRIBUTES LOAD 1 FT EACH SIDE OF 2'-0" SUMP (SPAN 4 FT C/C)

- $d = 3''$ COVER VERT STL FROM OUTSIDE FACE $+ 4/8'' + 4/16'' = 3.75''$
- $\phi V_c = 2\phi\sqrt{f'_c}\,bd = 4.27^K \gg V_{ACI} = \left(\frac{417\#/FT_{UNF}\times 4^{FT}}{2}\right)\times 1.6_{ACI} = 1.34^K$ ✓ OK
- $M_{U\,ACI\,w/SAN} = \frac{wl^2}{8} = \frac{(417\#/FT_{UNF}\times 1.6_{ACI}\times 1.3_{SAN})\times 4FT^2}{8}$ CONSER. $= 2.135^{K\cdot FT}_{ACI\,w/SAN}$ $(0.834^{K\cdot FT}_{UNF})$
- $R = M_u/\phi bd^2 = 168.7 \rightarrow \rho = 0.0029 \rightarrow A_s = \rho_{MIN}bd = 0.15\ IN^2/FT$

$\rightarrow$ USE #5 @ 8" C/C ($A_s = 0.46\,IN^2/FT$) ✓ OK

DESIGN CANTILEVERED PORTION

- WORST CASE EXTERIOR LOADING (ADJACENT TO TRENCH GRATING SUMP)
- LOAD =  ~ FIRST 3FT OF WALL PICK UP 1/2 OF 2FT SUMP HORIZONTAL SPAN

  225#/FT

  (i.e. $(3^{FT} + \frac{2^{FT}}{2}) / 3^{FT} \Rightarrow 1.333\uparrow$ INCREASE

- $V_{UNF} = W = (225^{\#}/_{FT} \times 2.33^{FT}) \times 1.333\uparrow = 0.35^{K}_{UNF}, (\times 1.6_{ACI})\ 0.56^{K}$

  $\times 0.5 \times$ 2.33

- $M_{UNF} = Wl/3 = 0.272^{KIFT},\ 0.44^{KIFT}$

~ USING 8" WALL w/ $d_{VERT\ STL} = 8'' - 3''\text{COVER} - 5/16'' = 4.7^{IN}$

OUTSIDE FACE MOMENT

- $\phi V_C = 5.34K \gg V_{ACI}$ ✓OK
- REF SHT D-10 FOR IRZ PAD CONCRETE WALLS RESTEEL DESIGN ←
- ACI 350 T&S ~ LONG DIR = 80FT > 40FT

  $A_{S\,REQ'D} = 0.004 \times 12'' \times 8'' = 0.38^{IN^2}/_{FT}$ ←

  USING #5 @ 8" o/c ($A_S = 0.46^{IN^2}/_{FT}$) ✓OK

  EF/EW

~ WILL BREAK 80FT DIRECTION INTO (5) 16FT POURS TO MINIMIZE CRACKING SLIGHTLY.

D-11

ACI 350-06- One Way Slab Design

d_b =	0.625	in	bar dia
s =	9	in	center to center spacing of bars
c_c =	3	in	Clear Cover
h =	8	in	Total Thickness of Section
f'c =	4000	psi	28 day conc strength
fy =	60000	psi	restl yield
Ma =	272.0	ft lbs	unfactored bending moment

R =	48.7
ρ =	0.0008
ρ used =	~~0.0011~~
As Req =	0.061 in^2

As trial =	0.41	sq.in/ft	
d =	4.69	in	effective section depth
ρ =	0.0073		steel ratio
n =	8.06		Es/Ec
k =	0.29		
j =	0.9033		

at Service Loading

k*d =	1.36	in	compression block depth
c =	1.60	in	neutral axis location
j*d =	4.23	in	internal moment arm
β =	2.07		strain gradient amp. Factor EQ 10-6
fs max =	15.26	ksi	max steel stress EQ 10-4

at Factored Loading

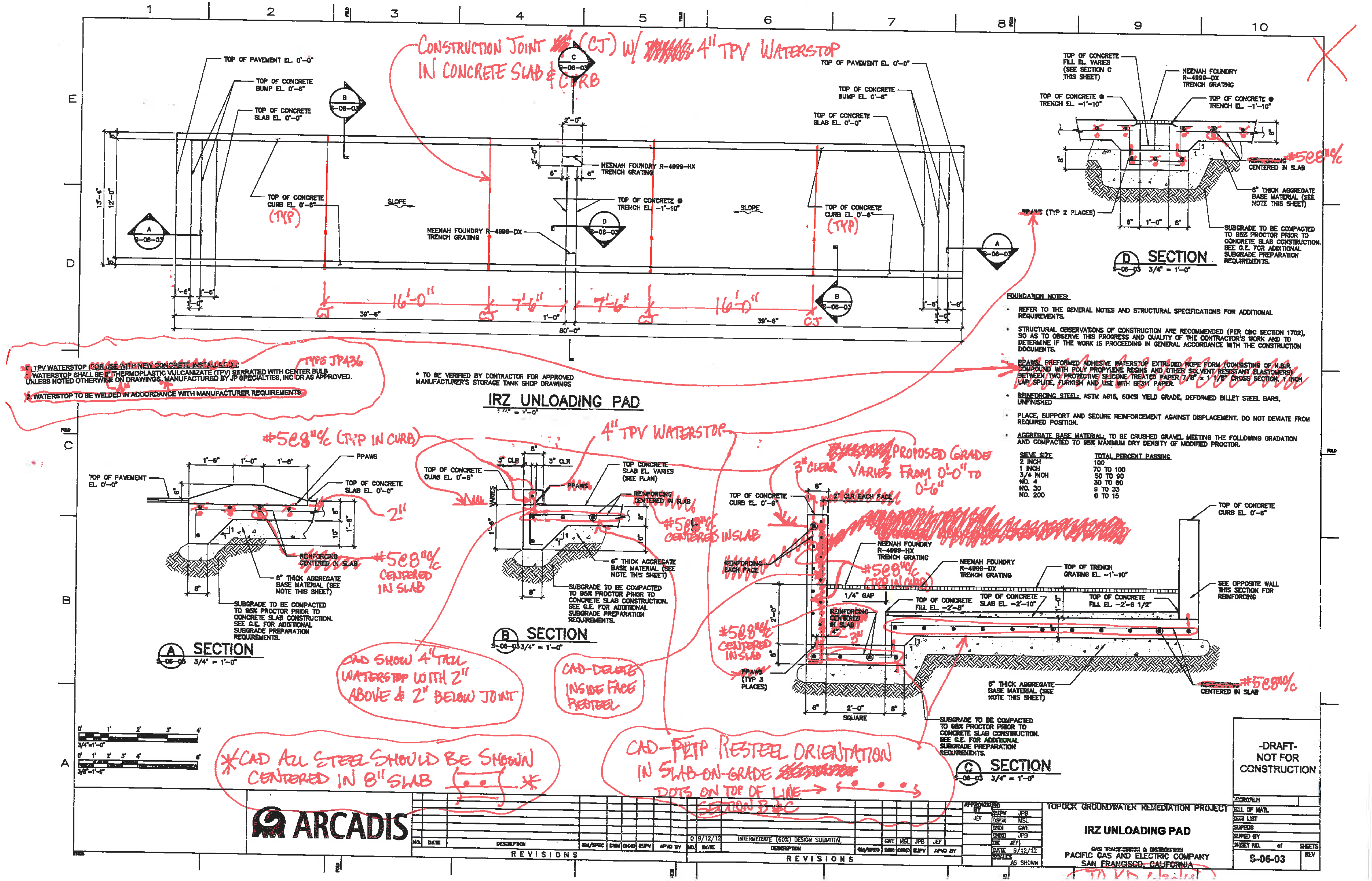
γ = u =	1.60		ACI factor
S_d =	2.21		environmental durability factor
Mu =	962.6	ft lbs	factored moment
a =	0.60	in	compression block depth
c =	0.708	in	neutral axis location
jd =	4.39	in	internal moment arm
φMn =	8,075.0	ft lbs	nominal moment capacity

φMn/Mu = 8.388

					Strength Check	Steel Check
#	5	@	9	c/c	Pass	Pass

Hook Length

As req =	0.061	sq in
As prov =	0.41	sq in
β =	1	Epoxy coating, 1.2 Epoxy coating
λ =	1	Lightweight Concrete 1.3
Side Cover =	0.7	Cover pependicular to hook >2.5", 2" bar extention
d_b =	0.625	(in) bar size
l_{dh} =	1.2	in



CONSTRUCTION JOINT (CJ) W/ 4" TPV WATERSTOP IN CONCRETE SLAB & CURB
TOP OF PAVEMENT EL. 0'-0"
TOP OF CONCRETE BUMP EL. 0'-6"
TOP OF CONCRETE SLAB EL. 0'-0"
TOP OF CONCRETE CURB EL. 0'-6" (TYP)
NEENAH FOUNDRY R-4999-HX TRENCH GRATING
TOP OF CONCRETE @ TRENCH EL. -1'-10"
NEENAH FOUNDRY R-4999-DX TRENCH GRATING
SLOPE
16'-0"
7'-6"
CJ
39'-6"
80'-0"
C. TPV WATERSTOP (FOR USE WITH NEW CONCRETE INSTALLATION):
1. WATERSTOP SHALL BE 6" THERMOPLASTIC VULCANIZATE (TPV) SERRATED WITH CENTER BULB UNLESS NOTED OTHERWISE ON DRAWINGS, MANUFACTURED BY JP SPECIALTIES, INC OR AS APPROVED.
2. WATERSTOP TO BE WELDED IN ACCORDANCE WITH MANUFACTURER REQUIREMENTS.
TYPE JP436
* TO BE VERIFIED BY CONTRACTOR FOR APPROVED MANUFACTURER'S STORAGE TANK SHOP DRAWINGS
IRZ UNLOADING PAD
TOP OF CONCRETE FILL EL. VARIES (SEE SECTION C THIS SHEET)
NEENAH FOUNDRY R-4999-DX TRENCH GRATING
REINFORCING CENTERED IN SLAB
#5@8"o/c
3" THICK AGGREGATE BASE MATERIAL (SEE NOTE THIS SHEET)
PPAWS (TYP 2 PLACES)
SUBGRADE TO BE COMPACTED TO 95% PROCTOR PRIOR TO CONCRETE SLAB CONSTRUCTION. SEE G.E. FOR ADDITIONAL SUBGRADE PREPARATION REQUIREMENTS.
D SECTION 3/4" = 1'-0"
FOUNDATION NOTES:
• REFER TO THE GENERAL NOTES AND STRUCTURAL SPECIFICATIONS FOR ADDITIONAL REQUIREMENTS.
• STRUCTURAL OBSERVATIONS OF CONSTRUCTION ARE RECOMMENDED (PER CBC SECTION 1702), SO AS TO OBSERVE THIS PROGRESS AND THE CONTRACTOR'S WORK AND TO DETERMINE IF THE WORK IS PROCEEDING IN GENERAL ACCORDANCE WITH THE CONSTRUCTION DOCUMENTS.
• PPAWS: PREFORMED ADHESIVE WATERSTOP EXTRUDED ROPE FORM (CONSISTING OF N.B.R. COMPOUND WITH POLY PROPYLENE RESINS AND OTHER SOLVENT RESISTANT ELASTOMERS) BETWEEN TWO PROTECTIVE SILICONE TREATED PAPER 7/8" x 1 1/8" CROSS SECTION, 1 INCH LAP SPLICE. FURNISH AND USE WITH SF311 PAPER.
• REINFORCING STEEL: ASTM A615, 60KSI YIELD GRADE, DEFORMED BILLET STEEL BARS, UNFINISHED
• PLACE, SUPPORT AND SECURE REINFORCEMENT AGAINST DISPLACEMENT. DO NOT DEVIATE FROM REQUIRED POSITION.
• AGGREGATE BASE MATERIAL: TO BE CRUSHED GRAVEL MEETING THE FOLLOWING GRADATION AND COMPACTED TO 95% MAXIMUM DRY DENSITY OF MODIFIED PROCTOR.
SIEVE SIZE | TOTAL PERCENT PASSING
2 INCH | 100
1 INCH | 70 TO 100
3/4 INCH | 50 TO 90
NO. 4 | 30 TO 60
NO. 30 | 9 TO 33
NO. 200 | 0 TO 15
#5@8"o/c (TYP IN CURB)
4" TPV WATERSTOP
PROPOSED GRADE VARIES FROM 0'-0" TO 0'-6"
3" CLEAR
2" CLR EACH FACE
A SECTION 3/4" = 1'-0"
B SECTION 3/4" = 1'-0"
C SECTION 3/4" = 1'-0"
CAD SHOW 4" TALL WATERSTOP WITH 2" ABOVE & 2" BELOW JOINT
CAD-DELETE INSIDE FACE RESTEEL
*CAD ALL STEEL SHOULD BE SHOWN CENTERED IN 8" SLAB
CAD-FLIP RESTEEL ORIENTATION IN SLAB-ON-GRADE DOTS ON TOP OF LINE SECTION B & C
6" THICK AGGREGATE BASE MATERIAL (SEE NOTE THIS SHEET)
SEE OPPOSITE WALL THIS SECTION FOR REINFORCING
-DRAFT- NOT FOR CONSTRUCTION
ARCADIS
INTERMEDIATE (60%) DESIGN SUBMITTAL 9/12/12
REVISIONS
TOPOCK GROUNDWATER REMEDIATION PROJECT
IRZ UNLOADING PAD
PACIFIC GAS AND ELECTRIC COMPANY SAN FRANCISCO, CALIFORNIA
S-06-03

ARCADIS

SUBJECT: TOPOK-MW-20 BENCH BLDG

JOB NO:

BY: MSL DATE: 10/7/15

CHKD: DATE:

PAGE E-1

SHEET 1

MW-20 BENCH BLDG

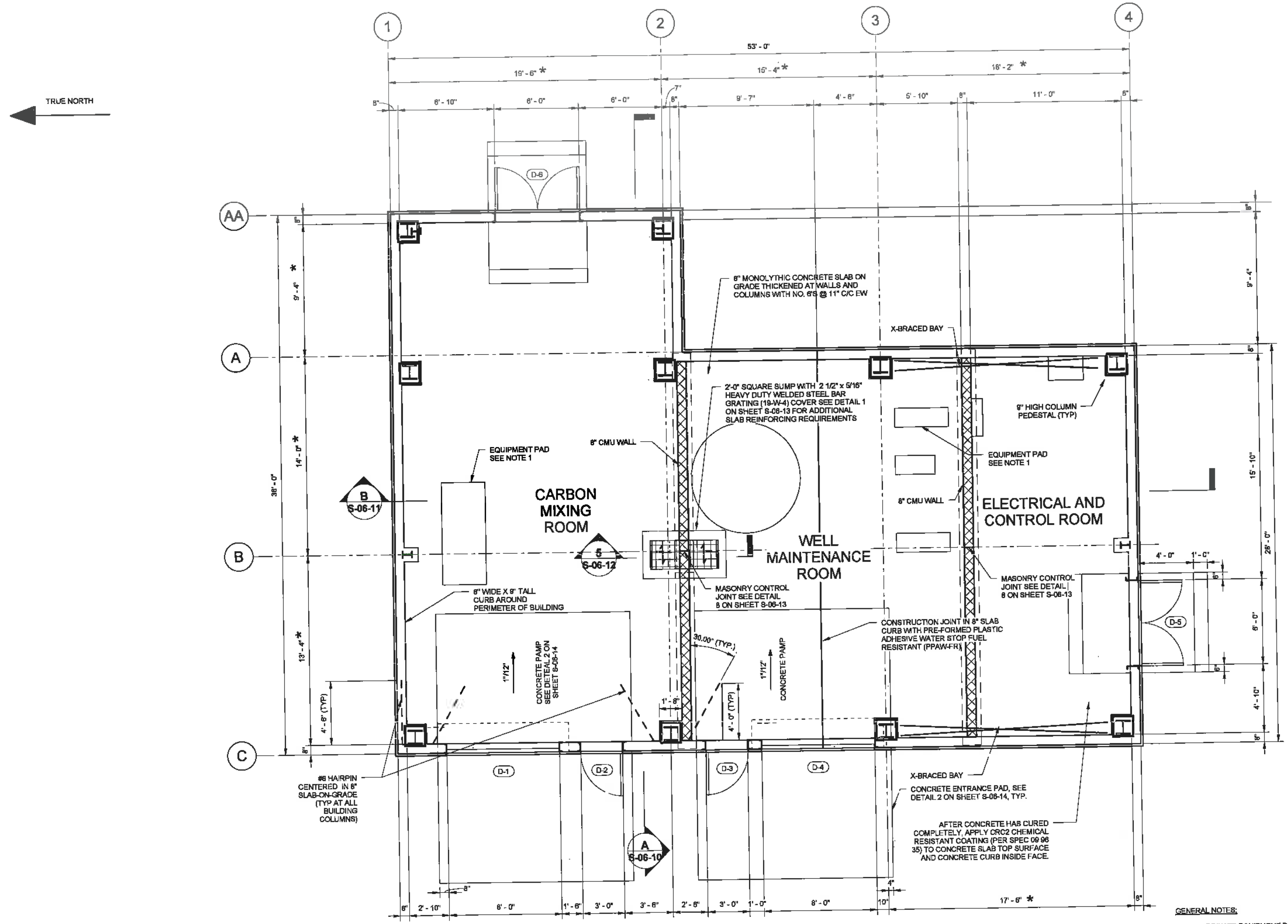
- REF SHT E-2 FOR BUILDING PLAN & SECTION
- REF SHT E-3 FOR CBC 2013/IBC 2012 WIND & SEISMIC LOADS
- DEAD LOADS:
  - WALLS
    - WALL PANEL = 1.5 psf (24 GA METAL WALL PANEL)
    - LINER = 1.5 psf
    - INSULATION = 1 psf
    - GIRTS 10#/ft / 5 ft o/c = 2 psf

      TOTAL = 6 psf
  - ROOF
    - ROOF PANEL = 1.5 psf (24 GA STANDING SEAM ROOF PANEL)
    - LINER = 1.5 psf
    - INSULATION = 1 psf
    - PURLINS 10#/ft / 4 ft o/c = 2.5 psf
    - MECH/ELEC = 5 ~~10~~ psf
    - COLLATERAL = 5 psf

      TOTAL = 16.5 psf ✓ MAX

      TOTAL = 4 psf ✓ MIN (NO MECH/ELEC, NO COLLATERAL, NO LINER, 1.5 psf SS→METAL)

E-2



FINISH FLOOR PLAN
1/4" = 1'-0"

GENERAL NOTES:

1. COORDINATE EQUIPMENT PADS WITH MECHANICAL DRAWINGS. SEE DETAIL 2 ON SHEET S-06-13 FOR CONSTRUCTION REQUIREMENTS.
2. CONCRETE SLAB-ON-GRADE IN BUILDING, CONCRETE RAMPS, AND HEAVY DUTY WELDED STEEL BAR GRATING IS DESIGNED FOR 3 TON FORKLIFT (RATED CAPACITY) AND HS-20 TRAFFIC LOADS (LOADS NOT ACTING SIMULTANEOUSLY).
3. ALL INTERIOR PIPE SUPPORTS TO BE DESIGNED BY CALIFORNIA P.E. HIRED BY CONTRACTOR AND PIPE SUPPORTS TO BE PORVIDED BY CONTRACTOR.

* COLUMN AND FOUNDATION LOCATIONS TO BE VERIFIED PER APPROVED PRE-ENGINEERED BUILDING COLUMN LOCATIONS.

- DRAFT -
NOT FOR CONSTRUCTION

ETIC ENGINEERING

NO.	DATE	DESCRIPTION	GM/SPEC	DWN	CHKD	SUP	APVD BY
1	09/08/14	INTERMEDIATE (90%) DESIGN SUBMITTAL		GWE	JR	MSL	LT

REVISIONS

SUP	MSL
	JR
	GWE
CHKD	JR
	LT
DATE	09/08/14
SCALES	NONE or AS SHOWN

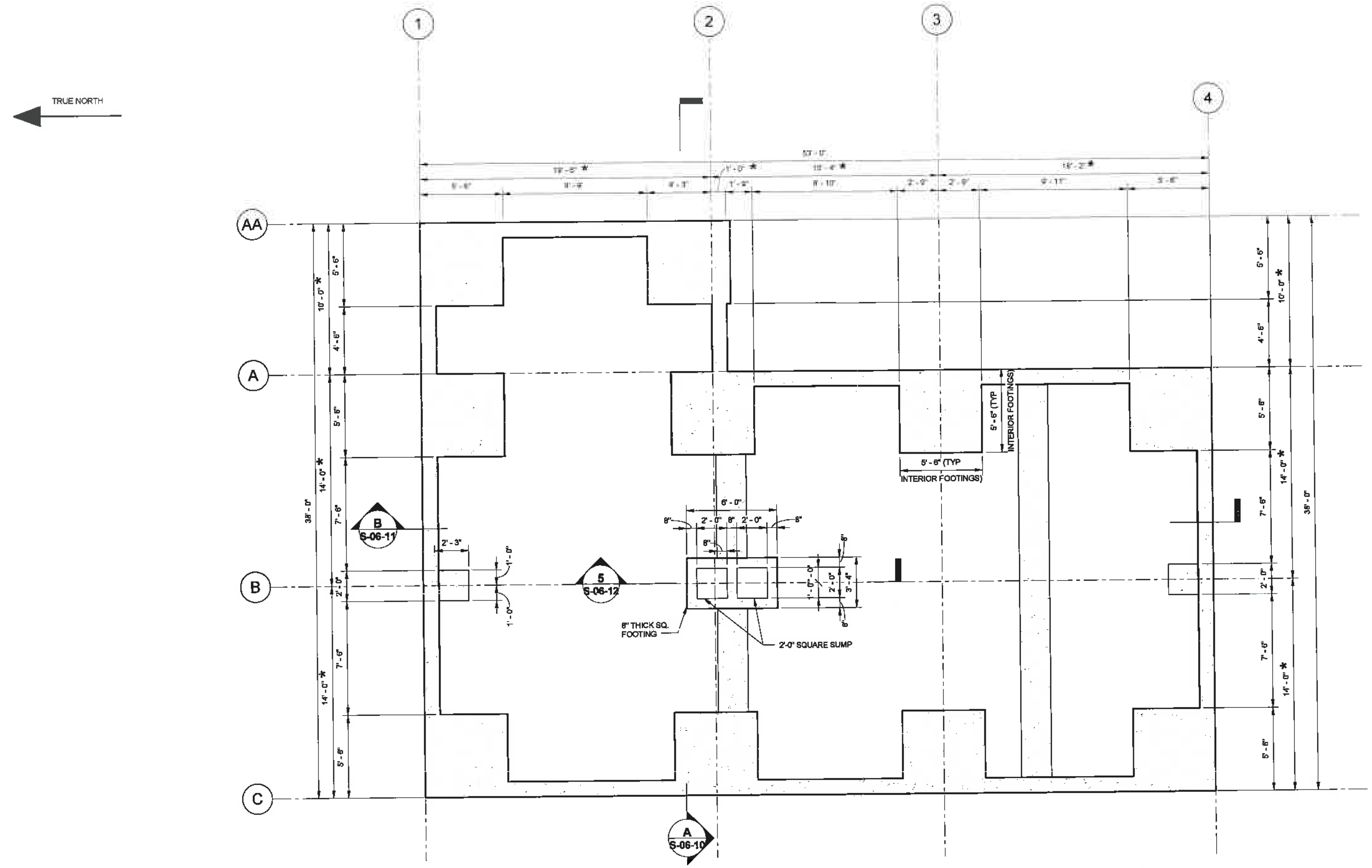
TOPOCK GROUNDWATER REMEDIATION PROJECT

MW-20 BENCH CARBON AMENDMENT BUILDING FINISH FLOOR PLAN

GAS TRANSMISSION & DISTRIBUTION
PACIFIC GAS AND ELECTRIC COMPANY
SAN FRANCISCO, CALIFORNIA

S-06-09

E-2A



FOUNDATION PLAN
1/4" = 1'-0"

NOTE:

1. P.E. SIGNED & SEALED BUILDING SHOP DRAWINGS AND DETAILED DESIGN CALCULATIONS ARE TO BE COMPLETED, SUBMITTED AND APPROVED BY THE ENGINEER OF RECORD PRIOR TO PLACEMENT OF FOUNDATION CONCRETE.

* COLUMN AND FOUNDATION LOCATIONS TO BE VERIFIED PER APPROVED PRE-ENGINEERED BUILDING COLUMN LOCATIONS

- DRAFT -
NOT FOR
CONSTRUCTION

ETIC ENGINEERING

NO.	DATE	DESCRIPTION	GM/SPEC	DWN	CHKD	SUPV	AP'D BY
1	09/08/14	INTERMEDIATE (90%) DESIGN SUBMITTAL		GWE	JR	MSL	LT

REVISIONS

SUPV MSL
DSGN JR
DWN GWE
CHKD JR
CK LT
DATE 09/08/14
SCALE NONE or AS SHOWN

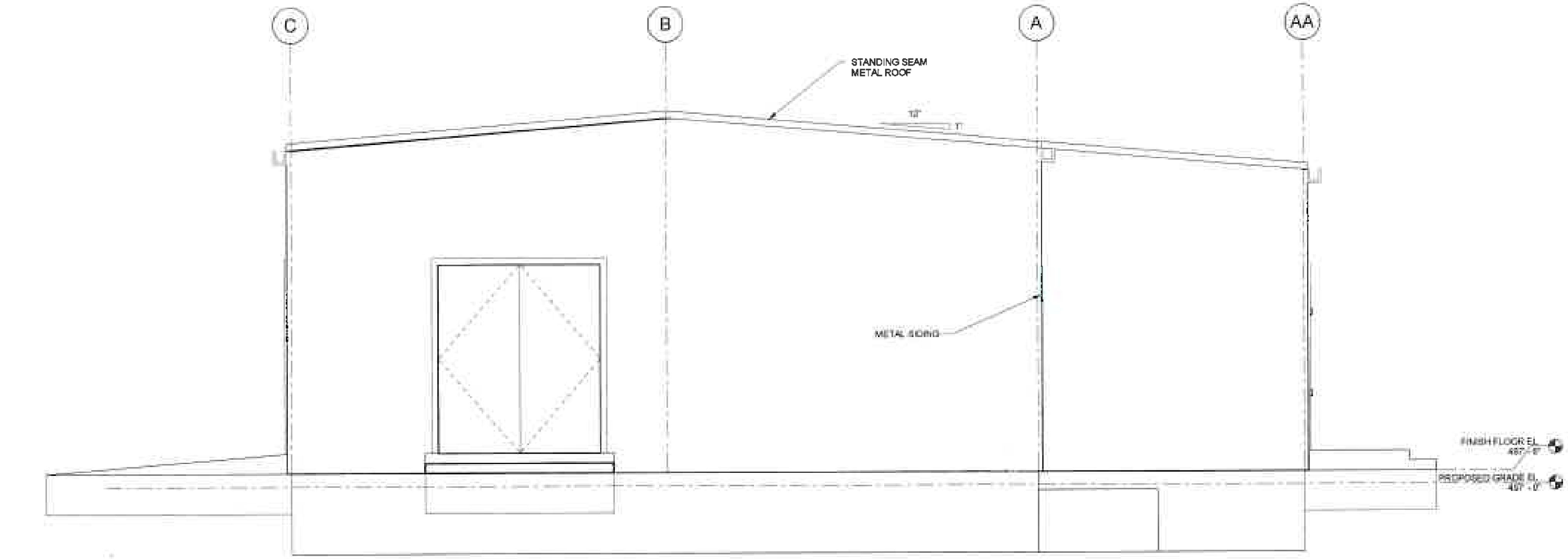
TOPOCK GROUNDWATER REMEDIATION PROJECT

MW-20 BENCH CARBON AMENDMENT BUILDING FOUNDATION PLAN

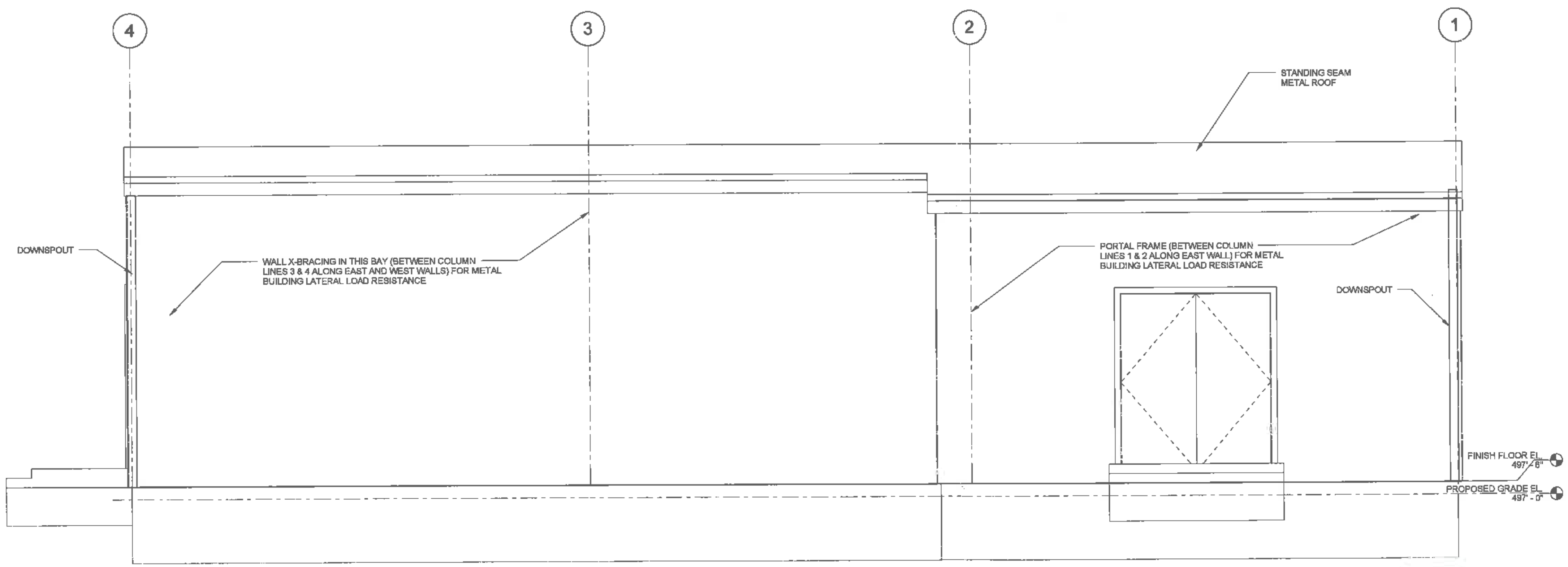
GAS TRANSMISSION & DISTRIBUTION
PACIFIC GAS AND ELECTRIC COMPANY
SAN FRANCISCO, CALIFORNIA

S-06-08

E-2B



SOUTH ELEVATION
3/8" = 1'-0"



EAST ELEVATION
3/8" = 1'-0"

BUILDING CODE NOTES:

1. CODE ITEMS

DESIGN CODES	2013 CALIFORNIA BUILDING CODE, 2012 INTERNATIONAL BUILDING CODE 2010 ASCE-7
BUILDING OCCUPANCY CLASSIFICATION	GROUP F-2
TYPE OF CONSTRUCTION	II-B
BUILDING AREA	1300 SF
BUILDING HEIGHT	1 STORY
FIRE SUPPRESSION SYSTEM	NONE

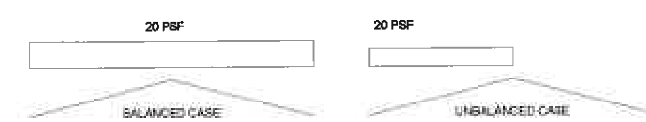
2. ALL FOUNDATIONS AND SLABS SHALL BEAR ON A 6 INCH MINIMUM THICKNESS OF GRANULAR BASE LEVELING COURSE MATERIAL. FOUNDATION DESIGN IS BASED ON 2,000 PSF ALLOWABLE BEARING PRESSURE IN CONFORMANCE WITH CBC TABLE 1806.2 FOR CLASSIFICATION(S) SW, SP, SM, SC, GM, AND/OR GC. A LICENSED GEOTECHNICAL ENGINEER SHALL INSPECT THE EXCAVATIONS AND CONFIRM THAT 2,000 PSF BEARING IS ALLOWED FOR THE FOUNDATIONS.

3. LIVE LOADING
GRADE SLAB - 3 TON FORKLIFT (RATED CAPACITY) AND HS-20 TRAFFIC LOADS (NOT ACTING SIMULTANEOUSLY)
ROOF - 20 PSF

4. METAL BUILDING DESIGN CRITERIA:
THE METAL BUILDING MANUFACTURER SHALL DESIGN THE BUILDING FOR THE FOLLOWING LOADS, BASED ON THE 2013 CALIFORNIA BUILDING CODE AND ASCE 7-10:

ROOF LOADING:
ROOF COLLATERAL LOAD - 5 PSF.

ROOF LIVE LOADING



METAL BUILDING LOAD COORDINATION - METAL BUILDING MANUFACTURER MUST COORDINATE EQUIPMENT LOADS WITH EQUIPMENT MANUFACTURER

WIND LOADING:
BASIC WIND SPEED (3 SECOND GUST) V=110 MPH - ULTIMATE, OR MINIMUM NET WIND PRESSURE, Pnet = 20 PSF WHICHEVER IS GREATER
WIND IMPORTANCE FACTOR - Iw = 1.0
RISK CATEGORY II.
WIND EXPOSURE C.
ENCLOSURE - PARTIALLY ENCLOSED.
INTERNAL PRESSURE COEFFICIENT - ±0.55.
ALL COMPONENTS AND CLADDING SHALL BE DESIGNED FOR THE CONDITIONS OF INTERNAL AND EXTERNAL PRESSURES.

SEISMIC CRITERIA:
SEISMIC IMPORTANCE FACTOR - Ie=1.0.
RISK CATEGORY II.
DESIGN CATEGORY - D
SITE CLASS - D
MAPPED SPECTRAL RESPONSE ACCELERATIONS - Ss=0.230, S1=0.120.
SPECTRAL RESPONSE COEFFICIENTS - Sds=0.245, Sd1=0.188.
SEISMIC FORCE RESISTING SYSTEM:
ORDINARY STEEL MOMENT FRAMES
Cs=7.5%, R=3.25, BASE SHEAR: V=1.79 KIPS (TO BE VERIFIED BY METAL BUILDING MFR)
ANALYSIS PROCEDURE - EQUIVALENT LATERAL FORCE.

FOUNDATIONS:
THE BUILDING FOUNDATIONS HAVE BEEN DESIGNED FOR THE FOLLOWING MAXIMUM SERVICE LOAD REACTIONS. THE METAL BUILDING MANUFACTURER SHAL PROPORTION THE BUILDING SUCH THAT THE ACTUAL REACTIONS DO NOT EXCEED THOSE LISTED. IF THE FINAL REACTIONS EXCEED THOSE LISTED, THE CONTRACTOR SHALL BEAR THE COST OF RE-DESIGNING THE FOUNDATIONS TO THE SATISFACTION OF THE ENGINEER, AT NO ADDITIONAL COST TO THE OWNER.

8.3 KIPS DOWNWARD
2.3 KIPS EAST-WEST SHEAR
2.1 KIPS NORTH-SOUTH SHEAR
5.1 KIPS NET UPLIFT

- DRAFT -
NOT FOR CONSTRUCTION

ETIC ENGINEERING

NO.	DATE	DESCRIPTION	GM/SPEC	DWN	CHKD	SUPV	APP'D BY
1	09/08/14	INTERMEDIATE (90%) DESIGN SUBMITTAL		GWE	JR	MSL	LT

REVISIONS

SUPV	MSL
DSGN	JR
DWN	GWE
CHKD	JR
CE	LT
DATE	09/08/14
SCALE	NONE or AS SHOWN

TOPOCK GROUNDWATER REMEDIATION PROJECT

MW-20 BENCH CARBON AMENDMENT
BUILDING ELEVATIONS (1 OF 2)

GAS TRANSMISSION & DISTRIBUTION
PACIFIC GAS AND ELECTRIC COMPANY
SAN FRANCISCO, CALIFORNIA

S-06-06

STRUCTURAL CALCULATIONS

FOR

Topok

Needles, CA

ARCADIS
1100 Superior Suite 1250
Cleveland, OH
Phone

Code Search

Code: International Building Code 2012

Occupancy:

Occupancy Group = U Utility & Miscellaneous

Risk Category & Importance Factors:

Risk Category =	II
Wind factor =	1.00
Snow factor =	1.00
Seismic factor =	1.00

Type of Construction:

Fire Rating:

Roof =	0.0 hr
Floor =	0.0 hr

Building Geometry:

Roof angle (θ)	1.00 / 12	4.8 deg
Building length (L)	53.0 ft	
Least width (B)	28.0 ft	~SHORT BLDG WIDTH
Mean Roof Ht (h)	13.2 ft	
Parapet ht above grd	0.0 ft	
Minimum parapet ht	0.0 ft	

Live Loads:

Roof

0 to 200 sf:	20 psf
200 to 600 sf:	24 - 0.02Area, but not less than 12 psf
over 600 sf:	12 psf

Floor:

Typical Floor	50 psf
Partitions	15 psf
Corridors above first floor	80 psf
Lobbies & first floor corridors	100 psf
Balconies (exterior)	50 psf

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MW-20 Bench Building
JOB NO. ______ SHEET NO. ______
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CHECKED BY ______ DATE ______

Wind Loads :

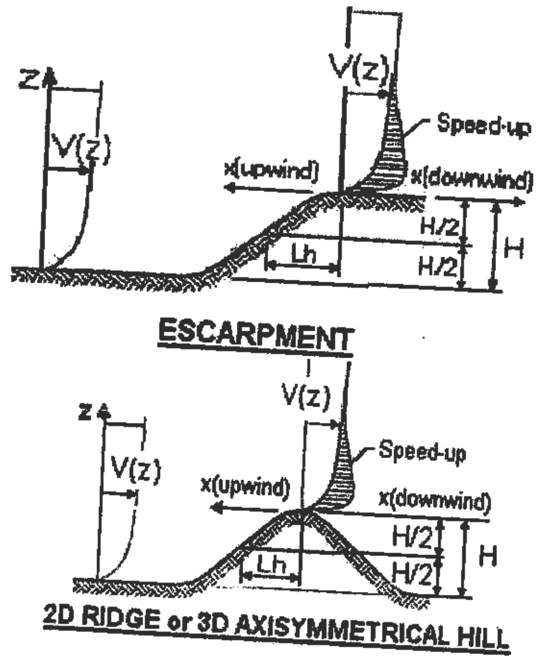
Ultimate Wind Speed	110 mph
Directionality (Kd)	0.85
Exposure Category	C
Enclosure Classif.	Partially Enclosed
Internal pressure	+/-0.55
Kh case 1	0.849
Kh case 2	0.849
Type of roof	Gable

Topographic Factor (Kzt)

Topography	Flat
Hill Height (H)	80.0 ft
Half Hill Length (Lh)	100.0 ft
Actual H/Lh =	0.80
Use H/Lh =	0.50
Modified Lh =	160.0 ft
From top of crest: x =	50.0 ft
Bldg up/down wind?	downwind

H/Lh= 0.50 — K_1 = 0.000
x/Lh = 0.31 — K_2 = 0.792
z/Lh = 0.09 — K_3 = 1.000
At Mean Roof Ht:

$Kzt = (1+K_1K_2K_3)^2 =$ 1.00



Gust Effect Factor

h = 13.2 ft
B = 28.0 ft
/z (0.6h) = 15.0 ft

Flexible structure if natural frequency < 1 Hz (T > 1 second).
However, if building h/B < 4 then probably rigid structure (rule of thumb).
h/B = 0.47 Rigid structure

G = 0.85 Using rigid structure default

Rigid Structure

ē =	0.20
ℓ =	500 ft
z_{min} =	15 ft
c =	0.20
g_Q, g_v =	3.4
L_z =	427.1 ft
Q =	0.93
I_z =	0.23
G =	0.89 use G = 0.85

Flexible or Dynamically Sensitive Structure

Natural Frequency (η_1) =	0.0 Hz
Damping ratio (β) =	0
/b =	0.65
/α =	0.15
Vz =	92.9
N_1 =	0.00
R_n =	0.000
R_h =	28.282
R_B =	28.282
R_L =	28.282
g_R =	0.000
R =	0.000
G =	0.000

η = 0.000 h = 13.2 ft
η = 0.000
η = 0.000

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Enclosure Classification

Test for Enclosed Building: A building that does not qualify as open or partially enclosed.

Test for Open Building: All walls are at least 80% open.
$A_o \geq 0.8A_g$

Test for Partially Enclosed Building:

	Input	
Ao	171.0	sf
Ag	636.0	sf
Aoi	84.0	sf
Agi	1586.0	sf

	Test
Ao ≥ 1.1Aoi	YES
Ao > 4' or 0.01Ag	YES
Aoi / Agi ≤ 0.20	YES

Building IS Partially Enclosed ✓
If overhead door open

Conditions to qualify as Partially Enclosed Building. Must satisfy all of the following:
$A_o \geq 1.1A_{oi}$
$A_o >$ smaller of 4' or 0.01 Ag
$A_{oi} / A_{gi} \leq 0.20$
Where:
Ao = the total area of openings in a wall that receives positive external pressure.
Ag = the gross area of that wall in which Ao is identified.
Aoi = the sum of the areas of openings in the building envelope (walls and roof) not including Ao.
Agi = the sum of the gross surface areas of the building envelope (walls and roof) not including Ag.

Reduction Factor for large volume partially enclosed buildings (Ri) :

If the partially enclosed building contains a single room that is unpartitioned , the internal pressure coefficient may be multiplied by the reduction factor Ri.

Total area of all wall & roof openings (Aog): 0 sf
Unpartitioned internal volume (Vi) : 0 cf
Ri = 1.00

Altitude adjustment to constant 0.00256 (caution - see code) :

Altitude = 0 feet
Constant = 0.00256

Average Air Density = 0.0765 lbm/ft^3

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A little higher but ok

Wind Loads - MWFRS all h (Enclosed/partially enclosed only)

Kh (case 2) = 0.85
Base pressure (q_h) = **22.4 psf**
Roof Angle (θ) = 4.8 deg
Roof tributary area - (h/2)*L: 350 sf
(h/2)*B: 185 sf

h = 13.2 ft ✓
ridge ht = 14.4 ft ✓
L = 53.0 ft ✓
B = 28.0 ft ✓

GCpi = +/-0.55 ✓
G = 0.85 ✓
z for qi : 13.2 ft
qi = 22.4 psf for positive internal pressures

Ultimate Wind Surface Pressures (psf)

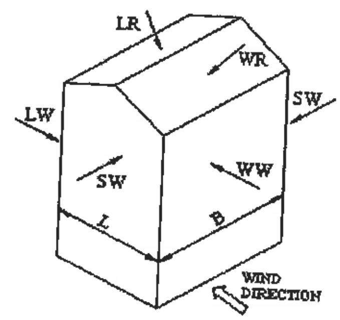
Surface	Wind Normal to Ridge B/L = 0.53 h/L = 0.47				Wind Parallel to Ridge L/B = 1.89 h/L = 0.25				
	Cp	q_hGC_p	w/+q_iGC_{pi}	w/-q_hGC_{pi}	Dist.*	Cp	q_hGC_p	w/ +q_iGC_{pi}	w/ -q_hGC_{pi}
Windward Wall (WW)	0.80	15.2	see table below			0.80	15.2	see table below	
Leeward Wall (LW)	-0.50	-9.5	-21.8	2.8		-0.32	-6.1	-18.4	6.2
Side Wall (SW)	-0.70	-13.3	-25.6	-1.0		-0.70	-13.3	-25.6	-1.0
Leeward Roof (LR)		**			Included in windward roof				
Windward Roof: 0 to h/2*	-0.90	-17.1	-29.4	-4.8	0 to h/2*	-0.90	-17.1	-29.4	-4.8
h/2 to h*	-0.90	-17.1	-29.4	-4.8	h/2 to h*	-0.90	-17.1	-29.4	-4.8
h to 2h*	-0.50	-9.50	-21.79	2.79	h to 2h*	-0.50	-9.5	-21.8	2.8
> 2h*	-0.30	-5.70	-17.99	6.59	> 2h*	-0.30	-5.7	-18.0	6.6

**Roof angle < 10 degrees. Therefore, leeward roof is included in windward roof pressure zones.

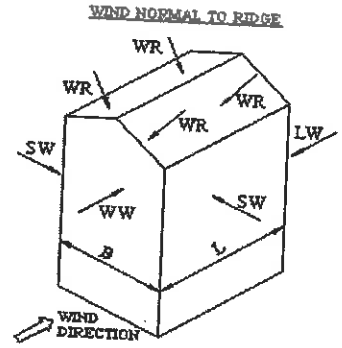
*Horizontal distance from windward edge

Windward Wall Pressures at "z" (psf)

	z	Kz	Kzt	Windward Wall q_zGC_p	w/+q_iGC_{pi}	w/-q_hGC_{pi}	Combined WW + LW Normal to Ridge	Parallel to Ridge
h=	0 to 15'	0.85	1.00	15.2	2.9	27.5	24.7	21.3



WIND NORMAL TO RIDGE



WIND PARALLEL TO RIDGE

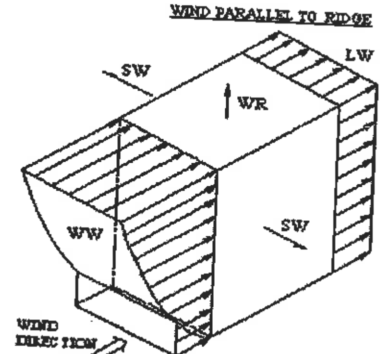
NOTE:
See figure in ASCE7 for the application of full and partial loading of the above wind pressures. There are 4 different loading cases.

Parapet

z	Kz	Kzt	qp (psf)
0.0 ft	0.85	1.00	0.0

Windward parapet: 0.0 psf (GCpn = +1.5)
Leeward parapet: 0.0 psf (GCpn = -1.0)

Windward roof overhangs (add to windward roof pressure) : 15.2 psf (upward)



TYPICAL WIND LOADING

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CHECKED BY		DATE	

Wind Loads - MWFRS h≤60' (Low-rise Buildings) Enclosed/partially enclosed only

Kz = Kh (case 1) = 0.85 ✓
Base pressure (qh) = 22.4 psf ✓ → 20psf MIN PG&E Design Criteria
GCpi = +/-0.55 ✓

Edge Strip (a) = 3.0 ft ✓
End Zone (2a) = 6.0 ft ✓
Zone 2 length = 14.0 ft ✓

Wind Pressure Coefficients

Surface	CASE A GCpf	CASE A θ = 4.8 deg w/-GCpi	CASE A w/+GCpi		CASE B GCpf	CASE B w/-GCpi	CASE B w/+GCpi
1	0.40	0.95	-0.15		-0.45	0.10	-1.00
2	-0.69	-0.14	-1.24		-0.69	-0.14	-1.24
3	-0.37	0.18	-0.92		-0.37	0.18	-0.92
4	-0.29	0.26	-0.84		-0.45	0.10	-1.00
5	-0.45	0.10	-1.00		0.40	0.95	-0.15
6	-0.45	0.10	-1.00		-0.29	0.26	-0.84
1E	0.61	1.16	0.06		-0.48	0.07	-1.03
2E	-1.07	-0.52	-1.62		-1.07	-0.52	-1.62
3E	-0.53	0.02	-1.08		-0.53	0.02	-1.08
4E	-0.43	0.12	-0.98		-0.48	0.07	-1.03
5E					0.61	1.16	0.06
6E					-0.43	0.12	-0.98

Ultimate Wind Surface Pressures (psf)

Surface		Case A	Case A		Case B	Case B
1		21.2	-3.4		2.2	-22.4
2		-3.1	-27.7		-3.1	-27.7
3		4.0	-20.6		4.0	-20.6
4		5.8	-18.8		2.2	-22.4
5		2.2	-22.4		21.2	-3.4
6		2.2	-22.4		5.8	-18.8
1E		25.9	1.3		1.6	-23.0
2E		-11.6	-36.2		-11.6	-36.2
3E		0.4	-24.1		0.4	-24.1
4E		2.7	-21.9		1.6	-23.0
5E					25.9	1.3
6E					2.7	-21.9

(Handwritten: surfaces 1 and 4 circled — 16.80 FT INTERIOR FRAME TRIB CONTROLS; surfaces 1E and 4E circled — 10.4 FT END FRAME TRIB AREA)

Parapet
Windward parapet = 0.0 psf (GCpn = +1.5)
Leeward parapet = 0.0 psf (GCpn = -1.0)

Windward roof overhangs = 15.6 psf (upward) add to windward roof pressure

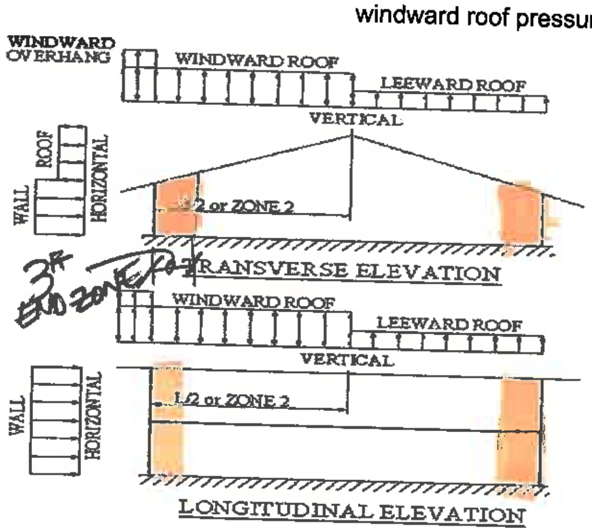
Horizontal MWFRS Simple Diaphragm Pressures (psf)

Transverse direction (normal to L)
Interior Zone: Wall 15.4 psf
Roof -7.2 psf **
End Zone: Wall 23.2 psf
Roof -12.1 psf **

Longitudinal direction (parallel to L)
Interior Zone: Wall 15.4 psf
End Zone: Wall 23.2 psf

** NOTE: Total horiz force shall not be less than that determined by neglecting roof forces (except for MWFRS moment frames).

The code requires the MWFRS be designed for a min ultimate force of 16 psf multiplied by the wall area plus an 8 psf force applied to the vertical projection of the roof.



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Wind Loads - Components & Cladding : h <= 60'

Ultimate Wind Pressures

Kh (case 1) = 0.85 ✓
Base pressure (qh) = **22.4 psf** ✓
Minimum parapet ht = 0.0 ft ✓
Roof Angle (θ) = 4.8 deg ✓
Type of roof = Gable

h = 13.2 ft ✓
a = 3.0 ft ✓
GCpi = +/-0.55 ✓

Roof

	GCp +/- GCpi			Surface Pressure (psf)			User input	
Area	10 sf	50 sf	100 sf	10 sf	50 sf	100 sf	25 sf	75 sf
Negative Zone 1	-1.55	-1.48	-1.45	-34.6	-33.1	-32.4	-33.8	-32.7
Negative Zone 2	-2.35	-1.86	-1.65	-52.5	-41.6	-36.9	-46.3	-38.8
Negative Zone 3	-3.35	-2.16	-1.65	-74.9	-48.3	-36.9	-59.8	-41.6
Positive All Zones	0.85	0.78	0.75	19.0	17.4	16.8	18.1	17.0
Overhang Zone 1&2	-1.70	-1.63	-1.60	-38.0	-36.4	-35.8	-37.1	-36.0
Overhang Zone 3	-2.80	-1.40	-0.80	-62.6	-31.3	-17.9	-44.8	-23.5

Overhang pressures in the table above assume an internal pressure coefficient (Gcpi) of 0.0
Overhang soffit pressure equals adjacent wall pressure minus internal pressure of -12.3 / 12.3 psf

Parapet

qp = 0.0 psf

CASE A = pressure towards building (pos)
CASE B = pressure away from bldg (neg)

	Surface Pressure (psf)			User input
Solid Parapet Pressure	10 sf	100 sf	500 sf	40 sf
CASE A : Interior zone:	0.0	0.0	0.0	0.0
Corner zone:	0.0	0.0	0.0	0.0
CASE B : Interior zone:	0.0	0.0	0.0	0.0
Corner zone:	0.0	0.0	0.0	0.0

Walls

	GCp +/- GCpi			Surface Pressure (psf)			User input	
Area	10 sf	100 sf	500 sf	10 sf	100 sf	500 sf	50 sf	200 sf
Negative Zone 4	-1.54	-1.38	-1.27	-34.4	-30.9	-28.4	-31.9	-29.8
Negative Zone 5	-1.81	-1.49	-1.27	-40.5	-33.4	-28.4	-35.5	-31.2
Positive Zone 4 & 5	1.45	1.29	1.18	32.4	28.9	26.4	29.9	27.8

Note: GCp reduced by 10% due to roof angle <= 10 deg.

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Wind Loads - Rooftop Structures & Equipment

Ultimate Wind Pressures

Building (L) = 53.0 ft ✓
Building (B) = 28.0 ft ✓
Directionality (Kd) = 0.85 ✓

Rooftop Structures & Equipment #1

Equipment length parallel to L = 15.0 ft
Equipment length parallel to B = 10.0 ft
Height of equipment = 10.0 ft
Base pressure (qh) = **22.4** psf ✓

Vertical wind pressure		Wind normal to building B		Wind normal to building L	
Ar =	150.0 sf	Ar =	100.0 sf	Ar =	150.0 sf
GCr =	1.499	GCr =	1.73	GCr =	1.79
F = qhGCr Ar =	**33.5** Ar (psf)	F = qhGCr Ar =	**38.7** Ar (psf)	F = qhGCr Ar =	**39.9** Ar (psf)
Fv =	**5.0** kips	Fh =	**3.9** kips	Fh =	**6.0** kips

Rooftop Structures & Equipment #2

Equipment length parallel to L = 15.0 ft
Equipment length parallel to B = 10.0 ft
Height of equipment = 10.0 ft
Base pressure (qh) = **22.4** psf

Vertical wind pressure		Wind normal to building B		Wind normal to building L	
Ar =	150.0 sf	Ar =	100.0 sf	Ar =	150.0 sf
GCr =	1.499	GCr =	1.73	GCr =	1.79
F = qhGCr Ar =	**33.5** Ar (psf)	F = qhGCr Ar =	**38.7** Ar (psf)	F = qhGCr Ar =	**39.9** Ar (psf)
Fv =	**5.0** kips	Fh =	**3.9** kips	Fh =	**6.0** kips

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DATE

Wind Loads - Other Structures:

Ultimate Wind Pressures

Importance Factor =	1.00		
Gust Effect Factor (G) =	0.85	Wind Speed =	110 mph
Kzt =	1.00	Exposure =	C

A. Solid Freestanding Walls & Solid Signs (& open signs with less than 30% open)

Dist to sign top (h)	8.0 ft	s/h =	1.00
Height (s)	8.0 ft	B/s =	25.00
Width (B)	200.0 ft	Lr/s =	0.00
Wall Return (Lr) =		Kz =	0.849
Directionality (Kd)	0.85	qz =	22.4 psf
Percent of open area to gross area	0.0%	Open reduction factor =	1.00

Case C reduction factors

Factor if s/h>0.8 =	0.80
Wall return factor for Cf at 0 to s =	1.00

Case A & B

C_f =	1.30
F = qz G Cf As =	**24.7 As**
As =	10.0 sf
F =	247 lbs

CaseC

Horiz dist from windward edge	Cf	F=qzGCfAs (psf)
0 to s	3.29	62.5 **As**
s to 2s	2.07	39.2 **As**
2s to 3s	1.59	30.1 **As**
3s to 4s	1.31	24.8 **As**
4s to 5s	1.23	23.4 **As**
5s to 10s	0.78	16.0 **As**
>10s	0.44	16.0 **As**

B. Open Signs & Lattice Frameworks (openings 30% or more of gross area)

Height to centroid of Af (z)	15.0 ft
Width (zero if round)	0.0 ft
Diameter (zero if rect)	2.0 ft
Percent of open area to gross area	35.0%
Directionality (Kd)	0.85

D(qz)^.5 =	9.46
$\in$ =	0.65
C_f =	1.1

Kz =	0.849
Base pressure (qz) =	22.4 psf
$F = q_z G C_f A_f$ =	**20.9 Af**
Solid Area: A_f =	10.0 sf
F =	209 lbs

C. Chimneys, Tanks, Rooftop Equipment (h>60') & Similar Structures

Height to centroid of Af (z)	15.0 ft
Cross-Section	Square
Directionality (Kd)	0.90
Height (h)	15.0 ft
Width (D)	1.0 ft
Type of Surface	N/A

Kz =	0.849
Base pressure (qz) =	23.7 psf
h/D =	15.00

Square (wind along diagonal)

Cf =	1.28
F = qz G Cf Af =	**25.7 Af**
Af =	sf
F =	0 lbs

Square (wind normal to face)

C_f =	1.67
$F = q_z G C_f A_f$ =	**33.5 Af**
A_f =	10.0 sf
F =	335 lbs

D. Trussed Towers

Height to centroid of Af (z)	15.0 ft
$\in$ =	0.27
Tower Cross Section	square
Member Shape	flat
Directionality (Kd)	1.00

Kz =	0.849
Base pressure (qz) =	26.3 psf
Diagonal wind factor =	1.2
Round member factor =	1.000

Square (wind along tower diagonal)

Cf =	3.24
F = qz G Cf Af =	**72.4 Af**
Solid Area: Af =	10.0 sf
F =	724 lbs

Square (wind normal to face)

C_f =	2.70
$F = q_z G C_f A_f$ =	**60.3 Af**
Solid Area: A_f =	10.0 sf
F =	603 lbs

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Snow Loads :

Roof slope	=	4.8 deg
Horiz. eave to ridge dist (W)	=	14.0 ft
Roof length parallel to ridge (L)	=	53.0 ft

Type of Roof			Hip and gable w/ trussed systems
Ground Snow Load	Pg	=	0.0 psf
Risk Category		=	II
Importance Factor	I	=	1.0
Thermal Factor	Ct	=	1.00
Exposure Factor	Ce	=	1.0
Pf = 0.7*Ce*Ct*I*Pg		=	0.0 psf
Unobstructed Slippery Surface (per Section 7.4)			yes
Sloped-roof Factor	Cs	=	1.00
Balanced Snow Load	**Ps**	**=**	**0.0 psf**
Rain on Snow Surcharge Angle			0.28 deg
Code Maximum Rain Surcharge			5.0 psf
Rain on Snow Surcharge		=	0.0 psf
Ps plus rain surcharge		=	0.0 psf
Minimum Snow Load	Pm	=	0.0 psf
Uniform Roof Design Snow Load		=	**0.0 psf**

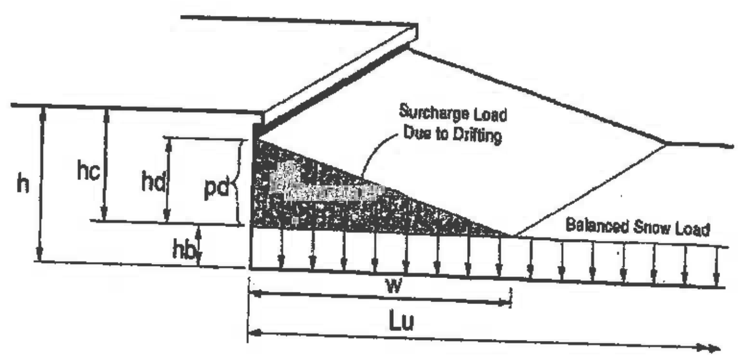
NOTE: Alternate spans of continuous beams and other areas shall be loaded with half the design roof snow load so as to produce the greatest possible effect - see code.

Unbalanced Snow Loads - for Hip & Gable roofs only

Required if slope is between 7 on 12 =	30.26 deg	
and 2.38 deg =	2.38 deg	**Unbalanced snow loads must be applied**
Windward snow load =	0.0 psf	= 0.3Ps
Leeward snow load from ridge to 6.8' =	3.0 psf	= hdγ / √S + Ps
Leeward snow load from 6.8' to the eave =	0.0 psf	= Ps

Windward Snow Drifts 1 - Against walls, parapets, etc more than 15' long

Upwind fetch	lu	=	220.0 ft
Projection height	h	=	5.2 ft
Snow density	g	=	14.0 pcf
Balanced snow height	hb	=	0.00 ft
	hc	=	5.20 ft
#DIV/0! #DIV/0!	**#DIV/0!**		
Drift height	hd	=	#DIV/0!
Drift width	w	=	#DIV/0!
Surcharge load:	pd = γ*hd	=	**#DIV/0!**
Balanced Snow load:		=	0.0 psf
			#DIV/0!



Windward Snow Drifts 2 - Against walls, parapets, etc > 15'

Upwind fetch	lu	=	220.0 ft
Projection height	h	=	5.2 ft
Snow density	g	=	14.0 pcf
Balanced snow height	hb	=	0.00 ft
	hc	=	5.20 ft
#DIV/0! #DIV/0!	**#DIV/0!**		
Drift height	hd	=	#DIV/0!
Drift width	w	=	#DIV/0!
Surcharge load:	pd = γ*hd	=	**#DIV/0!**
Balanced Snow load:		=	0.0 psf
			#DIV/0!

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Seismic Loads:

Risk Category : II ✓
Importance Factor (I) : 1.00
Site Class : D

Ss (0.2 sec) = 23.00 %g ✓
S1 (1.0 sec) = 12.00 %g

Fa =	1.600	Sms =	0.368	S_{DS} =	0.245	Design Category =	B ✓
Fv =	2.320	Sm1 =	0.278	S_{D1} =	0.186	Design Category =	C ✓

Seismic Design Category = C ✓
Number of Stories: 1
Structure Type: Moment-resisting frame systems of steel
Horizontal Struct Irregularities: 2) Reentrant Corners
Vertical Structural Irregularities: No vertical Irregularity
Flexible Diaphragms: No
Building System: **Moment-resisting Frame Systems** ✓
Seismic resisting system: **Steel ordinary moment frames** ✓
System Structural Height Limit: **Height not limited**
Actual Structural Height (hn) = 13.2 ft

DESIGN COEFFICIENTS AND FACTORS

Response Modification Coefficient (R) = 3.5 ✓
Over-Strength Factor (Ωo) = 3
Deflection Amplification Factor (Cd) = 3
S_{DS} = 0.245
S_{D1} = 0.186

INCLUDE 5psf COLLATERAL

Seismic Load Effect (E) = ρQ_E +/- $0.2S_{DS}$ D = ρQ_E +/- 0.049D
Special Seismic Load Effect (Em) = $\Omega o Q_E$ +/- $0.2S_{DS}$ D = 3.0 Q_E +/- 0.049D

ρ = redundancy coefficient
Q_E = horizontal seismic force
D = dead load

PERMITTED ANALYTICAL PROCEDURES

- 16.5psf ROOF DL × [(28ft×53') + (10'×20.75')] = 27,910#
- 6psf × 12' EAVE × [(53'×2) + 28' + 28' + 10'] = 13,104#
- (50#/ft COLUMNS × 13' TALL × 10) + (30#/ft × 13' TALL × 4) = 8,060#
- (75#/ft BEAMS × [(2×38') + (2×28') + 19.5] = 11,363#

TOTAL = 60,437#
× 0.07 = 4,250#

Simplified Analysis - Use Equivalent Lateral Force Analysis

Equivalent Lateral-Force Analysis - Permitted

Building period coef. (C_T) = 0.028
Approx fundamental period (Ta) = $C_T h_n$^ = 0.221 sec x= 0.80
Cu = 1.53
Tmax = CuTa = 0.337
User calculated fundamental period (T) = 0 sec
Use T = 0.221
Long Period Transition Period (TL) = ASCE7 map = 12
Seismic response coef. (Cs) = $S_{DS}I/R$ = 0.070
need not exceed Cs = Sd1 I /RT = 0.240
but not less than Cs = 0.044SdsI = 0.011
USE Cs = 0.070
Design Base Shear V = 0.070W

Model & Seismic Response Analysis - Permitted (see code for procedure)

ALLOWABLE STORY DRIFT

Structure Type: All other structures
Allowable story drift = 0.020hsx where hsx is the story height below level x

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Code Search

Code: International Building Code 2012

Occupancy:

Occupancy Group = U Utility & Miscellaneous

Risk Category & Importance Factors:

Risk Category =	II
Wind factor =	1.00
Snow factor =	1.00
Seismic factor =	1.00

Type of Construction:

Fire Rating:

Roof =	0.0 hr
Floor =	0.0 hr

Building Geometry:

Roof angle (θ)	1.00 / 12	4.8 deg
Building length (L)	53.0 ft	
Least width (B)	38.0 ft	Widest Portion of Bldg
Mean Roof Ht (h)	13.2 ft	
Parapet ht above grd	0.0 ft	
Minimum parapet ht	0.0 ft	

Live Loads:

Roof

0 to 200 sf:	20 psf
200 to 600 sf:	24 - 0.02Area, but not less than 12 psf
over 600 sf:	12 psf

Floor:

Typical Floor	50 psf
Partitions	15 psf
Corridors above first floor	80 psf
Lobbies & first floor corridors	100 psf
Balconies (exterior)	50 psf

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Wind Loads :

Ultimate Wind Speed	110 mph
Directionality (Kd)	0.85
Exposure Category	C
Enclosure Classif.	Partially Enclosed
Internal pressure	+/-0.55
Kh case 1	0.849
Kh case 2	0.849
Type of roof	Gable

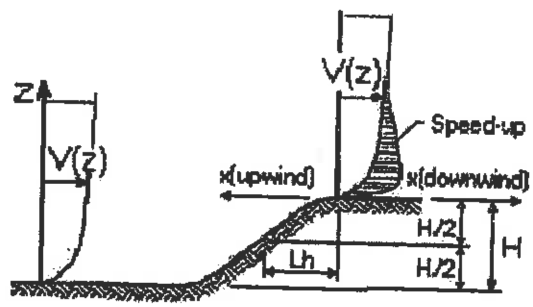
Topographic Factor (Kzt)

Topography	Flat
Hill Height (H)	80.0 ft
Half Hill Length (Lh)	100.0 ft
Actual H/Lh =	0.80
Use H/Lh =	0.50
Modified Lh =	160.0 ft
From top of crest: x =	50.0 ft
Bldg up/down wind?	downwind

H/Lh= 0.50		K_1 =	0.000
x/Lh = 0.31		K_2 =	0.792
z/Lh = 0.09		K_3 =	1.000

At Mean Roof Ht:

$Kzt = (1+K_1K_2K_3)^2 =$ 1.00



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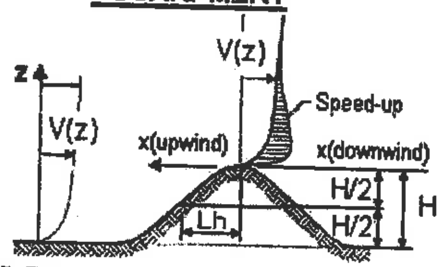

2D RIDGE or 3D AXISYMMETRICAL HILL

Gust Effect Factor

h =	13.2 ft
B =	38.0 ft
/z (0.6h) =	15.0 ft

Flexible structure if natural frequency < 1 Hz (T > 1 second).
However, if building h/B < 4 then probably rigid structure (rule of thumb).
h/B = 0.35 Rigid structure.

G = 0.85 Using rigid structure default

Rigid Structure

ē =	0.20
ℓ =	500 ft
z_{min} =	15 ft
c =	0.20
g_Q, g_v =	3.4
L_z =	427.1 ft
Q =	0.93
I_z =	0.23
G =	0.89 use G = 0.85

Flexible or Dynamically Sensitive Structure

Natural Frequency (η_1) =	0.0 Hz				
Damping ratio (β) =	0				
/b =	0.65				
/α =	0.15				
Vz =	92.9				
N_1 =	0.00				
R_n =	0.000				
R_h =	28.282	η =	0.000	h =	13.2 ft
R_B =	28.282	η =	0.000		
R_L =	28.282	η =	0.000		
g_R =	0.000				
R =	0.000				
G =	0.000				

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Enclosure Classification

Test for Enclosed Building: A building that does not qualify as open or partially enclosed.

Test for Open Building: All walls are at least 80% open.
Ao ≥ 0.8Ag

Test for Partially Enclosed Building:

	Input			Test
Ao	171.0	sf	Ao ≥ 1.1Aoi	YES
Ag	636.0	sf	Ao > 4' or 0.01Ag	YES
Aoi	84.0	sf	Aoi / Agi ≤ 0.20	YES
Agi	1586.0	sf		

Building IS Partially Enclosed ✓

(If overhead door is open

Conditions to qualify as Partially Enclosed Building. Must satisfy all of the following:
- Ao ≥ 1.1Aoi
- Ao > smaller of 4' or 0.01 Ag
- Aoi / Agi ≤ 0.20

Where:
Ao = the total area of openings in a wall that receives positive external pressure.
Ag = the gross area of that wall in which Ao is identified.
Aoi = the sum of the areas of openings in the building envelope (walls and roof) not including Ao.
Agi = the sum of the gross surface areas of the building envelope (walls and roof) not including Ag.

Reduction Factor for large volume partially enclosed buildings (Ri) :

If the partially enclosed building contains a single room that is unpartitioned , the internal pressure coefficient may be multiplied by the reduction factor Ri.

Total area of all wall & roof openings (Aog):	0 sf
Unpartitioned internal volume (Vi) :	0 cf
Ri =	1.00

Altitude adjustment to constant 0.00256 (caution - see code) :

Altitude = 0 feet
Constant = 0.00256

Average Air Density = 0.0765 lbm/ft^3

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Wind Loads - MWFRS all h (Enclosed/partially enclosed only)

Kh (case 2) =	0.85 ✓	h =	13.2 ft ✓	GCpi =	+/-0.55 ✓
Base pressure (q_h) =	**22.4 psf** ✓	ridge ht =	14.8 ft ✓	G =	0.85 ✓
Roof Angle (θ) =	4.8 deg ✓	L =	53.0 ft ✓	z for qi :	13.2 ft
Roof tributary area - (h/2)*L:	350 sf	B =	38.0 ft ✓	qi =	22.4 psf for positive internal pressures
(h/2)*B:	251 sf				

Ultimate Wind Surface Pressures (psf)

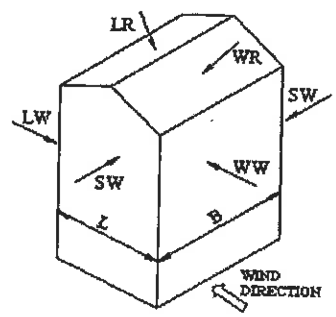
Surface	Wind Normal to Ridge B/L = 0.72		h/L = 0.35		Wind Parallel to Ridge L/B = 1.39			h/L = 0.25	
	Cp	q_hGC_p	w/+q_iGC_{pi}	w/-q_hGC_{pi}	Dist.*	Cp	q_hGC_p	w/ +q_iGC_{pi}	w/ -q_hGC_{pi}
Windward Wall (WW)	0.80	15.2	see table below			0.80	15.2	see table below	
Leeward Wall (LW)	-0.50	-9.5	-21.8	2.8		-0.42	-8.0	-20.3	4.3
Side Wall (SW)	-0.70	-13.3	-25.6	-1.0		-0.70	-13.3	-25.6	-1.0
Leeward Roof (LR)		**				Included in windward roof			
Windward Roof: 0 to h/2*	-0.90	-17.1	-29.4	-4.8	0 to h/2*	-0.90	-17.1	-29.4	-4.8
h/2 to h*	-0.90	-17.1	-29.4	-4.8	h/2 to h*	-0.90	-17.1	-29.4	-4.8
h to 2h*	-0.50	-9.50	-21.79	2.79	h to 2h*	-0.50	-9.5	-21.8	2.8
> 2h*	-0.30	-5.70	-17.99	6.59	> 2h*	-0.30	-5.7	-18.0	6.6

**Roof angle < 10 degrees. Therefore, leeward roof is included in windward roof pressure zones.

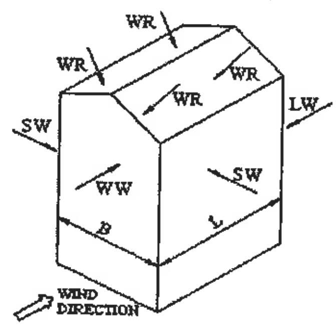
*Horizontal distance from windward edge

Windward Wall Pressures at "z" (psf)

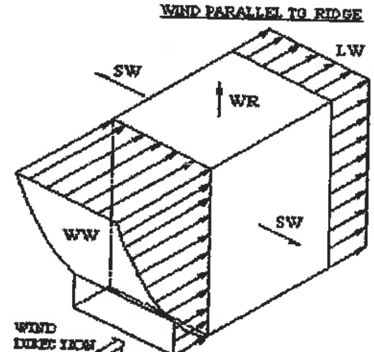
	z	Kz	Kzt	Windward Wall q_zGC_p	w/+q_iGC_{pi}	w/-q_hGC_{pi}	Combined WW + LW Normal to Ridge	Parallel to Ridge
h=	0 to 15'	0.85	1.00	15.2	2.9	27.5	24.7	23.2



WIND NORMAL TO RIDGE



WIND PARALLEL TO RIDGE



TYPICAL WIND LOADING

NOTE:
See figure in ASCE7 for the application of full and partial loading of the above wind pressures. There are 4 different loading cases.

Parapet

z	Kz	Kzt	qp (psf)
0.0 ft	0.85	1.00	0.0

Windward parapet: 0.0 psf (GCpn = +1.5)
Leeward parapet: 0.0 psf (GCpn = -1.0)

Windward roof overhangs (add to windward roof pressure) : 15.2 psf (upward)

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Code Search

Code: International Building Code 2012

Occupancy:

Occupancy Group = U Utility & Miscellaneous

Risk Category & Importance Factors:

Risk Category =	II
Wind factor =	1.00
Snow factor =	1.00
Seismic factor =	1.00

Type of Construction:

Fire Rating:

Roof =	0.0 hr
Floor =	0.0 hr

Building Geometry:

Roof angle (θ)	1.00 / 12	4.8 deg
Building length (L)	53.0 ft	
Least width (B)	28.0 ft	
Mean Roof Ht (h)	13.2 ft	
Parapet ht above grd	0.0 ft	
Minimum parapet ht	0.0 ft	

Live Loads:

Roof

0 to 200 sf:	20 psf
200 to 600 sf:	24 - 0.02Area, but not less than 12 psf
over 600 sf:	12 psf

Floor:

Typical Floor	50 psf
Partitions	15 psf
Corridors above first floor	80 psf
Lobbies & first floor corridors	100 psf
Balconies (exterior)	50 psf

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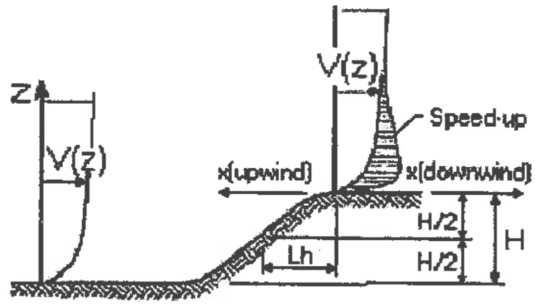
Wind Loads :

Ultimate Wind Speed	110 mph
Directionality (Kd)	0.85
Exposure Category	C
Enclosure Classif.	Enclosed Building
Internal pressure	+/-0.18
Kh case 1	0.849
Kh case 2	0.849
Type of roof	Gable



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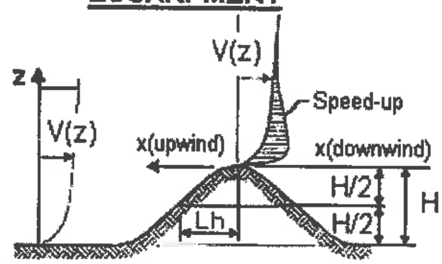

2D RIDGE or 3D AXISYMMETRICAL HILL

Topographic Factor (Kzt)

Topography		Flat
Hill Height	(H)	80.0 ft
Half Hill Length (Lh)		100.0 ft
Actual H/Lh	=	0.80
Use H/Lh	=	0.50
Modified Lh	=	160.0 ft
From top of crest: x =		50.0 ft
Bldg up/down wind?		downwind

H/Lh= 0.50	K_1 =	0.000
x/Lh = 0.31	K_2 =	0.792
z/Lh = 0.09	K_3 =	1.000

At Mean Roof Ht:

$Kzt = (1+K_1K_2K_3)^2 =$ 1.00

Gust Effect Factor

h =	13.2 ft
B =	28.0 ft
/z (0.6h) =	15.0 ft

Flexible structure if natural frequency < 1 Hz (T > 1 second).
However, if building h/B < 4 then probably rigid structure (rule of thumb).
h/B = 0.47 Rigid structure

G = 0.85 Using rigid structure default

Rigid Structure

ē =	0.20
ℓ =	500 ft
z_{min} =	15 ft
c =	0.20
g_Q, g_v =	3.4
L_z =	427.1 ft
Q =	0.93
I_z =	0.23
G =	0.89 use G = 0.85

Flexible or Dynamically Sensitive Structure

Natural Frequency (η_1) =	0.0 Hz				
Damping ratio (β) =	0				
/b =	0.65				
/α =	0.15				
Vz =	92.9				
N_1 =	0.00				
R_n =	0.000				
R_h =	28.282	η =	0.000	h =	13.2 ft
R_B =	28.282	η =	0.000		
R_L =	28.282	η =	0.000		
g_R =	0.000				
R =	0.000				
G =	0.000				

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Wind Loads - MWFRS all h (Enclosed/partially enclosed only)

Kh (case 2) =	0.85 ✓	h =	13.2 ft	GCpi =	+/-0.18
Base pressure (q_h) =	22.4 psf ✓	ridge ht =	14.4 ft	G =	0.85 ✓
Roof Angle (θ) =	4.8 deg	L =	53.0 ft	qi = qh	
Roof tributary area - (h/2)*L:	350 sf	B =	28.0 ft		
(h/2)*B:	185 sf				

Ultimate Wind Surface Pressures (psf)

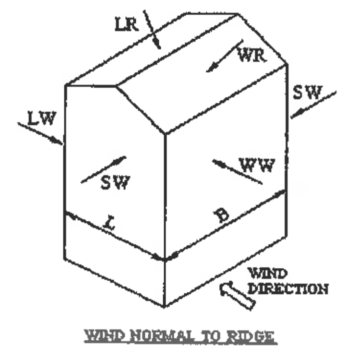
Surface	Wind Normal to Ridge B/L = 0.53 h/L = 0.47				Wind Parallel to Ridge L/B = 1.89 h/L = 0.25				
	Cp	q_hGC_p	w/+q_iGC_{pi}	w/-q_hGC_{pi}	Dist.*	Cp	q_hGC_p	w/ +q_iGC_{pi}	w/ -q_hGC_{pi}
Windward Wall (WW)	0.80	15.2	see table below			0.80	15.2	see table below	
Leeward Wall (LW)	-0.50	-9.5	-13.5	-5.5		-0.32	-6.1	-10.1	-2.1
Side Wall (SW)	-0.70	-13.3	-17.3	-9.3		-0.70	-13.3	-17.3	-9.3
Leeward Roof (LR)		**			Included in windward roof				
Windward Roof: 0 to h/2*	-0.90	-17.1	-21.1	-13.1	0 to h/2*	-0.90	-17.1	-21.1	-13.1
h/2 to h*	-0.90	-17.1	-21.1	-13.1	h/2 to h*	-0.90	-17.1	-21.1	-13.1
h to 2h*	-0.50	-9.50	-13.52	-5.48	h to 2h*	-0.50	-9.5	-13.5	-5.5
> 2h*	-0.30	-5.70	-9.72	-1.68	> 2h*	-0.30	-5.7	-9.7	-1.7

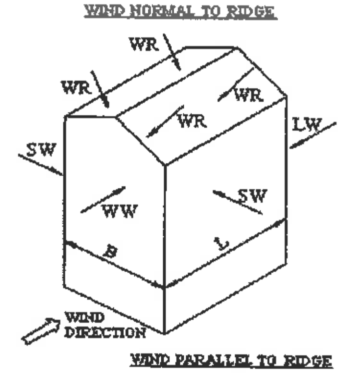
**Roof angle < 10 degrees. Therefore, leeward roof is included in windward roof pressure zones.

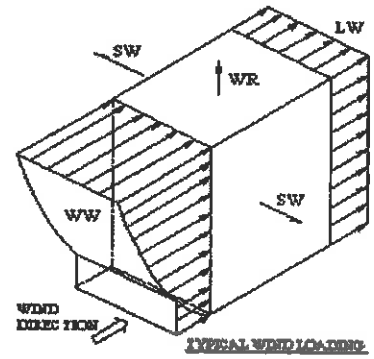
*Horizontal distance from windward edge

Windward Wall Pressures at "z" (psf)

	z	Kz	Kzt	Windward Wall q_zGC_p	w/+q_iGC_{pi}	w/-q_hGC_{pi}	Combined WW + LW Normal to Ridge	Parallel to Ridge
h=	0 to 15'	0.85	1.00	15.2	11.2	19.2	24.7	21.3







NOTE:
See figure in ASCE7 for the application of full and partial loading of the above wind pressures. There are 4 different loading cases.

Parapet

z	Kz	Kzt	qp (psf)
0.0 ft	0.85	1.00	0.0

Windward parapet: 0.0 psf (GCpn = +1.5)
Leeward parapet: 0.0 psf (GCpn = -1.0)

Windward roof overhangs (add to windward roof pressure) : 15.2 psf (upward)

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Wind Loads - MWFRS h≤60' (Low-rise Buildings) Enclosed/partially enclosed only

Kz = Kh (case 1) = 0.85 ✓
Base pressure (qh) = **22.4 psf** ✓
GCpi = +/-0.18 ✓

Edge Strip (a) = 3.0 ft ✓
End Zone (2a) = 6.0 ft ✓
Zone 2 length = 14.0 ft ✓

Wind Pressure Coefficients

	CASE A			CASE B		
		θ = 4.8 deg				
Surface	GCpf	w/-GCpi	w/+GCpi	GCpf	w/-GCpi	w/+GCpi
1	0.40	0.58	0.22	-0.45	-0.27	-0.63
2	-0.69	-0.51	-0.87	-0.69	-0.51	-0.87
3	-0.37	-0.19	-0.55	-0.37	-0.19	-0.55
4	-0.29	-0.11	-0.47	-0.45	-0.27	-0.63
5	-0.45	-0.27	-0.63	0.40	0.58	0.22
6	-0.45	-0.27	-0.63	-0.29	-0.11	-0.47
1E	0.61	0.79	0.43	-0.48	-0.30	-0.66
2E	-1.07	-0.89	-1.25	-1.07	-0.89	-1.25
3E	-0.53	-0.35	-0.71	-0.53	-0.35	-0.71
4E	-0.43	-0.25	-0.61	-0.48	-0.30	-0.66
5E				0.61	0.79	0.43
6E				-0.43	-0.25	-0.61

Ultimate Wind Surface Pressures (psf)

	Case A w/-GCpi	Case A w/+GCpi	Case B w/-GCpi	Case B w/+GCpi
1	13.0	4.9	-6.0	-14.1
2	-11.4	-19.4	-11.4	-19.4
3	-4.2	-12.3	-4.2	-12.3
4	-2.5	-10.5	-6.0	-14.1
5	-6.0	-14.1	13.0	4.9
6	-6.0	-14.1	-2.5	-10.5
1E	17.7	9.6	-6.7	-14.8
2E	-19.9	-27.9	-19.9	-27.9
3E	-7.8	-15.9	-7.8	-15.9
4E	-5.6	-13.6	-6.7	-14.8
5E			17.7	9.6
6E			-5.6	-13.6

Parapet

Windward parapet = 0.0 psf (GCpn = +1.5)
Leeward parapet = 0.0 psf (GCpn = -1.0)

Windward roof overhangs = 15.6 psf (upward) add to windward roof pressure

Horizontal MWFRS Simple Diaphragm Pressures (psf)

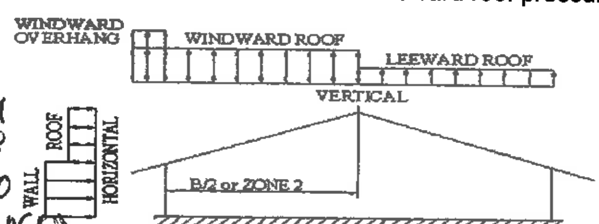
Transverse direction (normal to L)
Interior Zone: Wall 15.4 psf ✓
Roof -7.2 psf ** ✓
End Zone: Wall 23.2 psf ✓
Roof -12.1 psf ** ✓

Longitudinal direction (parallel to L)
Interior Zone: Wall 15.4 psf ✓
End Zone: Wall 23.2 psf ✓

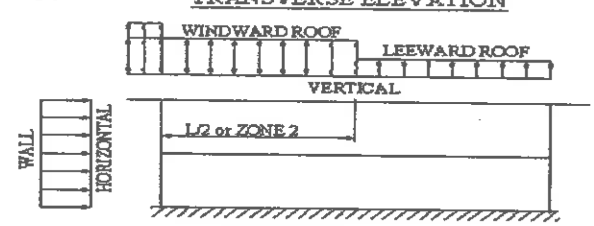
SAME AS 53'x28' o/o BLDG-ENCLOSED SHT E3

** NOTE: Total horiz force shall not be less than that determined by neglecting roof forces (except for MWFRS moment frames).

The code requires the MWFRS be designed for a min ultimate force of 16 psf multiplied by the wall area plus an 8 psf force applied to the vertical projection of the roof.



TRANSVERSE ELEVATION



LONGITUDINAL ELEVATION

FYI-53'x38' o/o BLDG ENCLOSED PRESSURES ARE THE SAME

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Wind Loads - Components & Cladding : h <= 60'

Ultimate Wind Pressures

Kh (case 1) =	0.85 ✓	h =	13.2 ft ✓
Base pressure (qh) =	**22.4 psf** ✓	a =	3.0 ft ✓
Minimum parapet ht =	0.0 ft	GCpi =	+/-0.18 ✓
Roof Angle (θ) =	4.8 deg		
Type of roof =	Gable		

ENCLOSED PRESSURES ARE LESS THAN E-3-PARTIALLY ENCLOSED

Roof

	GCp +/- GCpi			Surface Pressure (psf)			User input	
Area	10 sf	50 sf	100 sf	10 sf	50 sf	100 sf	25 sf	75 sf
Negative Zone 1	-1.18	-1.11	-1.08	-26.4	-24.8	-24.1	-25.5	-24.4
Negative Zone 2	-1.98	-1.49	-1.28	-44.3	-33.3	-28.6	-38.0	-30.6
Negative Zone 3	-2.98	-1.79	-1.28	-66.6	-40.0	-28.6	-51.5	-33.4
Positive All Zones	0.48	0.41	0.38	16.0	16.0	16.0	16.0	16.0
Overhang Zone 1&2	-1.70	-1.63	-1.60	-38.0 ✓	-36.4 ✓	-35.8 ✓	-37.1	-36.0
Overhang Zone 3	-2.80	-1.40	-0.80	-62.6 ✓	-31.3 ✓	-17.9 ✓	-44.8	-23.5

Overhang pressures in the table above assume an internal pressure coefficient (Gcpi) of 0.0
Overhang soffit pressure equals adjacent wall pressure minus internal pressure of -4 / 4 psf

Parapet

qp = 0.0 psf

CASE A = pressure towards building (pos)
CASE B = pressure away from bldg (neg)

Solid Parapet Pressure	Surface Pressure (psf) 10 sf	100 sf	500 sf	User input 40 sf
CASE A : Interior zone:	0.0	0.0	0.0	0.0
Corner zone:	0.0	0.0	0.0	0.0
CASE B : Interior zone:	0.0	0.0	0.0	0.0
Corner zone:	0.0	0.0	0.0	0.0

Walls

	GCp +/- GCpi			Surface Pressure (psf)			User input	
Area	10 sf	100 sf	500 sf	10 sf	100 sf	500 sf	50 sf	200 sf
Negative Zone 4	-1.17	-1.01	-0.90	-26.2	-22.6	-20.1	-23.7	-21.5
Negative Zone 5	-1.44	-1.12	-0.90	-32.2	-25.1	-20.1	-27.2	-22.9
Positive Zone 4 & 5	1.08	0.92	0.81	24.1	20.6	18.1	21.7	19.5

Note: GCp reduced by 10% due to roof angle <= 10 deg.

* FYI 53'x38' ENCLOSED C&C PRESSURES ARE SAME AS ABOVE

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Wind Loads - Rooftop Structures & Equipment

Ultimate Wind Pressures

Building (L) = 53.0 ft
Building (B) = 28.0 ft

Directionality (Kd) = 0.85

Rooftop Structures & Equipment #1

Equipment length parallel to L = 15.0 ft
Equipment length parallel to B = 10.0 ft
Height of equipment = 10.0 ft

Base pressure (qh) = **22.4** psf

Vertical wind pressure		Wind normal to building B		Wind normal to building L	
Ar =	150.0 sf	Ar =	100.0 sf	Ar =	150.0 sf
GCr =	1.499	GCr =	1.73	GCr =	1.79
F = qhGCr Ar =	**33.5** Ar (psf)	F = qhGCr Ar =	**38.7** Ar (psf)	F = qhGCr Ar =	**39.9** Ar (psf)
Fv =	**5.0** kips	Fh =	**3.9** kips	Fh =	**6.0** kips

Rooftop Structures & Equipment #2

Equipment length parallel to L = 15.0 ft
Equipment length parallel to B = 10.0 ft
Height of equipment = 10.0 ft

Base pressure (qh) = **22.4** psf

Vertical wind pressure		Wind normal to building B		Wind normal to building L	
Ar =	150.0 sf	Ar =	100.0 sf	Ar =	150.0 sf
GCr =	1.499	GCr =	1.73	GCr =	1.79
F = qhGCr Ar =	**33.5** Ar (psf)	F = qhGCr Ar =	**38.7** Ar (psf)	F = qhGCr Ar =	**39.9** Ar (psf)
Fv =	**5.0** kips	Fh =	**3.9** kips	Fh =	**6.0** kips

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Wind Loads - Other Structures:

Ultimate Wind Pressures

Importance Factor =	1.00		
Gust Effect Factor (G) =	0.85	Wind Speed =	110 mph
Kzt =	1.00	Exposure =	C

A. Solid Freestanding Walls & Solid Signs (& open signs with less than 30% open)

		s/h =	1.00
Dist to sign top (h)	8.0 ft	B/s =	25.00
Height (s)	8.0 ft	Lr/s =	0.00
Width (B)	200.0 ft	Kz =	0.849
Wall Return (Lr) =		qz =	22.4 psf
Directionality (Kd)	0.85		
Percent of open area to gross area	0.0%	Open reduction factor =	1.00

Case C reduction factors
Factor if s/h>0.8 = 0.80
Wall return factor for Cf at 0 to s = 1.00

Case A & B

C_f =	1.30
F = qz G Cf As =	**24.7 As**
As =	10.0 sf
F =	247 lbs

CaseC

Horiz dist from windward edge	Cf	F=qzGCfAs (psf)
0 to s	3.29	62.5 **As**
s to 2s	2.07	39.2 **As**
2s to 3s	1.59	30.1 **As**
3s to 4s	1.31	24.8 **As**
4s to 5s	1.23	23.4 **As**
5s to 10s	0.78	16.0 **As**
>10s	0.44	16.0 **As**

B. Open Signs & Lattice Frameworks (openings 30% or more of gross area)

Height to centroid of Af (z)	15.0 ft		
Width (zero if round)	0.0 ft		
Diameter (zero if rect)	2.0 ft	D(qz)^.5 =	9.46
Percent of open area to gross area	35.0%	I =	0.65
Directionality (Kd)	0.85	C_f =	1.1

Kz =	0.849
Base pressure (qz) =	22.4 psf
$F = q_z G C_f A_f$ =	**20.9 Af**
Solid Area: A_f =	10.0 sf
F =	209 lbs

C. Chimneys, Tanks, Rooftop Equipment (h>60') & Similar Structures

Height to centroid of Af (z)	15.0 ft
Cross-Section	Square
Directionality (Kd)	0.90
Height (h)	15.0 ft
Width (D)	1.0 ft
Type of Surface	N/A

Kz =	0.849
Base pressure (qz) =	23.7 psf
h/D =	15.00

Square (wind along diagonal)

Cf =	1.28
F = qz G Cf Af =	**25.7 Af**
Af =	sf
F =	0 lbs

Square (wind normal to face)

C_f =	1.67
$F = q_z G C_f A_f$ =	**33.5 Af**
A_f =	10.0 sf
F =	335 lbs

D. Trussed Towers

Height to centroid of Af (z)	15.0 ft
ϵ =	0.27
Tower Cross Section	square
Member Shape	flat
Directionality (Kd)	1.00

Kz =	0.849
Base pressure (qz) =	26.3 psf
Diagonal wind factor =	1.2
Round member factor =	1.000

Square (wind along tower diagonal)

Cf =	3.24
F = qz G Cf Af =	**72.4 Af**
Solid Area: Af =	10.0 sf
F =	724 lbs

Square (wind normal to face)

C_f =	2.70
$F = q_z G C_f A_f$ =	**60.3 Af**
Solid Area: A_f =	10.0 sf
F =	603 lbs

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Wind Loads - MWFRS h≤60' (Low-rise Buildings) Enclosed/partially enclosed only

Kz = Kh (case 1) = 0.85 ✓
Base pressure (qh) = **22.4 psf** ✓
GCpi = +/-0.55 ✓

Edge Strip (a) = 3.8 ft ✓
End Zone (2a) = 7.6 ft ✓
Zone 2 length = 19.0 ft ✓

Wind Pressure Coefficients

Surface	CASE A GCpf	CASE A θ = 4.8 deg w/-GCpi	CASE A w/+GCpi	CASE B GCpf	CASE B w/-GCpi	CASE B w/+GCpi
1	0.40	0.95	-0.15	-0.45	0.10	-1.00
2	-0.69	-0.14	-1.24	-0.69	-0.14	-1.24
3	-0.37	0.18	-0.92	-0.37	0.18	-0.92
4	-0.29	0.26	-0.84	-0.45	0.10	-1.00
5	-0.45	0.10	-1.00	0.40	0.95	-0.15
6	-0.45	0.10	-1.00	-0.29	0.26	-0.84
1E	0.61	1.16	0.06	-0.48	0.07	-1.03
2E	-1.07	-0.52	-1.62	-1.07	-0.52	-1.62
3E	-0.53	0.02	-1.08	-0.53	0.02	-1.08
4E	-0.43	0.12	-0.98	-0.48	0.07	-1.03
5E				0.61	1.16	0.06
6E				-0.43	0.12	-0.98

Ultimate Wind Surface Pressures (psf)

Surface	CASE A w/-GCpi	CASE A w/+GCpi	CASE B w/-GCpi	CASE B w/+GCpi
1	21.2 ✓	-3.4 ✓	2.2	-22.4
2	-3.1	-27.7	-3.1	-27.7
3	4.0	-20.6	4.0	-20.6
4	5.8 ✓	-18.8 ✓	2.2	-22.4
5	2.2	-22.4	21.2	-3.4
6	2.2	-22.4	5.8	-18.8
1E	25.9 ✓	1.3 ✓	1.6	-23.0
2E	-11.6	-36.2	-11.6	-36.2
3E	0.4	-24.1	0.4	-24.1
4E	2.7 ✓	-21.9 ✓	1.6	-23.0
5E			25.9	1.3
6E			2.7	-21.9

Parapet

Windward parapet = 0.0 psf (GCpn = +1.5)
Leeward parapet = 0.0 psf (GCpn = -1.0)

Windward roof overhangs = 15.6 psf (upward) add to windward roof pressure

Horizontal MWFRS Simple Diaphragm Pressures (psf)

Transverse direction (normal to L)

Interior Zone: Wall 15.4 psf ✓
Roof -7.2 psf ✓**
End Zone: Wall 23.2 psf ✓
Roof -12.1 psf ✓**

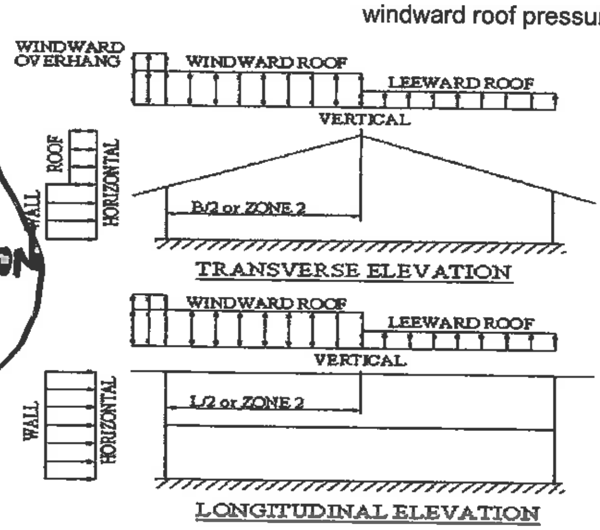
SAME AS 53'x28' O/O BLDG ON SH E-3

Longitudinal direction (parallel to L)

Interior Zone: Wall 15.4 psf ✓
End Zone: Wall 23.2 psf ✓

** NOTE: Total horiz force shall not be less than that determined by neglecting roof forces (except for MWFRS moment frames).

The code requires the MWFRS be designed for a min ultimate force of 16 psf multiplied by the wall area plus an 8 psf force applied to the vertical projection of the roof.



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Wind Loads - Components & Cladding : h <= 60'

Ultimate Wind Pressures

Kh (case 1) = 0.85 ✓
Base pressure (qh) = **22.4 psf** ✓
Minimum parapet ht = 0.0 ft ✓
Roof Angle (θ) = 4.8 deg ✓
Type of roof = Gable

h = 13.2 ft ✓
a = 3.8 ft ✓
GCpi = +/-0.55 ✓

Roof

	GCp +/- GCpi			Surface Pressure (psf)			User input	
Area	10 sf	50 sf	100 sf	10 sf	50 sf	100 sf	25 sf	75 sf
Negative Zone 1	-1.55	-1.48	-1.45	-34.6 ✓	-33.1 ✓	-32.4 ✓	-33.8	-32.7
Negative Zone 2	-2.35	-1.86	-1.65	-52.5 ✓	-41.6 ✓	-36.9 ✓	-46.3	-38.8
Negative Zone 3	-3.35	-2.16	-1.65	-74.9 ✓	-48.3 ✓	-36.9 ✓	-59.8	-41.6
Positive All Zones	0.85	0.78	0.75	19.0 ✓	17.4 ✓	16.8 ✓	18.1	17.0
Overhang Zone 1&2	-1.70	-1.63	-1.60	-38.0 ✓	-36.4 ✓	-35.8 ✓	-37.1	-36.0
Overhang Zone 3	-2.80	-1.40	-0.80	-62.6 ✓	-31.3 ✓	-17.9 ✓	-44.8	-23.5

Overhang pressures in the table above assume an internal pressure coefficient (Gcpi) of 0.0
Overhang soffit pressure equals adjacent wall pressure minus internal pressure of -12.3 / 12.3 psf

SAME KH
53' x 28' o/o
BLDG ON SHT E-3

Parapet

qp = 0.0 psf

CASE A = pressure towards building (pos)
CASE B = pressure away from bldg (neg)

Solid Parapet Pressure	Surface Pressure (psf)			User input
	10 sf	100 sf	500 sf	40 sf
CASE A : Interior zone:	0.0	0.0	0.0	0.0
Corner zone:	0.0	0.0	0.0	0.0
CASE B : Interior zone:	0.0	0.0	0.0	0.0
Corner zone:	0.0	0.0	0.0	0.0

Walls

	GCp +/- GCpi			Surface Pressure (psf)			User input	
Area	10 sf	100 sf	500 sf	10 sf	100 sf	500 sf	50 sf	200 sf
Negative Zone 4	-1.54	-1.38	-1.27	-34.4 ✓	-30.9	-28.4 ✓	-31.9	-29.8
Negative Zone 5	-1.81	-1.49	-1.27	-40.5 ✓	-33.4	-28.4 ✓	-35.5	-31.2
Positive Zone 4 & 5	1.45	1.29	1.18	32.4 ✓	28.9	26.4 ✓	29.9	27.8

Note: GCp reduced by 10% due to roof angle <= 10 deg.

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Wind Loads - Rooftop Structures & Equipment

Ultimate Wind Pressures

Building (L) = 53.0 ft
Building (B) = 38.0 ft

Directionality (Kd) = 0.85

Rooftop Structures & Equipment #1

Equipment length parallel to L = 15.0 ft
Equipment length parallel to B = 10.0 ft
Height of equipment = 10.0 ft

Base pressure (qh) = **22.4** psf ✓

Vertical wind pressure		Wind normal to building B		Wind normal to building L	
Ar =	150.0 sf	Ar =	100.0 sf	Ar =	150.0 sf
GCr =	1.500	GCr =	1.80	GCr =	1.79
F = qhGCr Ar =	**33.5** Ar (psf)	F = qhGCr Ar =	**40.2** Ar (psf)	F = qhGCr Ar =	**39.9** Ar (psf)
Fv =	**5.0** kips	Fh =	**4.0** kips	Fh =	**6.0** kips

Rooftop Structures & Equipment #2

Equipment length parallel to L = 15.0 ft
Equipment length parallel to B = 10.0 ft
Height of equipment = 10.0 ft

Base pressure (qh) = **22.4** psf

Vertical wind pressure		Wind normal to building B		Wind normal to building L	
Ar =	150.0 sf	Ar =	100.0 sf	Ar =	150.0 sf
GCr =	1.500	GCr =	1.80	GCr =	1.79
F = qhGCr Ar =	**33.5** Ar (psf)	F = qhGCr Ar =	**40.2** Ar (psf)	F = qhGCr Ar =	**39.9** Ar (psf)
Fv =	**5.0** kips	Fh =	**4.0** kips	Fh =	**6.0** kips

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Seismic Loads:

Risk Category : II
Importance Factor (I) : 1.00
Site Class : D

Ss (0.2 sec) = 23.00 %g
S1 (1.0 sec) = 12.00 %g

Fa =	1.600	Sms =	0.368	S_{DS} =	0.245	Design Category =	B ✓
Fv =	2.320 ✓	Sm1 =	0.278	S_{D1} =	0.186	Design Category =	C ✓

Seismic Design Category = C ✓
Number of Stories: 1
Structure Type: Moment-resisting frame systems of steel
Horizontal Struct Irregularities: 2) Reentrant Corners
Vertical Structural Irregularities: No vertical Irregularity
Flexible Diaphragms: No
Building System: **Moment-resisting Frame Systems** ✓
Seismic resisting system: **Steel ordinary moment frames** ✓
System Structural Height Limit: **Height not limited**
Actual Structural Height (hn) = 13.2 ft

DESIGN COEFFICIENTS AND FACTORS

Response Modification Coefficient (R) = 3.5 ✓
Over-Strength Factor (Ωo) = 3
Deflection Amplification Factor (Cd) = 3
S_{DS} = 0.245
S_{D1} = 0.186

Seismic Load Effect (E) = $\rho Q_E \pm 0.2S_{DS} D$ = $\rho Q_E \pm$ 0.049D
Special Seismic Load Effect (Em) = $\Omega o Q_E \pm 0.2S_{DS} D$ = $3.0 Q_E \pm$ 0.049D

ρ = redundancy coefficient
Q_E = horizontal seismic force
D = dead load

PERMITTED ANALYTICAL PROCEDURES

Simplified Analysis - Use Equivalent Lateral Force Analysis

Equivalent Lateral-Force Analysis - Permitted
Building period coef. (C_T) = 0.028
Approx fundamental period (Ta) = $C_T h_n$^ = 0.221 sec x= 0.80
User calculated fundamental period (T) = 0 sec
Long Period Transition Period (TL) = ASCE7 map = 12
Seismic response coef. (Cs) = $S_{DS}I/R$ = 0.070
need not exceed Cs = Sd1 I /RT = 0.240
but not less than Cs = 0.044SdsI = 0.011
USE Cs = 0.070 — SAME AS 53'x28' % BLDG
Design Base Shear V = 0.070W

Cu = 1.53
Tmax = CuTa = 0.337
Use T = 0.221

Model & Seismic Response Analysis - Permitted (see code for procedure)

ALLOWABLE STORY DRIFT

Structure Type: All other structures
Allowable story drift = 0.020hsx where hsx is the story height below level x

Seismic Loads - cont. :

Seismic Design Category (SDC)= C
I = 1.00
Sds = 0.245

CONNECTIONS

Force to connect smaller portions of structure to remainder of structure

Fp = 0.133Sdsw$_p$ = 0.033 w$_p$
or Fp = 0.05w$_p$ = 0.05 w$_p$ Use Fp = 0.05 w$_p$ w$_p$ = weight of smaller portion

Beam, girder or truss connection for resisting horizontal force parallel to member

F_P = no less than 0.05 times dead plus live load vertical reaction

Anchorage of Structural Walls to elements providing lateral support

Fp = 0.20Ww = 0.20 Ww or
See ASCE7 Sect 12.11.2.1 for flexible diaphrams
Fp =0.4SdsIWw = 0.098 Ww (for rigid diaphragm)

Fp = 0.2 Ww
but Fp shall not be less than 5 psf

MEMBER DESIGN

Bearing Walls and Shear Walls (out of plane force)

Fp = 0.4SdsIWw = 0.098 w_w
but not less than 0.10 w_w Use Fp = 0.10 w_w

Diaphragms

Fp = 0.2ISdsWp + Vpx = 0.049 Wp + Vpx

ARCHITECTURAL COMPONENTS SEISMIC COEFFICIENTS

Architectural Component : Interior Nonstructural Walls and Partitions: Plain (unreinforced) masonry walls

Importance Factor (Ip) : 1.0

Component Amplification Factor (a_p) = 1 h= 13.2 feet
Comp Response Modification Factor (R_p) = 1.5 z= 50.0 feet z/h = 1.00

Fp = 0.4a_pSdsIpWp(1+2z/h)/Rp = 0.196 Wp
not greater than Fp = 1.6SdsIpWp = 0.393 Wp
but not less than Fp = 0.3SdsIpWp = 0.074 Wp use Fp = 0.196 Wp

MECH AND ELEC COMPONENTS SEISMIC COEFFICIENTS

Mech or Electrical Component : Elevator and escalator components.

Importance Factor (Ip) : 1.5

Component Amplification Factor (a_p) = 1 h= 13.2 feet
Comp Response Modification Factor (R_p) = 2.5 z= 50.0 feet z/h = 1.00

Fp = 0.4a_pSdsIpWp(1+2z/h)/Rp = 0.177 Wp
not greater than Fp = 1.6SdsIpWp = 0.589 Wp
but not less than Fp = 0.3SdsIpWp = 0.110 Wp use Fp = 0.177 Wp

ARCADIS

SUBJECT: TOPOK – MW-20 BENCH BLDG

BY: MSL DATE: 10/9/15

PAGE E-4

CHKD: DATE:

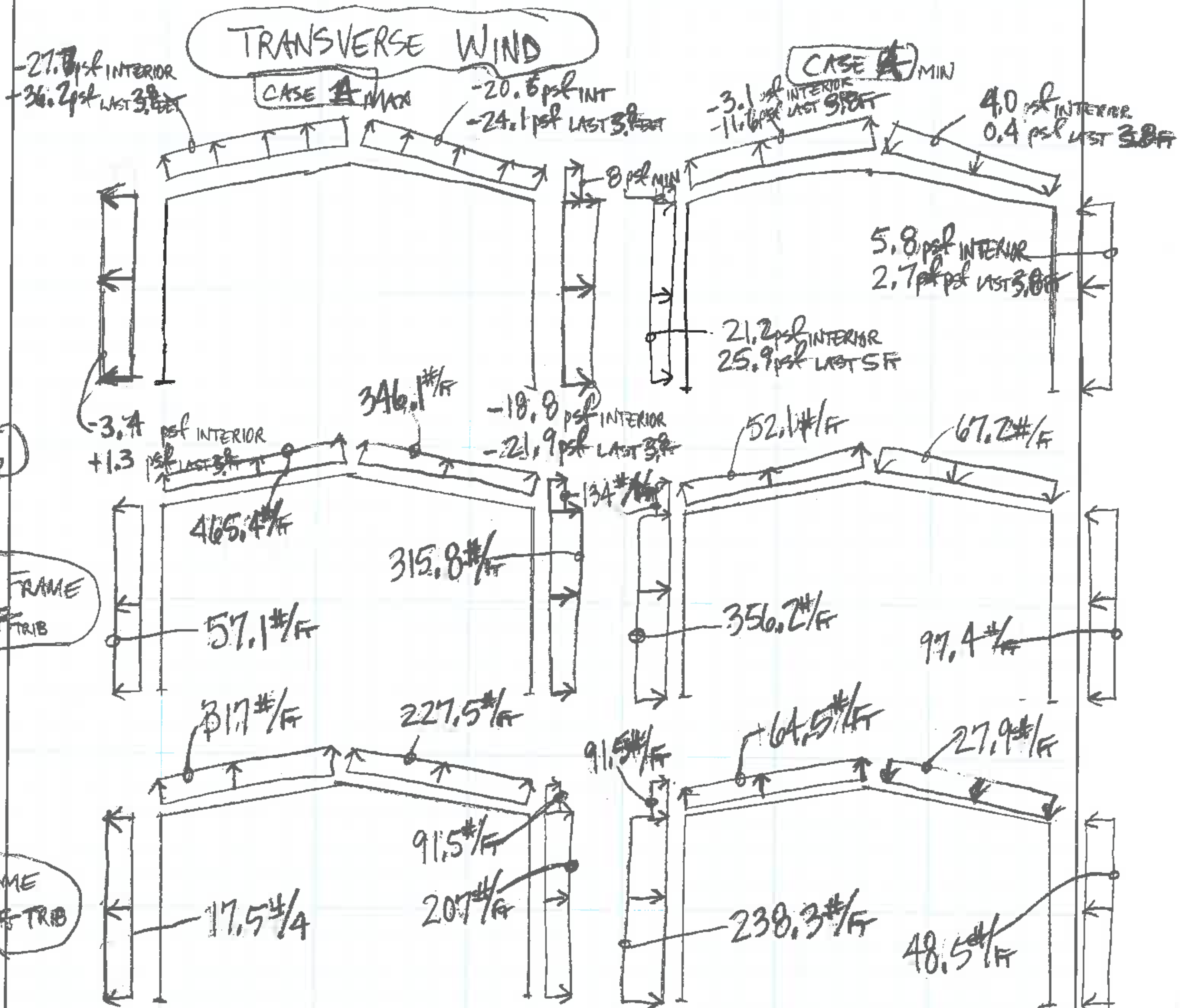
SHEET 1

JOB NO:

- ROOF LIVE LOAD = 20 psf
- FRAME LAYOUT:

~ INTERIOR FRAME = $\left(\frac{19'6'' - 1'3''}{2}\right) + \frac{15'4''}{2} = 16.8$ FT TRIB AREA

~ END FRAME = $1'3'' + \left(\frac{19'6'' - 1'3''}{2}\right) = 10.4$ FT TRIB AREA

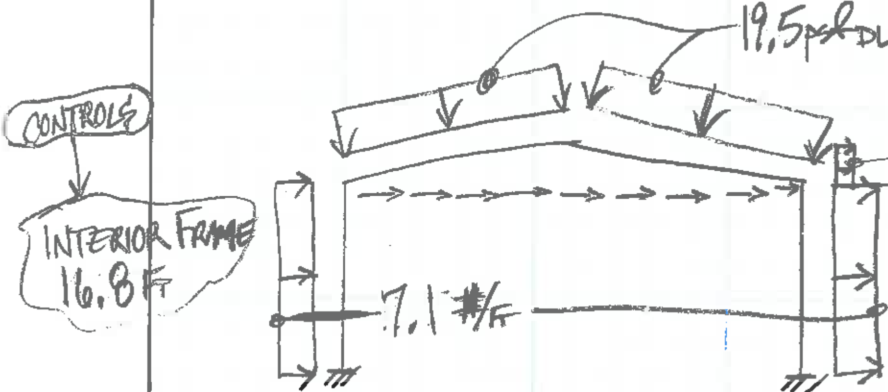


ARCADIS

SUBJECT: TOPOK-MW-20 BENCH BLDG | BY: MSL | DATE: 10/9/15 | PAGE E-5
JOB NO: | CHKD: | DATE: | SHEET 1

SEISMIC LOADS ~ $C_S = 0.07W$ (SHT E-3) ← N/A, WIND CONTROLS PER SHT E-6

- ROOF MAX = 16.5psf × C_S = 1.16psf ; BEAM DL = 70#/FT × C_S = 4.9#/FT
- WALL MAX = 6psf × " = 0.42psf ; COLUMN DL = 50#/FT × C_S = 3.5#/FT



[(4.9#/FT × 38FT) + (1.16psf × 38FT × 16.85FT)] / 1'-5"

= 654#/FT OVER 1'-5"

OR

24.4#/FT OVER 50FT

~ REFERENCE SHT E-6 FOR RISA 2D FRAME

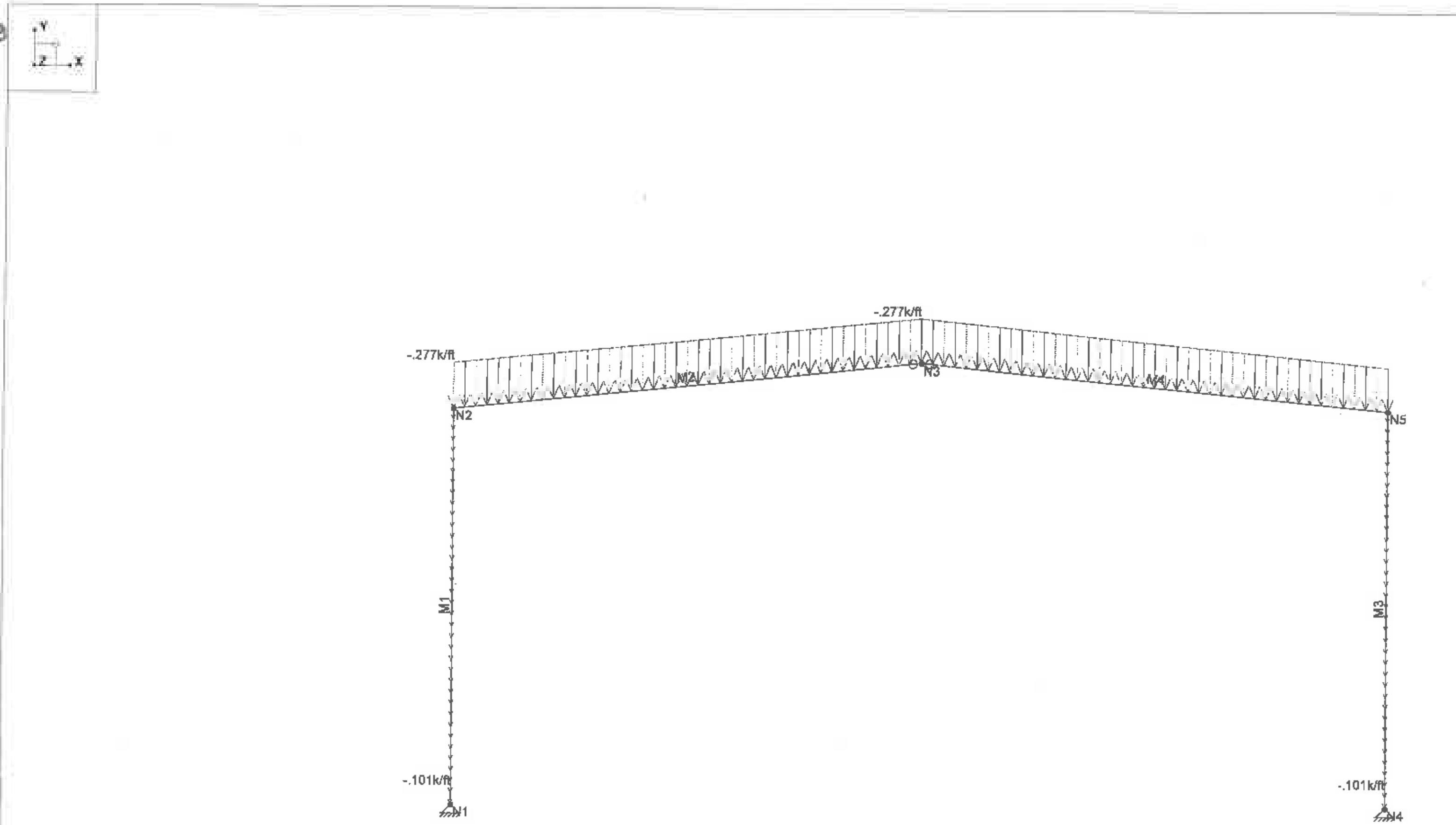
- MAX TENSION = 5.06K (LC#1) — HAIRPIN ← CONTROLS
- MAX GRAVITY = 11.5K (LC#1) ← CONTROLS
- MAX SLIDING OUT = 1.98K (LC#5) ← CONTROLS (USE 2.73K UNF NUCOR) — SHT E-8 LC#4
- MAX UPLIFT = 2.08K (LC#6) ← CONTROLS

~ REF SHT E-7 FOR NUCOR LOADS

- 1 SPAN @ 30' SPAN WIDTH × 12FT EAVE @ 25FT BAY SPACING

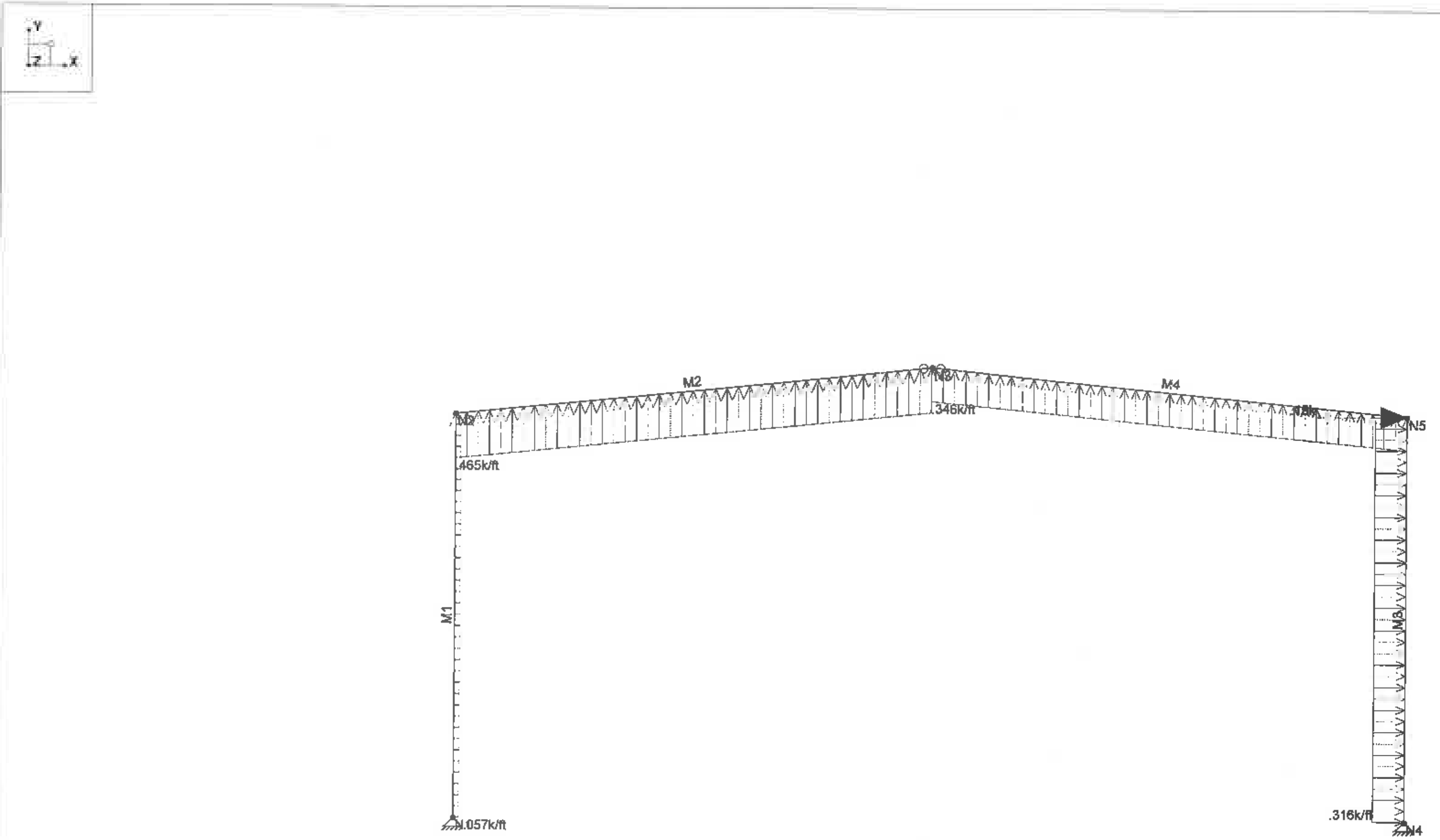
	RDL		RLL		WIL		WIR	
	X	Y	X	Y	X	Y	X	Y
COL 1	0.2	1.3	1.0	7.7	2.6	-1.5	-4.3	-6.0
COL 2	-0.2	1.3	-1.0	7.7	4.3	-6.0	-2.6	-1.5 K

E-6



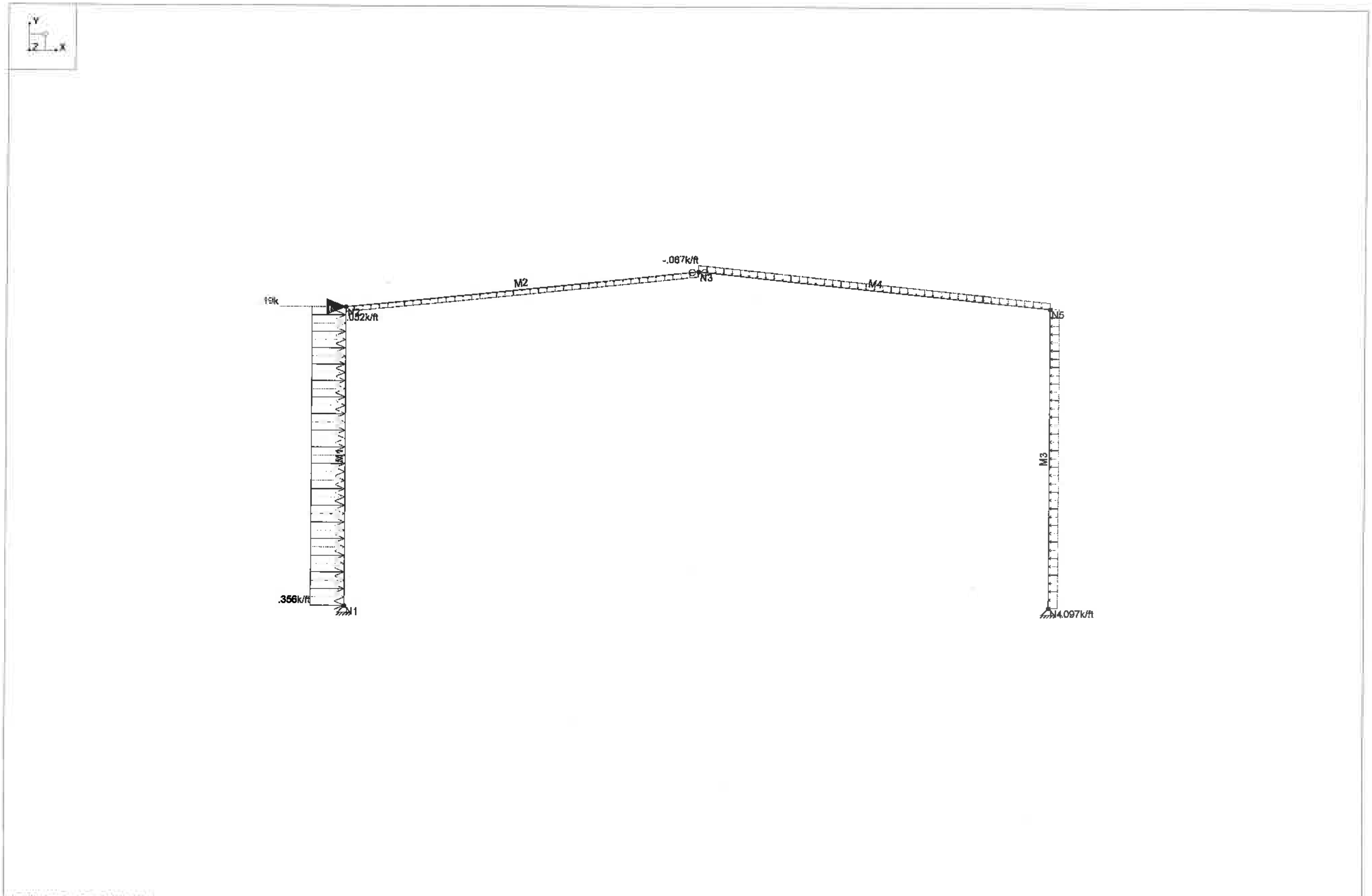
Loads: BLC 1, DL max (1)

ARCADIS	Topok MW-20 Bench Building - 28 ft	SK - 8
Matt Ltoycz		Oct 9, 2015 at 11:56 AM
		Typical Frame MW-20 Bench Bldg.r2d



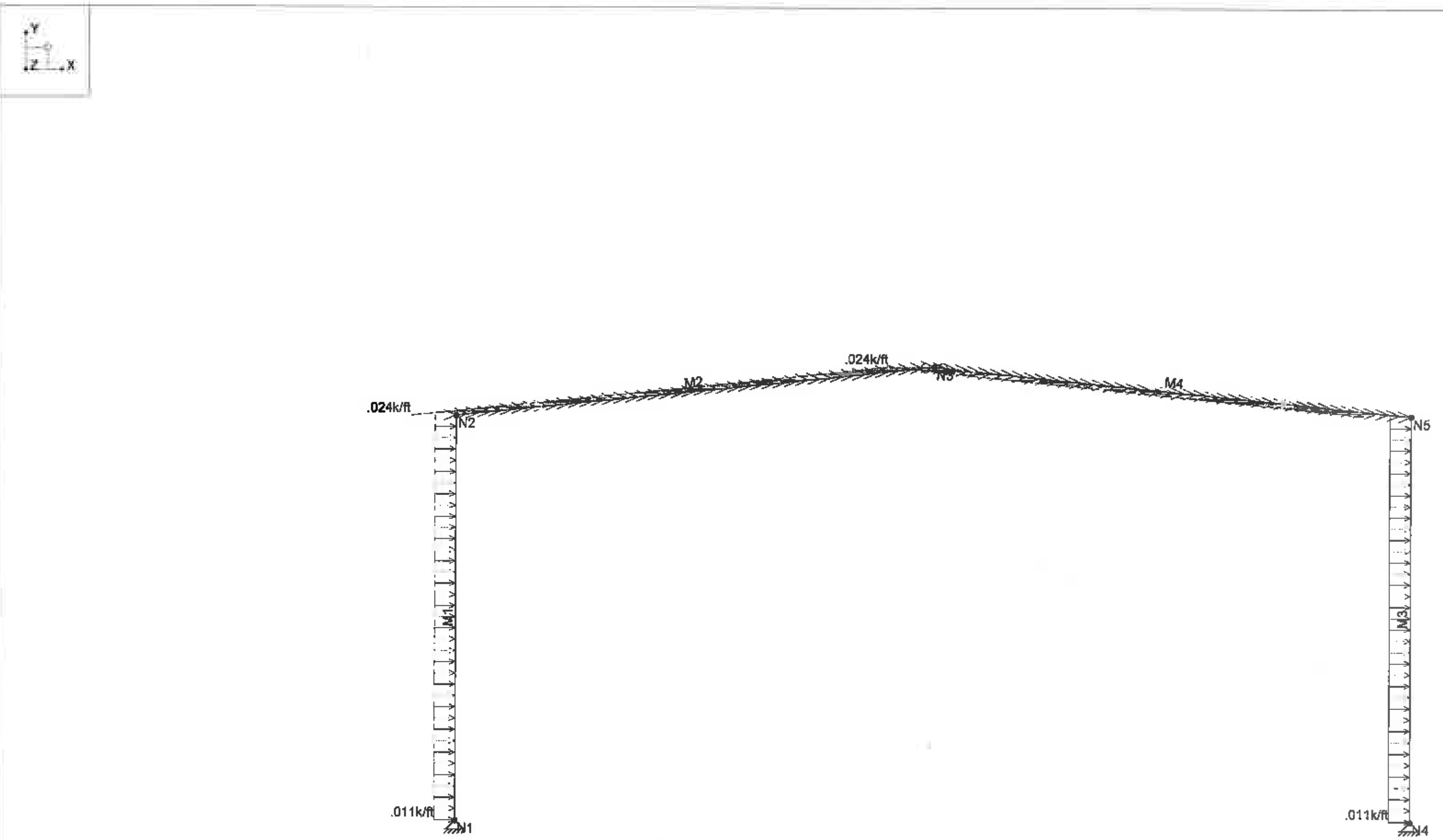
Loads: BLC 2, W1 wall and roof

ARCADIS	Topok MW-20 Bench Building - 28 ft	SK - 9
Matt Ltoycz		Oct 9, 2015 at 11:56 AM
		Typical Frame MW-20 Bench Bldg.r2d



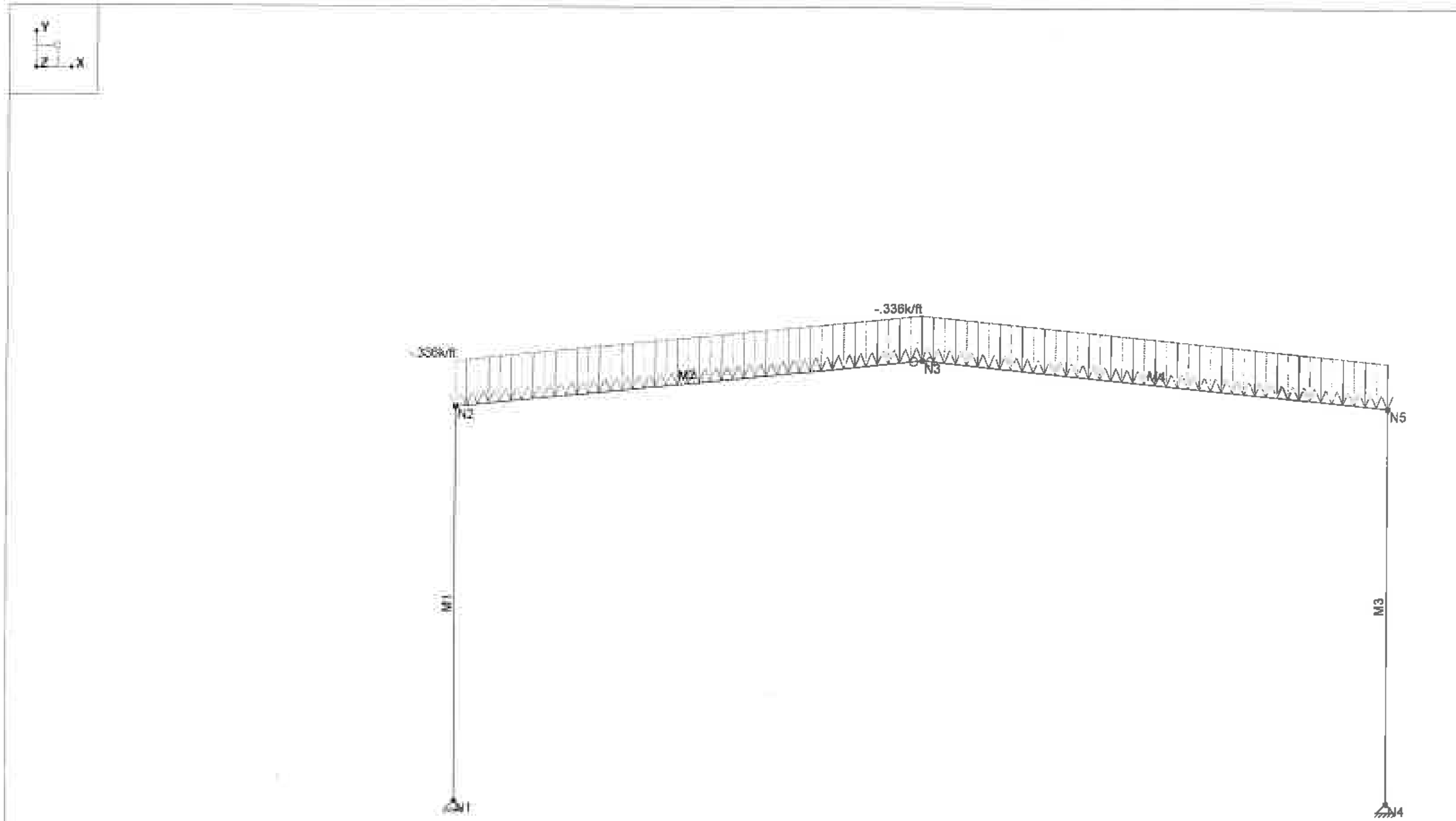
Loads: BLC 3, W2 wall and roof

ARCADIS	Topok MW-20 Bench Building - 28 ft	SK - 13
Matt Ltoycz		Oct 9, 2015 at 11:57 AM
		Typical Frame MW-20 Bench Bldg.r2d



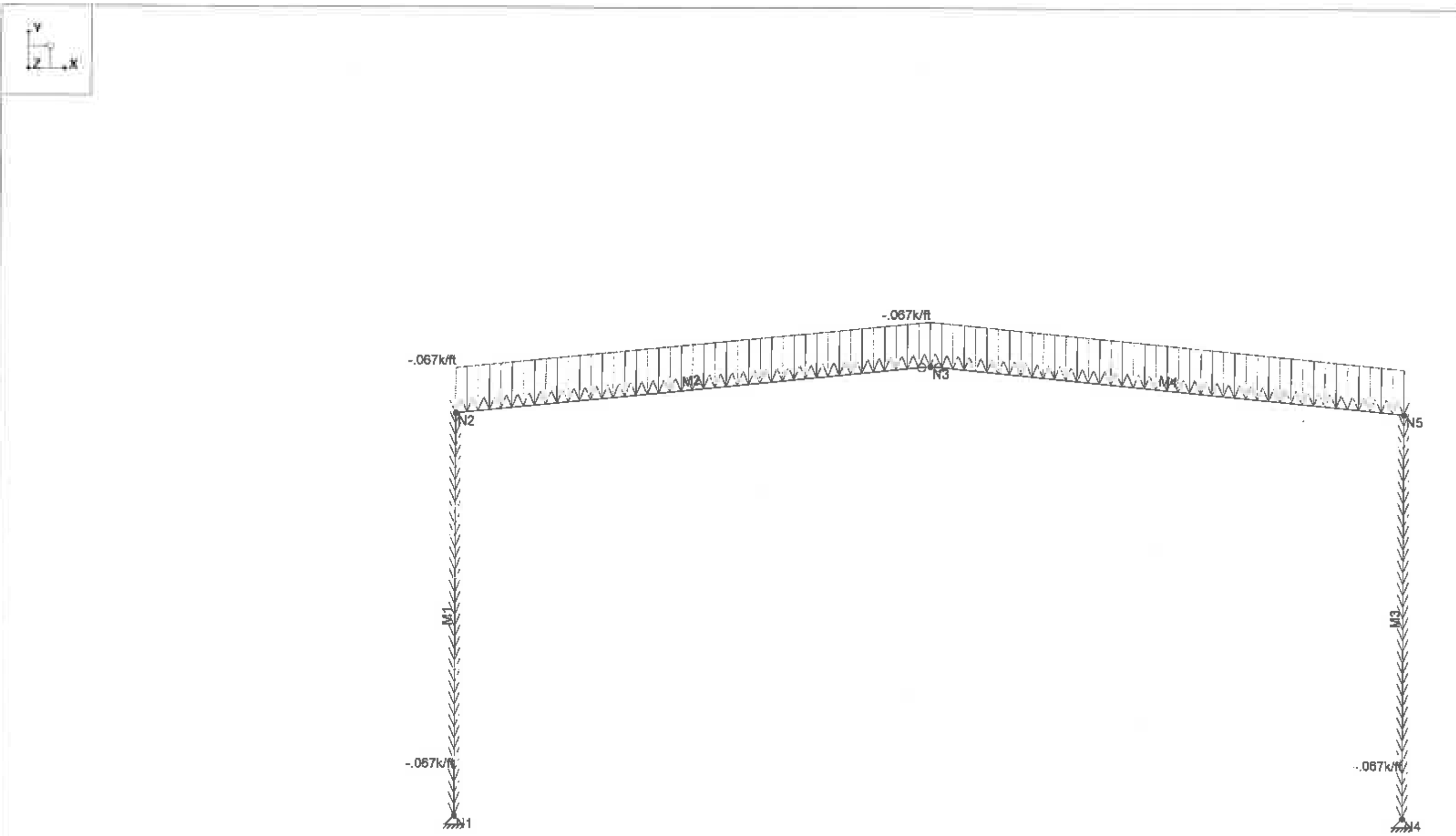
Loads: BLC 4, E

ARCADIS	Topok MW-20 Bench Building - 28 ft	SK - 10
Matt Ltoycz		Oct 9, 2015 at 11:56 AM
		Typical Frame MW-20 Bench Bldg.r2d



Loads: BLC 6, Lr roof

ARCADIS	Topok MW-20 Bench Building - 28 ft	SK - 11
Matt Ltoycz		Oct 9, 2015 at 11:56 AM
		Typical Frame MW-20 Bench Bldg.r2d



Loads: BLC 7, MIN DL (1)

ARCADIS	Topok MW-20 Bench Building - 28 ft	SK - 12
Matt Ltoycz		Oct 9, 2015 at 11:56 AM
		Typical Frame MW-20 Bench Bldg.r2d

Joint Coordinates and Temperatures

	Label	X [ft]	Y [ft]	Temp [F]
1	N1	0	0	0
2	N2	0	12	0
3	N3	14	13.42	0
4	N4	28	0	0
5	N5	28	12	0
6	N6	0	0	0

Joint Boundary Conditions

	Joint Label	X [k/in]	Y [k/in]	Rotation[k-ft/rad]	Footing
1	N1	Reaction	Reaction		
2	N4	Reaction	Reaction		

Member Primary Data

	Label	I Joint	J Joint	Rotate(deg)	Section/Shape	Type	Design List	Material	Design Rules
1	M1	N1	N2		W10x49	None	None	A36 Gr.36	Typical
2	M2	N2	N3		W24x76	None	None	A36 Gr.36	Typical
3	M3	N4	N5		W10x49	None	None	A36 Gr.36	Typical
4	M4	N3	N5		W24x76	None	None	A36 Gr.36	Typical

Joint Loads and Enforced Displacements (BLC 2 : W1 wall and roof)

	Joint Label	L,D,M	Direction	Magnitude[(k,k-ft), (in,rad), (k*s^2/ft...
1	N5	L	X	.19

Joint Loads and Enforced Displacements (BLC 3 : W2 wall and roof)

	Joint Label	L,D,M	Direction	Magnitude[(k,k-ft), (in,rad), (k*s^2/ft...
1	N2	L	X	.19

Member Point Loads

Member Label	Direction	Magnitude[k,k-ft]	Location[ft,%]
No Data to Print ...			

Member Distributed Loads (BLC 1 : DL max (1))

	Member Label	Direction	Start Magnitude[k/ft,F]	End Magnitude[k/ft,F]	Start Location[ft,%]	End Location[ft,%]
1	M2	Y	-.277	-.277	0	%100
2	M4	Y	-.277	-.277	0	%100
3	M1	Y	-.101	-.101	0	%100
4	M3	Y	-.101	-.101	0	%100

Member Distributed Loads (BLC 2 : W1 wall and roof)

	Member Label	Direction	Start Magnitude[k/ft,F]	End Magnitude[k/ft,F]	Start Location[ft,%]	End Location[ft,%]
1	M1	X	-.057	-.057	0	%100
2	M3	X	.316	.316	0	%100
3	M2	Y	.465	.465	0	%100
4	M4	Y	.346	.346	0	%100

Member Distributed Loads (BLC 3 : W2 wall and roof)

Member Label	Direction	Start Magnitude[k/ft,F]	End Magnitude[k/ft,F]	Start Location[ft,%]	End Location[ft,%]

Member Distributed Loads (BLC 3 : W2 wall and roof) (Continued)

	Member Label	Direction	Start Magnitude[k/ft,F]	End Magnitude[k/ft,F]	Start Location[ft,%]	End Location[ft,%]
1	M1	X	.356	.356	0	%100
2	M3	X	-.097	-.097	0	%100
3	M2	Y	.052	.052	0	%100
4	M4	Y	-.067	-.067	0	%100

Member Distributed Loads (BLC 4 : E)

	Member Label	Direction	Start Magnitude[k/ft,F]	End Magnitude[k/ft,F]	Start Location[ft,%]	End Location[ft,%]
1	M2	X	.024	.024	0	%100
2	M4	X	.024	.024	0	%100
3	M1	X	.011	.011	0	%100
4	M3	X	.011	.011	0	%100

Member Distributed Loads (BLC 6 : Lr roof)

	Member Label	Direction	Start Magnitude[k/ft,F]	End Magnitude[k/ft,F]	Start Location[ft,%]	End Location[ft,%]
1	M2	Y	-.336	-.336	0	%100
2	M4	Y	-.336	-.336	0	%100

Member Distributed Loads (BLC 7 : MIN DL (1))

	Member Label	Direction	Start Magnitude[k/ft,F]	End Magnitude[k/ft,F]	Start Location[ft,%]	End Location[ft,%]
1	M2	Y	-.067	-.067	0	%100
2	M4	Y	-.067	-.067	0	%100
3	M1	Y	-.067	-.067	0	%100
4	M3	Y	-.067	-.067	0	%100

Basic Load Cases

	BLC Description	Category	X Gravity	Y Gravity	Joint	Point	Distributed
1	DL max (1)	None		-1			4
2	W1 wall and roof	None			1		4
3	W2 wall and roof	None			1		4
4	E	None		-1			4
6	Lr roof	None					2
7	MIN DL (1)	None		-1			4

Load Combinations

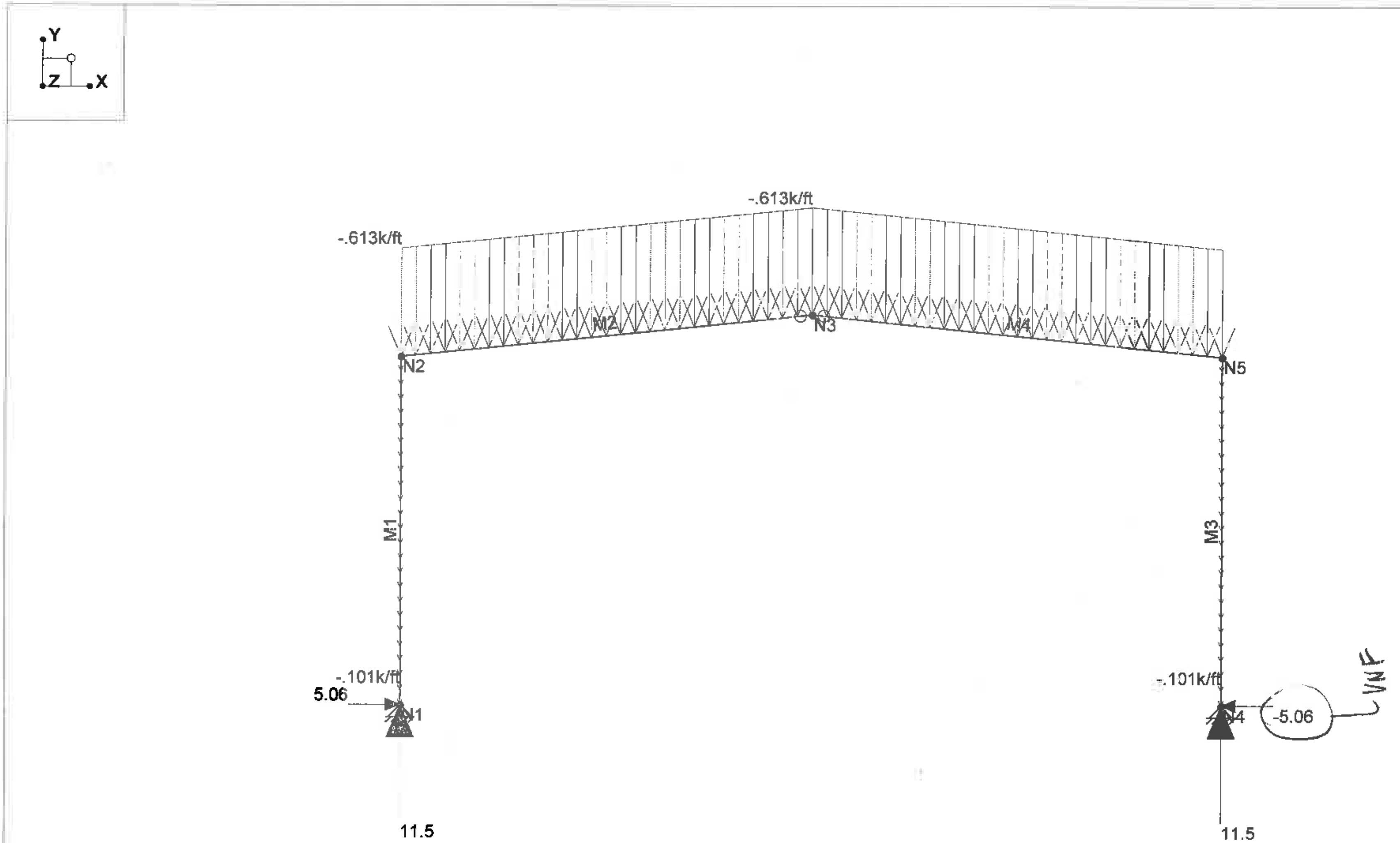
	Description	So...	P...	S...	BLC	Fac...	BLC	Fac...	BLC	Fac...	BLC	Fac...	BLC	Fac...	BLC	Fac...	BLC	Fac...	BLC	Fac...
1	DL max 1 + Lr	Yes			1	1	6	1												
2	DL max 1 + 0.75 Lr + (0.6*0.75) W1 wall...	Yes			1	1	6	.75	2	.45										
3	DL max 1 + 0.75 Lr + (0.6*0.75) W2 wall...	Yes			1	1	6	.75	3	.45										
4	DL max 1 + 0.6W1 wall and roof	Yes			1	1	2	.6												
5	DL max 1 + 0.6W2 wall and roof	Yes			1	1	3	.6												
6	0.6DL min 1 + 0.6W1 wall & roof	Yes			7	.6	2	.6												
7	0.6DL min 1 + 0.6W2 wall and roof	Yes			7	.6	3	.6												
8	(1+0.105Sds) DL max 1 + 0.75 Lr + 0.5...	Yes			1	1.026	6	.75			4	.525								
9	0.6DL min 1 + 0.7E	Yes			7	.56	4	.7												
10	1.2DL max 1 + 1.6 Lr + 1.0 Lrr max 1 + ...	Yes			1	1.2	6	1.6			2	.5								
11	1.2DL max 1 + 1.6 Lr + 1.0 Lrr max 1 + ...	Yes			1	1.2	6	1.6			3	.5								
12	1.2DL max 1 + 0.5 Lr + 0.5 Lrr max 1 + ...	Yes			1	1.2	6	.5			2	1								
13	1.2DL max 1 + 0.5 Lr + 0.5 Lrr max 1 + ...	Yes			1	1.2	6	.5			3	1								
14	0.9DL max 1 + 1.0W1 roof and wall	Yes			1	.9	2	1												
15	0.9DL min 1 + 1.0W1 roof and wall	Yes			7	.9	2	1												
16	0.9DL max 1 + 1.0W2 roof and wall	Yes			1	.9	3	1												
17	0.9DL min 1 + 1.0W2 roof and wall	Yes			7	.9	3	1												

Load Combinations (Continued)

	Description	So...	P...	S...	BLC	Fac...	BLC	Fac...	BLC	Fac...	BLC	Fac...	BLC	Fac...	BLC	Fac...	BLC	Fac...	BLC	Fac...
18	1.2DL max 1 + 1.0E	Yes			1	1.2	4	1												
19	0.9DL min 1 + 1.0E	Yes			7	.9	4	1												

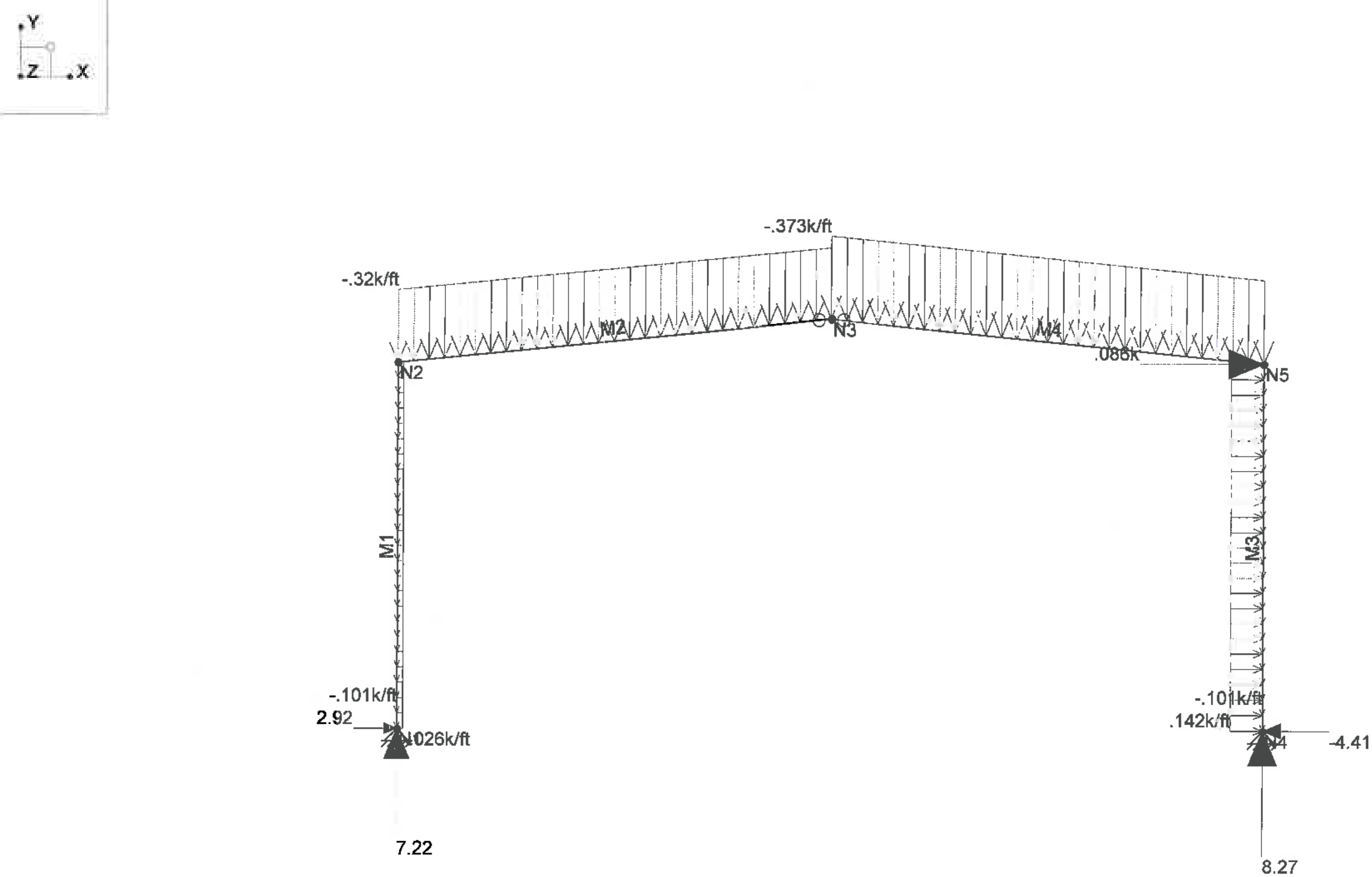
Load Combination Design

	Description	ASIF	CD	ABIF	Service	Hot Rolled	Cold Form...	Wood	Concrete	Masonry	Footings	Aluminum
1	DL max 1 + Lr					Yes	Yes	Yes	Yes	Yes	Yes	Yes
2	DL max 1 + 0...					Yes	Yes	Yes	Yes	Yes	Yes	Yes
3	DL max 1 + 0...					Yes	Yes	Yes	Yes	Yes	Yes	Yes
4	DL max 1 + 0...					Yes	Yes	Yes	Yes	Yes	Yes	Yes
5	DL max 1 + 0...					Yes	Yes	Yes	Yes	Yes	Yes	Yes
6	0.6DL min 1 ...					Yes	Yes	Yes	Yes	Yes	Yes	Yes
7	0.6DL min 1 ...					Yes	Yes	Yes	Yes	Yes	Yes	Yes
8	(1+0.105Sds)...					Yes	Yes	Yes	Yes	Yes	Yes	Yes
9	0.6DL min 1 ...					Yes	Yes	Yes	Yes	Yes	Yes	Yes
10	1.2DL max 1 ...					Yes	Yes	Yes	Yes	Yes	Yes	Yes
11	1.2DL max 1 ...					Yes	Yes	Yes	Yes	Yes	Yes	Yes
12	1.2DL max 1 ...					Yes	Yes	Yes	Yes	Yes	Yes	Yes
13	1.2DL max 1 ...					Yes	Yes	Yes	Yes	Yes	Yes	Yes
14	0.9DL max 1 ...					Yes	Yes	Yes	Yes	Yes	Yes	Yes
15	0.9DL min 1 ...					Yes	Yes	Yes	Yes	Yes	Yes	Yes
16	0.9DL max 1 ...					Yes	Yes	Yes	Yes	Yes	Yes	Yes
17	0.9DL min 1 ...					Yes	Yes	Yes	Yes	Yes	Yes	Yes
18	1.2DL max 1 ...					Yes	Yes	Yes	Yes	Yes	Yes	Yes
19	0.9DL min 1 ...					Yes	Yes	Yes	Yes	Yes	Yes	Yes



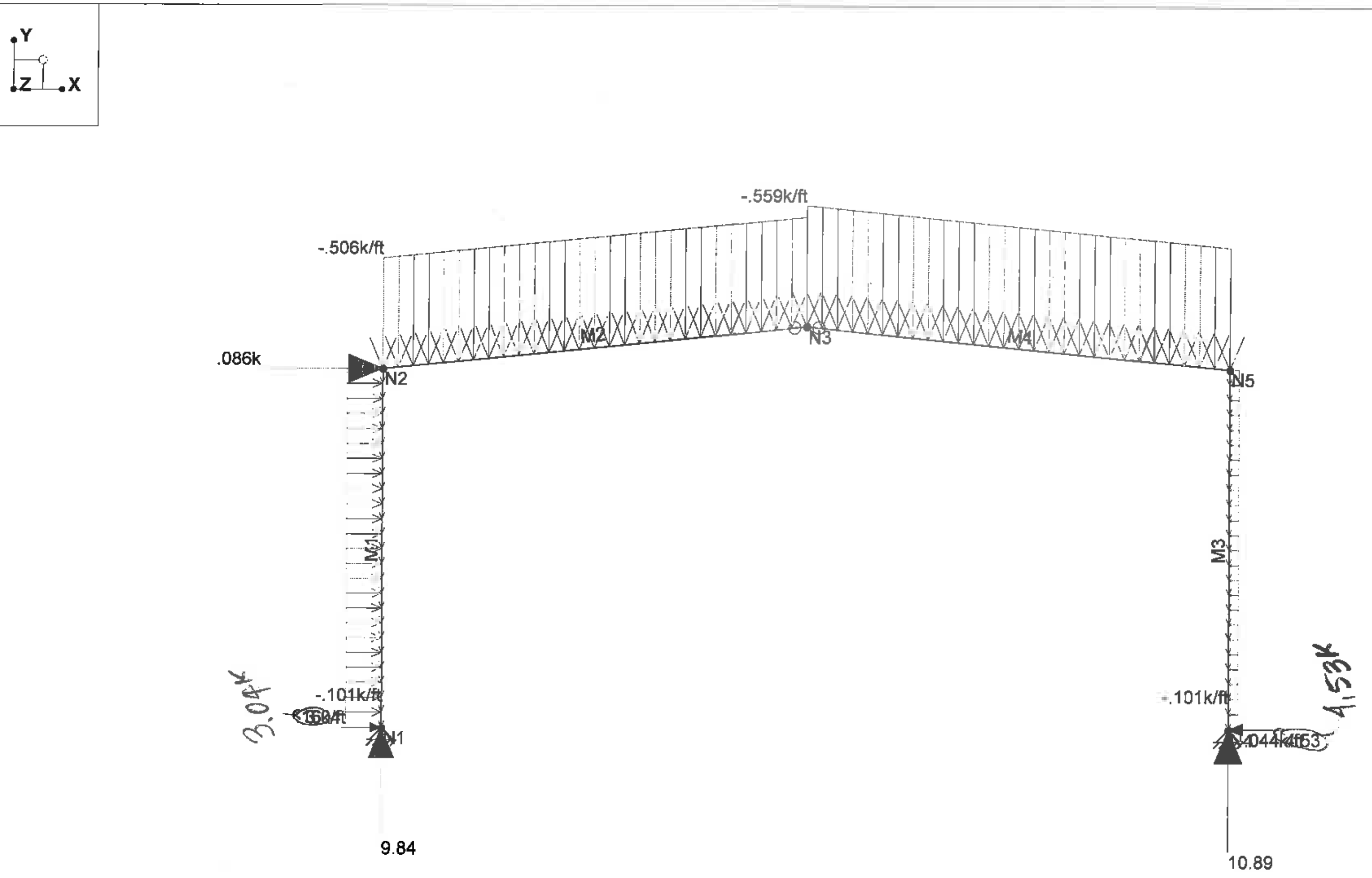
Loads: LC 1, DL max 1 + Lr
Results for LC 1, DL max 1 + Lr
Z-moment Reaction Units are k and k-ft

ARCADIS	Topok MW-20 Bench Building - 28 ft	SK - 14
Matt Ltoycz		Oct 9, 2015 at 11:58 AM
		Typical Frame MW-20 Bench Bldg.r2d



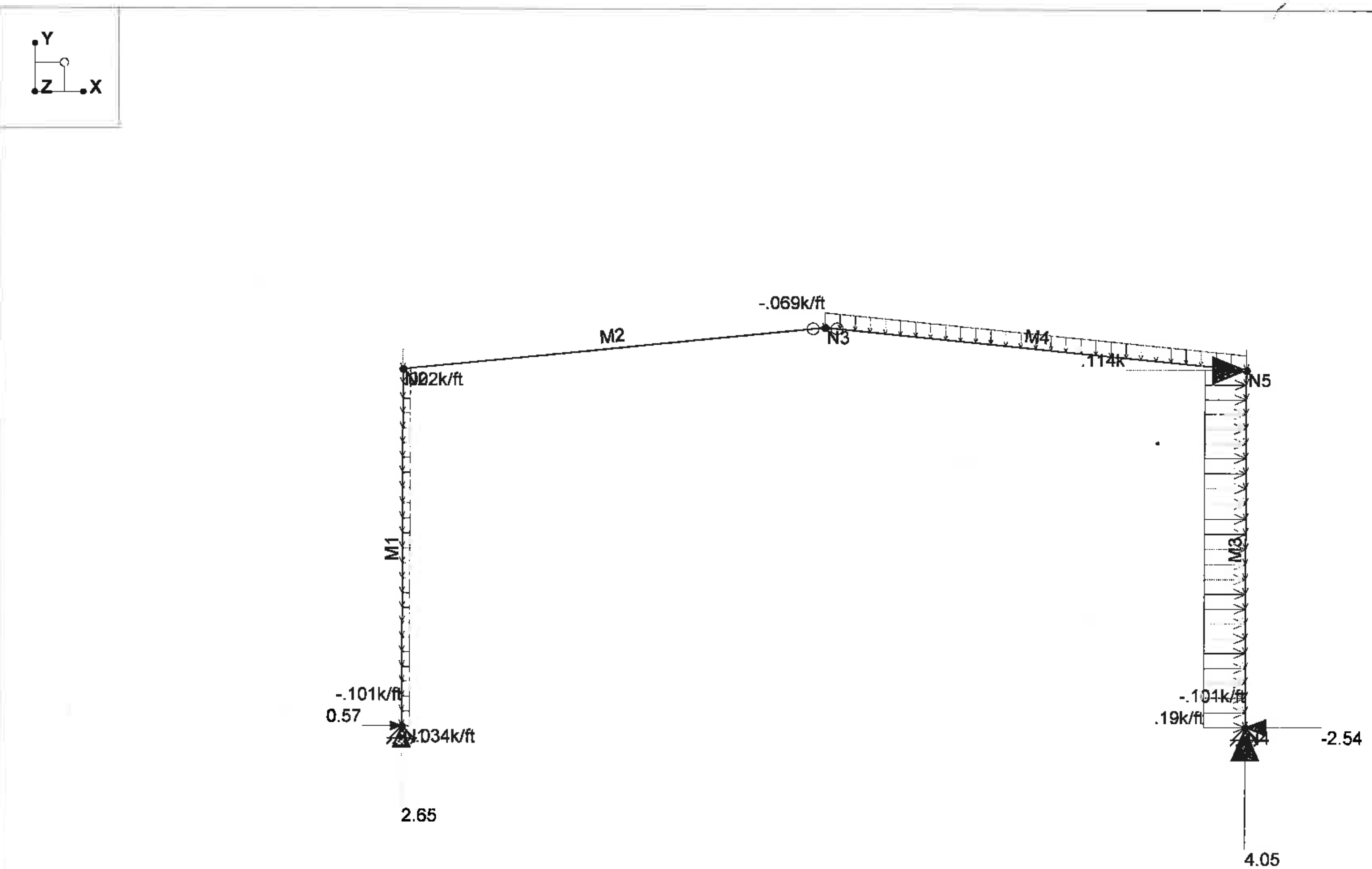
Loads: LC 2, DL max 1 + 0.75 Lr + (0.6*0.75) W1 wall & roof
Results for LC 2, DL max 1 + 0.75 Lr + (0.6*0.75) W1 wall & roof
Z-moment Reaction Units are k and k-ft

ARCADIS	Topok MW-20 Bench Building - 28 ft	SK - 15
Matt Ltoycz		Oct 9, 2015 at 11:58 AM
		Typical Frame MW-20 Bench Bldg.r2d



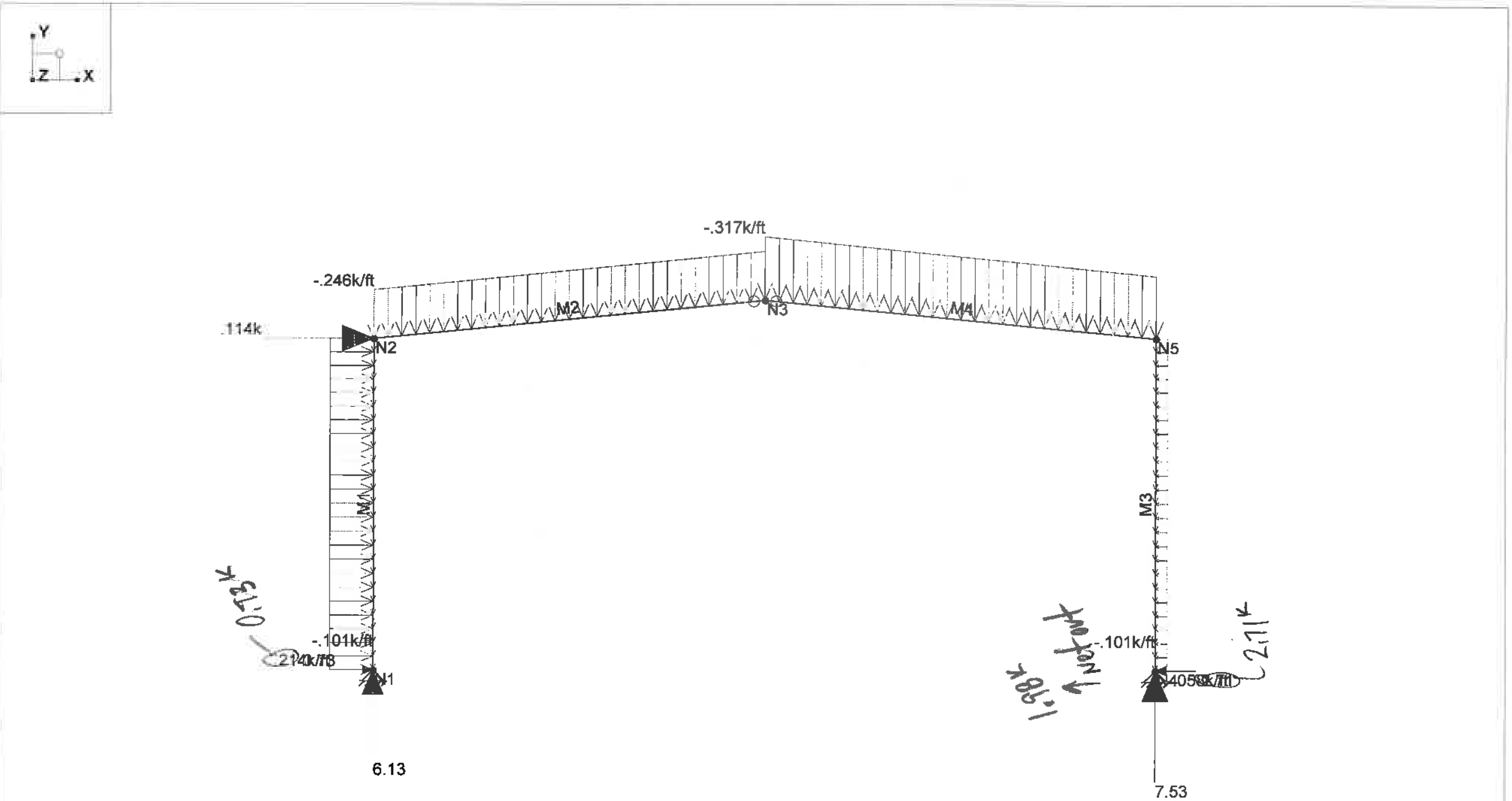
Loads: LC 3, DL max 1 + 0.75 Lr + (0.6*0.75) W2 wall and roof
Results for LC 3, DL max 1 + 0.75 Lr + (0.6*0.75) W2 wall and roof
Z-moment Reaction Units are k and k-ft

ARCADIS	Topok MW-20 Bench Building - 28 ft	SK - 16
Matt Ltoycz		Oct 9, 2015 at 11:58 AM
		Typical Frame MW-20 Bench Bldg.r2d



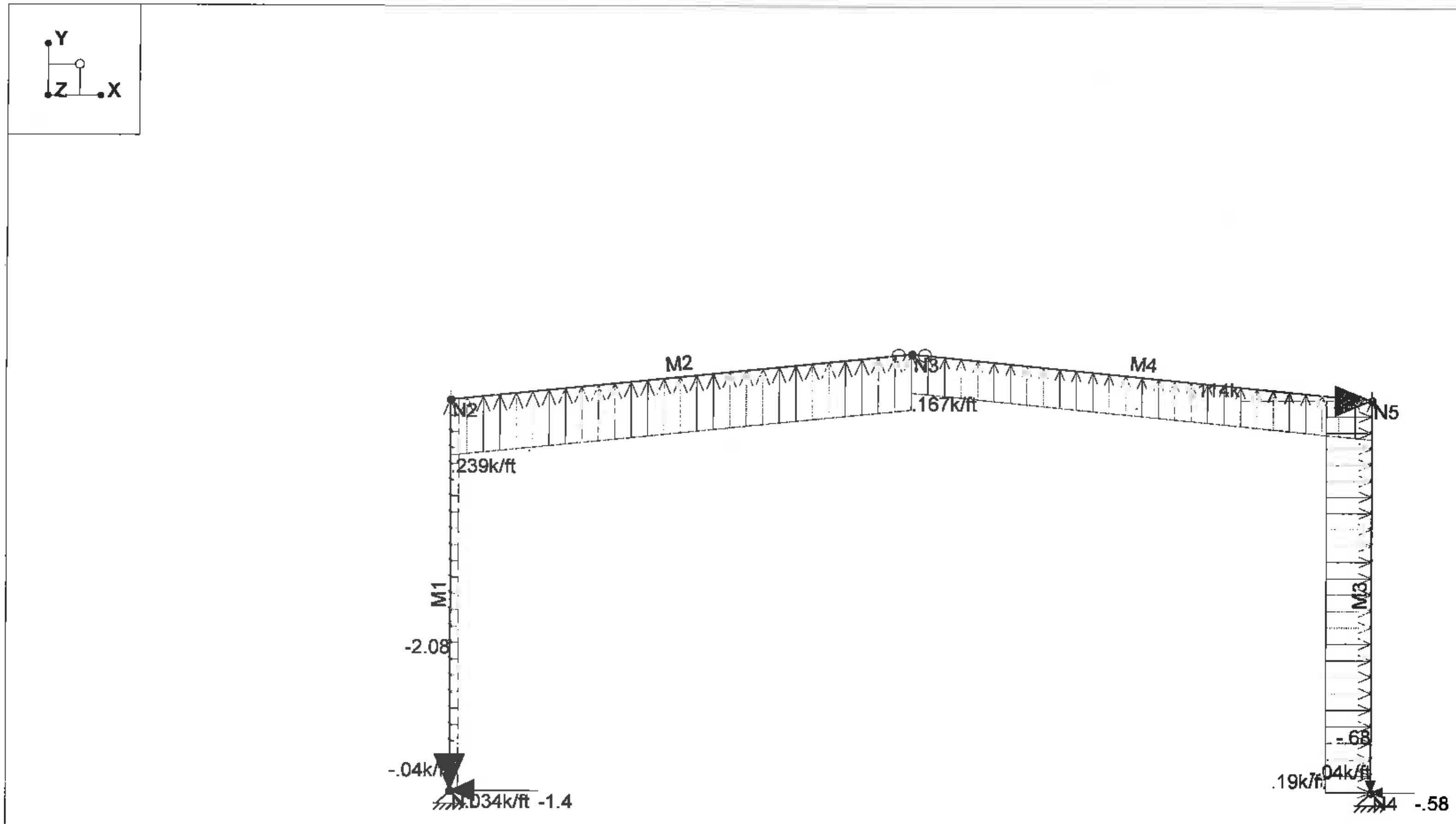
Loads: LC 4, DL max 1 + 0.6W1 wall and roof
Results for LC 4, DL max 1 + 0.6W1 wall and roof
Z-moment Reaction Units are k and k-ft

ARCADIS	Topok MW-20 Bench Building - 28 ft	SK - 17
Matt Ltoycz		Oct 9, 2015 at 11:58 AM
		Typical Frame MW-20 Bench Bldg.r2d



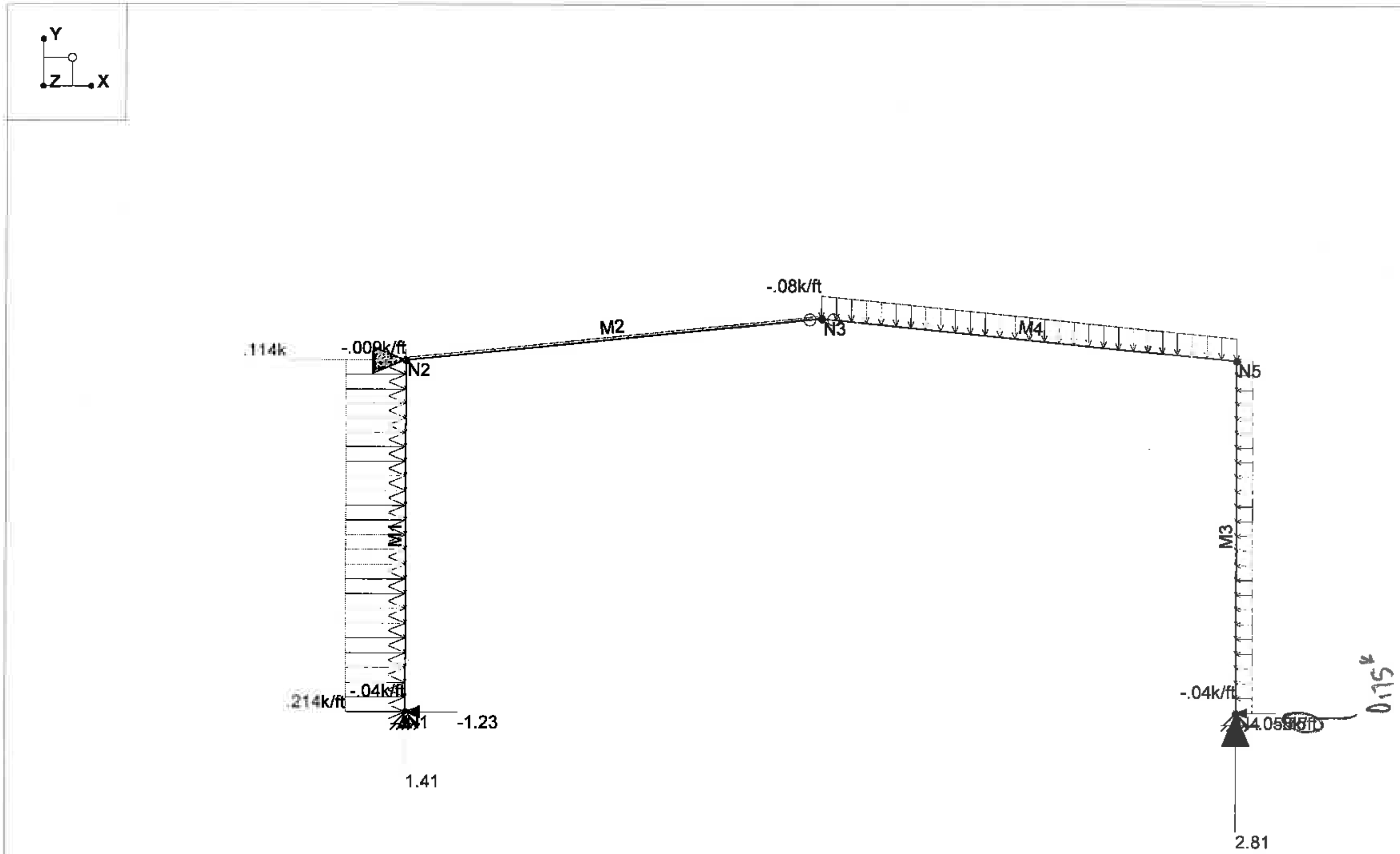
Loads: LC 5, DL max 1 + 0.6W2 wall and roof
Results for LC 5, DL max 1 + 0.6W2 wall and roof
Z-moment Reaction Units are k and k-ft

ARCADIS	Topok MW-20 Bench Building - 28 ft	SK - 18
Matt Ltoycz		Oct 9, 2015 at 11:58 AM
		Typical Frame MW-20 Bench Bldg.r2d



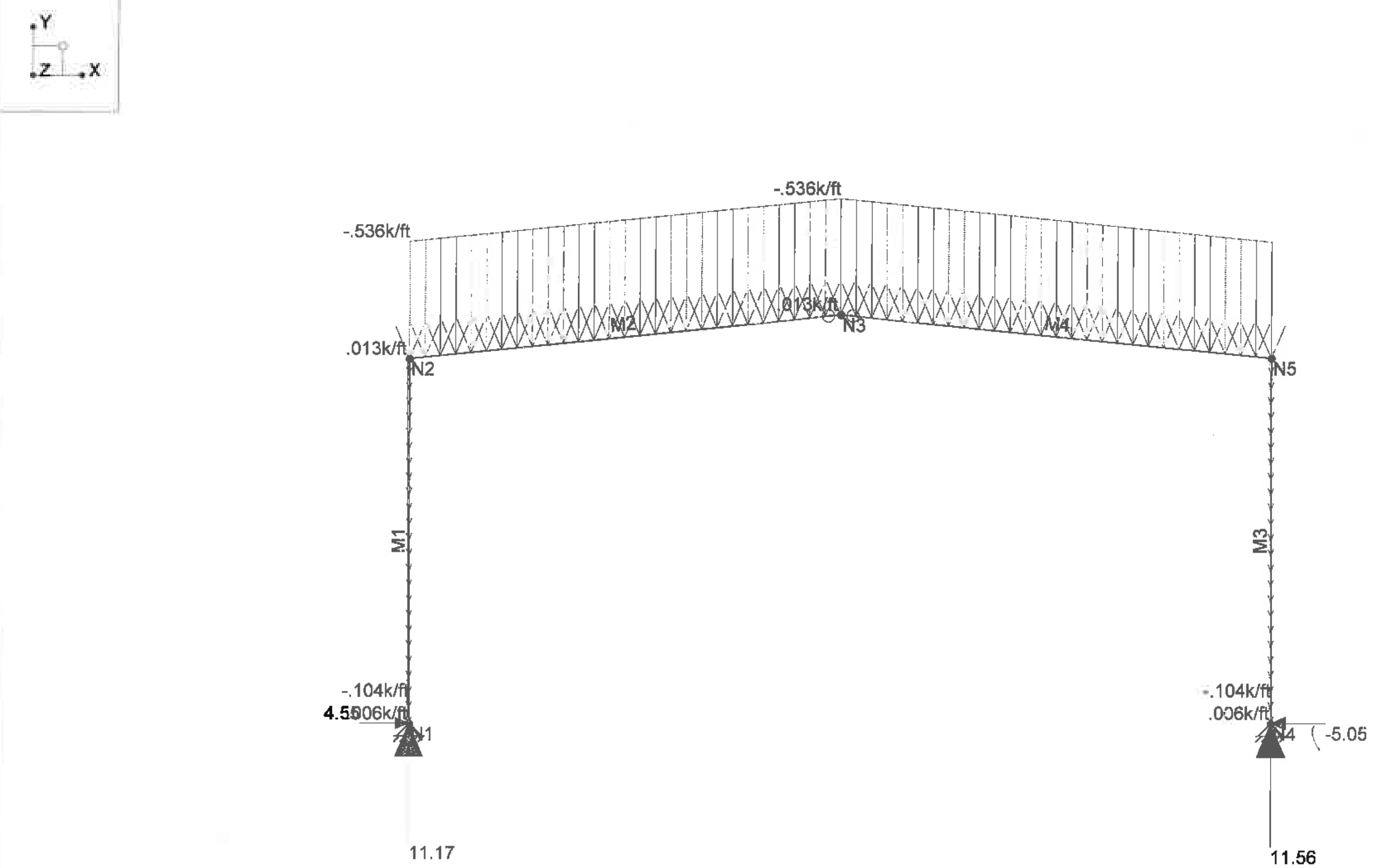
Loads: LC 6, 0.6DL min 1 + 0.6W1 wall & roof
Results for LC 6, 0.6DL min 1 + 0.6W1 wall & roof
Z-moment Reaction Units are k and k-ft

ARCADIS	Topok MW-20 Bench Building - 28 ft	SK - 19
Matt Ltoycz		Oct 9, 2015 at 11:58 AM
		Typical Frame MW-20 Bench Bldg.r2d



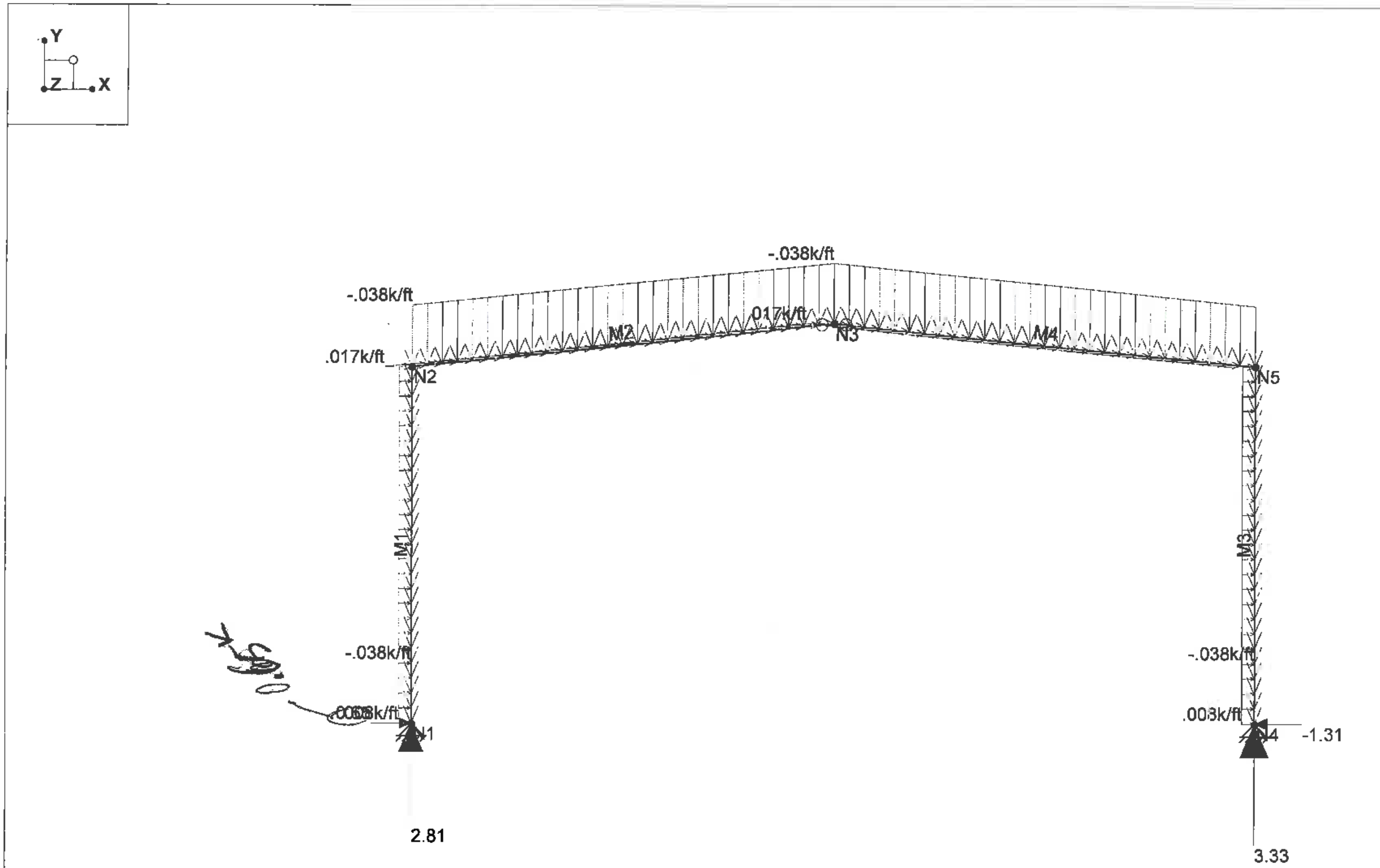
Loads: LC 7, 0.6DL min 1 + 0.6W2 wall and roof
Results for LC 7, 0.6DL min 1 + 0.6W2 wall and roof
Z-moment Reaction Units are k and k-ft

ARCADIS	Topok MW-20 Bench Building - 28 ft	SK - 20
Matt Ltoycz		Oct 9, 2015 at 11:59 AM
		Typical Frame MW-20 Bench Bldg.r2d



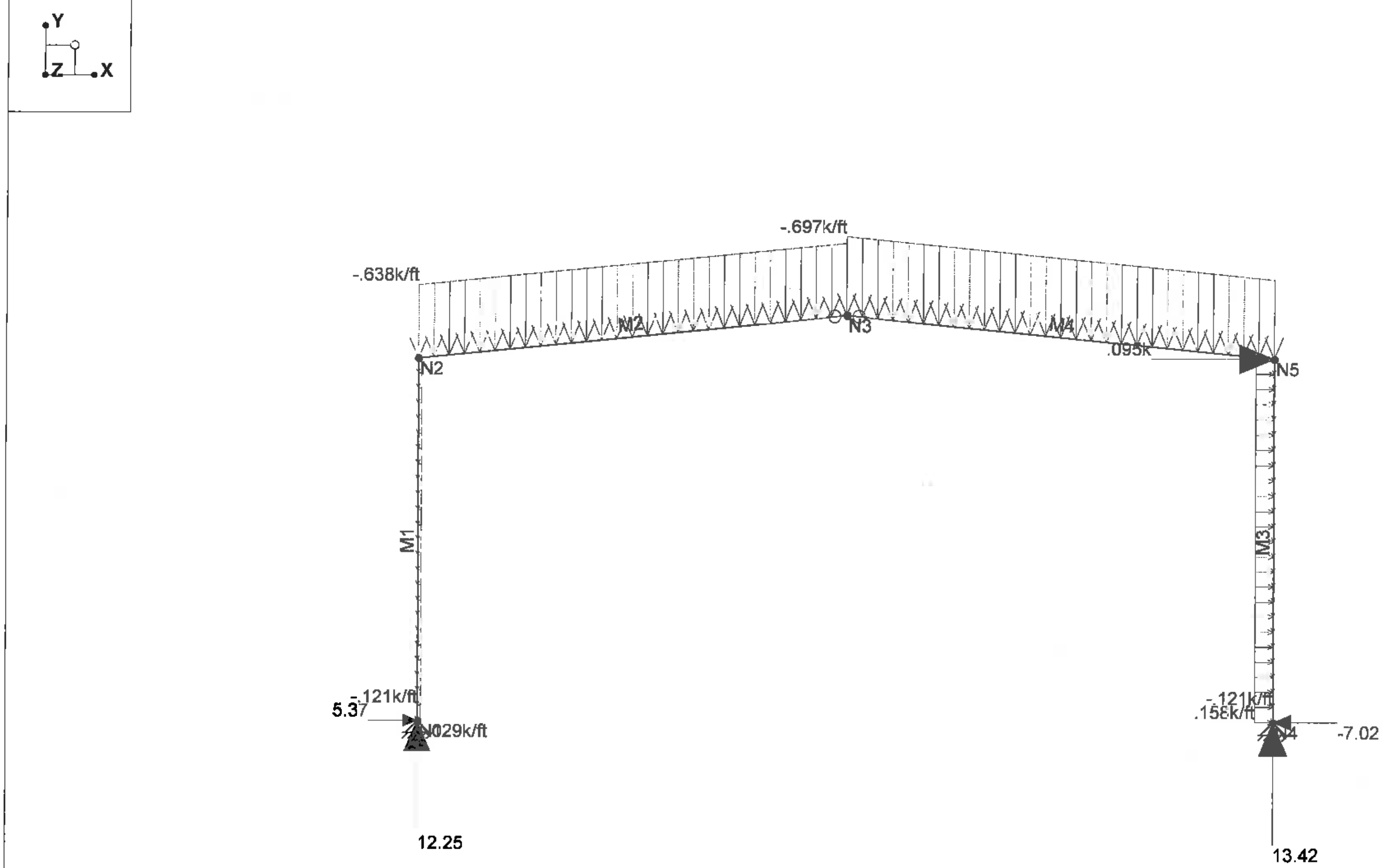
Loads: LC 8, (1+0.105Sds) DL max 1 + 0.75 Lr + 0.525E
Results for LC 8, (1+0.105Sds) DL max 1 + 0.75 Lr + 0.525E
Z-moment Reaction Units are k and k-ft

ARCADIS	Topok MW-20 Bench Building - 28 ft	SK - 21
Matt Ltoycz		Oct 9, 2015 at 11:59 AM
		Typical Frame MW-20 Bench Bldg.r2d



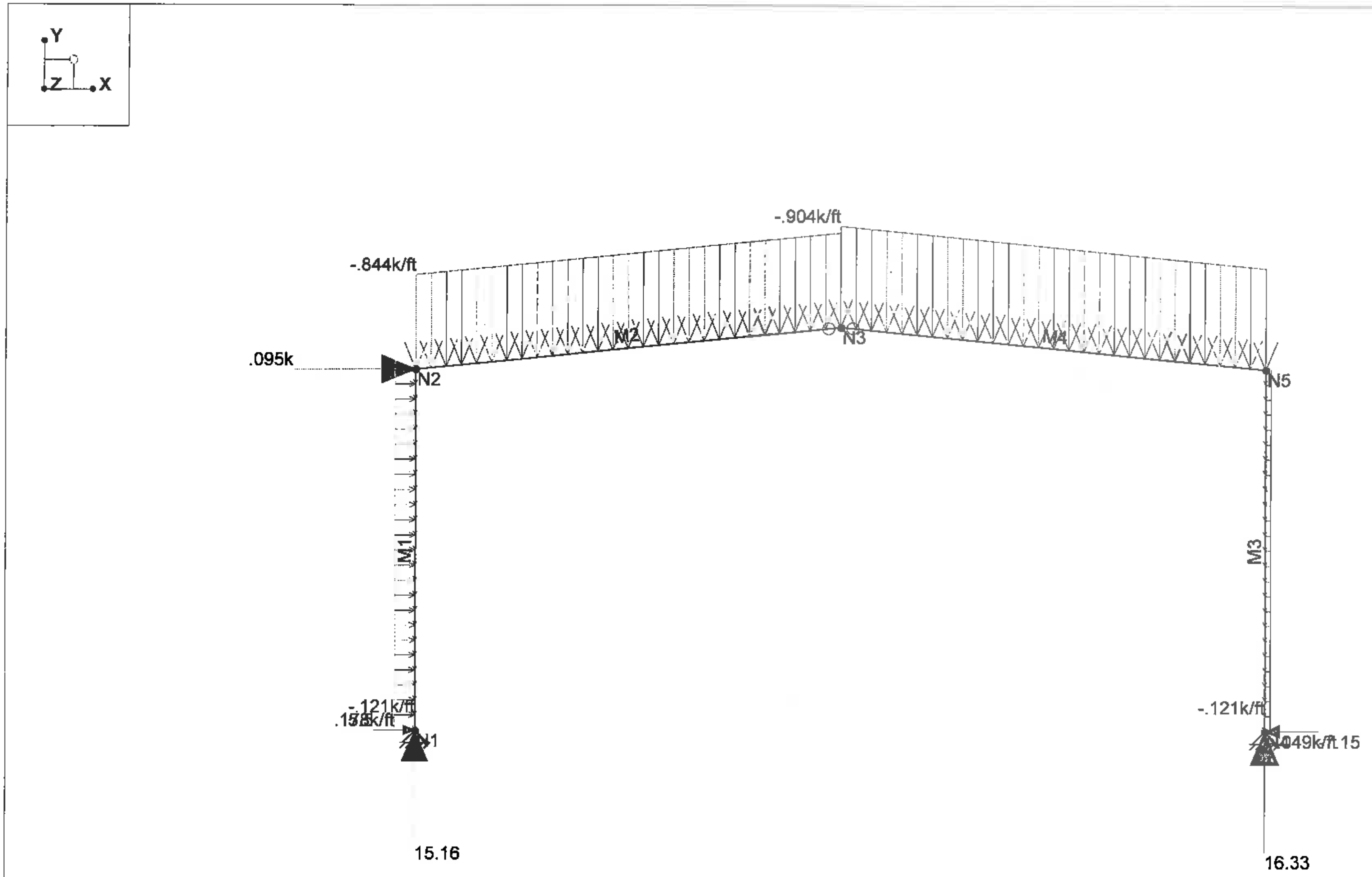
Loads: LC 9, 0.6DL min 1 + 0.7E
Results for LC 9, 0.6DL min 1 + 0.7E
Z-moment Reaction Units are k and k-ft

ARCADIS	Topok MW-20 Bench Building - 28 ft	SK - 22
Matt Ltoycz		Oct 9, 2015 at 11:59 AM
		Typical Frame MW-20 Bench Bldg.r2d



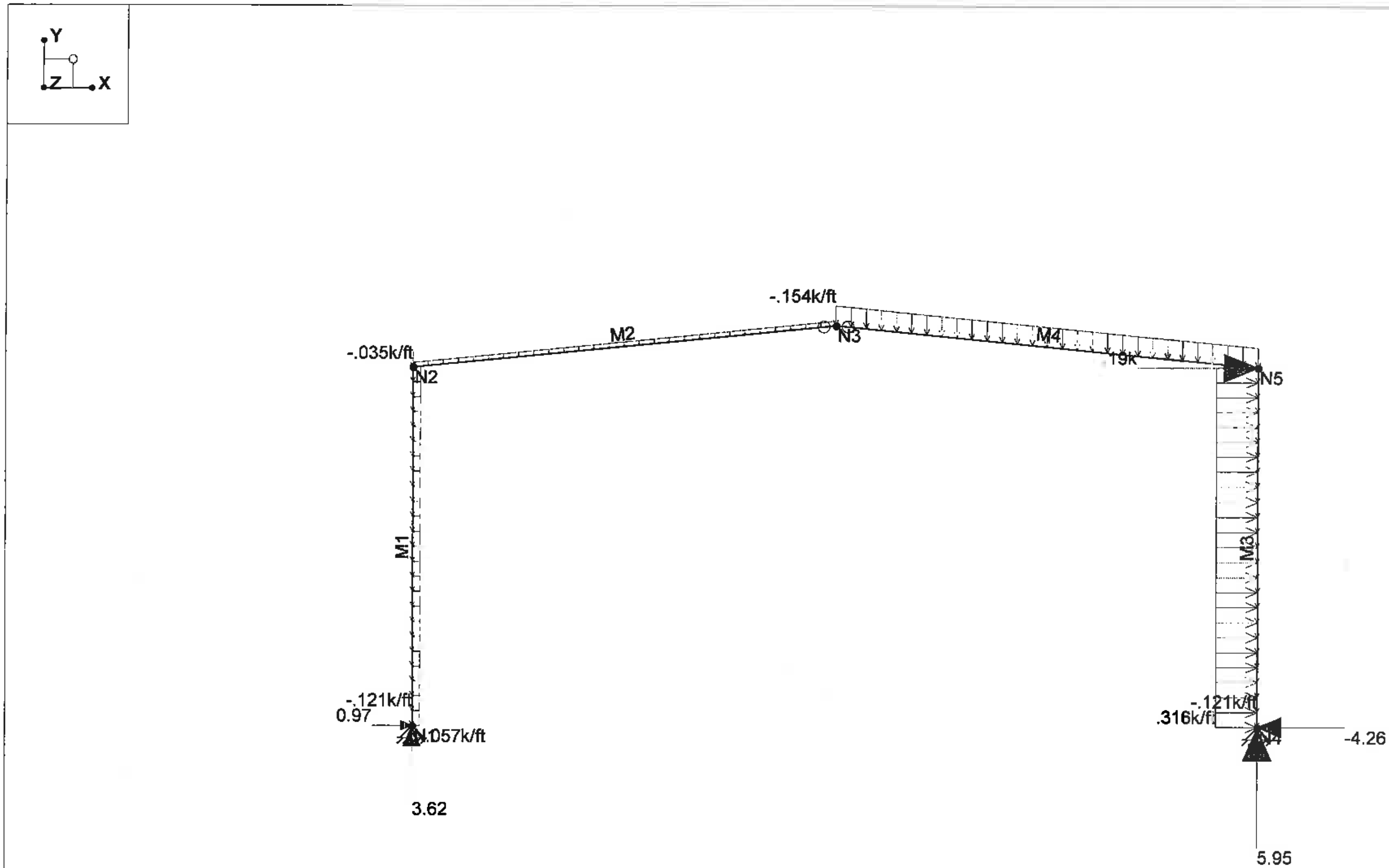
Loads: LC 10, 1.2DL max 1 + 1.6 Lr + 1.0 Lrr max 1 + 0.5 W1 wall and roof
Results for LC 10, 1.2DL max 1 + 1.6 Lr + 1.0 Lrr max 1 + 0.5 W1 wall and roof
Z-moment Reaction Units are k and k-ft

ARCADIS	Topok MW-20 Bench Building - 28 ft	SK - 23
Matt Ltoycz		Oct 9, 2015 at 11:59 AM
		Typical Frame MW-20 Bench Bldg.r2d



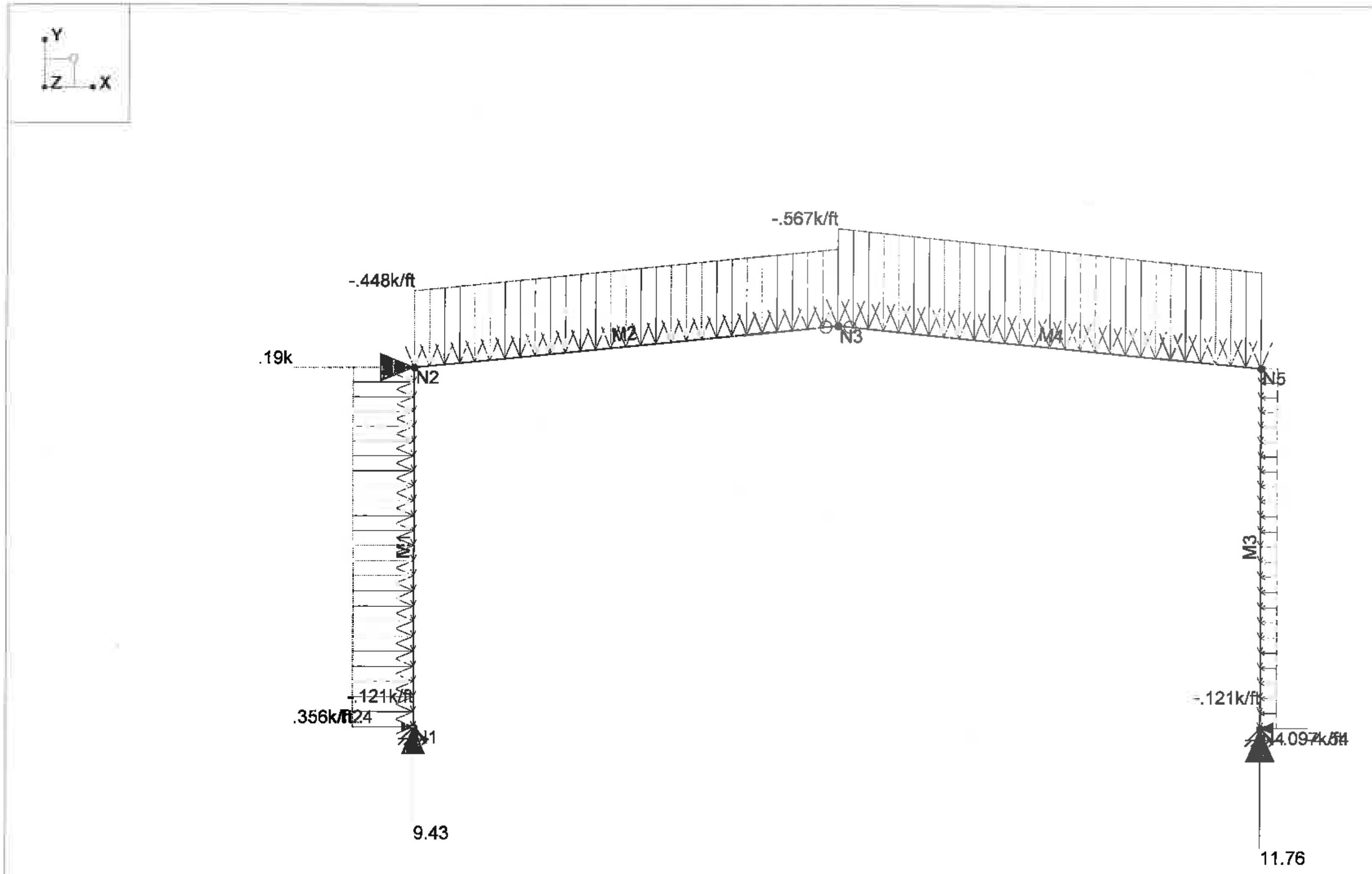
Loads: LC 11, 1.2DL max 1 + 1.6 Lr + 1.0 Lrr max 1 + 0.5 W2 wall and roof
Results for LC 11, 1.2DL max 1 + 1.6 Lr + 1.0 Lrr max 1 + 0.5 W2 wall and roof
Z-moment Reaction Units are k and k-ft

ARCADIS	Topok MW-20 Bench Building - 28 ft	SK - 24
Matt Ltoycz		Oct 9, 2015 at 11:59 AM
		Typical Frame MW-20 Bench Bldg.r2d



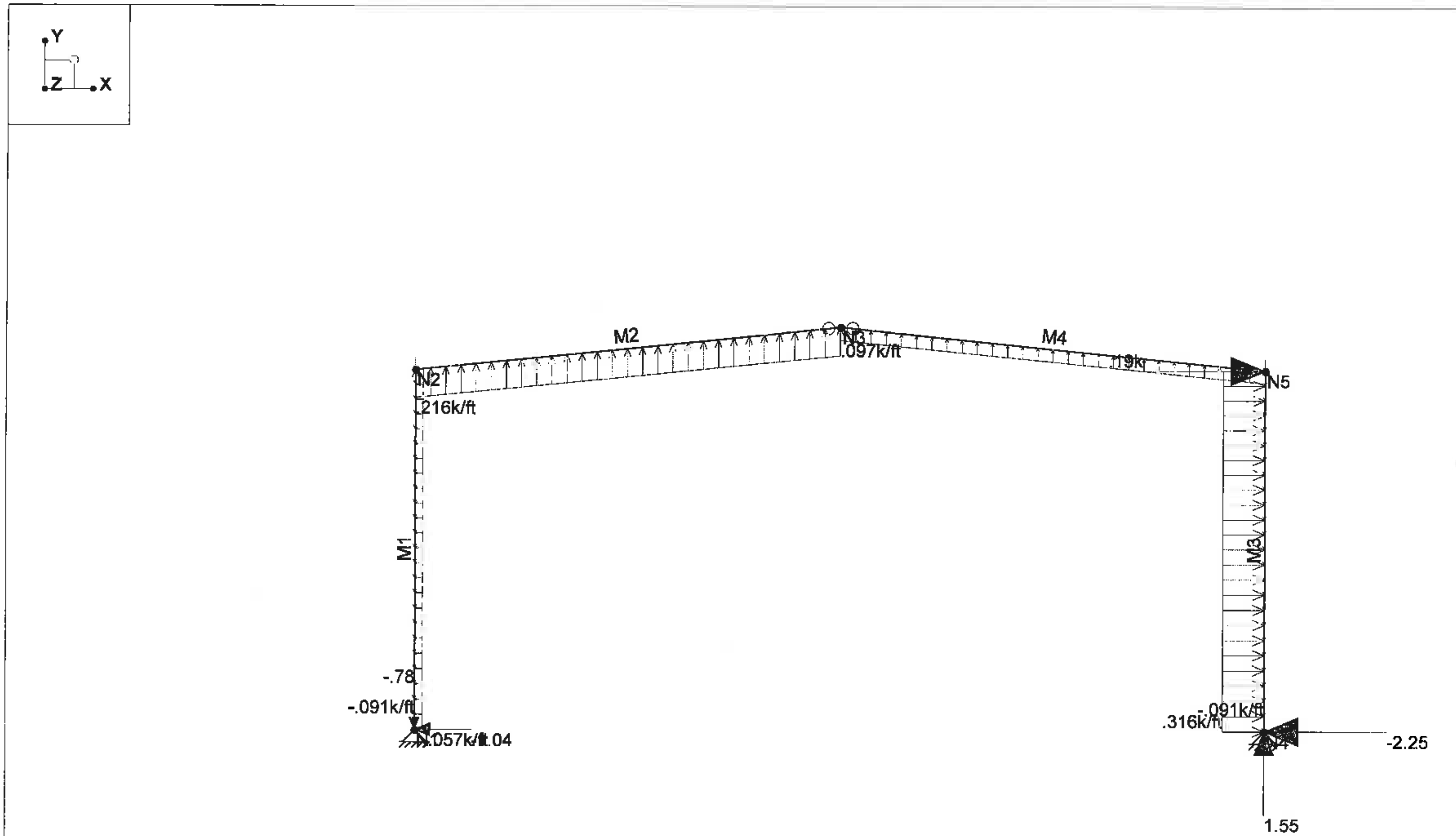
Loads: LC 12, 1.2DL max 1 + 0.5 Lr + 0.5 Lrr max 1 + 1.0 W1 wall and roof
Results for LC 12, 1.2DL max 1 + 0.5 Lr + 0.5 Lrr max 1 + 1.0 W1 wall and roof
Z-moment Reaction Units are k and k-ft

ARCADIS	Topok MW-20 Bench Building - 28 ft	SK - 25
Matt Ltoycz		Oct 9, 2015 at 12:00 PM
		Typical Frame MW-20 Bench Bldg.r2d



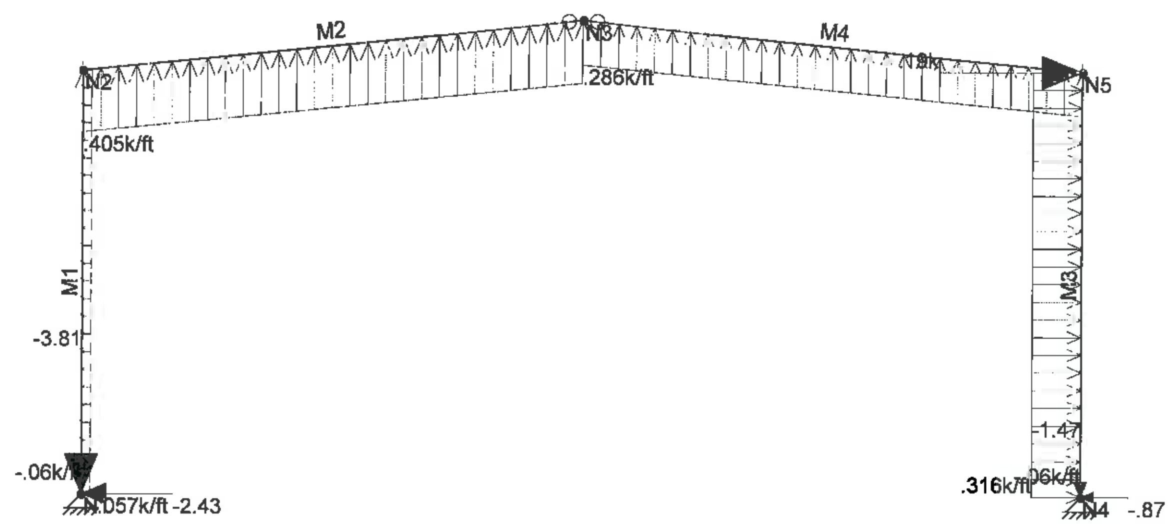
Loads: LC 13, 1.2DL max 1 + 0.5 Lr + 0.5 Lrr max 1 + 1.0 W2 wall and roof
Results for LC 13, 1.2DL max 1 + 0.5 Lr + 0.5 Lrr max 1 + 1.0 W2 wall and roof
Z-moment Reaction Units are k and k-ft

ARCADIS	Topok MW-20 Bench Building - 28 ft	SK - 26
Matt Ltoycz		Oct 9, 2015 at 12:00 PM
		Typical Frame MW-20 Bench Bldg.r2d



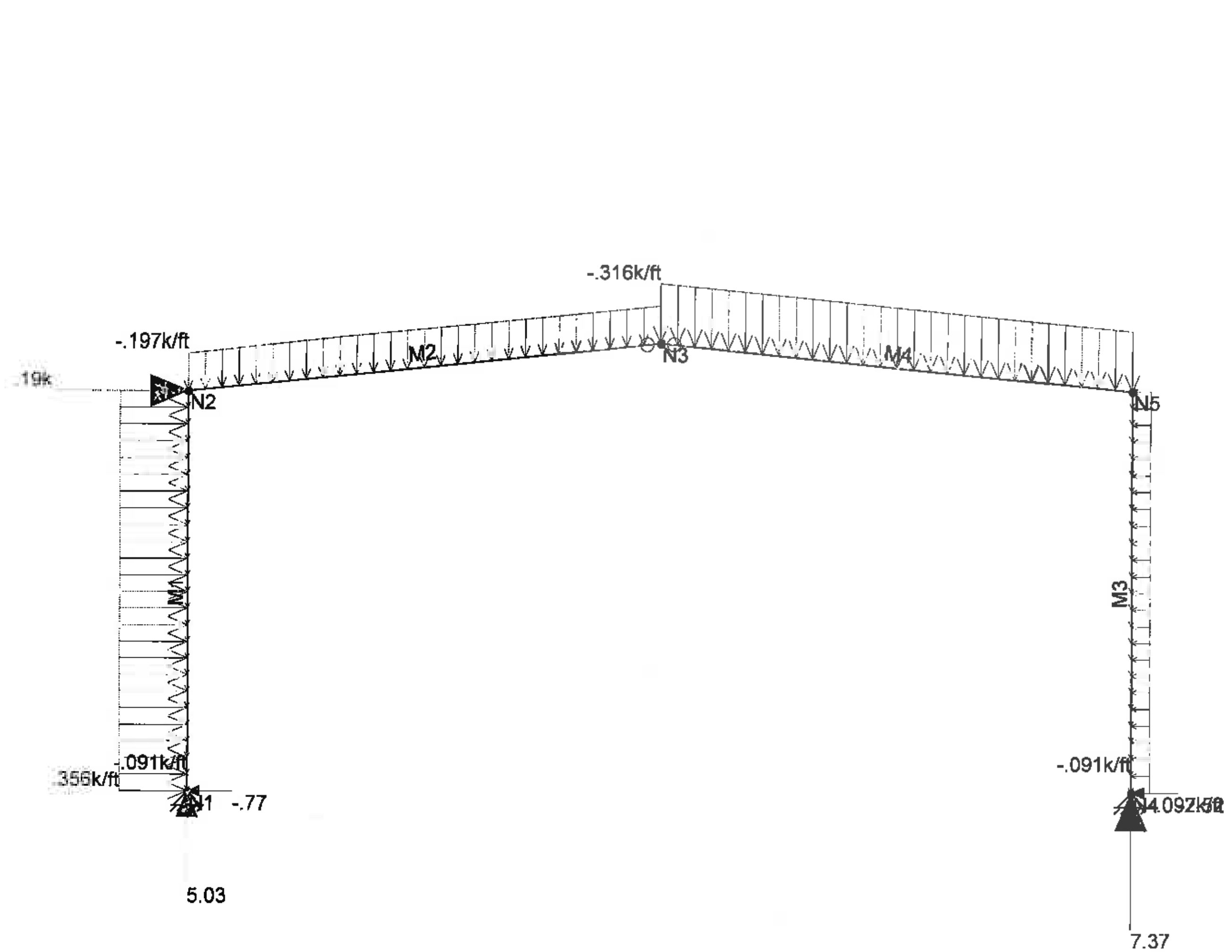
Loads: LC 14, 0.9DL max 1 + 1.0W1 roof and wall
Results for LC 14, 0.9DL max 1 + 1.0W1 roof and wall
Z-moment Reaction Units are k and k-ft

ARCADIS	Topok MW-20 Bench Building - 28 ft	SK - 27
Matt Ltoycz		Oct 9, 2015 at 12:00 PM
.		Typical Frame MW-20 Bench Bldg.r2d



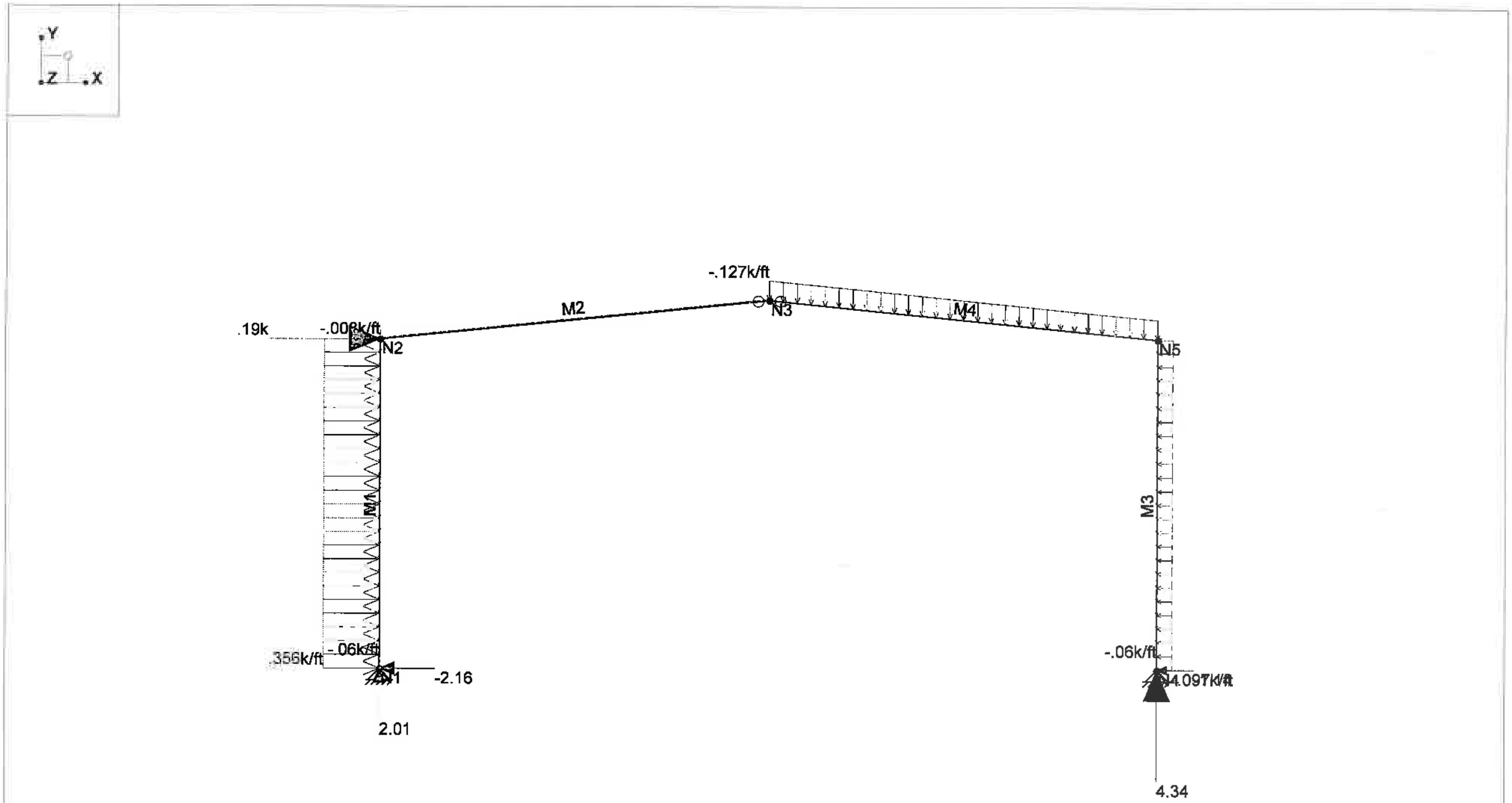
Loads: LC 15, 0.9DL min 1 + 1.0W1 roof and wall
Results for LC 15, 0.9DL min 1 + 1.0W1 roof and wall
Z-moment Reaction Units are k and k-ft

ARCADIS	Topok MW-20 Bench Building - 28 ft	SK - 28
Matt Ltoycz		Oct 9, 2015 at 12:00 PM
		Typical Frame MW-20 Bench Bldg.r2d



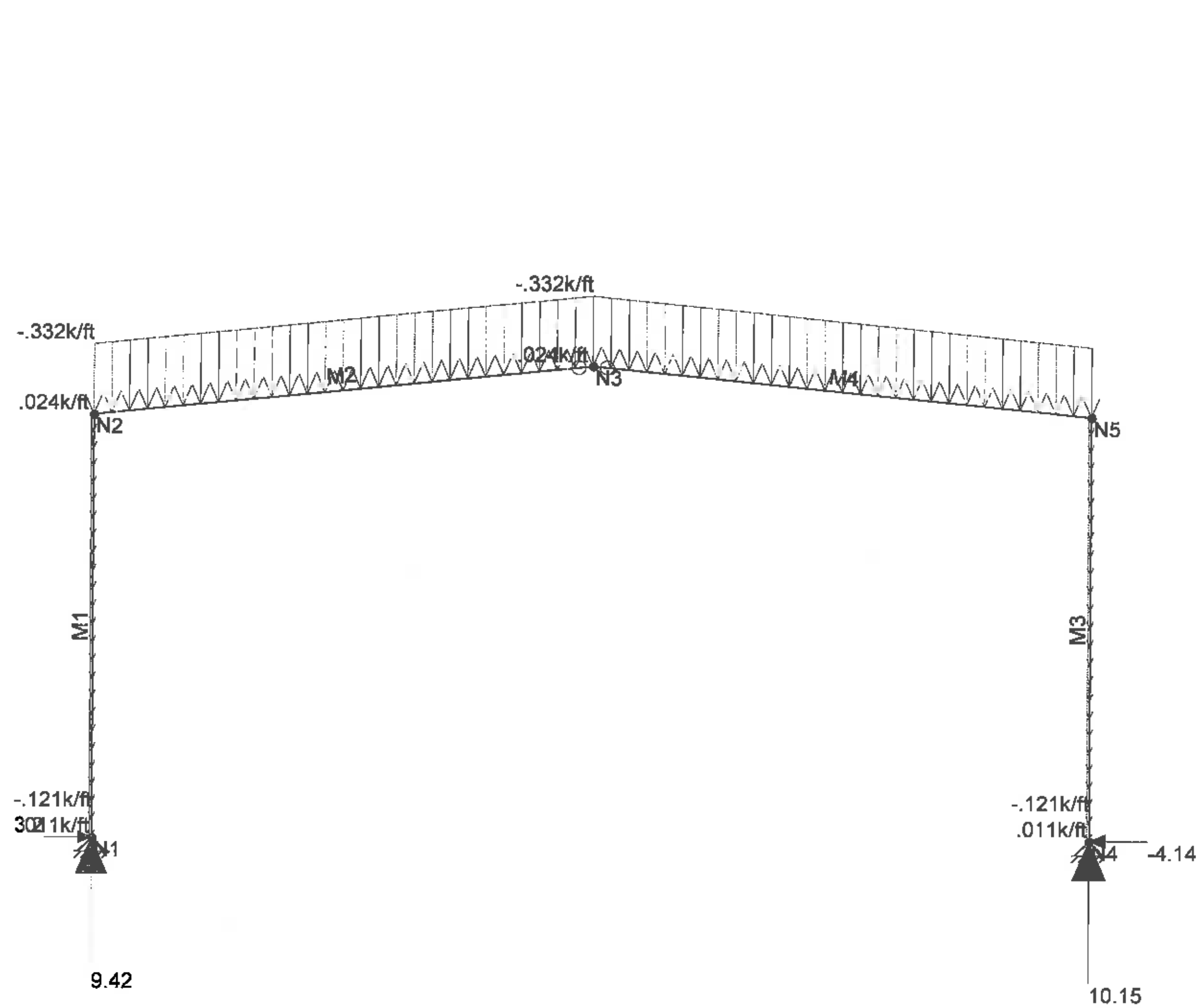
Loads: LC 16, 0.9DL max 1 + 1.0W2 roof and wall
Results for LC 16, 0.9DL max 1 + 1.0W2 roof and wall
Z-moment Reaction Units are k and k-ft

ARCADIS	Topok MW-20 Bench Building - 28 ft	SK - 29
Matt Ltoycz		Oct 9, 2015 at 12:00 PM
		Typical Frame MW-20 Bench Bldg.r2d



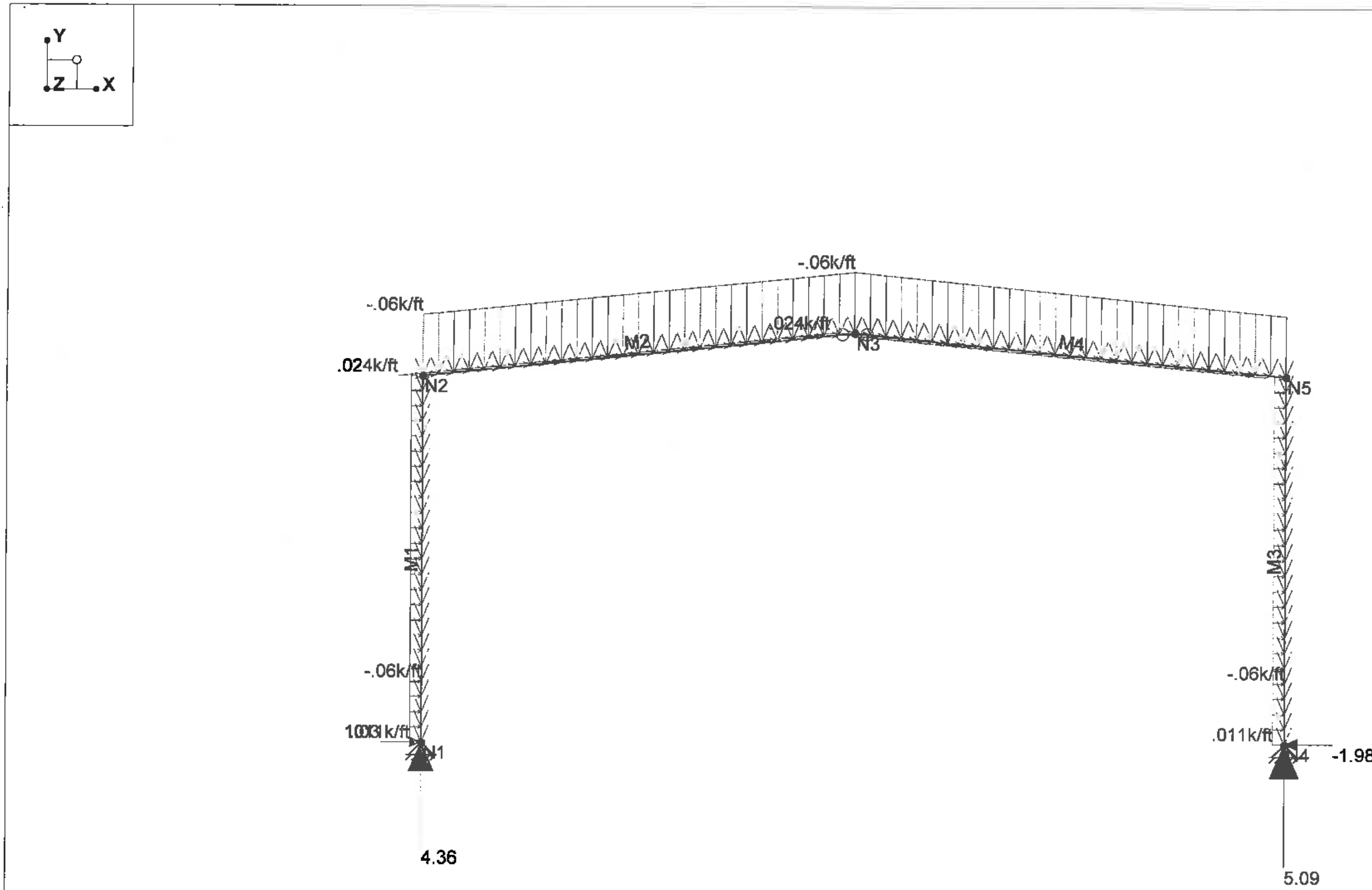
Loads: LC 17, 0.9DL min 1 + 1.0W2 roof and wall
Results for LC 17, 0.9DL min 1 + 1.0W2 roof and wall
Z-moment Reaction Units are k and k-ft

ARCADIS	Topok MW-20 Bench Building - 28 ft	SK - 30
Matt Ltoycz		Oct 9, 2015 at 12:01 PM
		Typical Frame MW-20 Bench Bldg.r2d



Loads: LC 18, 1.2DL max 1 + 1.0E
Results for LC 18, 1.2DL max 1 + 1.0E
Z-moment Reaction Units are k and k-ft

ARCADIS	Topok MW-20 Bench Building - 28 ft	SK - 31
Matt Ltoycz		Oct 9, 2015 at 12:01 PM
		Typical Frame MW-20 Bench Bldg.r2d



Loads: LC 19, 0.9DL min 1 + 1.0E
Results for LC 19, 0.9DL min 1 + 1.0E
Z-moment Reaction Units are k and k-ft

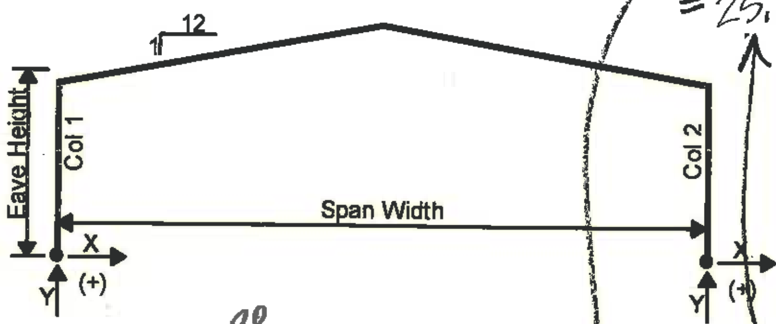
ARCADIS	Topok MW-20 Bench Building - 28 ft	SK - 32
Matt Ltoycz		Oct 9, 2015 at 12:01 PM
		Typical Frame MW-20 Bench Bldg.r2d

TABLE OF CONTENTS

*ASSUME TABLE BELOW IS BASED ON 25FT BAY SPACINGS'

FRAME COLUMN BASE REACTIONS
GABLE, CLEAR SPAN @ 30'-0"

7.7K/20psf = 385SF/(30FT SPAN/2) = 25.67FT BAY SPACING



Reactions are presented below by case to be used in any required combination. Abbreviations are defined as follows:

- RDL => Roof Dead Load
- RLL => Roof Live Load
- W1L => Wind Load to Left
- W1R => Wind Load to Right

* [# of Spans] @ [Span Width] x [Eave Height]
** [Width] x [Length] † [# of Bolts] @ [Bolt Dia.]

USE 16.8FT BAY SPACING

16.8FT / 25.67FT = 0.66

≈20

Frame Description*	Column	Column Base Reactions (kips) RDL X	RDL Y	RLL X	RLL Y	W1L X	W1L Y	W1R X	W1R Y	Base-plate Size**	Anchor Bolts†	
1@30' x 12'	COL 1	0.2	1.3	1.0	7.7	2.6	-1.5	-4.3	-6.0	8"x10"	2 @ 3/4"	
RLL = 20 psf	COL 2	-0.2	1.3	-1.0	7.7	4.3	-6.0	-2.6	-1.5	8"x10"	2 @ 3/4"	
1@30' x 12'	COL 1	0.2	1.3	2.0	11.6	2.4	-1.5	-4.5	-6.0	8"x10"	2 @ 3/4"	
RLL = 30 psf	COL 2	-0.2	1.3	-2.0	11.6	4.5	-6.0	-2.4	-1.5	8"x10"	2 @ 3/4"	
1@30' x 12'	COL 1	0.3	1.4	3.2	15.5	2.3	-1.5	-4.6	-6.0	8"x10"	2 @ 3/4"	
RLL = 40 psf	COL 2	-0.3	1.4	-3.2	15.5	4.6	-6.0	-2.3	-1.5	8"x10"	2 @ 3/4"	
1@30' x 18'	COL 1	0.1	1.6	0.5	7.7	4.1	0.2	-6.3	-8.0	8"x10"	2 @ 3/4"	****
RLL = 20 psf	COL 2	-0.1	1.6	-0.5	7.7	6.3	-8.0	-4.1	0.3	8"x10"	2 @ 3/4"	****
1@30' x 18'	COL 1	0.1	1.5	1.1	11.6	4.0	0.3	-6.5	-8.1	8"x10"	2 @ 3/4"	****
RLL = 30 psf	COL 2	-0.1	1.5	-1.1	11.6	6.5	-8.1	-4.0	0.3	8"x10"	2 @ 3/4"	****
1@30' x 18'	COL 1	0.1	1.5	1.7	15.5	3.9	0.4	-6.5	-8.1	8"x10"	2 @ 3/4"	****
RLL = 40 psf	COL 2	-0.1	1.5	-1.7	15.5	6.5	-8.1	-3.9	0.3	8"x10"	2 @ 3/4"	****
1@30' x 24'	COL 1	0.1	1.6	0.7	7.7	4.5	1.3	-7.4	-9.1	8"x10"	2 @ 3/4"	
RLL = 20 psf	COL 2	-0.1	1.6	-0.7	7.7	7.4	-9.1	-4.5	1.3	8"x10"	2 @ 3/4"	
1@30' x 24'	COL 1	0.1	1.6	1.0	11.6	4.5	1.2	-7.4	-9.0	8"x10"	2 @ 3/4"	
RLL = 30 psf	COL 2	-0.1	1.6	-1.0	11.6	7.4	-9.0	-4.5	1.2	8"x10"	2 @ 3/4"	
1@30' x 24'	COL 1	0.1	1.6	1.3	15.5	4.5	1.3	-7.4	-9.0	8"x10"	2 @ 3/4"	
RLL = 40 psf	COL 2	-0.1	1.6	-1.3	15.5	7.4	-9.0	-4.5	1.3	8"x10"	2 @ 3/4"	
1@30' x 30'	COL 1	0.1	1.7	0.7	7.7	4.6	2.2	-8.1	-9.9	8"x10"	2 @ 3/4"	
RLL = 20 psf	COL 2	-0.1	1.7	-0.7	7.7	8.1	-9.9	-4.6	2.2	8"x10"	2 @ 3/4"	
1@30' x 30'	COL 1	0.1	1.7	1.0	11.6	4.7	2.2	-8.2	-10.0	8"x10"	2 @ 3/4"	
RLL = 30 psf	COL 2	-0.1	1.7	-1.0	11.6	8.2	-10.0	-4.7	2.2	8"x10"	2 @ 3/4"	
1@30' x 30'	COL 1	0.1	1.9	1.5	15.5	7.3	6.9	11.2	-15.5	8"x10"	2 @ 1"	
RLL = 40 psf	COL 2	-0.1	1.9	-1.5	15.5	11.2	-15.4	-7.3	6.9	8"x10"	2 @ 1"	

**** *For 18' eave height, tapered beam frames, baseplate length = 12".*
**** *For 20' eave height, tapered beam frames, baseplate length = 14".*

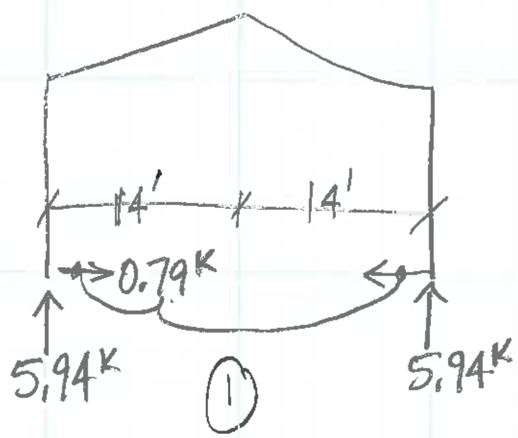
(NUCOR LOADS-CON'T) ~ UNF LOADS

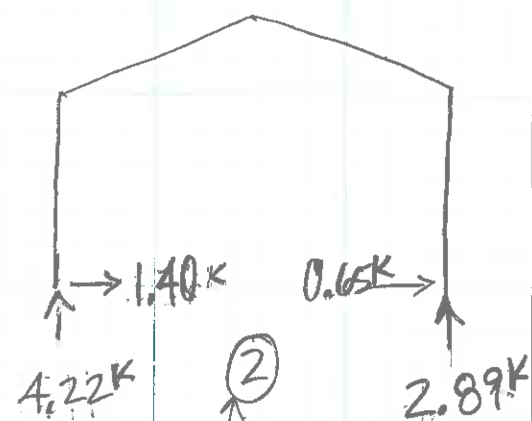
(1) D+Lr

(2) D+0.75Lr+(0.6x0.75)W

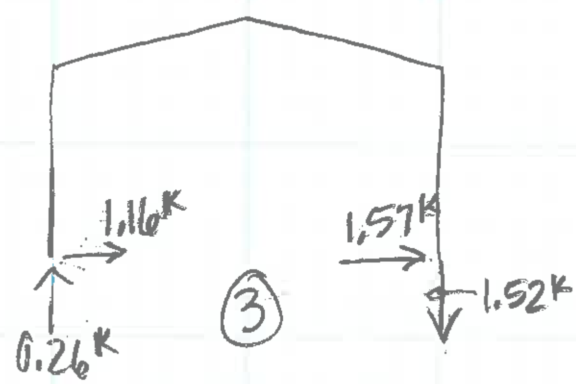
(3) D+0.6W_IL (3A) W_IR

(4) 0.6D+0.6W_IL (4A) W_IR

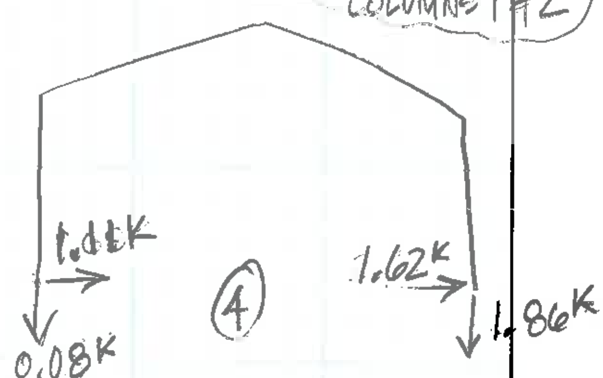




2A → SAME AS 2 JUST FLIP COLUMNS 1&2



3A-SAME AS 3 JUST FLIP COLUMNS 1&2



4A-SAME AS 4 JUST FLIP COLUMNS 1&2

ARCADIS

SUBJECT: TOPOK-MW-20 BENCH BLDG FOUNDATION DESIGN

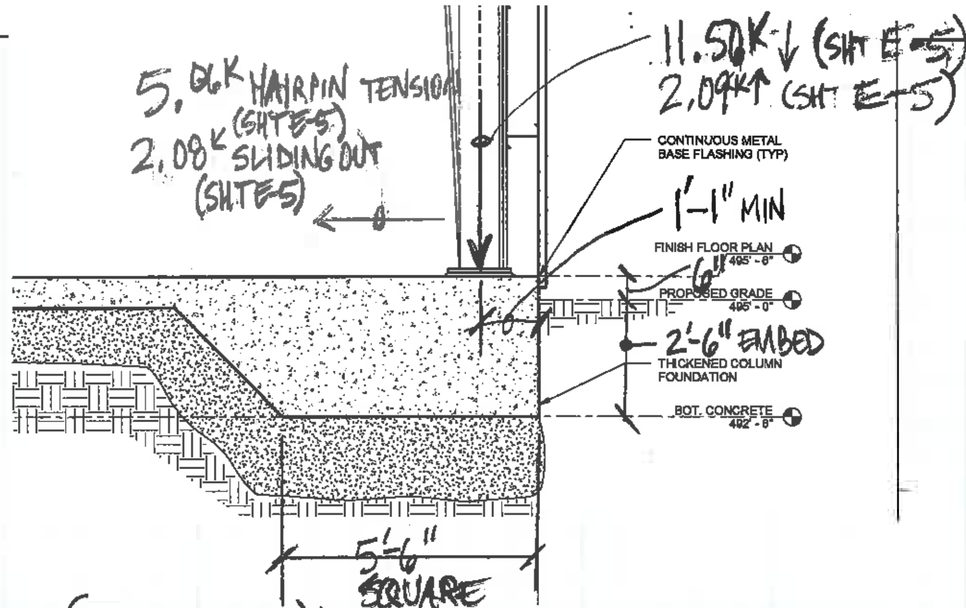
JOB NO:

BY: MSL DATE: 10/12/15

CHKD: DATE:

PAGE E-9

SHEET 1



(TYP A3, C3 & A2 & C2)

- NET ALLOWABLE BEARING PRESSURE = 2,000 psf.
- CHECK 5'-6" SQ FTG:
  - $\Sigma P = 11.5^K\downarrow + (5.5^{ft} \times 5.5^{ft} \times 3' \text{THICK} \times 150_{pcf})$ [13.61K] $= 25.11^K$
  - $A = 30.25 ft^2$, $y = 2.75^{ft}$, $I = \frac{bh^3}{12} = 76.26^{ft^4}$ (b, h = 5.5ft)
  - $\Sigma M_{⊄} = [(11.5^K) \times (2.75^{ft} - 1.083')] + (5.06^K \times (0.75^{ft} + \frac{8"}{2}))$ [19.17 KIF] [5.46 KIF] $= 24.63^K$
  - $q = P/A +/- My/I = 0.83$ KSF +/- 0.89 KSF √OK
    1.72 KSF & 0.00 KSF < 2,000 psf √OK
- $e = M/P = 0.98 \rightarrow f_p \times 0.5 \times [3 \times (2.75' - 0.98')] \times 5.5^{ft} = 25.11^K$
  $f_p = 1.72$ KSF √OK

ARCADIS

SUBJECT: TOPOK-MW-20 BENCH BLDG FDN DESIGN | BY: M$L | DATE: 10/12/15 | PAGE E-10

JOB NO: | CHKD: | DATE: | SHEET 1

*USE 5'-6" SQ FOR A3 & C-3

→ SLIDING RESISTANCE

- SLIDING OUT = 2.73^K UNF (NUCOR - SHT E8) LC#3
- SLIDING RESISTANCE =

①  $688psf \times 0.5 \times 2.5^F_{DEEP} \times 5^F = 4.3^K$

[110pcf × (3-0.5) × 2.5F EMBED = 688psf

② DL FRICTION = $(11.25^K - 2.08^K_{UPLIFT}) \times 0.3\mu$ = 2.75^K

= 7.05^K ≈ FS = 2.58 > 1.5 ✓OK

→ UPLIFT RESISTANCE

- MAX UPLIFT = 2.08^K
- DL FDN = $(5F \times 5F) \times 3' \times 150pcf = 11.25^K$ > ↩ FS = 5.4 > 1.5 ✓OK

→ TENSION RESISTANCE

- MAX TENSION = 5.06^K
- HAIRPIN SIZE = $A_S = \frac{T}{\phi f_y} = \frac{5.06^K \times 1.6_{AEL}}{0.9 \times 60ksi} = 0.15 IN^2$

→ USE #6 HAIRPIN ($A_S = 0.44 IN^2$/EA) ✓OK

ARCADIS

SUBJECT: TOPOK – MW-20 BENCH BLDG FDN DESIGN | BY: MSL | DATE: 10/12/15 | PAGE E-10A

JOB NO: | CHKD: | DATE: | SHEET 1

• CHECK 2A FOR ADD'L LEAN-TO LOADS

• ADD'L P = 1.89K

• CHECK 5'-6" SQ FTG

~ $\Sigma P = 27^K$, A, y, & I SAME AS SHT E-9

~ $\circlearrowleft \Sigma M_{\text{℄}} = 0$; 27.80 K-FT

~ $q = P/A \pm My/I = 0.89 \pm 1.00$ KSF — NO GOOD

~ $e = M/P = 1.03 \rightarrow f_p = 1.90$ KSF < 2 KSF ✓OK

~ NO NEED TO CHECK SLIDING RESISTANCE, UPLIFT OR HAIRPIN SINCE DESIGN SHOULD NOT CHANGE

~~TRY A4 & C4 COLUMNS~~ A1 & C1 & AA1 & AA2 – END FRAME

- TRIB AREA (A1 & C1) = $\left(\frac{19'6'' - 1'3''}{2}\right) + 1'3'' = 10.4$ FT
  - $\frac{\text{END FRAME}}{\text{INT FRAME}} = \frac{10.4\,FT}{16.8\,FT} = 0.619$

$\times \frac{(47\% \uparrow \text{ IN LOADS} \times 3.8\,FT) + [(10.4\,FT - 3.8\,FT) \times 1.0]}{10.4\,FT} = 1.17$

$= 0.725 \rightsquigarrow$ USE 75% OF A3 & C3 LOADS

- CHECK 4'-6" SQ FTG
  - $\Sigma P = (11.5^K \times 0.75) + (4'6''SQ^2 \times 3' \times 150\,pcf) = 17.73^K$
  - $A = 20.25\,FT^2$, $y = 2.25\,FT$, $I = \frac{bh^3}{12} = 34.17\,FT^4$
  - $\circlearrowleft \Sigma M_{\mathbb{C}} = 0$; $[(11.5^K \times 0.75) \times (2.25\,FT - 1.083\,FT)] + [5.06^K \times 0.75 \times (1.083\,FT)]$
    $= (10.07 + 4.11)^{KIFT} = 14.18^{KIFT}$
  - $q = P/A \pm My/I = 0.88\,KSF \pm 0.93\,KSF$ – NO GOOD
  - $e = M/P = 0.799 \rightarrow f_p \times 0.5 \times 4.5\,FT \times [3 \times (2.25' - 0.799)] = 17.73^K$
    $f_p = 1.81\,KSF < 2\,KSF$ ✓OK

ARCADIS

SUBJECT: TOPOCK - MW 20 BENCH BLDG
FDN DESIGN
JOB NO:

BY: MSL DATE: 10/12/15
CHKD: DATE:

PAGE E-12
SHEET 1

→ SLIDING RESISTANCE:

- SLIDING OUT = $2.73^K \times 0.75 = 2.05^K$
- SLIDING RESISTANCE = $2.73^K + 3.87^K = 6.60^K$ ✓OK

FS = 3.22 > 1.5 ✓OK

→ UPLIFT RESISTANCE

- MAX UPLIFT = $2.08^K \times 0.75 = 1.56^K$
- DL FDN = 9.11^K > ← FS = 5.84 > 1.5 ✓OK

→ #6 HAIRPIN ✓OK

AGM Form 30 12-01

ARCADIS

SUBJECT: TOPOK – MW-20 BENCH BLDG FDN DESIGN | BY: MSL | DATE: 10/12/15 | PAGE E-12A
JOB NO: | CHKD: | DATE: | SHEET 1

~ CHECK 1A FOR ADD'L LEAN-TO LOADS

- ADD'L $P\downarrow = \left(\left[\left(\frac{19.5' - 1.25'}{2}\right) + 1.25'\right] * \frac{10FT}{2}\right) \times (16.5\,psf_{DL} * 20\,psf_{LL})$

  $= 1.89^K$

- SAME LATERAL LOADS

- CHECK 4'-6" SQ FTG

  ~ $\Sigma P = 19.62^K$, A, y, I ~ the same as SHT E-11

  ~ $\varsigma \Sigma M_{¢} = 0$; $\left[(11.50^K \times 0.75) + 1.89^K\right] \times (2.25' - 1.083')$ (12.27 K·F)
  $+ \left[5.06^K \times 0.75 \times (1.083^F)\right]$ (4.11)

  $= 16.38^{K \cdot F}$

  ~ $q = P/A \pm My/I = 0.97\,ksf \pm 1.08\,ksf$ ~ NO ECC

  ~ $e = M/P = 0.83 \rightarrow f_p \times 0.5 \times 4.5^{Ft} \times \left[3 \times (2.25' - 0.83')\right] = 19.62^K$

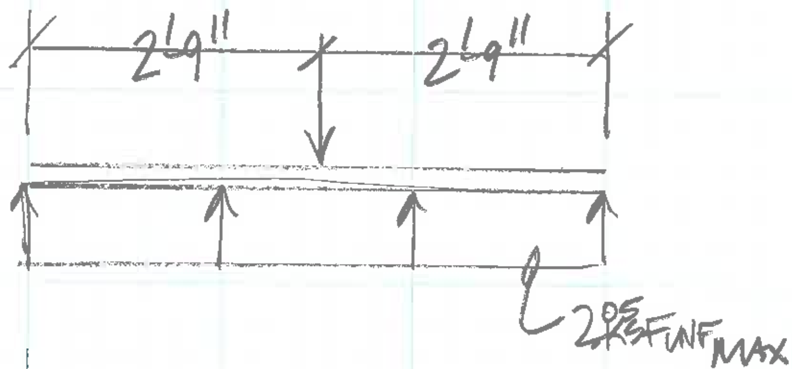
  $f_p = 2.05\,KSF \approx 2\,KSF$ ✓OK

  (ΣP & $M^{¢}$ CONSERVATIVE)

  ~ NO NEED TO CHECK SLIDING OR UPLIFT OR HAIRPIN SINCE SAME CROSS-SECTION

FDN RESTEEL DESIGN

- SINCE 5'-6" SQ INTERIOR FRAME IS HEAVIEST LOADED & LARGEST FTG IN SIZE, WILL BASE RESTEEL DESIGN ON THAT



~ BOT STL

- $M_{ACI} = \frac{wl^2}{2} = \frac{(2.05\,ksf\ unf \times 1.6\,ACI) \times 2.75\,ft^2}{2} = 12.40\,k\text{-}ft$
- $V_{ACI} = wl = 9.02^K$
- $d = 36'' - 3''\,cover - 8/8 - 8/16'' = 31.5''$
- $\phi V_c = 2\phi\sqrt{f'_c}\,bd = 35.86^K > V_{ACI}$ ✓ OK
- $R = 13.89 \rightarrow \rho = 0.0002 \rightarrow A_s = 0.12\,in^2/ft$

  ~ USING #6 @ 11" o/c ($A_s = 0.48\,in^2/ft$) ✓ OK

~ TOP STL

- $M_{ACI} = \frac{(3' \times 150\,pcf) \times 1.6\,ACI \times 2.75\,ft^2}{2} = 2.72\,k\text{-}ft$
- $V_{ACI} = wl = 1.98^K$

~ PER ABOVE, #6 @ 11" o/c T&B IN 36" SOG ✓ OK

E-14

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Profis Anchor 2.6.1

Company:	ARCADIS	Page:	1
Specifier:	Matt Lotycz	Project:	Topok - MW-20 Bench
Address:		Sub-Project I Pos. No.:	
Phone I Fax:	|	Date:	10/12/2015
E-Mail:			

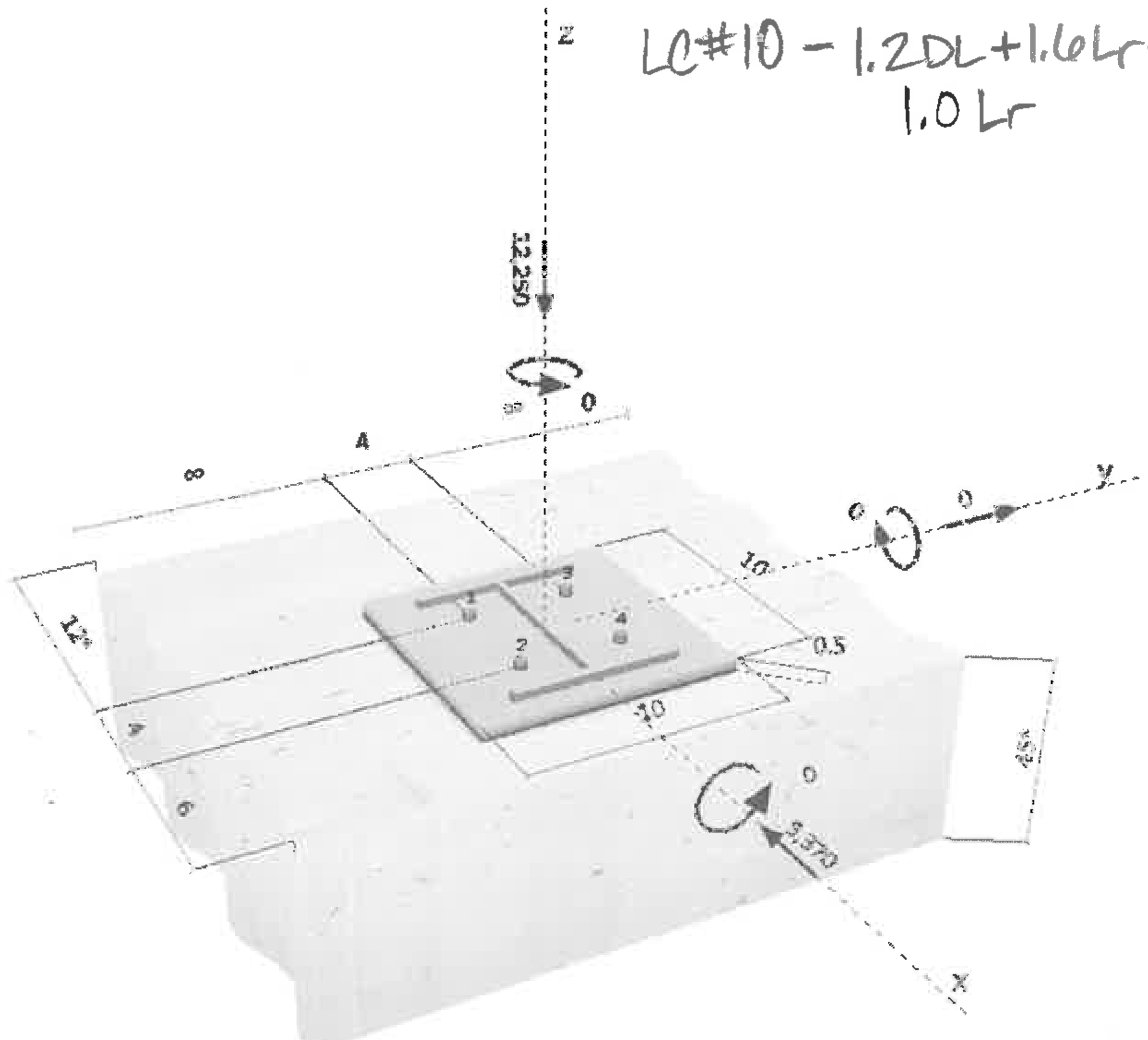
Specifier's comments: LC#10 - Max Vertical Down and Max Horizontal

1 Input data

Anchor type and diameter:	**Heavy Hex Head ASTM F 1554 GR. 36 1/2**
Effective embedment depth:	h_{ef} = 24.000 in.
Material:	ASTM F 1554
Proof:	Design method ACI 318-11 / CIP
Stand-off installation:	e_b = 0.000 in. (no stand-off); t = 0.500 in.
Anchor plate:	l_x x l_y x t = 10.000 in. x 10.000 in. x 0.500 in.; (Recommended plate thickness: not calculated
Profile:	W shape (AISC); (L x W x T x FT) = 7.930 in. x 6.500 in. x 0.245 in. x 0.400 in.
Base material:	cracked concrete, 4000, f_c' = 4000 psi; h = 45.000 in. ✓
Reinforcement:	tension: condition B, shear: condition B; ✓
	edge reinforcement: none or < No. 4 bar

Geometry [in.] & Loading [lb, in.lb]

LC#10 - 1.2DL+1.6Lr+ 1.0Lr

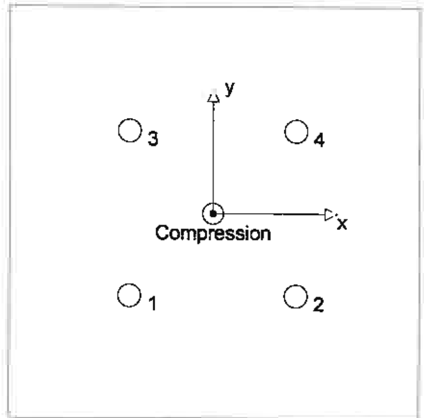


Input data and results must be checked for agreement with the existing conditions and for plausibility!
PROFIS Anchor (c) 2003-2009 Hilti AG, FL-9494 Schaan Hilti is a registered Trademark of Hilti AG, Schaan

Company:	ARCADIS	Page:	2
Specifier:	Matt Lotycz	Project:	Topok - MW-20 Bench
Address:		Sub-Project I Pos. No.:	
Phone I Fax:	|	Date:	10/12/2015
E-Mail:			

2 Load case/Resulting anchor forces

Load case: Design loads



Anchor reactions [lb]
Tension force: (+Tension, -Compression)

Anchor	Tension force	Shear force	Shear force x	Shear force y
1	0	1343	-1343	0
2	0	1343	-1343	0
3	0	1343	-1343	0
4	0	1343	-1343	0

max. concrete compressive strain: 0.03 [‰]
max. concrete compressive stress: 122 [psi]
resulting tension force in (x/y)=(0.000/0.000): 0 [lb]
resulting compression force in (x/y)=(0.000/0.000): 12250 [lb]

3 Tension load

	Load N_{ua} [lb]	Capacity ϕN_n [lb]	Utilization $\beta_N = N_{ua}/\phi N_n$	Status
Steel Strength*	N/A	N/A	N/A	N/A
Pullout Strength*	N/A	N/A	N/A	N/A
Concrete Breakout Strength**	N/A	N/A	N/A	N/A
Concrete Side-Face Blowout, direction **	N/A	N/A	N/A	N/A

* anchor having the highest loading **anchor group (anchors in tension)

Input data and results must be checked for agreement with the existing conditions and for plausibility!
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4 Shear load

	Load V_{ua} [lb]	Capacity ϕV_n [lb]	Utilization $\beta_V = V_{ua}/\phi V_n$	Status
Steel Strength*	1343	3212	42	OK
Steel failure (with lever arm)*	N/A	N/A	N/A	N/A
Pryout Strength**	5370	68433	8	OK
Concrete edge failure in direction x-**	5370	15341	36	OK

* anchor having the highest loading **anchor group (relevant anchors)

4.1 Steel Strength

$V_{sa} = n\ 0.6\ A_{se,V}\ f_{uta}$ ACI 318-11 Eq. (D-29)

$\phi\ V_{steel} \geq V_{ua}$ ACI 318-11 Table D.4.1.1

Variables

n	$A_{se,V}$ [in.^{2}]	f_{uta} [psi]
1	0.14	58000

Calculations

V_{sa} [lb]
4942

Results

V_{sa} [lb]	ϕ_{steel}	$\phi\ V_{sa}$ [lb]	V_{ua} [lb]
4942	0.650	3212	1343

4.2 Pryout Strength

$V_{cpg} = k_{cp} \left[\left(\frac{A_{Nc}}{A_{Nc0}} \right) \psi_{ec,N}\ \psi_{ed,N}\ \psi_{c,N}\ \psi_{cp,N}\ N_b \right]$ ACI 318-11 Eq. (D-41)

$\phi\ V_{cpg} \geq V_{ua}$ ACI 318-11 Table D.4.1.1

A_{Nc} see ACI 318-11, Part D.5.2.1, Fig. RD.5.2.1(b)

$A_{Nc0} = 9\ h_{ef}^2$ ACI 318-11 Eq. (D-5)

$\psi_{ec,N} = \left(\frac{1}{1 + \frac{2\ e_N}{3\ h_{ef}}} \right) \leq 1.0$ ACI 318-11 Eq. (D-8)

$\psi_{ed,N} = 0.7 + 0.3 \left(\frac{c_{a,min}}{1.5 h_{ef}} \right) \leq 1.0$ ACI 318-11 Eq. (D-10)

$\psi_{cp,N} = \text{MAX} \left(\frac{c_{a,min}}{c_{ac}}, \frac{1.5 h_{ef}}{c_{ac}} \right) \leq 1.0$ ACI 318-11 Eq. (D-12)

$N_b = 16\ \lambda_a \sqrt{f'_c}\ h_{ef}^{5/3}$ ACI 318-11 Eq. (D-7)

Variables

k_{cp}	h_{ef} [in.]	$e_{c1,N}$ [in.]	$e_{c2,N}$ [in.]	$c_{a,min}$ [in.]
2	24.000	0.000	0.000	6.000

$\psi_{c,N}$	c_{ac} [in.]	k_c	λ_a	f'_c [psi]
1.000	-	16	1.000	4000

Calculations

A_{Nc} [in.^{2}]	A_{Nc0} [in.^{2}]	$\psi_{ec1,N}$	$\psi_{ec2,N}$	$\psi_{ed,N}$	$\psi_{cp,N}$	N_b [lb]
1672.00	5184.00	1.000	1.000	0.750	1.000	202070

Results

V_{cpg} [lb]	$\phi_{concrete}$	$\phi\ V_{cpg}$ [lb]	V_{ua} [lb]
97761	0.700	68433	5370

Input data and results must be checked for agreement with the existing conditions and for plausibility!
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4.3 Concrete edge failure in direction x-

$V_{cbg} = \left(\frac{A_{Vc}}{A_{Vc0}}\right) \psi_{ec,V}\, \psi_{ed,V}\, \psi_{c,V}\, \psi_{h,V}\, \psi_{parallel,V}\, V_b$	ACI 318-11 Eq. (D-31)
$\phi\, V_{cbg} \geq V_{ua}$	ACI 318-11 Table D.4.1.1
A_{Vc} see ACI 318-11, Part D.6.2.1, Fig. RD.6.2.1(b)	
$A_{Vc0} = 4.5\, c_{a1}^2$	ACI 318-11 Eq. (D-32)
$\psi_{ec,V} = \left(\frac{1}{1 + \frac{2e_V'}{3c_{a1}}}\right) \leq 1.0$	ACI 318-11 Eq. (D-36)
$\psi_{ed,V} = 0.7 + 0.3\left(\frac{c_{a2}}{1.5c_{a1}}\right) \leq 1.0$	ACI 318-11 Eq. (D-38)
$\psi_{h,V} = \sqrt{\frac{1.5c_{a1}}{h_a}} \geq 1.0$	ACI 318-11 Eq. (D-39)
$V_b = \left(7 \left(\frac{l_e}{d_a}\right)^{0.2} \sqrt{d_a}\right) \lambda_a \sqrt{f_c'}\, c_{a1}^{1.5}$	ACI 318-11 Eq. (D-33)

Variables

c_{a1} [in.]	c_{a2} [in.]	e_{cV} [in.]	$\psi_{c,V}$	h_a [in.]
12.000	-	0.000	1.000	45.000

l_e [in.]	λ_a	d_a [in.]	f_c' [psi]	$\psi_{parallel,V}$
4.000	1.000	0.500	4000	1.000

Calculations

A_{Vc} [in.^{2}]	A_{Vc0} [in.^{2}]	$\psi_{ec,V}$	$\psi_{ed,V}$	$\psi_{h,V}$	V_b [lb]
720.00	648.00	1.000	1.000	1.000	19724

Results

V_{cbg} [lb]	$\phi_{concrete}$	$\phi\, V_{cbg}$ [lb]	V_{ua} [lb]
21916	0.700	15341	5370

5 Warnings

- Load re-distributions on the anchors due to elastic deformations of the anchor plate are not considered. The anchor plate is assumed to be sufficiently stiff, in order not to be deformed when subjected to the loading! Input data and results must be checked for agreement with the existing conditions and for plausibility!
- Condition A applies when supplementary reinforcement is used. The Φ factor is increased for non-steel Design Strengths except Pullout Strength and Pryout strength. Condition B applies when supplementary reinforcement is not used and for Pullout Strength and Pryout Strength. Refer to your local standard.
- Checking the transfer of loads into the base material and the shear resistance are required in accordance with ACI 318 or the relevant standard!

Fastening meets the design criteria! √

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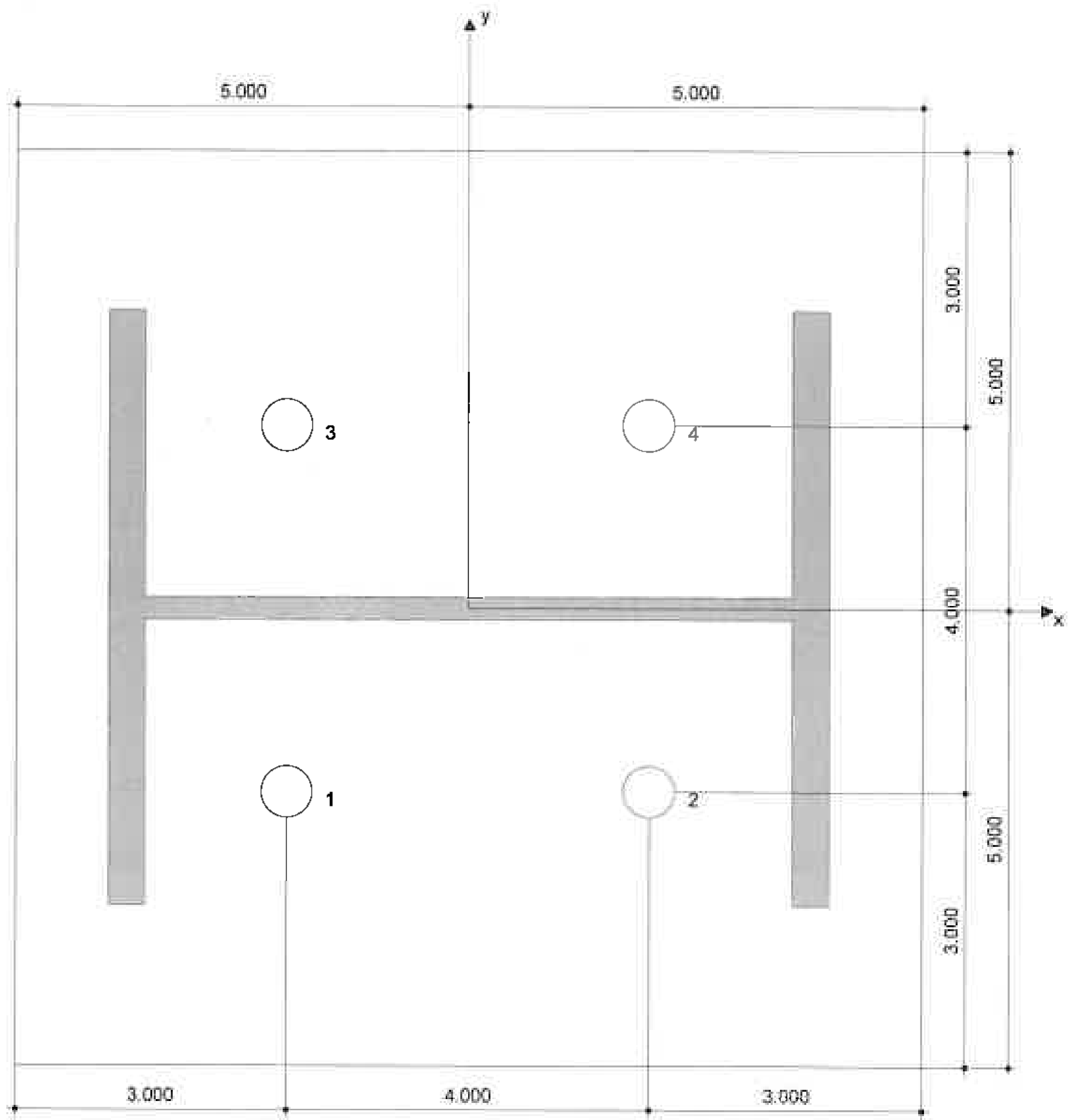
6 Installation data

Anchor plate, steel: -
Profile: W shape (AISC); 7.930 x 6.500 x 0.245 x 0.400 in.
Hole diameter in the fixture: d_f = 0.563 in.
Plate thickness (input): 0.500 in.
Recommended plate thickness: not calculated
Cleaning: No cleaning of the drilled hole is required

Anchor type and diameter: Heavy Hex Head ASTM F 1554 GR. 36 1/2
Installation torque: -0.009 in.lb
Hole diameter in the base material: - in.
Hole depth in the base material: 24.000 in.
Minimum thickness of the base material: 25.844 in.



Coordinates Anchor in.

Anchor	x	y	c_{-x}	c_{+x}	c_{-y}	c_{+y}
1	-2.000	-2.000	12.000	10.000	-	-
2	2.000	-2.000	16.000	6.000	-	-
3	-2.000	2.000	12.000	10.000	-	-
4	2.000	2.000	16.000	6.000	-	-

Input data and results must be checked for agreement with the existing conditions and for plausibility!
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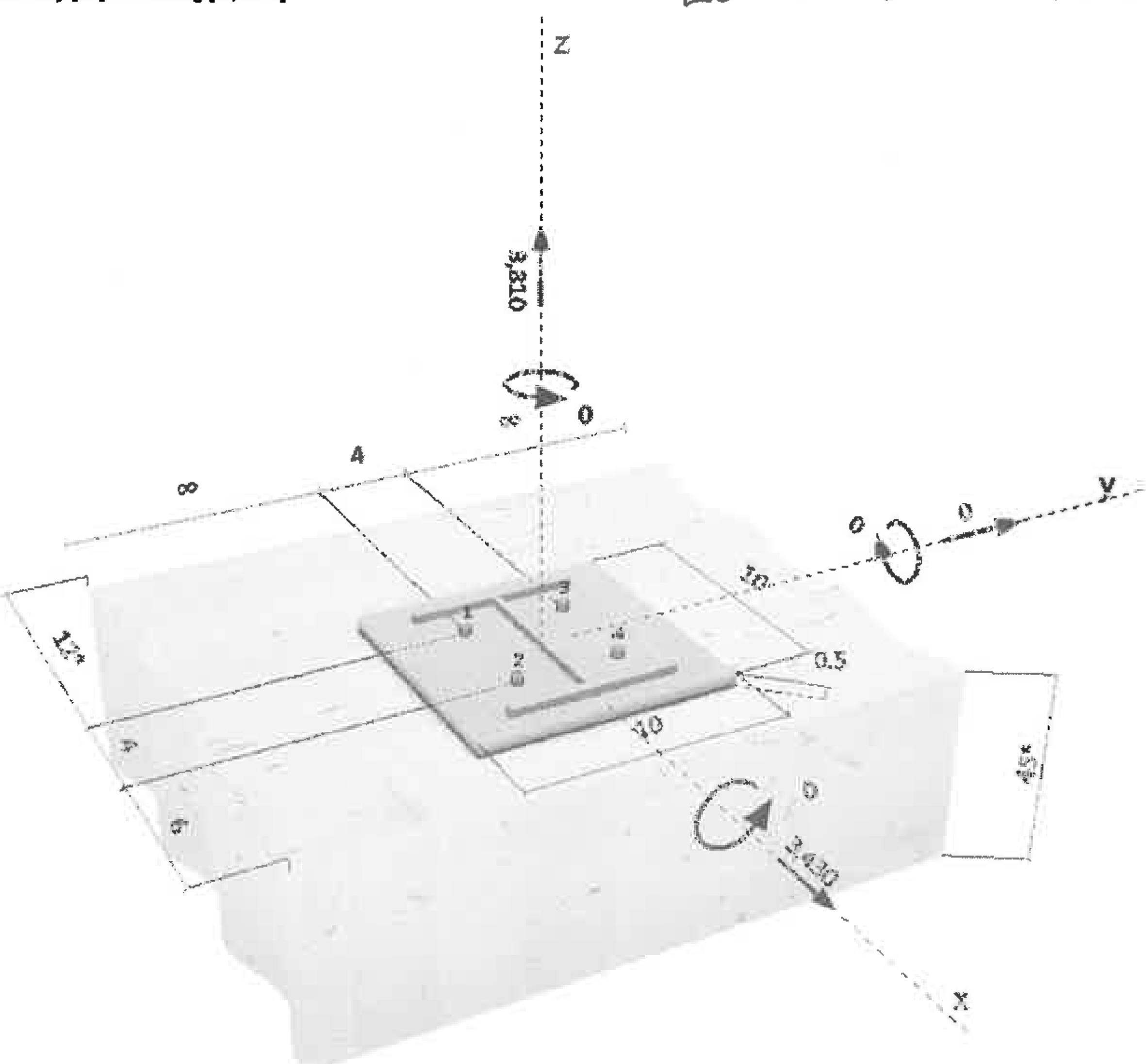
Specifier's comments: LC#15 - Max Uplift and Max Horizontal

1 Input data

Anchor type and diameter:	**Heavy Hex Head ASTM F 1554 GR. 36 1/2**
Effective embedment depth:	h_{ef} = 24.000 in.
Material:	ASTM F 1554
Proof:	Design method ACI 318-11 / CIP
Stand-off installation:	e_b = 0.000 in. (no stand-off); t = 0.500 in.
Anchor plate:	l_x x l_y x t = 10.000 in. x 10.000 in. x 0.500 in.; (Recommended plate thickness: not calculated
Profile:	W shape (AISC); (L x W x T x FT) = 7.930 in. x 6.500 in. x 0.245 in. x 0.400 in.
Base material:	cracked concrete, 4000, f_c' = 4000 psi; h = 45.000 in. ✓
Reinforcement:	tension: condition B, shear: condition B; ✓
	edge reinforcement: none or < No. 4 bar ✓

LC#15 – 0.9DL+1.0W

Geometry [in.] & Loading [lb, in.lb]



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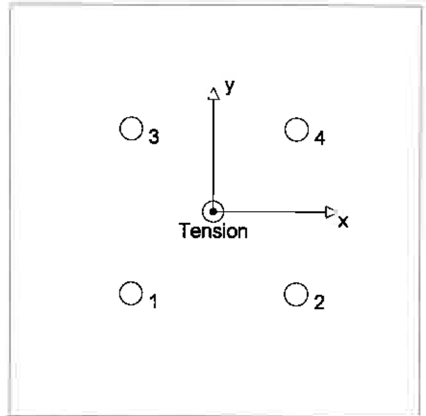
2 Load case/Resulting anchor forces

Load case: Design loads

Anchor reactions [lb]
Tension force: (+Tension, -Compression)

Anchor	Tension force	Shear force	Shear force x	Shear force y
1	952	857	857	0
2	952	857	857	0
3	952	857	857	0
4	952	857	857	0

max. concrete compressive strain: - [‰]
max. concrete compressive stress: - [psi]
resulting tension force in (x/y)=(0.000/0.000): 3810 [lb]
resulting compression force in (x/y)=(0.000/0.000): 0 [lb]



3 Tension load

	Load N_{ua} [lb]	Capacity ϕN_n [lb]	Utilization $\beta_N = N_{ua}/\phi N_n$	Status
Steel Strength*	952	6177	16	OK
Pullout Strength*	952	10461	10	OK
Concrete Breakout Strength**	3810	34216	12	OK
Concrete Side-Face Blowout, direction x+**	1905	32271	6	OK

* anchor having the highest loading **anchor group (anchors in tension)

3.1 Steel Strength

$N_{sa} = n\, A_{se,N}\, f_{uta}$ ACI 318-11 Eq. (D-2)
$\phi\, N_{steel} \geq N_{ua}$ ACI 318-11 Table D.4.1.1

Variables

n	$A_{se,N}$ [in.^{2}]	f_{uta} [psi]
1	0.14	58000

Calculations

N_{sa} [lb]
8236

Results

N_{sa} [lb]	ϕ_{steel}	$\phi\, N_{sa}$ [lb]	N_{ua} [lb]
8236	0.750	6177	952

3.2 Pullout Strength

$N_{pN} = \psi_{c,p}\, N_p$ ACI 318-11 Eq. (D-13)
$N_p = 8\, A_{brg}\, f'_c$ ACI 318-11 Eq. (D-14)
$\phi\, N_{pN} \geq N_{ua}$ ACI 318-11 Table D.4.1.1

Variables

$\psi_{c,p}$	A_{brg} [in.^{2}]	λ_a	f'_c [psi]
1.000	0.47	1.000	4000

Calculations

N_p [lb]
14944

Results

N_{pn} [lb]	$\phi_{concrete}$	$\phi\, N_{pn}$ [lb]	N_{ua} [lb]
14944	0.700	10461	952

Input data and results must be checked for agreement with the existing conditions and for plausibility!
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3.3 Concrete Breakout Strength

$N_{cbg} = \left(\frac{A_{Nc}}{A_{Nc0}}\right) \psi_{ec,N}\, \psi_{ed,N}\, \psi_{c,N}\, \psi_{cp,N}\, N_b$ ACI 318-11 Eq. (D-4)

$\phi\, N_{cbg} \geq N_{ua}$ ACI 318-11 Table D.4.1.1

A_{Nc} see ACI 318-11, Part D.5.2.1, Fig. RD.5.2.1(b)

$A_{Nc0} = 9\, h_{ef}^2$ ACI 318-11 Eq. (D-5)

$\psi_{ec,N} = \left(\frac{1}{1 + \frac{2\, e_N}{3\, h_{ef}}}\right) \leq 1.0$ ACI 318-11 Eq. (D-8)

$\psi_{ed,N} = 0.7 + 0.3 \left(\frac{c_{a,min}}{1.5 h_{ef}}\right) \leq 1.0$ ACI 318-11 Eq. (D-10)

$\psi_{cp,N} = \text{MAX}\left(\frac{c_{a,min}}{c_{ac}}, \frac{1.5 h_{ef}}{c_{ac}}\right) \leq 1.0$ ACI 318-11 Eq. (D-12)

$N_b = 16\, \lambda_a \sqrt{f'_c}\, h_{ef}^{5/3}$ ACI 318-11 Eq. (D-7)

Variables

h_{ef} [in.]	$e_{c1,N}$ [in.]	$e_{c2,N}$ [in.]	$c_{a,min}$ [in.]	$\psi_{c,N}$
24.000	0.000	0.000	6.000	1.000

c_{ac} [in.]	k_c	λ_a	f'_c [psi]
-	16	1.000	4000

Calculations

A_{Nc} [in.^{2}]	A_{Nc0} [in.^{2}]	$\psi_{ec1,N}$	$\psi_{ec2,N}$	$\psi_{ed,N}$	$\psi_{cp,N}$	N_b [lb]
1672.00	5184.00	1.000	1.000	0.750	1.000	202070

Results

N_{cbg} [lb]	$\phi_{concrete}$	$\phi\, N_{cbg}$ [lb]	N_{ua} [lb]
48880	0.700	34216	3810

3.4 Concrete Side-Face Blowout, direction x+

$N_{sb} = 160\, c_{a1} \sqrt{A_{brg}}\, \lambda_a \sqrt{f'_c}$ ACI 318-11 Eq. (D-16)

$N_{sbg} = \alpha_{group}\, N_{sb}$ ACI 318-11 Eq. (D-17)

$\phi\, N_{sbg} \geq N_{ua}$ ACI 318-11 Table (D.4.1.1)

$\alpha_{group} = \left(1 + \frac{s}{6\, c_{a1}}\right)$ see ACI 318-11, Part D.5.4.2 Eq. (D-17)

Variables

c_{a1} [in.]	c_{a2} [in.]	A_{brg} [in.^{2}]	λ_a	f'_c [psi]	s [in.]
6.000	-	0.47	1.000	4000	4.000

Calculations

α_{group}	N_{sb} [lb]
1.111	41492

Results

N_{sbg} [lb]	$\phi_{concrete}$	$\phi\, N_{sbg}$ [lb]	$N_{ua,edge}$ [lb]
46102	0.700	32271	1905

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4 Shear load

	Load V_{ua} [lb]	Capacity ϕV_n [lb]	Utilization $\beta_V = V_{ua}/\phi V_n$	Status
Steel Strength*	857	3212	27	OK
Steel failure (with lever arm)*	N/A	N/A	N/A	N/A
Pryout Strength**	3430	68433	6	OK
Concrete edge failure in direction x+**	3430	5966	58	OK

* anchor having the highest loading **anchor group (relevant anchors)

4.1 Steel Strength

$V_{sa} = n\ 0.6\ A_{se,V}\ f_{uta}$ ACI 318-11 Eq. (D-29)

$\phi\ V_{steel} \geq V_{ua}$ ACI 318-11 Table D.4.1.1

Variables

n	$A_{se,V}$ [in.^{2}]	f_{uta} [psi]
1	0.14	58000

Calculations

V_{sa} [lb]
4942

Results

V_{sa} [lb]	ϕ_{steel}	$\phi\ V_{sa}$ [lb]	V_{ua} [lb]
4942	0.650	3212	857

4.2 Pryout Strength

$V_{cpg} = k_{cp}\left[\left(\frac{A_{Nc}}{A_{Nc0}}\right)\psi_{ec,N}\ \psi_{ed,N}\ \psi_{c,N}\ \psi_{cp,N}\ N_b\right]$ ACI 318-11 Eq. (D-41)

$\phi\ V_{cpg} \geq V_{ua}$ ACI 318-11 Table D.4.1.1

A_{Nc} see ACI 318-11, Part D.5.2.1, Fig. RD.5.2.1(b)

$A_{Nc0} = 9\ h_{ef}^2$ ACI 318-11 Eq. (D-5)

$\psi_{ec,N} = \left(\frac{1}{1+\frac{2\ e_N}{3\ h_{ef}}}\right) \leq 1.0$ ACI 318-11 Eq. (D-8)

$\psi_{ed,N} = 0.7 + 0.3\left(\frac{c_{a,min}}{1.5h_{ef}}\right) \leq 1.0$ ACI 318-11 Eq. (D-10)

$\psi_{cp,N} = \text{MAX}\left(\frac{c_{a,min}}{c_{ac}}, \frac{1.5h_{ef}}{c_{ac}}\right) \leq 1.0$ ACI 318-11 Eq. (D-12)

$N_b = 16\ \lambda_a \sqrt{f'_c}\ h_{ef}^{5/3}$ ACI 318-11 Eq. (D-7)

Variables

k_{cp}	h_{ef} [in.]	$e_{c1,N}$ [in.]	$e_{c2,N}$ [in.]	$c_{a,min}$ [in.]
2	24.000	0.000	0.000	6.000

$\psi_{c,N}$	c_{ac} [in.]	k_c	λ_a	f'_c [psi]
1.000	-	16	1.000	4000

Calculations

A_{Nc} [in.^{2}]	A_{Nc0} [in.^{2}]	$\psi_{ec1,N}$	$\psi_{ec2,N}$	$\psi_{ed,N}$	$\psi_{cp,N}$	N_b [lb]
1672.00	5184.00	1.000	1.000	0.750	1.000	202070

Results

V_{cpg} [lb]	$\phi_{concrete}$	$\phi\ V_{cpg}$ [lb]	V_{ua} [lb]
97761	0.700	68433	3430

Input data and results must be checked for agreement with the existing conditions and for plausibility!
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4.3 Concrete edge failure in direction x+

$V_{cbg} = \left(\frac{A_{Vc}}{A_{Vc0}}\right) \psi_{ec,V}\, \psi_{ed,V}\, \psi_{c,V}\, \psi_{h,V}\, \psi_{parallel,V}\, V_b$ ACI 318-11 Eq. (D-31)

$\phi\, V_{cbg} \geq V_{ua}$ ACI 318-11 Table D.4.1.1

A_{Vc} see ACI 318-11, Part D.6.2.1, Fig. RD.6.2.1(b)

$A_{Vc0} = 4.5\, c_{a1}^2$ ACI 318-11 Eq. (D-32)

$\psi_{ec,V} = \left(\frac{1}{1 + \frac{2e_V'}{3c_{a1}}}\right) \leq 1.0$ ACI 318-11 Eq. (D-36)

$\psi_{ed,V} = 0.7 + 0.3\left(\frac{c_{a2}}{1.5c_{a1}}\right) \leq 1.0$ ACI 318-11 Eq. (D-38)

$\psi_{h,V} = \sqrt{\frac{1.5c_{a1}}{h_a}} \geq 1.0$ ACI 318-11 Eq. (D-39)

$V_b = \left(7\left(\frac{l_e}{d_a}\right)^{0.2} \sqrt{d_a}\right) \lambda_a \sqrt{f'_c}\, c_{a1}^{1.5}$ ACI 318-11 Eq. (D-33)

Variables

c_{a1} [in.]	c_{a2} [in.]	e_{cV} [in.]	$\psi_{c,V}$	h_a [in.]
6.000	-	0.000	1.000	45.000

l_e [in.]	λ_a	d_a [in.]	f'_c [psi]	$\psi_{parallel,V}$
4.000	1.000	0.500	4000	1.000

Calculations

A_{Vc} [in.^{2}]	A_{Vc0} [in.^{2}]	$\psi_{ec,V}$	$\psi_{ed,V}$	$\psi_{h,V}$	V_b [lb]
198.00	162.00	1.000	1.000	1.000	6974

Results

V_{cbg} [lb]	$\phi_{concrete}$	$\phi\, V_{cbg}$ [lb]	V_{ua} [lb]
8523	0.700	5966	3430

5 Combined tension and shear loads

β_N	β_V	ζ	Utilization $\beta_{N,V}$ [%]	Status
0.154	0.575	5/3	45	OK

$\beta_{NV} = \beta_N^{\zeta} + \beta_V^{\zeta} <= 1$

6 Warnings

- Load re-distributions on the anchors due to elastic deformations of the anchor plate are not considered. The anchor plate is assumed to be sufficiently stiff, in order not to be deformed when subjected to the loading! Input data and results must be checked for agreement with the existing conditions and for plausibility!
- Condition A applies when supplementary reinforcement is used. The Φ factor is increased for non-steel Design Strengths except Pullout Strength and Pryout strength. Condition B applies when supplementary reinforcement is not used and for Pullout Strength and Pryout Strength. Refer to your local standard.
- Checking the transfer of loads into the base material and the shear resistance are required in accordance with ACI 318 or the relevant standard!

Fastening meets the design criteria!

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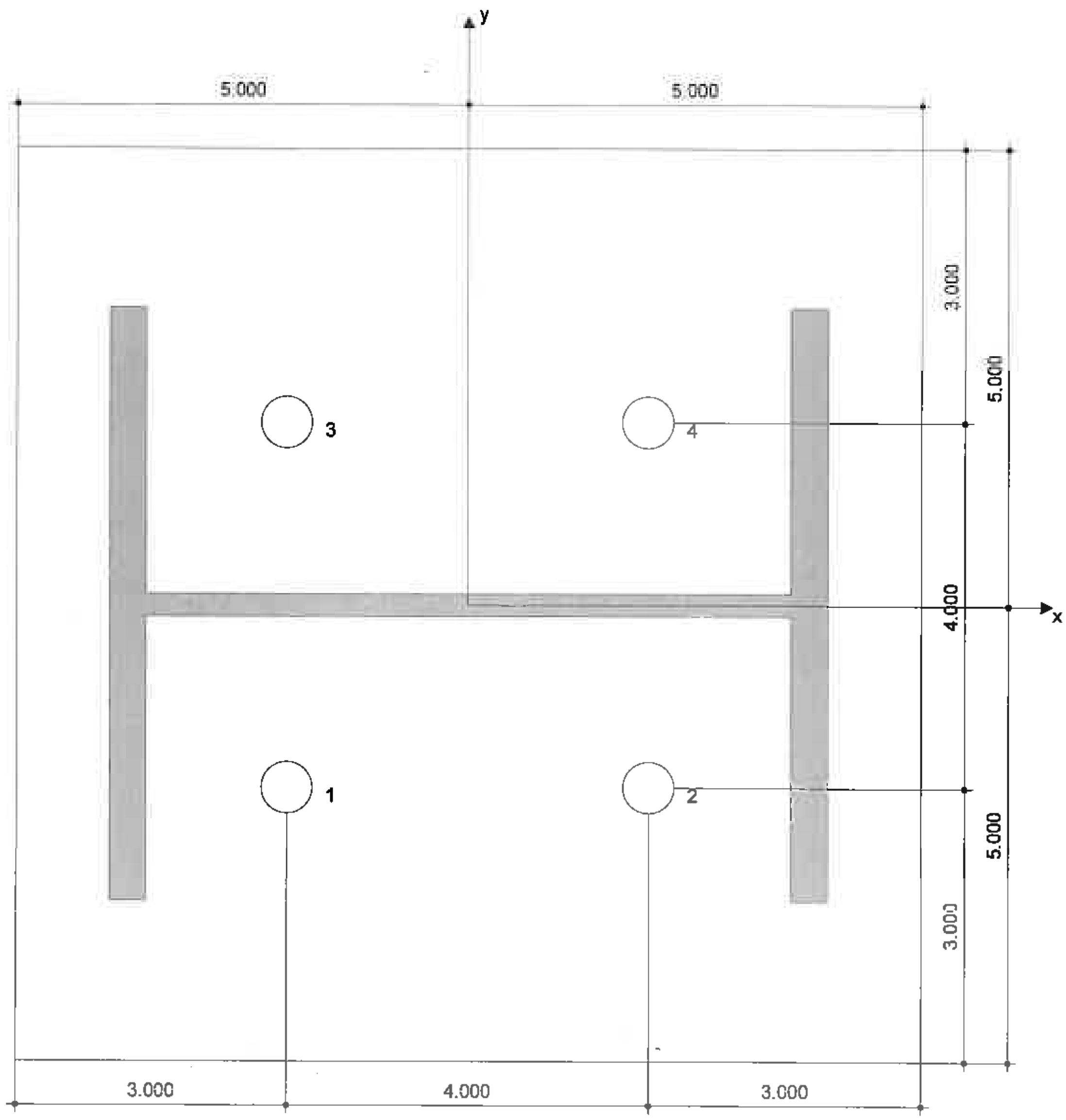
7 Installation data

Anchor plate, steel: -
Profile: W shape (AISC); 7.930 x 6.500 x 0.245 x 0.400 in.
Hole diameter in the fixture: d_f = 0.563 in.
Plate thickness (input): 0.500 in.
Recommended plate thickness: not calculated
Cleaning: No cleaning of the drilled hole is required

Anchor type and diameter: Heavy Hex Head ASTM F 1554 GR. 36 1/2
Installation torque: -0.009 in.lb
Hole diameter in the base material: - in.
Hole depth in the base material: 24.000 in.
Minimum thickness of the base material: 25.844 in.



Coordinates Anchor in.

Anchor	x	y	c_{-x}	c_{+x}	c_{-y}	c_{+y}
1	-2.000	-2.000	12.000	10.000	-	-
2	2.000	-2.000	16.000	6.000	-	-
3	-2.000	2.000	12.000	10.000	-	-
4	2.000	2.000	16.000	6.000	-	-

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SLAB-ON-GRADE DESIGN

- MODULUS OF SUBGRADE REACTION = 100 kcf ← CONSERVATIVE SINCE (kcf: LOOSE SAND 30-100; MEDIUM SAND 60-500; SAND W/ SILT 150-300)
- NET ALLOWABLE SOIL BEARING PRESSURE = 2,000 psf (GEOTECH REPORT)
- Refer to Sht E-17 thru E-22 For SLAB-ON-GRADE DESIGN

~ E-17 ~ 3 TON FORKLIFT

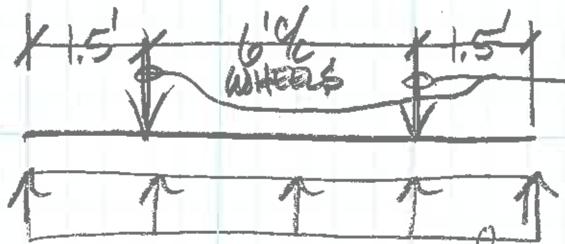
~ E-18 ~ HS-20 WHEEL LOAD - 32,000# AXLE → 16,000# WHEEL LOAD @ 100 kcf

~ E-19 ~ " " " - 32,000# × 1.25 IMPACT = 40,000# AXLE → 20,000# WHEEL LOAD @ 130 kcf

~ E-20 ~ WALL LOAD = (509.5' - 497.5') × 62 psf DL 8" CMU = 744#/FT

~ E-21 ~ HS 20 WHEEL LOAD

↳ 32,000# AXLE × 1.25 IMPACT = 40,000# / 3.5 FT DISTRIBUTION (CONSERVATIVE) = 11,429# IN 1 FT SLAB SECTION



$M_{UNF} = 3.75^{K\cdot FT} \times 1.6_{ACI} = 6^{K\cdot FT}_{ACI}$

$V_{UNF} = 3.6^K \times 1.6_{ACI} = 5.76^K_{ACI}$ ← TOO CONSERVATIVE $= (3.6^K / 1.25_{IMPACT}) \times 1.6_{ACI} = 4.60^K$

— 8" SOG w/ #6 @ 11" o/c CENTERED ~ $d = 8/2 - 6/16" = 3.62^{IN}$

- 4500 psi: $\phi V_c = 2\phi\sqrt{f'_c}\,bd = 4.37^K \approx 4.6^K$ ✓OK B/C 3.5 FT SLAB DISTRIBUTION IS CONSERVATIVE
- $R = M_u/\phi bd^2 = 508.7 \rightarrow \rho = 0.0086 \rightarrow A_s = \rho bd = 0.37^{IN^2/FT}$

#6 @ 11" o/c CENTERED ($A_s = 0.48^{IN^2/FT}$) > ✓OK

AGM Form 30 12-01

E-17

"GRDSLAB.xls" Program
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CONCRETE SLAB ON GRADE ANALYSIS

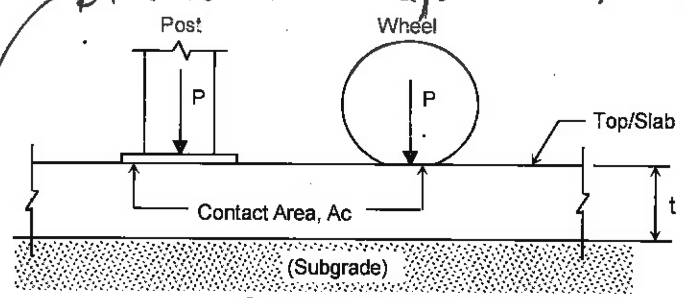
For Slab Subjected to Interior Concentrated Post or Wheel Loading
Assuming ACI-360 "Type B" Design - Reinforced for Shrinkage and Temperature Only

Job Name:	Topok - ~~Workshop~~ Building	Subject:	Slab-on-Grade
Job Number:	RC000753.0008	Originator:	MSL	Checker:

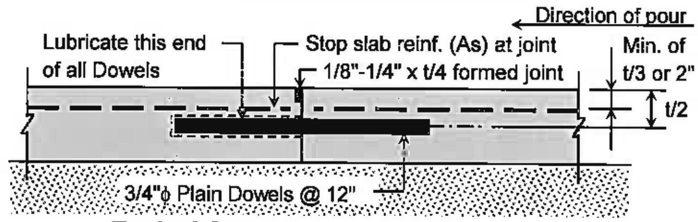
MW-20 BENCH   3 TON FORKLIFT ≈ 6,000# × 1.25 = 7,500#

Input Data:

Slab Thickness, t =	8.000	in.
Concrete Strength, f 'c =	4000	psi
Conc. Unit Weight, wc =	150	pcf
Reinforcing Yield, fy =	60000	psi
Subgrade Modulus, k =	100	pci
Concentrated Load, P =	7750.00	lbs.
Contact Area, Ac =	72.00	in.^2
Factor of Safety, FS =	2.00	
Dowel Bar Dia., db =	0.750	in.
Dowel Bar Spacing, s =	11.000	in.
Const. Joint Width, z =	0.1250	in.
Joint Spacing, L =	15.000	ft.
Temperature Range, ΔT =	50.00	deg.
Increase for 2nd Wheel, i =	15	%



Concrete Slab on Grade



Typical Construction Joint for Load Transfer

Results:

Check Slab Flexural Stress: (assuming unreinforced slab with interior load condition)

Effective Load Radius, a =	4.787	in.	a = SQRT(Ac/π)
Modulus of Elasticity, Ec =	3834254	psi	Ec = 33*wc^1.5*SQRT(f 'c)
Modulus of Rupture, MR =	569.21	psi	MR = 9*SQRT(f 'c)
Cracking Moment, Mr =	6.07	ft-k/ft.	Mr = MR*(12*t^2/6)/12000 (per 1' = 12" width)
Poisson's Ratio, μ =	0.15		μ = 0.15 (assumed for concrete)
Radius of Stiffness, Lr =	35.968	in.	Lr = (Ec*t^3/(12*(1-μ^2)*k))^0.25
Equivalent Radius, b =	4.633	in.	b = SQRT(1.6*a^2+t^2)-0.675*t , for a < 1.724*t
1 Load: fb1(actual) =	177.21	psi	fb1(actual) = 3*P*(1+μ)/(2*π*t^2)*(LN(Lr/b)+0.6159) (Ref. 1)
2 Loads: fb2(actual) =	203.79	psi	fb2(actual) = fb1(actual)*(1+i/100)
Fb(allow) =	284.60	psi >	Fb(allow) = MR/FS **Fb(allow) >= fb(actual), O.K.** ✓

Check Slab Bearing Stress: (assuming working stress) (Ref. 4)

fp(actual) =	107.64	psi	fp(actual) = P/Ac
Fp(allow) =	2390.68	psi	Fp(allow) = 4.2*MR **Fp(allow) >= fp(actual), O.K.** ✓

Check Slab Punching Shear Stress: (assuming working stress) (Ref. 4)

bo =	33.941	in.	bo = 4*SQRT(Ac) (assumed shear perimeter)
fv(actual) =	14.69	psi	fv(actual) = P/(t*(bo+4*t))
Fv(allow) =	153.69	psi	Fv(allow) = 0.27*MR **Fv(allow) >= fv(actual), O.K.** ✓

Shrinkage and Temperature Reinf.: (assuming subgrade drag method) (Ref. 3)

Friction Factor, F =	1.50		F = 1.5 (assumed friction factor between subgrade and slab)
Slab Weight, W =	100.00	psf	W = wc*(t/12)
Reinf. Allow. Stress, fs =	45000	psi	fs = 0.75*fy
As =	0.025	in.^2/ft.	As = F*L*W/(2*fs)

< #6@11" o/c (As = 0.48 in²/ft)

(continued)

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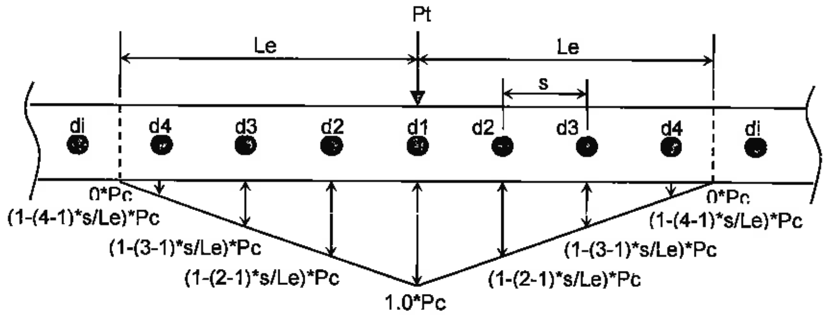
Determine Estimated Crack Width: (assuming no use of stabilized or granular subbase)

Slab-base Frict. Adjust., C =	1.00		C = 1.0 (assumed value for no subbase)
Thermal Expansion, α =	0.0000055	in./in./deg	α = 5.5x10^(-6) (assumed thermal expansion coefficient)
Shrinkage Coefficient, ε =	0.00035	in./in.	ε = 3.5x10^(-4) (assumed coefficient of shrinkage)
Est. Crack Width, ΔL =	0.1125	in.	ΔL = C*L*12*(α*ΔT+ε) (Ref. 5)

Check Bearing Stress on Dowels at Construction Joints with Load Transfer: (Ref. 2)



Assumed Load Transfer Distribution for Dowels at Construction Joint

Le =	35.968	in.	Le = 1.0*Lr = applicable dist. each side of critical dowel
Effective Dowels, Ne =	3.33	bars	Ne = 1.0+2*Σ(1-d(n-1)*s/Le) (where: n = dowel #)
Joint Load, Pt =	3875.00	lbs.	Pt = 0.50*P (assumed load transferred across joint)
Critical Dowel Load, Pc =	1163.65	lbs.	Pc = Pt/Ne
Mod. of Dowel Suppt., kc =	1500000	psi	kc = 1.5x10^6 (assumed for concrete)
Mod. of Elasticity, Eb =	29000000	psi	Eb = 29x10^6 (assumed for steel dowels)
Inertia/Dowel Bar, Ib =	0.0155	in.^4	Ib = π*db^4/64
Relative Bar Stiffness, β =	0.889		β = (kc*db/(4*Eb*Ib))^(1/4)
fd(actual) =	2911.67	psi	fd(actual) = kc*(Pc*(2+β*z)/(4*β^3*Eb*Ib))
Fd(allow) =	4333.33	psi	Fd(allow) = (4-db)/3*f 'c **Fd(allow) >= fd(actual), O.K.** ✓

References:

1. "Load Testing of Instumented Pavement Sections - Improved Techniques for Appling the Finite Element Method to Strain Predition in PCC Pavement Structures" - by University of Minnesota, Department of Civil Engineering (submitted to MN/DOT, March 24, 2002)
2. "Dowel Bar Opimization: Phases I and II - Final Report" - by Max L. Porter (Iowa State University, 2001)
3. "Design of Slabs-on-Ground" - ACI 360R-06 - by American Concrete Institute (2006)
4. "Slab Thickness Design for Industrial Concrete Floors on Grade" (IS195.01D) - by Robert G. Packard (Portland Cement Association, 1976)
5. "Streses and Stains in Rigid Pavements" (Lecture Notes 3) - by Charles Nunoo, Ph.D., P.E. (Florida International University, Miami FL - Fall 2002)

Comments:

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10/13/15

MW-20 BENCH

CONCRETE SLAB ON GRADE THICKNESS ANALYSIS

For Slab Subjected to Single Wheel Loading from Vehicles with Pneumatic Tires
Per PCA "Slab Thickness Design for Industrial Concrete Floors on Grade" - Figure 3, page 5

Job Name:	Topok - ~~Workshop~~ Building	Subject:	Slab-on-Grade
Job Number:	RC000753.0008	Originator:	MSL	Checker:	

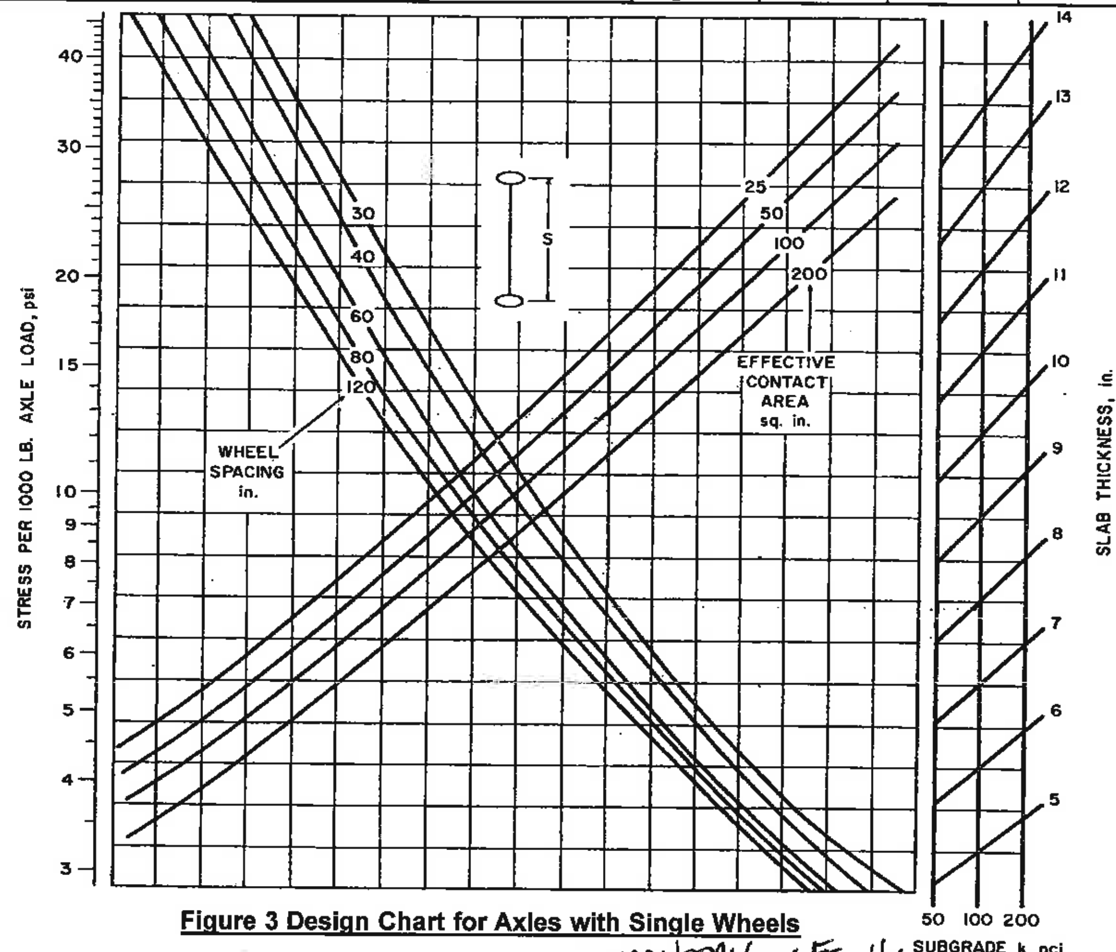

Figure 3 Design Chart for Axles with Single Wheels

CONSERV ~ 6FT — HS20

Input Data:

Concrete Strength, f 'c =	4000	psi
Subgrade Modulus, k =	100.00	pci
Axle Load, Pa =	32000.00	lbs.
Wheel Spacing, S =	37.00	in.
Tire Inflation Pressure, Ip =	110.00	psi
Factor of Safety, FS =	2.00	

Instructions for Use of Figure 3:

1. Enter chart with slab stress = 8.89
2. Move to right to eff. contact area = 145.45
3. Move up/down to wheel spacing = 37
4. Move to right to subgrade modulus = 100
5. Read required slab thickness, t

Results:

Wheel Load, Pw =	16000.00	lbs.	Pw = Pa/2 (1/2 of axle load for 2 wheels/axle)
Tire Contact Area, Ac =	145.45	in.^2	Ac = Pw/Ip
Effective Contact Area, Ac(eff) =	145.45	in.^2	Ac(eff) = determined from Figure 5, page 6
Concrete Flexual Strength, MR =	569.21	psi	MR = 9*SQRT(f 'c) (Modulus of Rupture)
Concrete Working Stress, WS =	284.60	psi	WS = MR/FS
Slab Stress/1000 lb. Axle Load =	8.89	psi	Ss = WS/(Pa/1000)
Slab Thickness, t =	7.900	in. < 8 IN	t = determined from Figure 3 above

√ OK

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10/13/15

E-19

"GRDSLAB.xls" Program
Version 1.6

MW-20 BENCH

CONCRETE SLAB ON GRADE THICKNESS ANALYSIS

For Slab Subjected to Single Wheel Loading from Vehicles with Pneumatic Tires
Per PCA "Slab Thickness Design for Industrial Concrete Floors on Grade" - Figure 3, page 5

Job Name:	Topok - ~~Workshop~~ Building	Subject:	Slab-on-Grade		
Job Number:	RC000753.0008	Originator:	MSL	Checker:	

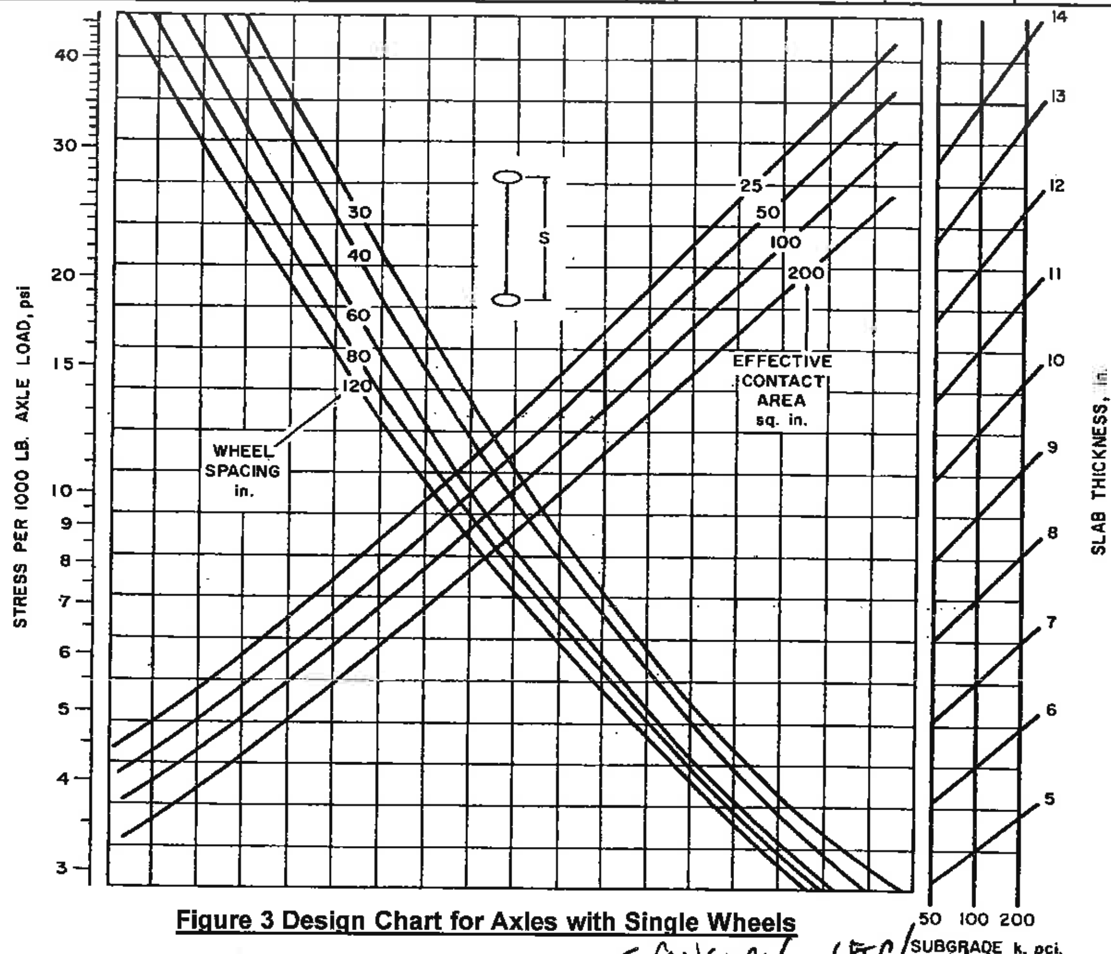

Figure 3 Design Chart for Axles with Single Wheels

CONSERV ~ 6FT C/C HS20

Input Data:

Concrete Strength, f 'c =	4000	psi
Subgrade Modulus, k =	130.00	pci
Axle Load, Pa =	40000.00	lbs.
Wheel Spacing, S =	37.00	in.
Tire Inflation Pressure, Ip =	110.00	psi
Factor of Safety, FS =	2.00	

Instructions for Use of Figure 3:

1. *Enter chart with slab stress = 7.12*
2. *Move to right to eff. contact area = 181.82*
3. *Move up/down to wheel spacing = 37*
4. *Move to right to subgrade modulus = 130*
5. *Read required slab thickness, t*

Results:

Wheel Load, Pw =	20000.00	lbs.	Pw = Pa/2 (1/2 of axle load for 2 wheels/axle)
Tire Contact Area, Ac =	181.82	in.^2	Ac = Pw/Ip
Effective Contact Area, Ac(eff) =	181.82	in.^2	Ac(eff) = determined from Figure 5, page 6
Concrete Flexual Strength, MR =	569.21	psi	MR = 9*SQRT(f 'c) (Modulus of Rupture)
Concrete Working Stress, WS =	284.60	psi	WS = MR/FS
Slab Stress/1000 lb. Axle Load =	7.12	psi	Ss = WS/(Pa/1000)
Slab Thickness, t =	7.900	in. < 8 IN	t = determined from Figure 3 above

√ OK

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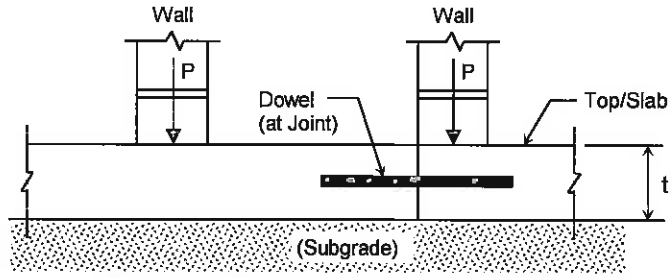
E-20

CONCRETE SLAB ON GRADE ANALYSIS
For Slab Subjected to Continuous Line Loading from Wall

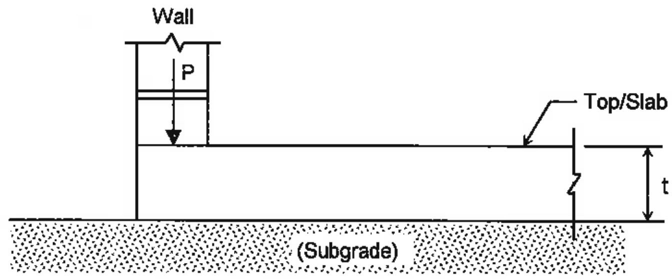
Job Name:	Topok - MW-20 Bench Building	Subject:	Slab-on-Grade		
Job Number:	RC000753.0008	Originator:	MSL	Checker:	

Input Data:

Slab Thickness, t =	8.000	in.
Concrete Strength, f 'c =	4000	psi
Subgrade Modulus, k =	100	pci
Wall Load, P =	750.00	lb./ft.



Concrete Slab Loaded Near Center or at Joint



Concrete Slab Loaded Near Free Edge

Results:

Design Parameters:

Modulus of Rupture, MR =	569.21	psi	MR = 9*SQRT(f 'c)
Allow. Bending Stress, Fb =	101.19	psi	Fb = 1.6*SQRT(f 'c) (as recommended in reference below)
Factor of Safety, FS =	5.625		FS = MR/Fb
Section Modulus, S =	128.00	in.^3/ft.	S = b*t^2/6
Modulus of Elasticity, Ec =	3604997	psi	Ec = 57000*SQRT(f 'c)
Width, b =	12.00	in.	b = 12" (assumed)
Moment of Inertia, I =	512.00	in.^4	I = b*t^3/12
Stiffness Factor, λ =	0.0201		λ = (k*b/(4*Ec*I))^(0.25)
Coefficient, Bλx =	0.3224		Bλx = coefficient from "*Beams on Elastic Foundations*" by M. Hetenyi

Wall Load Near Center of Slab or Keyed/Doweled Joints:

Allowable Wall Load, Pc = 1040.30 lb./ft.

Pc = 4*Fb*S*λ
= 12.8*SQRT(f 'c)*t^2*(k/(19000*SQRT(f 'c)*t^3))^(0.25)

Pc(allow) >= P, O.K. ✓

Wall Load Near Free Edge of Slab:

Allowable Wall Load, Pe = 806.68 lb./ft.

Pe = Fb*S*λ/Bλx
= 9.9256*SQRT(f 'c)*t^2*(k/(19000*SQRT(f 'c)*t^3))^(0.25)

Pe(allow) >= P, O.K. ✓

Reference:

"Concrete Floor Slabs on Grade Subjected to Heavy Loads"
Army Technical Manual TM 5-809-12, Air Force Manual AFM 88-3, Chapter 15 (1987)

Comments:

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E-21

"GRDSLAB.xls" Program
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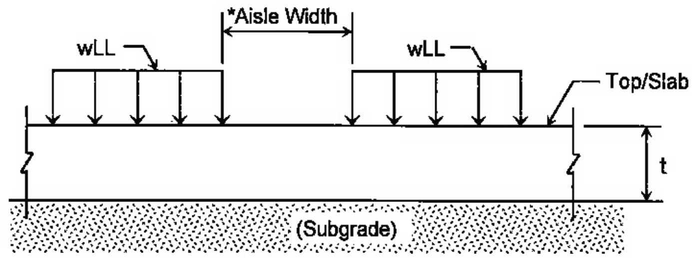
CONCRETE SLAB ON GRADE ANALYSIS
For Slab Subjected to Stationary Uniformly Distributed Live Loads

Job Name:	Topok - MW 20 Bench Building	Subject:	Slab-on-Grade		
Job Number:	RC000753.0008	Originator:	MSL	Checker:	

Input Data:

Slab Thickness, t =	8.000	in.
Concrete Strength, f 'c =	4000	psi
Subgrade Modulus, k =	100	pci
Factor of Safety, FS =	2.000	
Uniform Live Load, wLL =	500.00	psf



Concrete Slab on Grade with Uniform Loads

*Note: In an unjointed aisleway between uniformly distributed load areas, negative bending moment in slab may be up to twice as great as positive moment in slab beneath loaded area. Allowable uniform load determined below is based on critical aisle width and as a result, there are no restrictions on load layout configuration or uniformity of loading.

Results:

Design Parameters:

Modulus of Rupture, MR =	569.21	psi	MR = 9*SQRT(f 'c)
Allow. Bending Stress, Fb =	284.60	psi	Fb = MR/FS
Modulus of Elasticity, Ec =	3604997		Ec = 57000*SQRT(f 'c)
Poisson's Ratio, μ =	0.15		μ = 0.15 (assumed for concrete)
Radius of Stiffness, Lr =	35.42	in.	Lr = (Ec*t^3/(12*(1-μ^2)*k))^0.25
Critical Aisle Width, Wcr =	6.52	ft.	Wcr = (2.209*Lr)/12 (Ref. 3, Appendix 2 page 64) (presented for information only)

Stationary Uniformly Distributed Live Loads: ✓

Per Ref. #1: wLL(allow) = 1093.32 psf ✓ OK wLL(allow) = 257.876*Fb*SQRT(k*t/Ec)
wLL(allow) >= wLL, O.K. ✓

Per Ref. #2: wLL(allow) = 990.13 psf ✓ OK wLL(allow) = 0.123*Fb*SQRT(k*t)
wLL(allow) >= wLL, O.K. ✓

Reference:

1. "Concrete Floor Slabs on Grade Subjected to Heavy Loads"
   Army Technical Manual TM 5-809-12, Air Force Manual AFM 88-3, Chapter 15 (1987)
2. "Slab Thickness Design for Industrial Concrete Floors on Grade" (IS195.01D)
   by Robert G. Packard (Portland Cement Association, 1976)
3. "Design of Slabs-on-Ground" - ACI 360R-06 - by American Concrete Institute

Comments:

BEAM ON ELASTIC FOUNDATION ANALYSIS

For Soil Supported Beam, Combined Footing, Slab Strip or Mat Strip of Assumed Finite Length with Both Ends Free

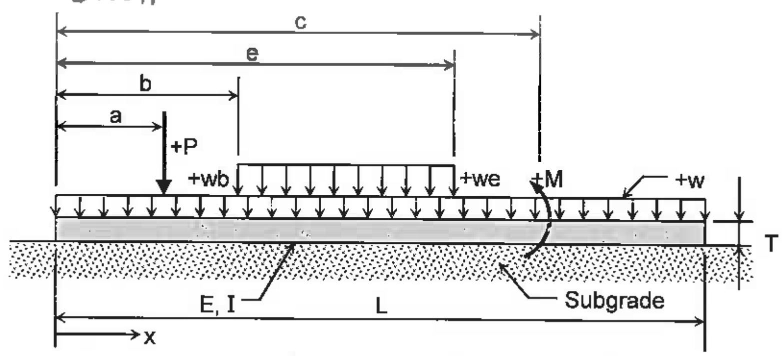
Job Name:	Topok - ~~Workshop~~ Building	Subject:	Slab-on-Grade		
Job Number:	RC000753.0008	Originator:	MSL	Checker:	

MW-20 BENCH

Input Data:

Beam Data:

Length, L = 9.0000 ✓ ft.
Width, B = 1.0000 ✓ ft.
Thickness, T = 0.6667 ✓ ft.
Modulus, E = 3600 ✓ ksi
Subgrade, K = 100 ✓ pci



Nomenclature

Beam Loadings:

Full Uniform:

w = 0.1000 ✓ kips/ft.

Distributed:

	Start b (ft.)	Start Wb (kips/ft.)	End e (ft.)	End We (kips/ft.)
#1:				
#2:				
#3:				
#4:				
#5:				
#6:				

Point Loads:

	a (ft.)	P (kips)
#1:	1.5000 ✓	5.71 ✓
#2:	7.5000 ✓	5.71 ✓
#3:		
#4:		
#5:		
#6:		
#7:		
#8:		
#9:		
#10:		
#11:		
#12:		

Moments:

	c (ft.)	M (ft-kips)
#1:		
#2:		
#3:		
#4:		

Comments:

Results:

Beam Flexiblity Criteria:

for β*L <= π/4 beam is rigid
for π/4 < β*L < π beam is semi-rigid
for β*L >= π beam is flexible
for β*L >= 6 beam is semi-infinite long

Inertia, I = 0.0247 ft.^4 I = B*T^3/12
β = 0.241 β = ((K*B)/(4*E*I))^(1/4)
β*L = 2.169 β*L = Flexibility Factor

Beam is semi-rigid

Max. Shears and Locations:

+V(max) = 3.64 k @ x = 7.50 ft.
-V(max) = -3.64 k @ x = 1.50 ft.

Max. Moments and Locations:

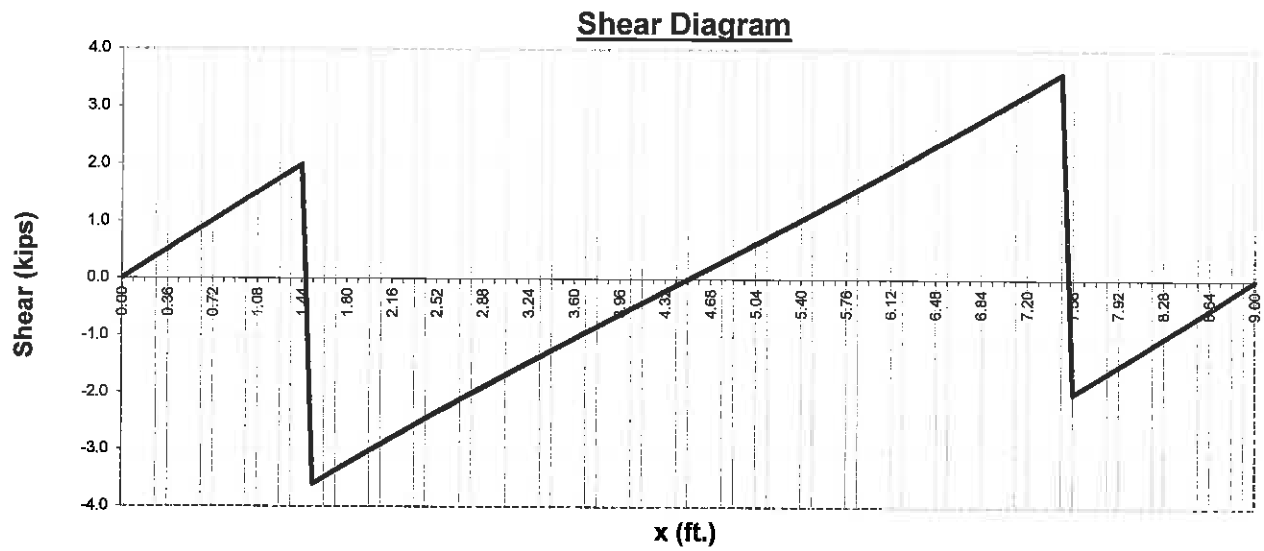
+M(max) = 1.57 ft-k @ x = 1.50 ft.
-M(max) = -3.75 ft-k @ x = 4.50 ft.

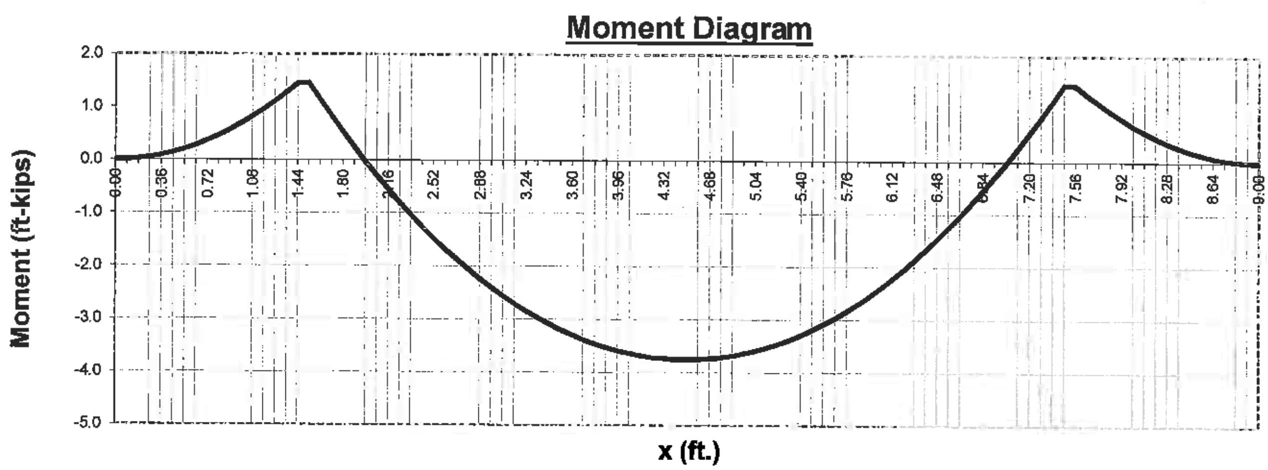
Max. Deflection and Location:

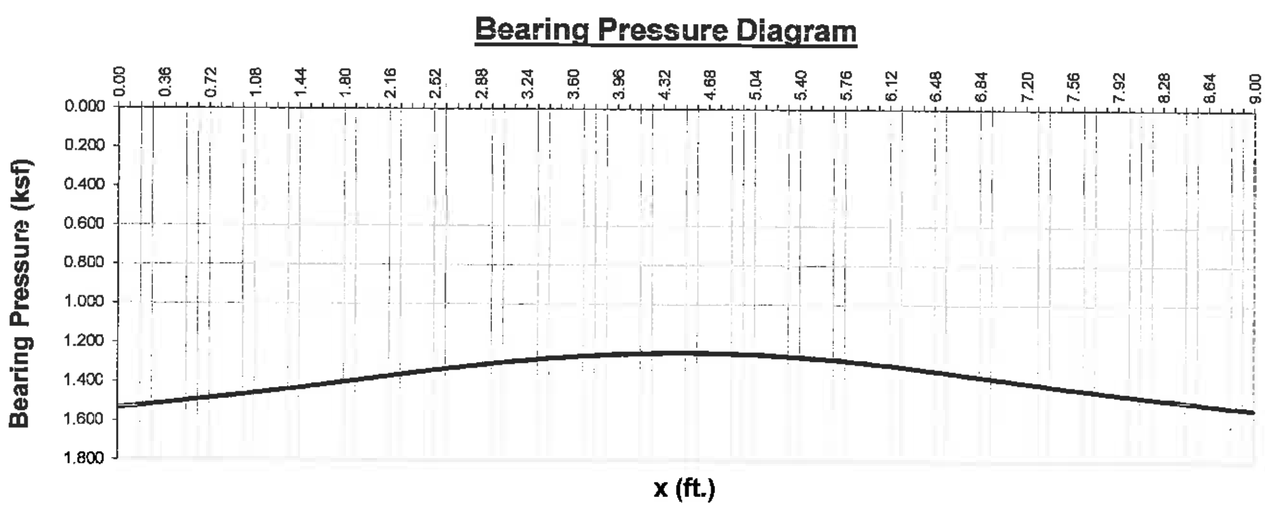
Δ(max) = -0.107 in. @ x = 0.00 ft.

Max. Soil Pressure and Location:

Q(max) = 1.534 ksf @ x = 0.00 ft.


Shear Diagram
Shear (kips)
x (ft.)


Moment Diagram
Moment (ft-kips)
x (ft.)


Bearing Pressure Diagram
Bearing Pressure (ksf)
x (ft.)

E-23

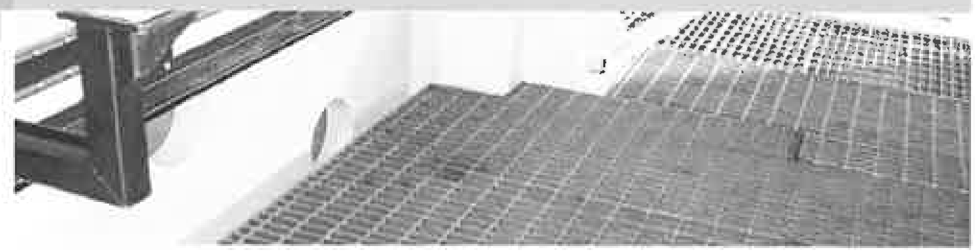
HOME | CAREERS

OHIO GRATINGS, INC.

Metal Grating Solutions

Heavy Duty Steel Resources & Links

HEAVY DUTY STEEL GRATING



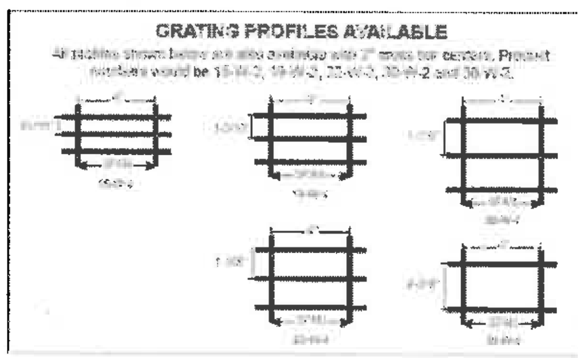
- Heavy Duty Steel Grating
- Heavy Duty Welded Steel Grating
- Heavy Duty Riveted Steel Grating
- Benefits of Heavy Duty Steel
- Heavy Duty Steel Design Criteria
- Grating Data
- Steel Grating Frames
- Grating Ordering Infomation
- Distributor Locator
- Request A Quote

PDF's

Product Catalog

W Series

Welded carbon heavy duty steel grating is the most popular choice where high strength is the primary grating requirement. The main bars are slotted and assembled with cross bars which are welded with one fillet weld at every joint. Stainless steel can also be provided for those high corrosive applications. This product meets the demanding vehicle loading requirements of AASHTO and is geared to handle heavy rolling loads. Slip resistant surfaces are available. The typical applications for our heavy duty steel products include airfield landing mats and trenches, airplane unloading ramps, highway bridge decking, sidewalks, concrete reinforcements, vault covers, ramps, docks, industrial flooring, trenches, off-shore drilling rigs and paper mills.



3-Part Specifications

- 15-W-4
- 19-W-4
- 22-W-4
- 30-W-4
- 38-W-4

Load Tables

- 15 Space
- 19 Space
- 22 Space
- 30 Space
- 38 Space

Applications for this product include:

- Cover Trenches in Plants
- Highway Trenches
- Airport Trenches
- Bridge Decking
- Access to Public/Government Buildings
- Sidewalk Grates
- Stair Treads
- Airport Ramps
- Airplane Landing Mats
- Machinery Support Trenches
- Bridge Sidewalks
- Entranceways to Buildings
- Commercial Entranceways
- Trench Grating

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info@ohiogratings.com • P: 800-321-9800 • F: 330-477-7872 • 5299 Southway St. SW, Canton Ohio 44706
Programmed & Maintained by OGI Business Applications Development

19-W-4

Bar Size, Inches	Wt.** Lbs. Sq. Ft.	Section Properties Sx**, in³ Ft. Width	Ix**, in⁴ Ft. Width	Cross Bar Size Inches	Maximum Safe Clear Span, Inches - Uniformly Distributed Load 1 Ton	3 Ton	5 Ton	H15/H20
1 x 1/4	9.71	0.421	0.211	3/8 Dia	7	6	7	9
1 x 3/8	14.61	0.632	0.316	3/8 Dia	9	8	9	11
1-1/4 x 1/4	11.87	0.658	0.411	3/8 Dia	10	8	9	12
1-1/4 x 3/8	17.23	0.987	0.617	3/8 Dia	14	10	12	14
1-1/2 x 1/4	14.01	0.947	0.711	3/8 Dia	13	10	11	14
1-1/2 x 5/16	17.23	1.184	0.889	3/8 Dia	16	11	13	16
1-1/2 x 3/8	20.46	1.421	1.066	3/8 Dia	19	13	14	18
1-3/4 x 1/4	16.16	1.289	1.128	3/8 Dia	17	12	14	17
1-3/4 x 3/8	23.67	1.934	1.692	3/8 Dia	25	17	18	21
2 x 1/4	18.30	1.684	1.684	3/8 Dia	22	15	16	20
2 x 5/16	22.60	2.105	2.105	3/8 Dia	26	18	19	23
2 x 3/8	26.89	2.526	2.526	3/8 Dia	33	21	22	26
2-1/4 x 1/4	20.46	2.132	2.398	3/8 Dia	28	18	19	23
2-1/4 x 3/8	30.12	3.197	3.597	3/8 Dia	41	25	26	31
2-1/2 x 1/4	22.80	2.632	3.289	3/8 Dia	34	22*	22	27
2-1/2 x 5/16	27.96	3.289	4.112	3/8 Dia	43	27	27	31
2-1/2 x 3/8	33.34	3.947	4.934	3/8 Dia	50	31	31	36
3 x 1/4	28.32	3.789	5.684	1 x 1/4	49	30	30	35
3 x 5/16	34.76	4.737	7.105	1 x 1/4	60	37	36	42
3 x 3/8	41.20	5.684	8.526	1 x 1/4	67*	44	43	49
3 x 1/2	54.09	7.579	11.368	1 x 1/4	78*	57	55	61*
3-1/2 x 1/4	32.61	5.158	9.026	1 x 1/4	66	40	39	45
3-1/2 x 3/8	47.65	7.737	13.539	1 x 1/4	85*	58	56	64
3-1/2 x 1/2	62.87	10.316	18.052	1 x 1/4	96	75*	72*	76*
4 x 1/4	36.91	6.737	13.473	1 x 1/4	85*	51	50	57
4 x 5/16	45.50	8.421	16.842	1 x 1/4	95*	63	61	70
4 x 3/8	54.09	10.105	20.210	1 x 1/4	96	75	72	80*
4 x 1/2	71.26	13.473	26.947	1 x 1/4	96	91*	88*	92*
4-1/2 x 1/4	41.20	8.526	19.184	1 x 1/4	96	64	61	70
4-1/2 x 3/8	60.53	12.789	28.776	1 x 1/4	96	94*	90	95*
4-1/2 x 1/2	79.85	17.052	38.367	1 x 1/4	96	96	96	96
5 x 1/4	45.50	10.526	26.315	1 x 1/4	96	78	75	85
5 x 5/16	56.24	13.158	32.894	1 x 1/4	96	96	92	96
5 x 3/8	66.97	15.789	39.473	1 x 1/4	96	96	96	96
5 x 1/2	88.44	21.052	52.630	1 x 1/4	96	96	96	96
5-1/2 x 1/4	49.79	12.737	35.025	1 x 1/4	96	94	89	96
5-1/2 x 3/8	73.42	19.105	52.538	1 x 1/4	96	96	96	96
5-1/2 x 1/2	97.03	25.473	70.051	1 x 1/4	96	96	96	96
6 x 1/4	54.09	15.158	45.473	1 x 1/4	96	96	96	96
6 x 5/16	66.87	18.947	56.841	1 x 1/4	96	96	96	96
6 x 3/8	79.85	22.736	68.209	1 x 1/4	96	96	96	96
6 x 1/2	105.62	30.315	90.945	1 x 1/4	96	96	96	96

*Span limited to 1/400 of span = Deflection. **Based on 10.105 bars/ft of grating width. Bearing bars 1-3/16" c.c. Note: When serrated grating is specified, the depth of grating required for a specified load will be 1/4" greater than that shown in these tables. Weights shown are for 4" cross bar centers. Add 1.13 lbs./sq. ft. (3/8" Dia.) or 2.55 lbs./sq. ft. (1" x 1/4") for 2" cross bar centers.

Bar Size Inches	Maximum Safe Concentrated Load*, Lbs. - 1'-0"	1'-6"	2'-0"	2'-6"	3'-0"	3'-6"	4'-0"	4'-6"	5'-0"	5'-6"	6'-0"	7'-0"	8'-0"
1 x 1/4	2807	1871	1403	1123	936	802							
1 x 3/8	4213	2809	2107	1685	1404	1204							
1-1/4 x 1/4	4387	2924	2193	1755	1462	1253	1097						
1-1/4 x 3/8	6580	4387	3290	2632	2193	1880	1645						
1-1/2 x 1/4	6315	4209	3157	2526	2104	1804	1578	1403					
1-1/2 x 5/16	7893	5262	3947	3157	2631	2255	1973	1754					
1-1/2 x 3/8	9473	6316	4737	3789	3158	2707	2368	2105					
1-3/4 x 1/4	8593	5729	4297	3437	2864	2455	2148	1910	1719				
1-3/4 x 3/8	12893	8596	6447	5157	4298	3684	3223	2865	2579				
2 x 1/4	11227	7484	5613	4491	3742	3208	2807	2495	2245				
2 x 5/16	14033	9356	7017	5613	4678	4010	3508	3119	2807				
2 x 3/8	16840	11227	8420	6736	5613	4811	4210	3742	3368				
2-1/4 x 1/4	14213	9476	7107	5685	4738	4061	3553	3158	2843	2584			
2-1/4 x 3/8	21313	14209	10657	8526	7104	6090	5328	4736	4263	3875			
2-1/2 x 1/4	17547	11698	8773	7019	5849	5013	4387	3899	3509	3190	2924		
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		

% Open Area**					
BB Size	CB Ctrs	Bearing Bar Thickness 1/4"	5/16"	3/8"	1/2"
Thru 2-1/2"	4" cc	[illegible]	[illegible]	[illegible]	[illegible]
	2" cc	[illegible]	[illegible]	[illegible]	[illegible]
3" to 6"	4" cc	[illegible]	[illegible]	[illegible]	[illegible]
	2" cc	[illegible]	[illegible]	[illegible]	[illegible]

CMU WALL DESIGN

- 12 FT CLEAR SPAN (509'-6" TO 497'-6")
- WIND LOAD = 20 psf MIN CONTROLS FOR INT WALL *
- SEISMIC LOAD = 62 psf DL × (C_s=0.07) = 4.3 psf
- $M_{UNF} = wl^2/8 = 360$ #·FT ≈ 4320 #·IN/FT ≈ 4,278 #·FT ~ W/IN 1% OK ✓ 20 psf INT WALL CONSERVATIVE
- $V_{UNF} = wl/2 = 120$ # ~ CALL FOR C-SHAPED WALL BRACE TO HANDLE 250#/FT

#4 @ 4'-0" o/c

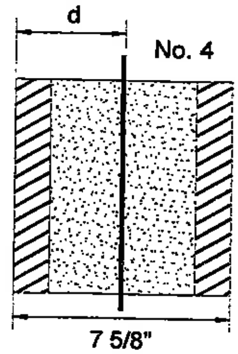
E-25

TABLE 3.1.1.4: Reinforced Wall Properties for Load Combinations Not Including Wind or Seismic

Concrete Masonry Wall Properties		
t_{nom}	8	in
Bar Size No.	4	
t_{fs} =	1.25	in
t_w =	1	in

Partially Grouted Masonry

Steel Reinforcement Properties		
Bar Area	0.20	in²
E_s	29,000,000	psi
F_y	60,000	psi
F_s	24,000	psi



Out-of-Plane Resisting Moment and Shear for Bars Positioned in the Center of the Wall

For Effective Depth, d = 3.81 in

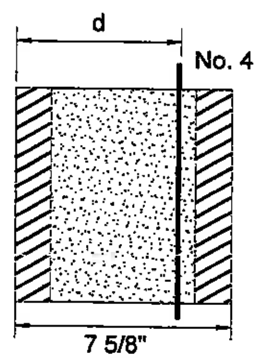
	f'm (psi)	1,350		1,500		2,000		3,000	
Spacing (in)	A_s (in²/ft)	M_R (in-lb/ft)	V_R (lb/ft)	M_R (in-lb/ft)	V_R (lb/ft)	M_R (in-lb/ft)	V_R (lb/ft)	M_R (in-lb/ft)	V_R (lb/ft)
8	0.30	14,301	1,681	15,381	1,772	18,684	2,046	24,341	2,288
16	0.15	11,374	1,681	12,171	1,772	12,460	2,046	12,661	2,288
24	0.10	8,311	1,681	8,348	1,772	8,441	2,046	8,557	2,288
32	0.08	6,306	1,681	6,331	1,772	6,394	2,046	6,472	2,288
40	0.06	5,086	1,681	5,104	1,772	5,150	2,046	5,208	2,288
48	0.05	4,264	1,681	4,278	1,772	4,314	2,046	4,359	2,288
56	0.04	3,655	1,441	3,667	1,519	3,698	1,754	3,736	1,961
64	0.04	3,198	1,261	3,209	1,329	3,236	1,535	3,269	1,716
72	0.03	2,843	1,121	2,852	1,181	2,876	1,364	2,906	1,525
96	0.03	2,132	840	2,139	886	2,157	1,023	2,179	1,144
120	0.02	1,706	672	1,711	709	1,726	818	1,743	915

Out-of-Plane Resisting Moment and Shear for Bars Positioned on the Tension Side of the Wall

For Effective Depth d = 4.63 in

Bar Size No. 4

Bar Area 0.20 in²



	f'm (psi)	1,350		1,500		2,000		3,000	
Spacing (in)	A_s (in²/ft)	M_R (in-lb/ft)	V_R (lb/ft)	M_R (in-lb/ft)	V_R (lb/ft)	M_R (in-lb/ft)	V_R (lb/ft)	M_R (in-lb/ft)	V_R (lb/ft)
8	0.30	19,813	2,039	21,276	2,150	25,744	2,482	30,108	2,775
16	0.15	**14,994**	2,039	**15,058**	2,150	15,236	2,482	15,464	2,775
24	0.10	10,162	2,039	10,204	2,150	10,309	2,482	10,440	2,775
32	0.08	7,704	2,039	7,732	2,150	7,803	2,482	7,891	2,775
40	0.06	6,210	2,039	6,230	2,150	6,283	2,482	6,346	2,775
48	0.05	5,204	2,039	5,220	2,150	5,261	2,482	5,310	2,775
56	0.04	4,461	1,748	4,474	1,842	4,509	2,127	4,551	2,379
64	0.04	3,903	1,529	3,915	1,612	3,945	1,862	3,982	2,081
72	0.03	3,469	1,359	3,480	1,433	3,507	1,655	3,540	1,850
96	0.03	2,602	1,020	2,610	1,075	2,630	1,241	2,655	1,388
120	0.02	2,082	816	2,088	860	2,104	993	2,124	1,110

Notes:
1. Masonry stress governs for M_R above bold line, steel stress governs below. If no bold line exists, masonry stress governs.
2. Bold values indicate tee beam behavior for partially grouted walls.

ARCADIS

SUBJECT: PG&E – TOPOK
HQ – DECON PAD

JOB NO:

BY: MGL DATE: 11/7/14

CHKD: DATE:

PAGE G-1

SHEET 1

HQ – DECON PAD

- REF SHT G-2 FOR DECON PAD PROJECT REQ'S
- REF SHT G-3 & G-4 FOR DRILL RIG INFO (SIZE, AXLE LOADS & LOCATIONS) ~46,000# ON 2 AXLES @ 4'-2" C/C B/W 2 AXLES
- REF SHT G-5 FOR HS-20 TRUCK LOADS & AXLE LOCATIONS & DIMENSIONS
- REF SHT D-1 THRU D-9 FOR PAD & CURB DESIGN

23,000# AXLES @ 4'-2" C/C ✓ OK

HS-20 TRAFFIC LOAD = $\frac{32,000\# \text{ AXLE}}{2 \text{ WHEELS}}$ = 16K @ 3.5 FT C/C

~EXISTING 8" SOG DESIGN W/ #5 @ 8" C/C EW CENTERED IS SUFFICIENT FOR LIGHTER RIG LOADS

AGM Form 30 12-01

G-1A

Lotycz, Matt

From:	Baxter, Jonathan
Sent:	Monday, November 10, 2014 1:16 PM
To:	Lotycz, Matt
Cc:	Sheu, Emily
Subject:	RE: PG&E Topock CHQ Engineering Support - Decon Pad
Attachments:	SOH03P01 14110711190.pdf

Thanks Matt – I think this looks good and agree with your changes reducing the containment volume and widening.

Emily – can you submit to ETIC – changing the title of the sheet to 'CHQ Decontamination Pad' instead of Decon Unloading Pad? Don't worry about the drawing number for now, we'll wait a bit before starting with those.

From: Lotycz, Matt
Sent: Friday, November 07, 2014 10:37 AM
To: Baxter, Jonathan
Subject: RE: PG&E Topock CHQ Engineering Support - Decon Pad

Jon – I have "looked into" the Decon Pad for the Topok HQ. As stated in your email below, using the 90% IRZ Unloading Pad drawing as a starting point I have marked up it up for what we need at the Decon Pad. I wanted to point out some things I changed and get your "buy-in" before you pass to EITC for drafting. Please confirm the following items listed and if you agree with my markups, please pass along to EITC (if not, let me know your thoughts and I will update my markups and send you an updated drawing markup to give to EITC next week):

1. Since the pad is only needed to wash-down the construction drill rigs (no containment volume needed), I have decreased the amount of containment volume (i.e. lessened the slope of the ramp on each side of the center trench) by almost 50% (1'-10" depth to 1'-0" depth).
2. Since this pad is being used to wash-down the construction drill rigs, I thought it would make sense to make the lane width (i.e. width between curbs on each side) wider (16'-0" instead of 12'-0") to allow for a person power-washing the drill rig at least 3'-0" of walking path on each side of drill rig (max 10ft wide).

Let me know your thoughts. Thanks and have a good weekend.

FYI – I am on a site visit next Monday and Tuesday (Nov 10th and 11th). Feel free to send me any information you have collected (via email) from your meetings with the client this past week. As of right now, I am in a holding pattern on my structural tasks until I get info from you on each of the structures needed for this HQ area.

Matt

From: Sheu, Emily
Sent: Tuesday, November 04, 2014 2:22 PM
To: Baxter, Jonathan; Lotycz, Matt
Subject: RE: PG&E Topock CHQ Engineering Support

Hi – Drill rig weight info is attached. Let me know if you need anything else!

Thanks,
Emily

G-2

Lotycz, Matt

From: Sheu, Emily
Sent: Tuesday, November 04, 2014 2:22 PM
To: Baxter, Jonathan; Lotycz, Matt
Subject: RE: PG&E Topock CHQ Engineering Support
Attachments: RE: Topock Arizona Compressor Station

Hi – Drill rig weight info is attached. Let me know if you need anything else!

Thanks,
Emily

From: Baxter, Jonathan
Sent: Tuesday, November 04, 2014 10:27 AM
To: Lotycz, Matt
Cc: Sheu, Emily
Subject: RE: PG&E Topock CHQ Engineering Support

Matt, see my answers below.

Emily - can you check with Katie Douglas or Greg Foote for drill rig weight? We compiled it at one point but I can't find it at the moment.

On Oct 30, 2014 6:58 AM, "Lotycz, Matt" <Matt.Lotycz@arcadis-us.com> wrote:
>
> Jon - Just checking to see if you have any answers on the 4 questions below on the decon pad (Tuesday, October 21, 2014 11:31 AM email) and if you have any of the information requested in my Thursday, October 09, 2014 2:22 PM email below. As of right now, I have not received any of the information I requested other than the plan view as-built of the parking canopy (which is still on hold). Just looking for an update from you. Thanks.
>
>
>
> Matt
>
>
>
> From: Lotycz, Matt
> Sent: Tuesday, October 21, 2014 11:31 AM
> To: Baxter, Jonathan
> Subject: RE: PG&E Topock CHQ Engineering Support
>
>
>
> Jon – Per your email below I can get started with the decon pad. Please answer the following 4 questions with regard to that:
>
>

>
> 1. Can we use the previous Topok MW-20 Bench unloading pad as the basis for the new decon pad?
> Yes, that can be the basis.
> 2. Is the plan view (1 long and narrow unloading pad) going to change based on the truck patterns or space availability in this HQ area?
> I don't expect it to, though the primary goal is to be able to drive in a drill rig, Decon it (pressure washer mostly) and then drive out. Rigs are up to 10' in width by 50' long.
> 3. Can you please confirm the containment volume required?
>No actual containment volume is needed.
> 4. Can you please confirm that the new decon pad will have the same truck loading (tanker load) as the MW-20 Bench unloading pad.
>I think the larger rigs weigh less than a fully loaded tanker, I will have to confirm with our geologists.
>
>
> Thanks again in advance for this information. I can provide a markup of the MW-20 Bench unloading pad to the sub once I hear from you. Thanks.
>
>
>
> Matt
>
>
>
> From: Baxter, Jonathan
> Sent: Tuesday, October 21, 2014 8:18 AM
> To: Lotycz, Matt
> Cc: Wuerl, Ben; Kirsch, Clair
> Subject: RE: PG&E Topock CHQ Engineering Support
>
>
>
> We can definitely use Toledo staff for anything that is in Revit. We do need to use our sub for as much other CAD/support as possible. We are still working with the client on the final layout and building types, I hope to have those answers in the next couple days. We should be able to proceed with the decon pad now. We need to finalize the water tank size and can then prepare the utility pads (generator, transformer, water tank).
>
>
>
> From: Lotycz, Matt
> Sent: Tuesday, October 21, 2014 6:54 AM
> To: Baxter, Jonathan
> Cc: Wuerl, Ben; Kirsch, Clair
> Subject: RE: PG&E Topock CHQ Engineering Support
>
>
>
> Jon – Please confirm that it is ok for me to use my own CAD drafters (Toledo staff – Clair Kirsch CAD Dept Manager) once my structural tasks start rolling later this month. That is how I submitted my time in my 9-26-14 email below but just wanted to confirm that was ok (I know in the past the MBE/DBE firm needed to do some drafting to meet some %'s). The reason I am asking is our Toledo drafters are slow and I would like to keep them plugged in as much as possible for the structural drafting when it begins later this month and

next. Let me know. Thanks.
>
>
>
> -Matt
>
>
>
> From: Lotycz, Matt
> Sent: Monday, October 20, 2014 12:40 PM
> To: Baxter, Jonathan (Jonathan.Baxter@arcadis-us.com)
> Cc: Wuerl, Ben
> Subject: RE: PG&E Topock CHQ Engineering Support
>
>
>
> Jon – please see email below for the items (first and last bulleted item) requested by 10-17-14 COB (last Friday) from your group. Please get me this info as I try to prepare 30% submittal drawings in early November.
>
>
>
> Since we are still waiting direction from client on whether they want us to design a parking canopy, can I assume this is not in 30% submittal? Also, if decision is not made by end of the month, this will not be in the 90% submittal in December.
>
>
>
> Keep in mind there are numerous other pieces of information needed from your group by end of the month for the other structures (see rest of bulleted item list in email below).
>
>
>
> Matt
>
>
>
> From: Lotycz, Matt
> Sent: Thursday, October 09, 2014 2:22 PM
> To: Baxter, Jonathan (Jonathan.Baxter@arcadis-us.com)
> Cc: Wuerl, Ben
> Subject: FW: PG&E Topock CHQ Engineering Support
>
>
>
> Jon –
>
>
>
> As you requested, I have added to my 9-26-14 email below with red-marks and yellow highlights for what information I need from Jon's group and when I need it by to meet 30% submittal (October 27, 2014)

deliverables (7 drawings of Crew/Shop Pre-Engineered Building and 2 drawings of Covered Parking Area) and final 90% submittal deliverable.
>
>
>
> Matt
>
>
>
> From: Lotycz, Matt
> Sent: Friday, September 26, 2014 2:21 PM
> To: Morris, Scott; Baxter, Jonathan (Jonathan.Baxter@arcadis-us.com)
> Cc: Kolodzaike, Ron (Ron.Kolodzaike@arcadis-us.com); Wuerl, Ben
> Subject: FW: PG&E Topock CHQ Engineering Support
>
>
>
> Scott and Jonathan,
>
>
>
> Once again, thanks for keeping our structural group in mind on your CA projects. I am estimating the following scope/hours/deliverables/assumptions to complete the 90% design of the PG&E Topock Construction Headquarters:
>
>
>
> Scope of Work and Estimate of Hours:
>
> Crew/Shop Pre-Engineered Building – 88 hours PSE + 68 hours ARCADIS CAD
> Covered Parking Area Structure – 84 hours PSE + 56 hours ARCADIS CAD
> Ground and Elevated Water Tank concrete pad and details – 24 hours PSE + 24 hours ARCADIS CAD
> Generator Concrete Pad Plan and Details – 6 hours PSE + 4 hours ARCADIS CAD
> Decon Unloading Pad Plan and Details – 12 hours PSE + 6 hours ARCADIS CAD
> Lab Construction Trailer & Conference Room/Consultant Construction Trailer & Office Trailer & Men's and Women's Concrete Pad Plan and Details – 32 hours PSE + 32 hours ARCADIS CAD
> ARCADIS QA/QC review by Structural Senior QA/QC reviewer (to be completed from pre-90% drawing set) – 10 hours SSE
> 30% & 90% submittals to client - 4 hours PSE + 4 hours ARCADIS CAD
> Review and respond to client 30% submittal review comments and ARCADIS Structural Senior QA/QC reviewer pre-90% submittal review – 12 hours PSE + 12 hours ARCADIS CAD
> Organize and combine structural calculations for submittal to local building code official – 2 hours PSE
>
>
>
> ü Matt Lotycz (ARCADIS Project Structural Engineer - PSE) – 264 hours @ $120/hr
>
> ü Chris Wancata (ARCADIS Structural Engineer I) or Greg Elkins (ARCADIS CAD Drafter) – 206 hours @ $90/hr
>
> ü Larry Tabat – (ARCADIS Principal Structural Engineer in White Plains, NY (MP) Office – SSE) – 10

hours @ $165/hr
>
> ü Total Structural Task Fee = $51,900
>
>
>
> Estimated Drawing Set (All sheets will be provided at 90%, with only sheets indicated 30% provided in that submittal)
>
> 1. Crew/Shop Pre-Engineered Building - Notes Sheet – 30%
>
> 2. Crew/Shop Pre-Engineered Building -Isometrics
>
> 3. Crew/Shop Pre-Engineered Building – Elevations – 30%
>
> 4. Crew/Shop Pre-Engineered Building – Elevations – 30%
>
> 5. Crew/Shop Pre-Engineered Building - Foundation Plan – 30%
>
> 6. Crew/Shop Pre-Engineered Building - Floor Plan– 30%
>
> 7. Crew/Shop Pre-Engineered Building - Typical Frame– 30%
>
> 8. Crew/Shop Pre-Engineered Building - Building Section– 30%
>
> 9. Crew/Shop Pre-Engineered Building – Building Sections and Details
>
> 10. Crew/Shop Pre-Engineered Building - Building Typical Details 1 of 2
>
> 11. Crew/Shop Pre-Engineered Building - Building Typical Details 2 of 2
>
> 12. Covered Parking Area – Foundation Plan– 30%
>
> 13. Covered Parking Area – Floor Plan
>
> 14. Covered Parking Area – Roof Framing Plan
>
> 15. Covered Parking Area – Roof Plan– 30%
>
> 16. Covered Parking Area – Sections
>
> 17. Covered Parking Area – Sections
>
> 18. Covered Parking Area – Details
>
> 19. Ground Supported Water Tank Concrete Pad Plan and Details
>
> 20. Elevated Water Tank Concrete Pad Plan and Details
>
> 21. Generator Concrete Pad Plan and Details
>

> 22. Decon Unloading Pad Plan and Details
>
> 23. Lab Construction Trailer Concrete Pad Plan and Details
>
> 24. Conference Room/Consultant Construction Trailer Concrete Pad Plan and Details
>
> 25. Office Trailer Concrete Pad Plan and Details
>
> 26. Men's and Women's Concrete Pad Plan and Details
>
>
>
> Deliverables:
>
> · &nbs

G-3

Lotycz, Matt

From: Stadeli, Robert <rstadeli@boartlongyear.com>
Sent: Wednesday, April 16, 2014 3:36 PM
To: Gonzales, James
Subject: RE: Topock Arizona Compressor Station
Attachments: 4775 .pdf

James, this is the heaviest DR Rig we may use, and the attached drawing shows the configuration for on highway use. If we are going from site to site, axle #2 is lifted and axle 5 is removed leaving just three axles with the following weights. 22,000 lbs on the single steer axle and 46,000 on the tandem drive axle

The other Dual Rotary option would be a three axle rig with the following weights
20,000 lbs on the single steer axle and 43,000 on the tandem drive axle

Let me know if you need anything more

Best regards

Robert Stadeli | Business Development/Contracts Manager | Boart Longyear Company | US Rotary
MBL: (503) 572-9396 | **Dir:** (385) 234-3820 | **Off:** (801) 973-6667 (ext 3820) | **E:** rstadeli@boartlongyear.com

---

From: Gonzales, James [mailto:James.Gonzales@arcadis-us.com]
Sent: Wednesday, April 16, 2014 9:53 AM
To: Stadeli, Robert
Subject: RE: Topock Arizona Compressor Station

Thanks Robert. Please forward the information as soon as you can.

From: Stadeli, Robert [mailto:rstadeli@boartlongyear.com]
Sent: Wednesday, April 16, 2014 8:37 AM
To: Gonzales, James
Subject: Re: Topock Arizona Compressor Station

James, I have someone working on this, hopefully will have something later today

---

Robert Stadeli | Business Development/Contracts Manager | Boart Longyear Company | US Rotary
MBL: (503) 572-9396 | **Dir:** (385) 234-3820 | **Off:** (801) 973-6667 (ext 3820) | **E:** rstadeli@boartlongyear.com

On Apr 14, 2014, at 2:25 PM, "Gonzales, James" <James.Gonzales@arcadis-us.com> wrote:

> Greetings Robert,
> I needs some information for the Boart Longyear Dual Rotary Rigs. Do you have a specification sheet for the DR-24? I believe this is the rig we discussed for the Topock drilling. We'll need to know a precise weight, if possible. Also, we would like to know the weight per axle or wheel. Is this something you can

provide us? We need this information for preliminary road design needed for the well Site locations at Topock.

Thanks,
James

From: Stadeli, Robert [mailto:rstadeli@boartlongyear.com]
Sent: Thursday, March 06, 2014 2:51 PM
To: Gonzales, James
Subject: RE: Topock Arizona Compressor Station

MBL: (503) 572-9396

Robert Stadeli | Business Development/Contracts Manager | Boart Longyear Company | US Rotary
MBL: (503) 572-9396 | **Dir:** (385) 234-3820 | **Off:** (801) 973-6667 (ext 3820) | **E:** rstadeli@boartlongyear.com

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From: Gonzales, James [mailto:James.Gonzales@arcadis-us.com]
Sent: Thursday, March 06, 2014 3:46 PM
To: Stadeli, Robert
Subject: RE: Topock Arizona Compressor Station

What's the best number to call you on?

From: Stadeli, Robert [mailto:rstadeli@boartlongyear.com]
Sent: Wednesday, March 05, 2014 4:51 PM
To: Gonzales, James
Subject: RE: Topock Arizona Compressor Station

Sure thing I got your invite

Robert Stadeli | Business Development/Contracts Manager | **Boart Longyear Company | US Rotary**
Dir: (385) 234-3820 | **MBL:** (503) 572-9396 | **Off:** (801) 973-6667 (ext 3820) | **E:** rstadeli@boartlongyear.com

---

From: Gonzales, James [mailto:James.Gonzales@arcadis-us.com]
Sent: Wednesday, March 05, 2014 2:55 PM
To: Stadeli, Robert
Subject: RE: Topock Arizona Compressor Station

Hi Robert,
I received you messages today. Thanks for the call back!

Sorry, but I'm pretty tied up today with other projects. Can we touch base tomorrow afternoon at 3pm to discuss the Topock Project? Let me know if this works and I'll set up a meeting reminder.

Thank you!

From: Stadeli, Robert [mailto:rstadeli@boartlongyear.com]
Sent: Wednesday, February 26, 2014 7:33 AM
To: Lamb, Jason

Cc: Gonzales, James
Subject: Re: Topock Arizona Compressor Station

James, I look forward to following up with you. I have recently been trying to get an update on this project.

Sincerely

Robert
Stadeli
Mbl: 503-572-9396

On Feb 26, 2014, at 7:43 AM, "Lamb, Jason" <JLamb@boartlongyear.com> wrote:

> Yes I am actually sitting with Robert in the Slc airport and he just filled me in on the project. I have copied him on the email and he will be in touch with you hopefully later today when we land. Thank you for reaching out.
>
> Jason Lamb
> Contracts Manager
> Boart Longyear
> (385) 234-3809 office
>
> On Feb 25, 2014, at 3:32 PM, "Gonzales, James" <James.Gonzales@arcadis-us.com> wrote:
>
> > Greetings Jason,
> >
> > I was given your name by Greg Zekoff in regards to drilling project that he and Robert Stadeli put together for Greg Foote of ARCADIS. The project involved sonic and dual rotary drilling and well installation at the compressor station in Topock Arizona. Greg Z. stated that you may be able to put me in contact with Robert Stadeli. We are starting to refine the costs and approach for this project, therefore, I have questions regarding the Dual Rotary portion. In addition, I wanted to stay in contact and keep refining the costs for eventual implementation possibly towards the end of this year. Are you familiar with this project and/or can you put me in touch with Robert?
> > Regards,
> > **James Gonzales, P.G.** | Project Geologist | james.gonzales@arcadis-us.com
> > ARCADIS U.S., Inc. | 320 Commerce, Suite 200 | Irvine, CA, 92602
> > T. 714.508.2652 | M. 714.702.6243 | F. 714.730.9345
> > www.arcadis-us.com
> > Professional Geologist CA # 8918
> > Certified Hydrogeologist CA # 984
> > ARCADIS, Imagine the result
> > Please consider the environment before printing this email.
> >
> > ---
> >
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G-4

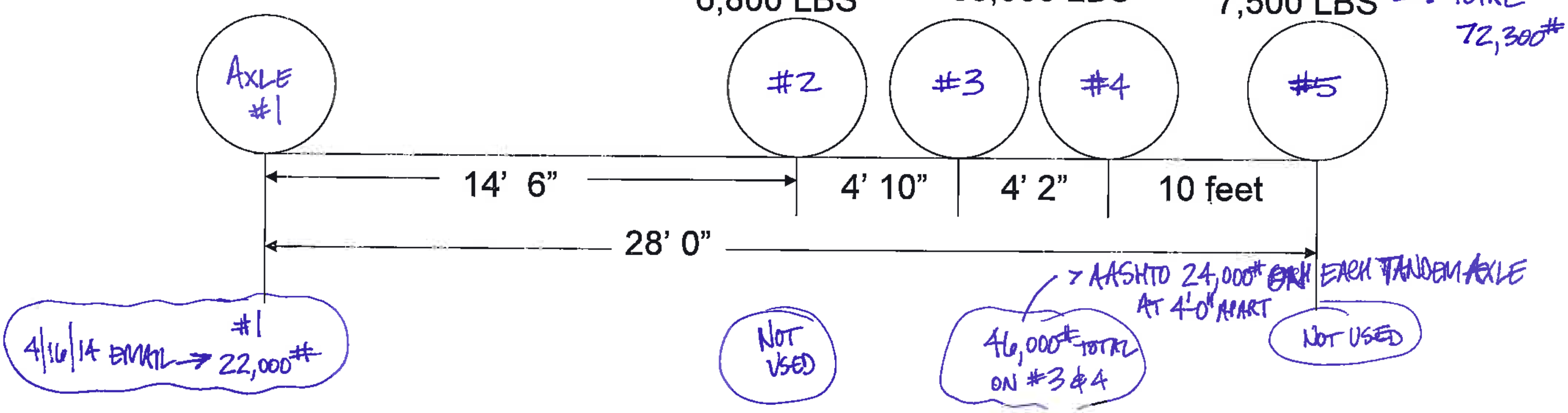
Unit # 4775, 2003 Mack **Vin #** 1M2AD64C23MOO1273

Nevada License # 25146A **Gross Weight** 71,000 LBS

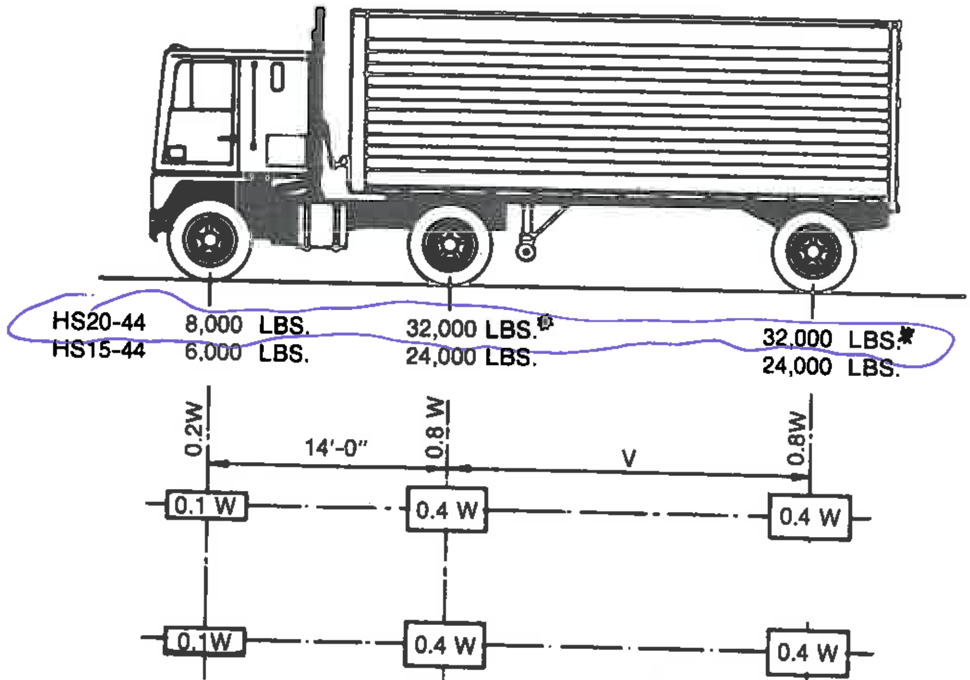
Length 40 feet **Height** 13 feet 6 inches, **Width** 96 inches (8')

Non divisible drilling Rig

Steer Axle	Drop/Pusher	Drive Axles	Tag Axle
425/65R22.5	295/75R22.5	11R22.5	255/70R22.5
20,000 LBS	6,800 LBS	38,000 LBS	7,500 LBS → TOTAL 72,300#



G-5



W = COMBINED WEIGHT ON THE FIRST TWO AXLES WHICH IS THE SAME AS FOR THE CORRESPONDING H TRUCK.
V = VARIABLE SPACING — 14 FEET TO 30 FEET INCLUSIVE. SPACING TO BE USED IS THAT WHICH PRODUCES MAXIMUM STRESSES.

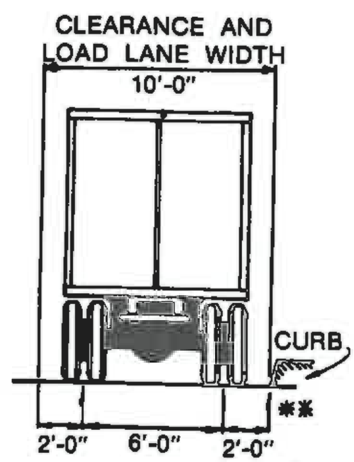


FIGURE 3.7.7A Standard HS Trucks

*In the design of timber floors and orthotropic steel decks (excluding transverse beams) for H 20 Loading, one axle load of 24,000 pounds or two axle loads of 16,000 pounds each, spaced 4 feet apart may be used, whichever produces the greater stress, instead of the 32,000-pound axle shown.

**For slab design, the center line of wheels shall be assumed to be 1 foot from face of curb. (See Article 3.24.2.)

3.10 CENTRIFUGAL FORCES

3.10.1 Structures on curves shall be designed for a horizontal radial force equal to the following percentage of the live load, without impact, in all traffic lanes:

$$C = 0.00117S^2D = \frac{6.68S^2}{R} \qquad (3\text{-}2)$$

where,

- C = the centrifugal force in percent of the live load, without impact;
- S = the design speed in miles per hour;
- D = the degree of curve;
- R = the radius of the curve in feet.

3.10.2 The effects of superelevation shall be taken into account.

3.10.3 The centrifugal force shall be applied 6 feet above the roadway surface, measured along the center line of the roadway. The design speed shall be determined with regard to the amount of superelevation provided in the roadway. The traffic lanes shall be loaded in accordance with the provisions of Article 3.7 with one standard truck on each design traffic lane placed in position for maximum loading.

3.10.4 Lane loads shall not be used in the computation of centrifugal forces.

3.10.5 When a reinforced concrete floor slab or a steel grid deck is keyed to or attached to its supporting members, it may be assumed that the deck resists, within its plane, the shear resulting from the centrifugal forces acting on the live load.

3.11 APPLICATION OF LIVE LOAD

3.11.1 Traffic Lane Units

In computing stresses, each 10-foot lane load or single standard truck shall be considered as a unit, and fractions of load lane widths or trucks shall not be used.

3.11.2 Number and Position of Traffic Lane Units

The number and position of the lane load or truck loads shall be as specified in Article 3.7 and, whether lane or truck loads, shall be such as to produce maximum stress, subject to the reduction specified in Article 3.12.

3.11.3 Lane Loads on Continuous Spans

For the determination of maximum negative moment in the design of continuous spans, the lane load shown in Figure 3.7.6B shall be modified by the addition of a second, equal weight concentrated load placed in one other span in the series in such position to produce the maximum effect. For maximum positive moment, only one concentrated load shall be used per lane, combined with as many spans loaded uniformly as are required to produce maximum moment.

3.11.4 Loading for Maximum Stress

3.11.4.1 On both simple and continuous spans, the type of loading, whether lane load or truck load, to be used shall be the loading which produces the maximum stress. The moment and shear tables given in Appendix A show which types of loading controls for simple spans.

3.11.4.2 For continuous spans, the lane loading shall be continuous or discontinuous; only one standard H or HS truck per lane shall be considered on the structure.

3.12 REDUCTION IN LOAD INTENSITY

3.12.1 Where maximum stresses are produced in any member by loading a number of traffic lanes simultaneously, the following percentages of the live loads may be used in view of the improbability of coincident maximum loading:

	Percent
One or two lanes	100
Three lanes	90
Four lanes or more	75

3.12.2 The reduction in load intensity specified in Article 3.12.1 shall not be applicable when distribution factors from Table 3.23.1 are used to determine moments in longitudinal beams.

3.12.3 The reduction in intensity of loads on transverse members such as floor beams shall be determined as in the case of main trusses or girders, using the number of traffic lanes across the width of roadway that must be loaded to produce maximum stresses in the floor beam.

3.3.5 Where the abrasion of concrete is not expected, the traffic may bear directly on the concrete slab. If considered desirable, ¼ inch or more may be added to the slab for a wearing surface.

3.3.6 The following weights are to be used in computing the dead load:

	#/cu.ft.
Steel or cast steel	490
Cast iron	450
Aluminum alloys	175
Timber (treated or untreated)	50
Concrete, plain or reinforced	150
Compacted sand, earth, gravel, or ballast	120
Loose sand, earth, and gravel	100
Macadam or gravel, rolled	140
Cinder filling	60
Pavement, other than wood block	150
Railway rails, guardrails, and fastenings (per linear foot of track)	200
Stone masonry	170
Asphalt plank, 1 in. thick	9 lb. sq. ft.

3.4 LIVE LOAD

The live load shall consist of the weight of the applied moving load of vehicles, cars, and pedestrians.

3.5 OVERLOAD PROVISIONS

3.5.1 For all loadings less than H 20, provision shall be made for an infrequent heavy load by applying Loading Combination IA (see Article 3.22), with the live load assumed to be H or HS truck and to occupy a single lane without concurrent loading in any other lane. The overload shall apply to all parts of the structure affected, except the roadway deck, or roadway deck plates and stiffening ribs in the case of orthotropic bridge superstructures.

3.5.2 Structures may be analyzed for an overload that is selected by the operating agency in accordance with Loading Combination Group IB in Article 3.22.

3.6 TRAFFIC LANES

3.6.1 The lane loading or standard truck shall be assumed to occupy a width of 10 feet.

3.6.2 These loads shall be placed in 12-foot wide design traffic lanes, spaced across the entire bridge roadway width measured between curbs.

3.6.3 Fractional parts of design lanes shall not be used, but roadway widths from 20 to 24 feet shall have two design lanes each equal to one-half the roadway width.

3.6.4 The traffic lanes shall be placed in such numbers and positions on the roadway, and the loads shall be placed in such positions within their individual traffic lanes, so as to produce the maximum stress in the member under consideration.

3.7 HIGHWAY LOADS

3.7.1 Standard Truck and Lane Loads*

3.7.1.1 The highway live loadings on the roadways of bridges or incidental structures shall consist of standard trucks or lane loads that are equivalent to truck trains. Two systems of loading are provided, the H loadings and the HS loadings—the HS loadings being heavier than the corresponding H loadings.

3.7.1.2 Each lane load shall consist of a uniform load per linear foot of traffic lane combined with a single concentrated load (or two concentrated loads in the case of continuous spans—see Article 3.11.3), so placed on the span as to produce maximum stress. The concentrated load and uniform load shall be considered as uniformly distributed over a 10-foot width on a line normal to the center line of the lane.

3.7.1.3 For the computation of moments and shears, different concentrated loads shall be used as indicated in Figure 3.7.6B. The lighter concentrated loads shall be used when the stresses are primarily bending stresses, and the heavier concentrated loads shall be used when the stresses are primarily shearing stresses.

*Note: The system of lane loads defined here (and illustrated in Figure 3.7.6.B) was developed in order to give a simpler method of calculating moments and shears than that based on wheel loads of the truck.

Appendix B shows the truck train loadings of the 1935 Specifications of AASHO and the corresponding lane loadings.

In 1944, the HS series of trucks was developed. These approximate the effect of the corresponding 1935 truck preceded and followed by a train of trucks weighing three-fourths as much as the basic truck.

3.7.2 Classes of Loading

There are four standard classes of highway loading: H 20, H 15, HS 20, and HS 15. Loading H 15 is 75% of Loading H 20. Loading HS 15 is 75% of Loading HS 20. If loadings other than those designated are desired, they shall be obtained by proportionately changing the weights shown for both the standard truck and the corresponding lane loads.

3.7.3 Designation of Loadings

The policy of affixing the year to loadings to identify them was instituted with the publication of the 1944 Edition in the following manner:

H 15 Loading, 1944 Edition shall be designated	H 15-44
H 20 Loading, 1944 Edition shall be designated	H 20-44
H 15-S 12 Loading, 1944 Edition shall be designated	HS 15-44
H 20-S 16 Loading, 1944 Edition shall be designated	HS 20-44

The affix shall remain unchanged until such time as the loading specification is revised. The same policy for identification shall be applied, for future reference, to loadings previously adopted by AASHTO.

3.7.4 Minimum Loading

Bridges supporting Interstate highways or other highways which carry, or which may carry, heavy truck traffic, shall be designed for HS 20-44 Loading or an Alternate Military Loading of two axles four feet apart with each axle weighing 24,000 pounds, whichever produces the greatest stress.

3.7.5 H Loading

The H loadings consist of a two-axle truck or the corresponding lane loading as illustrated in Figures 3.7.6A and 3.7.6B. The H loadings are designated H followed by a number indicating the gross weight in tons of the standard truck.

3.7.6 HS Loading

The HS loadings consist of a tractor truck with semitrailer or the corresponding lane load as illustrated in Figures 3.7.7A and 3.7.6B. The HS loadings are designated by the letters HS followed by a number indicating the gross weight in tons of the tractor truck. The variable axle spacing has been introduced in order that the spacing of axles may approximate more closely the tractor trailers now in use. The variable spacing also provides a more satisfactory loading for continuous spans, in that heavy axle loads may be so placed on adjoining spans as to produce maximum negative moments.

3.8 IMPACT

3.8.1 Application

Highway Live Loads shall be increased for those structural elements in Group A, below, to allow for dynamic, vibratory and impact effects. Impact allowances shall not be applied to items in Group B. It is intended that impact be included as part of the loads transferred from superstructure to substructure, but shall not be included in loads transferred to footings nor to those parts of piles or columns that are below ground.

3.8.1.1 Group A—Impact shall be included.

(1) Superstructure, including legs of rigid frames.
(2) Piers, (with or without bearings regardless of type) excluding footings and those portions below the ground line.
(3) The portions above the ground line of concrete or steel piles that support the superstructure.

3.8.1.2 Group B—Impact shall not be included.

(1) Abutments, retaining walls, piles except as specified in Article 3.8.1.1 (3).
(2) Foundation pressures and footings.
(3) Timber structures.
(4) Sidewalk loads.
(5) Culverts and structures having 3 feet or more cover.

3.8.2 Impact Formula

3.8.2.1 The amount of the impact allowance or increment is expressed as a fraction of the live load stress, and shall be determined by the formula:

$$I = \frac{50}{L + 125} \qquad (3\text{-}1)$$

in which,

I = impact fraction (maximum 30 percent);

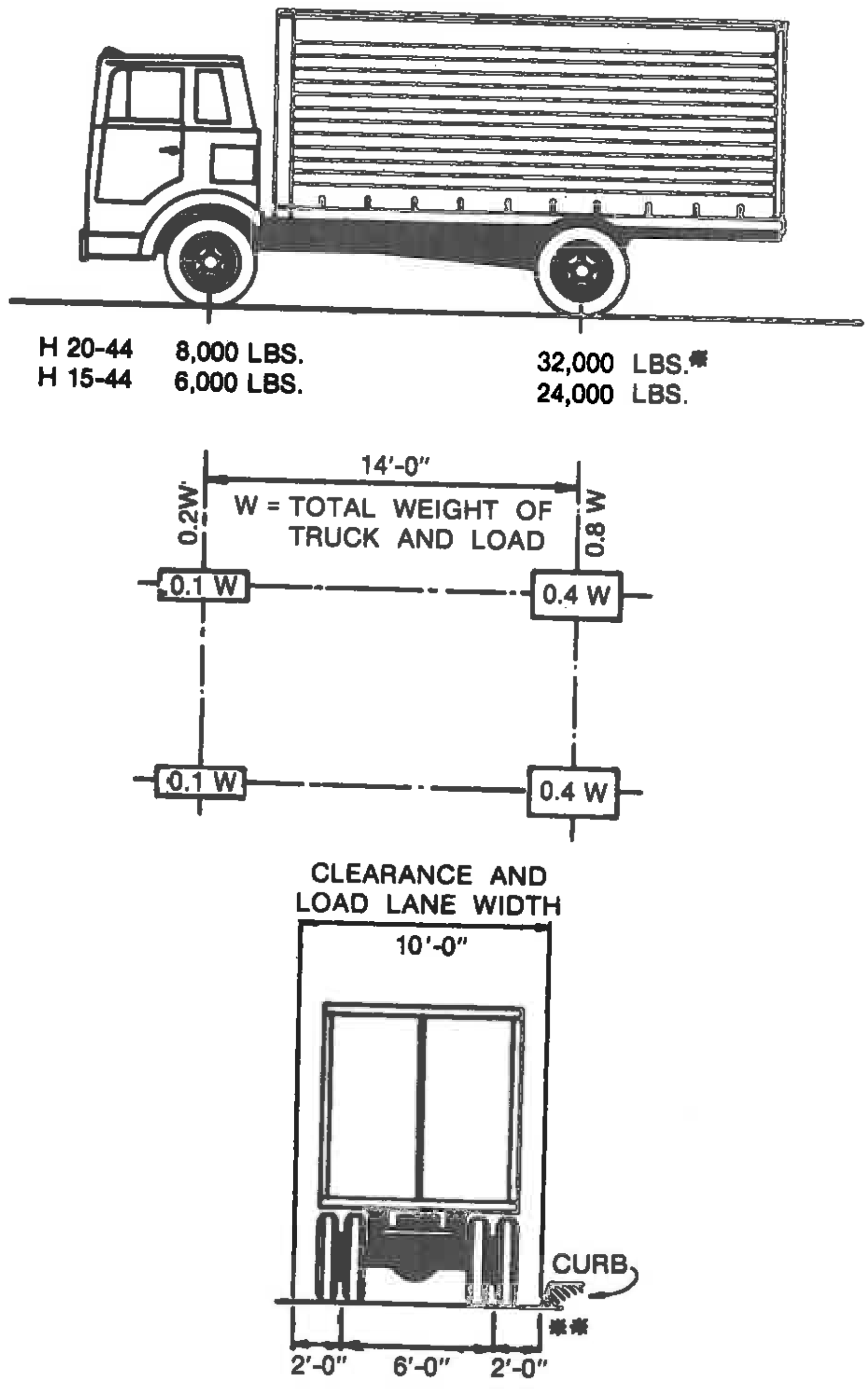


FIGURE 3.7.6A Standard H Trucks

*In the design of timber floors and orthotropic steel decks (excluding transverse beams) for H 20 Loading, one axle load of 24,000 pounds or two axle loads of 16,000 pounds each spaced 4 feet apart may be used, whichever produces the greater stress, instead of the 32,000-pound axle shown.

**For slab design, the center line of wheels shall be assumed to be 1 foot from face of curb. (See Article 3.24.2.)

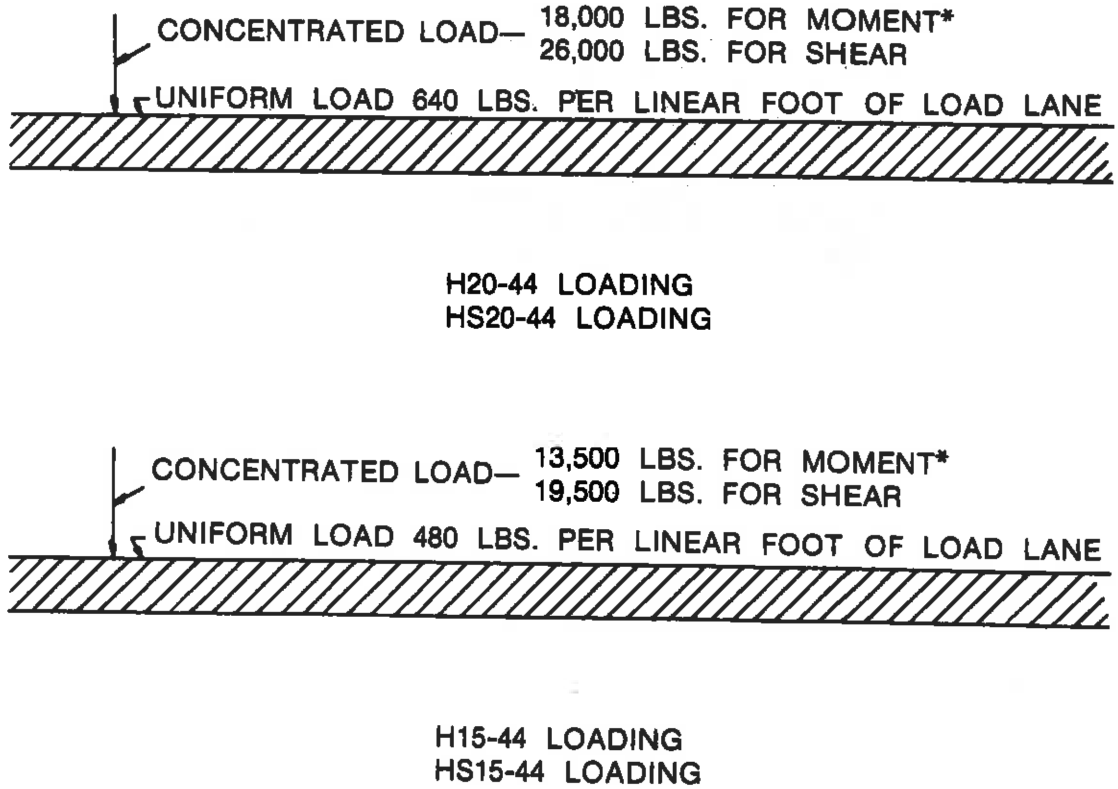


FIGURE 3.7.6B Lane Loading

*For the loading of continuous spans involving lane loading refer to Article 3.11.3 which provides for an additional concentrated load.

L = length in feet of the portion of the span that is loaded to produce the maximum stress in the member.

3.8.2.2 For uniformity of application, in this formula, the loaded length, L, shall be as follows:

(a) For roadway floors: the design span length.
(b) For transverse members, such as floor beams: the span length of member center to center of supports.
(c) For computing truck load moments: the span length, or for cantilever arms the length from the moment center to the farthermost axle.
(d) For shear due to truck loads: the length of the loaded portion of span from the point under consideration to the far reaction; except, for cantilever arms, use a 30% impact factor.
(e) For continuous spans: the length of span under consideration for positive moment, and the average of two adjacent loaded spans for negative moment.

3.8.2.3 For culverts with cover

0′0″ to 1′-0″ inc. I = 30%
1′-1″ to 2′-0″ inc. I = 20%
2′-1″ to 2′-11″ inc. I = 10%

3.9 LONGITUDINAL FORCES

Provision shall be made for the effect of a longitudinal force of 5% of the live load in all lanes carrying traffic headed in the same direction. All lanes shall be loaded for bridges likely to become one directional in the future. The load used, without impact, shall be the lane load plus the concentrated load for moment specified in Article 3.7, with reduction for multiple-loaded lanes as specified in Article 3.12. The center of gravity of the longitudinal force shall be assumed to be located 6 feet above the floor slab and to be transmitted to the substructure through the superstructure.

ARCADIS

SUBJECT: TOPOK – UTILITY PAD

JOB NO:

BY: MSL DATE: 12/19/14

CHKD: DATE:

PAGE H-1

SHEET 1

UTILITY PAD DESIGN

- REF SHT H-2A & 2B FOR FRP TANK LATERAL SEISMIC/WIND STRAPS
- REF SHT H-2 FOR UTILITY PAD DRAWING LAYOUT
- REF SHT A-6 FOR ASCE 7-10 SEISMIC INFO
  ~ PARK MOABI LOCATION (SHT H-3) ← W/IN 1% SO OK
- ASCE 7-05 ~ FIGURE 26.5-1B – CAT IV – "FIRE WATER TANK"
  BASIC WIND SPEED = 115 MPH (3 SECOND)

15,000 GAL FIRE WATER TANK

- REF SHT H-4 FOR TANK INFO
- REF SHT H-5 FOR TANK LATERAL SEISMIC LOADS
  AWWA D103 ~ $V_{SEISMIC} = 17.32^K$ → USE
  ASCE 7-10 ~ 15.7.6 ~ $V_{SEISMIC} = 16.08^K$
- REF SHT H-6 AWWA D103 ~ $V_{SEISMIC} = 9.82^K$
  $M_{SEISMIC} = 98.93^{K \cdot FT}$
  ~ ANCHORAGE REQ'D FOR OVERTURNING
- ASCE 7-10 15.4.2 RIGID NON-BLDG STRUCTURE
  (PER 15.7.6.1-a)

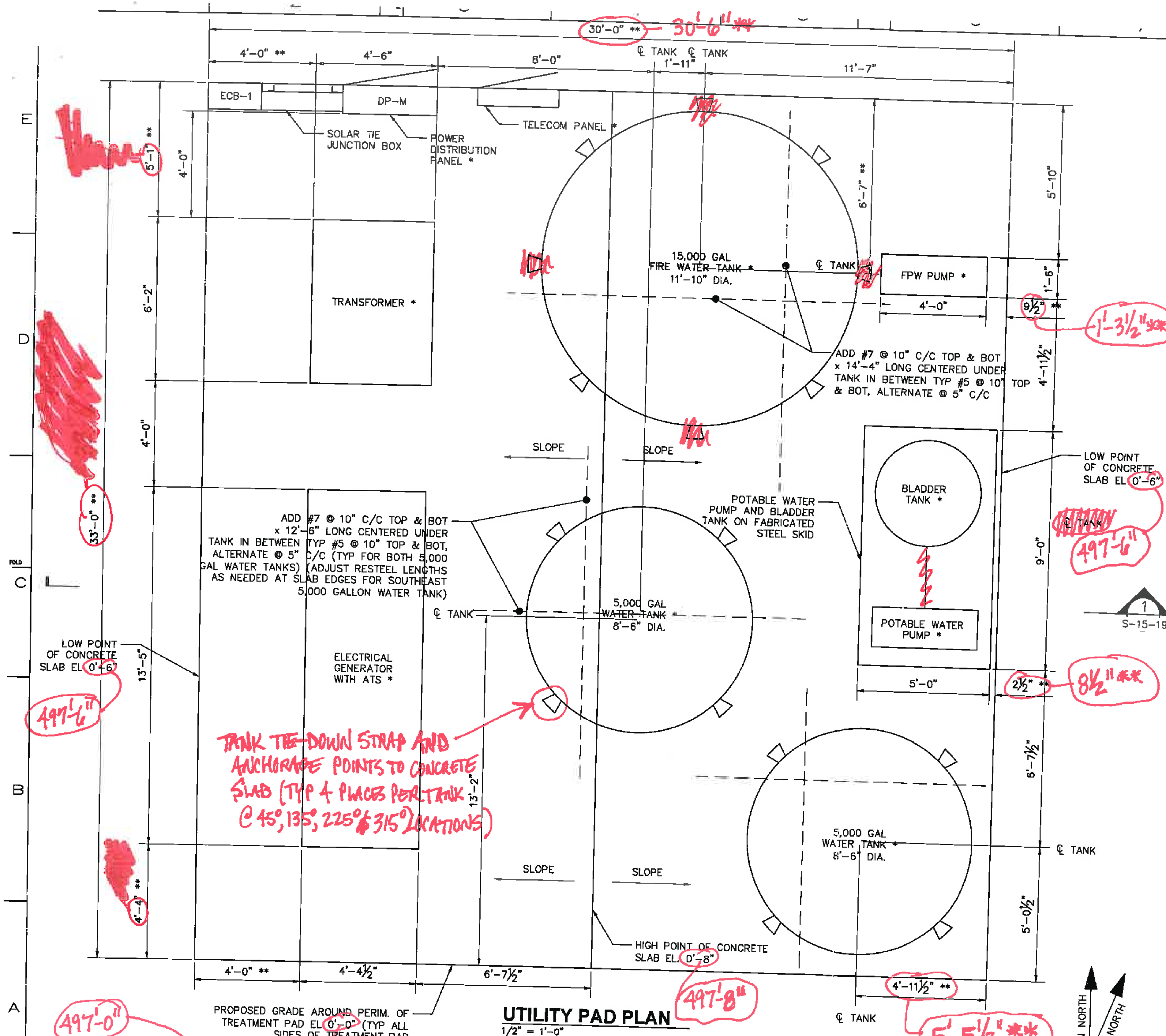
$$V = 0.30 S_{DS} W I_e = 0.3(0.245)(127{,}675^{\#})(1.5)$$

(127,675# = DL & FULL WATER)

$$= 14.08^K$$

USE

$$M_{SEISMIC} = 17.32^K \times (18.5^{FT}/2) = 160.2^{K \cdot FT}$$



UTILITY PAD PLAN

1/2" = 1'-0"

H-2

FOUNDATION NOTES:

1. IF THE BUILDING OFFICIAL OR GEOTECHNICAL ENGINEER DETERMINES THAT EXPANSIVE SOILS OR OTHER GEOLOGIC ISSUES OF CONCERN MAY BE PRESENT, THEN HE/SHE MAY REQUIRE THAT SPECIAL PROVISIONS BE MADE TO THE FOUNDATION DESIGN TO SAFEGUARD AGAINST DAMAGE DUE TO THE EXPANSIVENESS OR OTHER GEOLOGIC ISSUES. IF THIS BECOMES THE SITUATION THEN ALL FOUNDATION CONSTRUCTION MUST BE HALTED AND THE GEOTECHNICAL ENGINEER SHALL PROVIDE A GEOTECHNICAL REPORT WITH RECOMMENDATIONS IN CONSIDERATION OF THE CONDITIONS.
2. REFER TO THE GENERAL NOTES AND STRUCTURAL SPECIFICATIONS FOR ADDITIONAL REQUIREMENTS.
3. STRUCTURAL OBSERVATIONS OF CONSTRUCTION ARE RECOMMENDED (PER CBC SECTION 1702), SO AS TO OBSERVE THE PROGRESS AND QUALITY OF THE CONTRACTOR'S WORK AND TO DETERMINE IF THE WORK IS PROCEEDING IN GENERAL ACCORDANCE WITH THE CONSTRUCTION DOCUMENTS.
4. REINFORCING STEEL: ASTM A615, 60KSI YIELD GRADE, DEFORMED BILLET STEEL BARS, UNFINISHED
5. PLACE, SUPPORT AND SECURE REINFORCEMENT AGAINST DISPLACEMENT. DO NOT DEVIATE FROM REQUIRED POSITION.
6. AGGREGATE BASE MATERIAL: TO BE CRUSHED GRAVEL MEETING THE FOLLOWING GRADATION AND COMPACTED TO 95% MAXIMUM DRY DENSITY OF MODIFIED PROCTOR.

SIEVE SIZE	TOTAL PERCENT PASSING
2 INCH	100
1 INCH	70 TO 100
3/4 INCH	50 TO 90
NO. 4	30 TO 60
NO. 30	9 TO 33
NO. 200	0 TO 6

FOUNDATION DESIGN:

BASED UPON 2,000 PSF ALLOWABLE BEARING PRESSURE IN CONFORMANCE WITH CBC TABLE 1806.2 FOR CLASSIFICATION(S) SW, SP, SM, SC, GM AND/OR GC. A LICENSED GEOTECHNICAL ENGINEER SHALL PROVIDE SUBGRADE COMPACTION AND PREPARATION REQUIREMENTS, AND SHALL INSPECT THE EXCAVATIONS AND CONFIRM THAT 2,000 PSF BEARING IS ALLOWED FOR THE FOUNDATIONS. WHEN ENGINEERED FILL IS REQUIRED BY THE GEOTECHNICAL ENGINEER, IT SHALL BE TESTED AND INSPECTED BY THE GEOTECHNICAL ENGINEER.

* VERIFY SIZE WITH APPROVED TANK, PUMP, TRANSFORMER, GENERATOR AND ELECTRICAL/COMMUNICATION PANEL MANUFACTURER'S SHOP DRAWINGS.

** CONCRETE DIMENSIONS TO BE VERIFIED PER APPROVED TANK, PUMP, TRANSFORMER, GENERATOR, AND ELECTRICAL/COMMUNICATIONS PANEL MANUFACTURER'S SHOP DRAWINGS.

CODE DESIGN LOADS:

1. DESIGN CODES: 2013 CALIFORNIA BUILDING CODE; 2012 INTERNATIONAL BUILDING CODE; ASCE 7-10
2. RISK CATEGORY: IV
3. LIVE LOADS: 100 PSF
4. SNOW LOADING: N/A
5. FLOOD LOADS: N/A
6. WIND LOADS:
   BASIC WIND SPEED (3 SECOND GUST) V = 115 MPH – ULTIMATE OR MINIMUM NET WIND PRESSURE, Pnet = 20 PSF WHICHEVER IS GREATER
   WIND EXPOSURE C
7. SEISMIC LOADS:
   SEISMIC IMPORTANCE FACTOR – Ie – 1.5
   SEISMIC DESIGN CATEGORY – D
   SEISMIC SITE CLASS – D
   MAPPED SPECTRAL RESPONSE ACCELERATIONS – Ss = 0.230; S1 = 0.120
   SPECTRAL RESPONSE COEFFICIENTS – Sds = 0.245; Sd1 = 0.186
   ANALYSIS PROCEDURE – ASCE 7-10 CHAPTER 15 SEISMIC REQUIREMENTS FOR NON-BUILDING STRUCTURES FOR TANKS AND CHAPTER 13 SEISMIC DESIGN REQUIREMENTS FOR NON-STRUCTURAL COMPONENTS FOR PUMPS, TRANSFORMER, GENERATOR AND ELECTRICAL/COMMUNICATIONS PANELS, AND FABRICATED STEEL SKID

- DRAFT -
NOT FOR CONSTRUCTION

ETIC ENGINEERING

ARCADIS

NO.	DATE	DESCRIPTION	GM/SPEC	DWN	CHKD	SUPV	APVD BY
0	12/18/14	SUPPLEMENTAL PRE-FINAL (90%) DESIGN					

REVISIONS

12/30/14

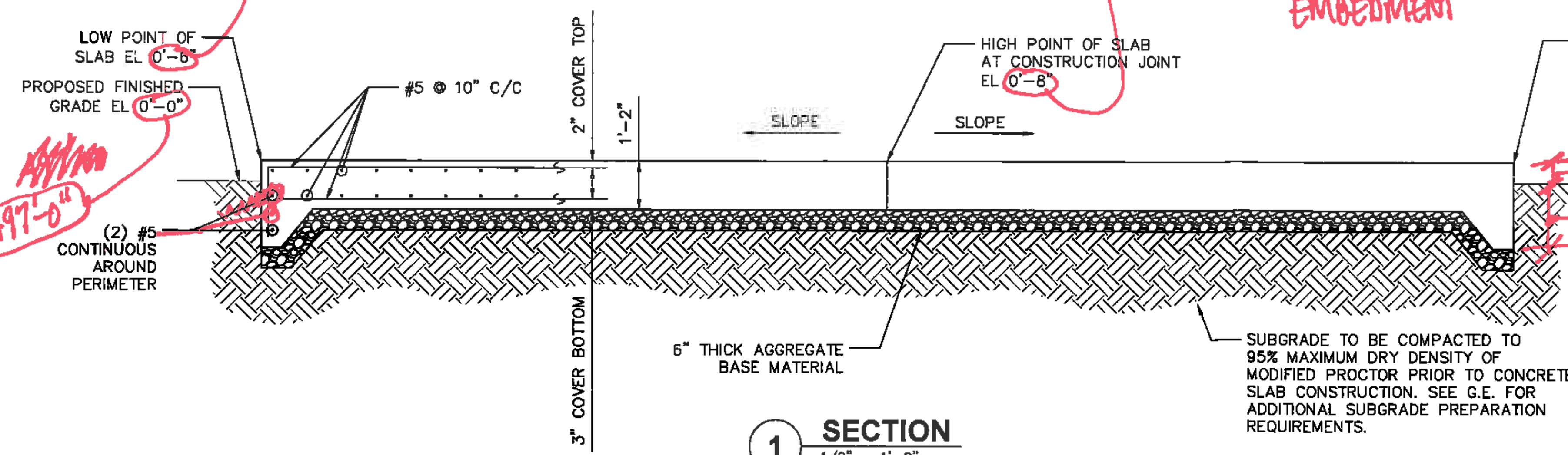
APPROVED BY: JEF; SO; SUPV JPB; DSGN CMW; DWN CMW; CHKD MSL; OK RAK; DATE 12/12/14; SCALES

TOPOCK GROUNDWATER REMEDIATION PROJECT

UTILITY PAD PLAN

GAS TRANSMISSION & DISTRIBUTION
PACIFIC GAS AND ELECTRIC COMPANY
SAN FRANCISCO, CALIFORNIA

MICROFILM; BILL OF MATL; DWG LIST; SUPSDS; SUPSD BY; SHEET NO. of SHEETS; REV



1 SECTION
1/2" = 1'-0"

NOTES:

1. 15,000 GALLON FIRE WATER TANK:

1.1. TANK TIE-DOWN STRAPS AND ANCHORAGE TO CONCRETE SLAB (FOR SEISMIC AND WIND LOADS SHOWN ON SHEET S-15-18) ARE TO BE DESIGNED AND PROVIDED BY TANK MANUFACTURER. HOWEVER, A MINIMUM OF 8 TIE-DOWN STRAPS (EQUALLY SPACED AROUND PERIMETER) TO BE PROVIDED. EACH TIE-DOWN STRAP TO HAVE A MINIMUM OF (3)-HDA-PF M16X190/60 GALVANIZED UNDERCUT ANCHORS @ 8" C/C MINIMUM SPACING AND EMBEDMENT (TANK MANUFACTURER TO DESIGN TIE-DOWN TO UNDERCUT ANCHOR CONNECTION). TANK MUST ALSO HAVE A MINIMUM OF (4)-L6x3½x5⁄16x8" LONG CLIP ANGLES LLV WITH (1)-3/4" DIAMETER GALVANIZED ADHESIVE ANCHOR WITH 9" EMBEDMENT IN EACH CLIP ANGLE. SPACE 4 CLIP ANGLES EQUALLY AROUND TANK PERIMETER.

1.2. STRUCTURAL DESIGN OF FOUNDATION SLAB ASSUMES A 15,000 GALLON FIRE WATER TANK OF THE FOLLOWING GEOMETRY:

1.2.1. APPROX 11'-10" DIA FLAT-BOTTOM TANK WITH ROUNDED ROOF TOP STARTING APPROX 18'-0" ABOVE TOP OF SLAB AND TOP OF ROOF AT APPROX 19'-3½" ABOVE TOP OF SLAB.

1.2.2. TANK CAPACITY = 15,000 GALLONS WITH LIQUID SPECIFIC GRAVITY SIMILAR TO WATER.

1.2.3. FRP TANK CONSTRUCTION WITH EMPTY WEIGHT = 2,500#.

2. 5,000 GALLON WATER TANK:

2.1. TANK TIE-DOWN STRAPS AND ANCHORAGE TO CONCRETE SLAB (FOR SEISMIC AND WIND LOADS SHOWN ON SHEET S-15-18) ARE TO BE DESIGNED AND PROVIDED BY TANK MANUFACTURER. HOWEVER, A MINIMUM OF 4 TIE-DOWN STRAPS (EQUALLY SPACED AROUND PERIMETER) TO BE PROVIDED. EACH TIE-DOWN STRAP TO HAVE A MINIMUM OF (3)-HDA-PF M16X190/60 GALVANIZED UNDERCUT ANCHORS @ 8" C/C MINIMUM SPACING AND EMBEDMENT (TANK MANUFACTURER TO DESIGN TIE-DOWN TO UNDERCUT ANCHOR CONNECTION). TANK MUST ALSO HAVE A MINIMUM OF (4)-L6x3½x5⁄16x8" LONG CLIP ANGLES LLV WITH (1)-3/4" DIAMETER GALVANIZED ADHESIVE ANCHOR WITH 9" EMBEDMENT IN EACH CLIP ANGLE. SPACE 4 CLIP ANGLES EQUALLY AROUND TANK PERIMETER.

2.2. STRUCTURAL DESIGN OF FOUNDATION SLAB ASSUMES A 5,000 GALLON WATER TANK OF THE FOLLOWING GEOMETRY:

2.2.1. APPROX 8'-6" DIA FLAT-BOTTOM TANK WITH ROUNDED ROOF TOP STARTING APPROX 11'-6" ABOVE TOP OF SLAB AND TOP OF ROOF AT APPROX 12'-9" ABOVE TOP OF SLAB.

2.2.2. TANK CAPACITY = 5,000 GALLONS WITH LIQUID SPECIFIC GRAVITY SIMILAR TO WATER.

2.2.3. FRP TANK CONSTRUCTION WITH EMPTY WEIGHT = 1,250#.

3. BLADDER TANK, TRANSFORMER, ELECTRICAL GENERATOR, PUMPS, ELECTRICAL/COMMUNICATION PANELS, AND FABRICATED STEEL SKID:

3.1. EQUIPMENT ANCHORAGE TO FABRICATED STEEL SKID AND FABRICATED STEEL SKID TO CONCRETE SLAB (FOR SEISMIC AND WIND LOADS SHOWN ON S-15-18) ARE TO BE DESIGNED AND PROVIDED BY EQUIPMENT MANUFACTURER

- DRAFT -
NOT FOR CONSTRUCTION

ETIC ENGINEERING
ARCADIS

NO.	DATE	DESCRIPTION	GM/SPEC	DWN	CHKD	SUPV	APVD BY
0	12/18/14	SUPPLEMENTAL PRE-FINAL (90%) DESIGN		CMW	MSL	JPB	RAK

REVISIONS

APPROVED BY	JEF
SO	
SUPV	JPB
DSGN	CMW
DWN	CMW
CHKD	MSL
OK	RAK
DATE	12/12/14
SCALES	

TOPOCK GROUNDWATER REMEDIATION PROJECT
UTILITY PAD SECTIONS
GAS TRANSMISSION & DISTRIBUTION
PACIFIC GAS AND ELECTRIC COMPANY
SAN FRANCISCO, CALIFORNIA

MICROFILM
BILL OF MAT'L
DWG LIST
SUPSDS
SUPSD BY
SHEET NO. of SHEETS
S-15-19 REV 0

H-2A

CONSERVATIVE

SNYDER INDUSTRIAL DESIGN

TOPOK

$S_{DS} = \left(\frac{2}{3}\right) F_a S_s = 0.933 > 0.245$ ✓OK

$S_{D1} = \left(\frac{2}{3}\right) F_v S_1 = 0.500 > 0.186$ ✓OK

Click here for download of Cone Bottom Tank Engineering Calculations

Click here for Snyder's Guidelines for Use and Installation (section 8.2 and 8.3 cover Seismic Restraint System Installation)

Seismic FAQs

Q1. What is Snyder's VST, Captor and Cone Bottom seismic systems design figures?

Created on: 8/22/2013; Modified on 8/22/2013;

Answer:

The seismic restraint system for VSTs and Captors offered by Snyder meets System meets IBC 2009 / CBC 2010 code with seismic loads ≤ .445g SDC (Seismic Design Category) "D" - Fa=1.0, Fv=1.5, Ss=1.4, S1=0.5). The seismic restraint system for Cone Bottom tanks offered by Snyder meets IBC 2009/CBC2010 code with seismic loads ≤.33g SDC "D" - Fa=1.0, Fv-1.5, SDS=1.105, SD1=0.597. If the requirement is greater than these design coefficients then you will need to contact Snyder to see if a system can be provided to meet the requirements for the site. This may change the price of the standard seismic system offered in Snyder's Industrial Tank Price List.

See question 9 for further explanation of Seismic Design Category (SDC).

Viewed: 152 times

Q2. What is IBC and CBC and how does it affect me?

Created on: 8/22/2013; Modified on 8/22/2013;

Answer:

IBC stands for International Building Code. CBC stands for California Building Code.

If you are in California, then the new California Building Code of 2007 (CBC 2007) took effect on January 1, 2008.

On July 1st of 2010 a new code was published for use in California. The new California Building Code of 2010 (CBC 2010) went into effect on January 1st of 2011. The new code is based on the

2009 IBC and ASCE/SEI 7-05. Here's how the transition to the new code works...all plans submitted to the state for permit on January 1st, 2011 or later, will be plan checked and constructed in accordance with the CBC 2010. As such, new calculations will be required. If a building was submitted for plan check on December 31, 2010 or earlier, it willl be plan checked and constructed in accordance with the CBC 2007 code. All 2007 code calculations will be valid for those structures.

Viewed: 77 times

Q3. Is the IBC and California building code (CBC) the same thing? If not, what are the differences, which code should I follow when designing projects in California?

Created on: 8/22/2013; Modified on 8/22/2013;

Answer:

Yes, but with amendments. The California Building Standards Council (CBSC) went through extensive review of the IBC and the California legislature adopted it by law as the new CBC in 2007, making it effective January 1, 2008. The current version is CBC 2010 and that is the code you must now follow depending on when the local jurisdiction you are working in adopts it and when the structure was submitted for plan check.

Viewed: 75 times

Q4. What about other states other than California?

Created on: 8/22/2013; Modified on 8/22/2013;

Answer:

Other states may have already or may be soon adopting IBC 2006. Typically many states follow the lead of California on seismic system design requirement. You will need to check with local authorities for requirements for your area and when they take effect.

Viewed: 56 times

Q5. What does the code require with regard to equipment anchorage?

Created on: 8/22/2013; Modified on 8/22/2013;

Answer:

The California / International Building Codes require all stationary equipment to be anchored to its supporting structure (CBC 2010, Section 1613 & IBC 2009, Section 1613). In addition, much of this equipment must have calculations to validate its method of anchorage (ASCE 7-05, Section 13). For floor mounted equipment the requirement is for equipment that weighs 400 pounds or more or is over 60 inches in height.

Viewed: 128 times

Q6. How do I know if Snyder's system will be accepted?

Created on: 8/22/2013; Modified on 8/22/2013;

Answer:

With IBC 2009 / CBC 2010 the seismic design coefficients are site specific so each zip code may have different requirements. Our standard calculations are based on the design coefficients of a specific zip code in California (see seismic design coefficients in question 1). To determine if our standard calculations will be accepted we recommend you present a copy of our standard seismic design calculations to the contractor and/or engineering firm and have them review the calculations for acceptance. If the calculations are not acceptable then you will need to have the contractor and/or engineering firm provide information on the design coefficients required for the project so they can be reviewed by Snyder.

Viewed: 82 times

Q7. What if I'm being asked to provide a wet stamp?

Created on: 8/22/2013; Modified on 8/22/2013;

Answer:

Original Wet Stamp calculations are listed in Snyder's price book as a purchased option for vertical tanks, double wall Captor tanks and cone bottom tanks. The wet stamps are broken down into three categories – Standard Calculation, Site Specific (VST/Captor), and Site Specific (CBT). The standard calculation is the calculation we already have done for a specific site that may work for your projects site. If, however, you require a "site specific" calculation which requires changes to the standard calculation then you would use the Site Specific calculation pricing. These site specific calculations will be provided in the same format at the standard calculation only they will be adjusted for the specific site design coefficients. If a "non-standard" format calculation is required please contact Snyder as these will need to be quoted on a case-by-case basis as priced by the Engineer contracted to provide the calculations.

A copy of our standard calculation can be provided (PDF format) at no charge by contacting your Snyder Regional Sales Manager or Customer Service.

Viewed: 88 times

Q8. What is a seismic design category?

Created on: 8/22/2013; Modified on 8/22/2013;

Answer:

The old Uniform Building Code (UBC) 1997 used maps with numbered zones, 0, 1, 2, 3, 4. These maps are practically obsolete (1969 was the last year such a map was put out). The current IBC 2009 code uses Seismic Design Category (SDC). A SDC is a classification assigned to a structure based on its occupancy or use (referred to as Occupancy Category) and on the level of expected soil modified seismic ground motion. This can be expressed schematically as follows:
[Occupancy Category] + [Soil modified seismic ground motion] → SDC

Seismic Design Category (SDC)	**What does it mean?**
A	Very small seismic vulnerability
B	Low to moderate seismic vulnerability
C	Moderate seismic vulnerability
D	High seismic vulnerability
E&F	Very high seismic vulnerability and near a major fault.

To determine the seismic design category you need to determine the Ss and S1 using maps or calculation tool. If you are working on a specified project then have the contractor or engineering firm responsible for the specification provide you with these figures.

Ss = the maximum considered earthquake spectral response acceleration at short periods (0.2 seconds).

S1 = the maximum considered earthquake spectral response acceleration at 1 second period.

Viewed: 77 times

Q9. What size pad do I need for the seismic restraint system?

Created on: 8/22/2013; Modified on 8/22/2013;

Answer:

The diameter of the pad required is outlined in the standard VST and/or Captor calculations. Please review the calculations and find the pad drawing that applies to the tank you are using or quoting for your project. The pad design is based on the default value allowed by code. It may be possible to use a smaller pad size if soil conditions are known. This would have to be done by the engineer on site.

The thickness of the pad will need to be determined by a local design engineer based on the soil conditions; however the pad should be thick enough for the anchor embedment outlined in the standard calculations.

Please note that if you need a site specific seismic calculation or a non-standard calculation, then the pad size may differ substantially from what is shown in the standard calculation.

Viewed: 130 times

Q10. Today's date is beyond the "expired" date on the structural stamp, is the calculation still valid?

Created on: 8/22/2013; Modified on 8/22/2013;

Answer:

The calculation is valid as long as the date on the calculation is prior to the expired stamp. The expiration date as related to the date of the permitted drawings, applies to the Engineer of Record's stamp.

Viewed: 68 times

Q11. What anchor bolts are approved?

Created on: 8/22/2013; Modified on 8/22/2013;

Answer:

Anchor bolts are not included with the seismic restraint system provided by Snyder Industries. These must be purchased separately. The structural engineer that did our standard calculations has reviewed the anchor bolt requirements carefully and maintains the Hilti HVA anchor system is acceptable for the parameters of our seismic calculation set submitted.

Per 2007 CBC Section 1912, concrete anchors shall be designed in accordance with Appendix D of ACI 318 as modified by Section 1908.1.16. Per that Section, in structures in Seismic Design

Category D, post-installed anchors shall have passed the Simulated Seismic Tests of ACI 355.2, which includes testing of the anchors in cracked concrete. However, Appendix D of ACI 318 does not apply to epoxy anchor systems. The scope is limited to cast in-place and mechanical anchors. it does not address epoxy anchor systems.

If calculations are required to utilize a specific anchor bolt other than Hilti HVA style then site specific calculations would be required (additional cost for calculations).

Viewed: 141 times

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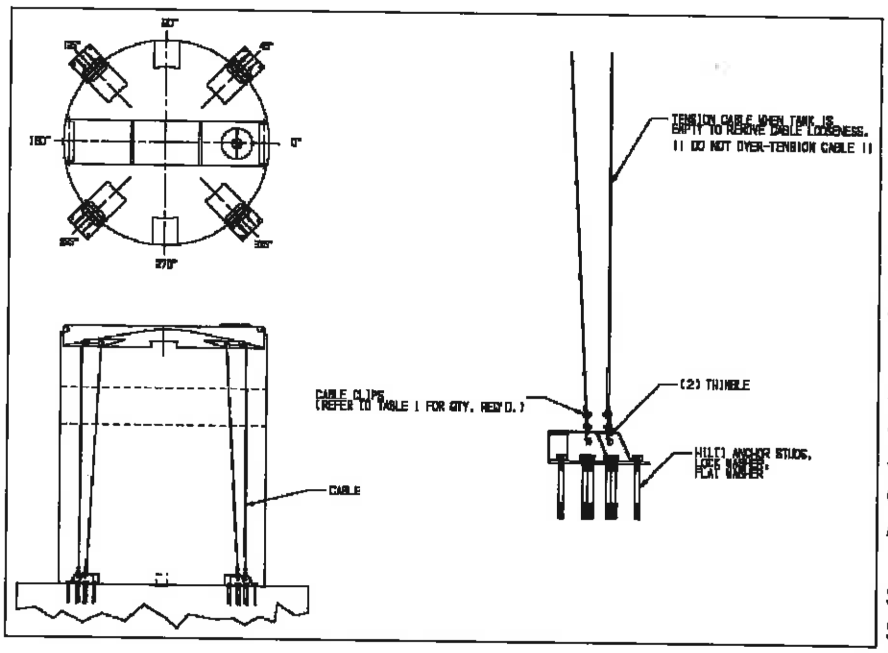
Seismic Restraint System



Snyder Seismic Restraint System not available for all Snyder tanks. Please check with Snyder Representative for details.

Design specifications subject to change without notice.

See Snyder Seismic System Q&A below, for further information.

Click here for download of Single Wall Vertical Tank Engineering Calculations

Click here for download of Captor Double Wall Tank Engineering Calculations

H-2B

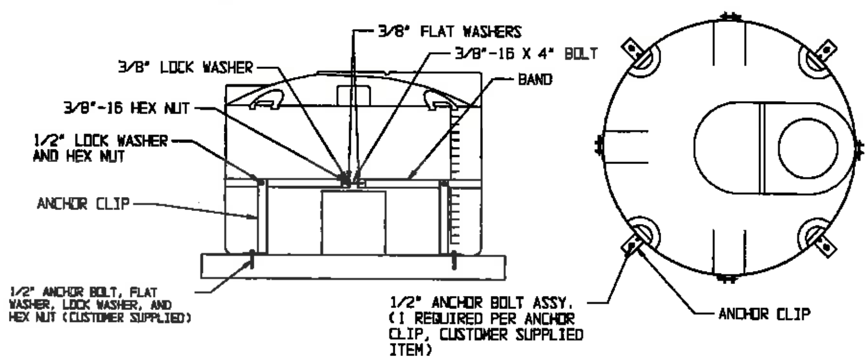
height of the fitting is above 100", an additional Flexmaster can be installed in the vertical configuration to provide additional movement capability.

8. TANK ACCESSORIES

8.1 LATERAL RESTRAINT SYSTEM (FLAT BOTTOM TANKS)

8.1.1 The lateral restraint system is designed for tank position restraint on a concrete pad inside of an enclosed building. **It is not designed for wind or seismic restraint capabilities.** Using the assembly drawing and table shown in Figure 8.1, verify that all parts are present.

8.1.2 Locate the tank on the concrete pad as desired. The pad required for the restraint system must be 18-3/4" larger in diameter than the tank diameter for proper application of 1/2" adhesive anchor bolts (assumes 6-3/8" edge distance required). Lay out the bands around the tank (alternate long bands and short bands if both lengths are provided) with the studs and angle ends sticking out away from the tank. Fasten the bands together with the 3/8" - 16 x 4" hex head bolts as shown in the drawing. Raise the bands 17" and loosely install the anchor clips using the 1/2" - 13 hex nuts and 1/2" washers provided. Tighten the 3/8" - 16 x 4" hex head bolts to remove band looseness. Mark the slot locations of the anchor clips, remove the clips, and install the required number of 1/2" anchor bolts. Anchor bolts are not provided by the manufacturer and must be purchased by the customer.



	QUANTITY REQUIRED					
TANK DIA. (IN.)	BAND 44 IN.	BAND 48 IN.	ANCHOR CLIPS	3/8"-16 X 4" BOLTS AND HEX NUTS	3/8" FLAT WASHERS	1/2" HEX NUTS AND FLAT WASHERS
48	0	3	3	3	6	3
64	0	4	4	4	8	4
86	5	0	5	5	10	5
90	3	3	6	6	12	6
102	7	0	7	7	14	7
120	4	4	8	8	16	8
137	4	5	9	9	18	9
142	0	9	9	9	18	9

Figure 8.1

8.1.3 Replace the anchor clips and secure the clips to both bands and the concrete pad. Do not over tighten the bands to the tank. The band tension should only remove looseness and not cause any tank deflection.

8.2 WIND/SEISMIC TANK RESTRAINT SYSTEM (FLAT BOTTOM TANKS)

allowable - service loads

8.2.1 The wind/seismic tank restraint system is designed for tank restraint on an appropriate concrete pad under 110 MPH wind or seismic zone 4 conditions. Using the assembly drawing and table sent with the assembly, verify that all parts are present. Please see Figure 8.2 for a restraint system installation and assembly information.

8.2.2 Locate the tank on the concrete pad as desired. Lay out all anchors required (4 or 8) equally spaced, (4 anchors must be directly below the tank tie down locations). Make sure all anchors are located next to the tank with the front face of the anchor weldment located next to the tank. Mark all the anchor bolt locations, remove the anchors and install the required Hilti adhesive model HVA anchor bolts as specified in the assembly drawing and table sent with the assembly. These anchor bolts are not provided by the manufacturer and must be purchased by the customer. Customer must follow all Hilti anchor bolt installation instructions.

8.2.3 Replace the anchors and secure the anchors to the concrete. Fasten the tank to the concrete pad with the required cable (make sure the cable sheath is on the cable and located around the lug locations) as shown by the assembly drawing utilizing the cable thimbles and clamps provided. Tension the cable <u>before</u> filling the tank to remove cable looseness. Do not over-tension the cables as this may cause tank damage. The cable tension will change with tank loading and temperature changes - <u>DO NOT</u> re-tension the cables.

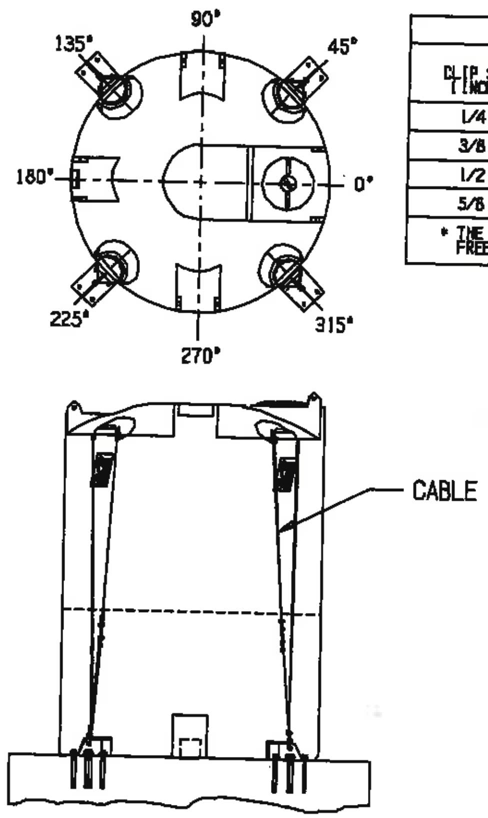


TABLE 1

CLIP SIZE (INCHES)	ROPE SIZE (INCHES)	MINIMUM # CLIPS REQ.	AMOUNT OF ROPE TURN-BACK (INCHES)	*TORQUE IN Ft. Lbs
1/4	1/4	2	4-3/4	15
3/8	3/8	2	6-1/2	45
1/2	1/2	3	11-1/2	65
5/8	5/8	3	12	95

* (THE TIGHTENING TORQUE VALUES SHOWN ARE BASED UPON THE THREADS BEING CLEAN, DRY, AND FREE OF LUBRICATION.)

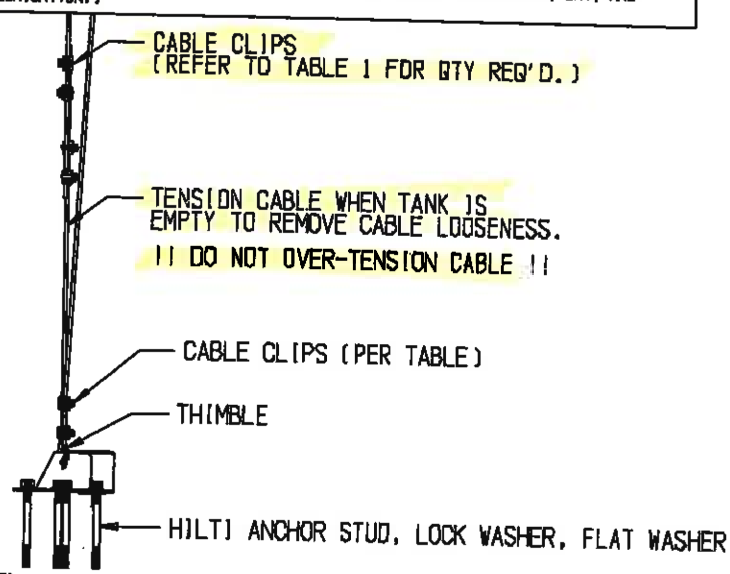
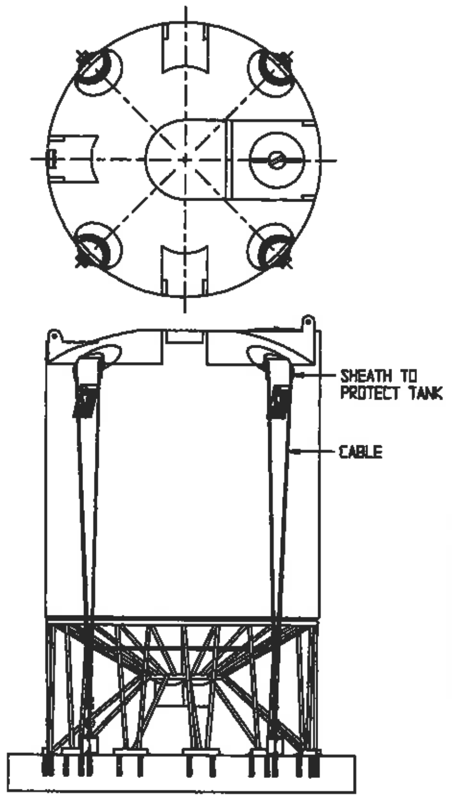
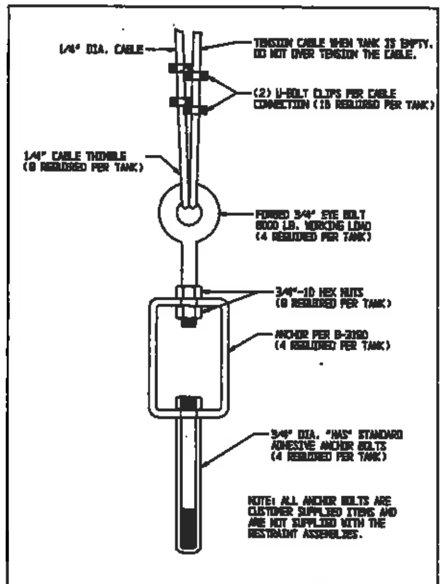


Figure 8.2

8.3 WIND/SEISMIC TANK RESTRAINT SYSTEM (CONE BOTTOM TANKS)

8.3.1 The wind/seismic tank restraint system is designed for cone bottom tank restraint on an appropriate concrete pad under 110 MPH wind or seismic zone 4 conditions using a SII cone stand for proper tank support. Using the assembly drawing and table shown in Figure 8.3, verify that all parts are present.





ANCHOR ASSEMBLY DETAIL

TANK	TANK	1.9 SPECIFIC GRAVITY FLUID	
SIZE	DIAMETER	STAND	STAND ANCHOR BOLTS
(GALLONS)	(INCHES)	REQUIRED	REQUIRED
500	64	78800	8 EA. 1/2" DIA. "HAS" STANDARD
500	86	79000	8 EA. 1/2" DIA. "HAS" STANDARD
1000	64	78800	8 EA. 1/2" DIA. "HAS" STANDARD
1400	86	79000	8 EA. 1/2" DIA. "HAS" STANDARD
1500	64	78800	8 EA. 1/2" DIA. "HAS" STANDARD
1650	86	78900*	8 EA. 1/2" DIA. "HAS" STANDARD
2000	90	79300	24 EA. 3/4" DIA. "HAS" STANDARD
2500	90	79300	24 EA. 3/4" DIA. "HAS" STANDARD
2600	90	79400	24 EA. 3/4" DIA. "HAS" STANDARD

*NOTE: 79000 STAND ACCEPTABLE FOR SPECIFIC GRAVITIES UNDER 1.7

TANK	TANK	1.9 SPECIFIC GRAVITY FLUID	
SIZE	DIAMETER	STAND	STAND ANCHOR BOLTS
(GALLONS)	(INCHES)	REQUIRED	REQUIRED
3000	90	79300	24 EA. 3/4" DIA. "HAS" STANDARD
3900	90	79300	24 EA. 3/4" DIA. "HAS" STANDARD
4100	90	79900	24 EA. 3/4" DIA. "HAS" STANDARD
4400	90	79800	24 EA. 3/4" DIA. "HAS" STANDARD
5500	90	79800	24 EA. 3/4" DIA. "HAS" STANDARD
5600	90	79800	24 EA. 3/4" DIA. "HAS" STANDARD
6000	142	79500	24 EA. 3/4" DIA. "HAS" STANDARD
6500	90	79800	24 EA. 3/4" DIA. "HAS" STANDARD
7400	142	79500	24 EA. 3/4" DIA. "HAS" STANDARD
11500	142	79500	24 EA. 3/4" DIA. "HAS" STANDARD

Figure 8.3

8.3.2 Locate the tank and stand on the concrete pad as desired. The pad required for the restraint system must be 24" larger in diameter than the tank diameter for proper application of 3/4" adhesive anchor bolts (assumes 10" edge distance required. Lay out the four anchors provided directly below the tank tie down locations. Make sure all anchors are located so the hole in the anchor aligns with the tank wall. Mark all the anchor bolt locations (stand and anchor positions), remove the stand and anchors and install the required Hilti adhesive model HVA anchor bolts as specified by the assembly drawing and the SII seismic restraint drawing B-3182. These anchor bolts are not provided by the manufacturer and must be purchased by the customer.

8.3.3 Replace the stand and anchors and secure to the concrete pad. Install the 3/4" eyebolts loosely as shown by the drawing. Fasten the tank to the concrete pad with the required cable (make sure the cable sheath is on the cable and located around the lug locations) as shown by the assembly drawing utilizing the cable thimbles and clamps provided. Tension the cable before filling the tank to remove cable looseness. Do not over-tension the cables as this may cause tank damage. The cable tension will change with tank loading and temperature changes - DO NOT re-tension the cables.

8.4 STEEL LADDERS

8.4.1 Steel ladders are designed in accordance with OSHA 1910.27 and are to be mounted next to the tank on a concrete pad at the same elevation as the bottom of the tank. The concrete pad area that the ladder mounts to must be of sufficient size as to comply with OSHA standards regarding proper access to and from the ladder. This should be determined by the construction site engineer based on the specific application. The pad must be of sufficient size to allow proper attachment of 1/4" anchor bolts (check with anchor bolt manufacturer for embedment and edge distance required). The ladder mounting system is designed to allow for tank expansion and contraction due to temperature and loading changes. Using the assembly drawing and table shown in Figure 8.4, verify that all parts are present and assemble accordingly.

NOTE: This ladder is provided for tank inspection only. At no time should the operator step off this ladder onto the tank unless stepping onto an approved work platform with guard rails or utilizing some other approved safety device. Proper safety equipment (i.e. guard rails, safety harness, etc.) must be used to step onto the tank. Consult applicable regulations to determine proper equipment for other than inspection work.

8.4.2 Attach the two pivoting attachment arms to the ladder using 1 ea. 1/2"-13 x 2" hex head bolt and 2 ea. 1/2" - 13 hex nuts. Double nut each bolt by tightening the first nut to 85 ft. - lbs. of torque and then jamming the second nut to the first nut by holding the first nut and tightening the second to 85 ft. - lbs. of torque. Position the ladder on the tank and attach the top pivoting attachment arms to the tank with the ladder attachment tube and cotter pin provided (see Figure 8.4). Position the ladder parallel with the side of the tank and mark the 1/4" anchor bolt locations. Install appropriate 1/4" anchor bolts and attach the bottom of the ladder to the concrete pad. Anchor bolts are not provided by the manufacturer and must be purchased by the customer.

8.5 STEEL LADDER CAGES

8.5.1 Using the assembly drawing shown in Figure 8.5 and the instructions in section 8.5.2, verify that all parts are present and assemble accordingly. These cages are designed for use only with the SII steel ladder design. Cages are required for ladders used to ascend to heights exceeding 20 ft.

NOTE: Assembly is easier if the cages are installed on the ladder before the ladder installation to the tank.

8.5.2 Install the cages loosely using the u-bolts provided starting with the top cage unit (4 ft. unit with a larger bolt pattern). The bottom cage unit must have a larger diameter at the bottom than at the top of the unit and the bottom edge of the unit be located a minimum of 7 feet and a maximum of 8 feet above the ground. When the cage units have been properly located and spaced evenly, tighten the u-bolts securely.

8.6 FRP LADDERS (up to 300" height)

8.6.1 FRP ladders are designed in accordance with OSHA 1910.27 and are to be mounted next to the tank on a concrete pad at the same elevation as the bottom of the tank. The concrete pad area that the ladder mounts to must be of sufficient size as to comply with OSHA standards regarding proper access to and from the ladder. This should be determined by the construction site engineer based on the specific application. The pad must be of sufficient size to allow proper attachment of 5/8" anchor bolts (check with anchor bolt manufacture for embedment and edge distance required). The ladder mounting system is designed to allow for tank expansion and contraction due to temperature and loading changes. Using the assembly drawing and table shown in Figure 8.6, verify that all parts are present and assemble accordingly.

10.1.2 Snyder Industries, Inc. warrants to the purchaser for use that if any manufactured tank product is proven to be defective in material or workmanship within 3 YEARS from the date of original invoice from factory, and Snyder Industries, Inc. is notified within 15 days after such defect is discovered, Snyder Industries, Inc. will (at company option) either replace or repair said part. Snyder Industries, Inc. warrants to the purchaser for use that if any tank fitting, attachment, or accessory product is proven to be defective in material or workmanship within 1 YEAR from the date of original invoice from factory, and Snyder Industries, Inc. is notified within 15 days after such defect is discovered, Snyder Industries, Inc. will (at company option) either replace or repair said part. This Snyder Industries Standard Limited Warranty does not apply to damage resulting from misuse, improper application of recommended materials, neglect, material wear, accident, or improper installation or maintenance. Said part will not be considered defective if it substantially fulfills performance specifications. THE FOREGOING STANDARD LIMITED WARRANTY IS EXCLUSIVE AND IN LIEU OF ALL OTHER WARRANTIES OF MERCHANTABILITY, FITNESS FOR PURPOSE AND OF ANY OTHER TYPE, WHETHER EXPRESSED OR IMPLIED. Snyder Industries, Inc. neither assumes nor authorizes anyone to assume for it any other obligation or liability in connection with said tank product and will not be liable for incidental or consequential damages. THE REMEDIES STATED HEREIN SHALL BE THE EXCLUSIVE REMEDIES AVAILABLE UNDER THIS STANDARD WARRANTY. CLAIMS UNDER THIS STANDARD LIMITED WARRANTY SHALL BE HANDLED UNDER THE SNYDER INDUSTRIES, INC. SERVICE POLICY. Snyder Industries, Inc. will not be responsible for any charges incurred in repairing or servicing any Snyder Industries, Inc. product except as such repairs are made at Snyder Industries, Inc. or by Snyder Industries, Inc. personnel or as approved in writing from Snyder Industries, Inc. Customer Service.

10.2 SII WARRANTY EXCEPTIONS

10.2.1 Distributors and their authorized distribution have the responsibility of calling to the attention of their customers any exceptions to the Snyder Industries, Inc. standard limited warranty, prior to acceptance of an order from the customer for any Snyder Industries, Inc. product.

10.2.2 Due to the uniqueness of tank applications, Snyder Industries, Inc. may offer warranties other than the standard warranty. These warranty statements will be in writing from Snyder Industries, Inc. The warranty period may be longer than 3 years as in the case for purchased extended warranties, or the warranty period may be shorter than 3 years as in the case for certain chemical/material applications. Please consult Snyder Industries, Inc. if you have any questions regarding warranty coverage and/or requirements.

10.3 RETURN MERCHANDISE/WARRANTY CLAIM PROCEDURE

10.3.1 SII has specific procedures for return merchandise and warranty claims. To make a claim, please contact the Customer Service Department at SII by mail, phone or e-mail:

Snyder Industries, Inc.
P.O. BOX 4583
Lincoln, NE 68504
(402) 467-5221
FAX: (402) 467-6493
E-mail: sales@snydernet.com

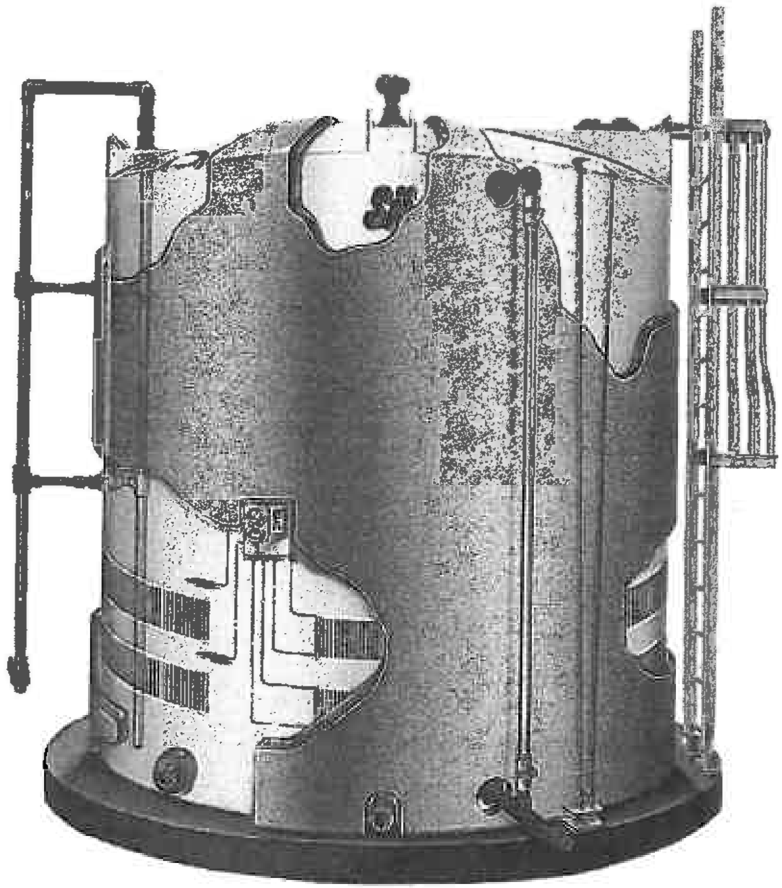
The following information will be required to assist in filing your claim:

1. Product identification (tank size, part number, serial number, etc.)
2. SII customer order number
3. Name and phone number of person making the claim
4. Distributor/company name, address, and phone number
5. Description of reason for claim
6. Pictures of failure and installation
7. MSDS of chemicals stored
8. Temperature of tank application

REVISED: 08/30/05 P/N: 998062

GUIDELINES FOR

USE AND INSTALLATION



PROVIDING INDUSTRY WITH TANK SOLUTIONS

Protect your warranty – Read these instructions!

SII SNYDER INDUSTRIES, INC.

P.O. Box 4583 • Lincoln, Nebraska • 68504 • Phone: 402-467-5221
Fax: 402-465-1220 • www.snydernet.com

TABLE OF CONTENTS

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USGS Design Maps Summary Report

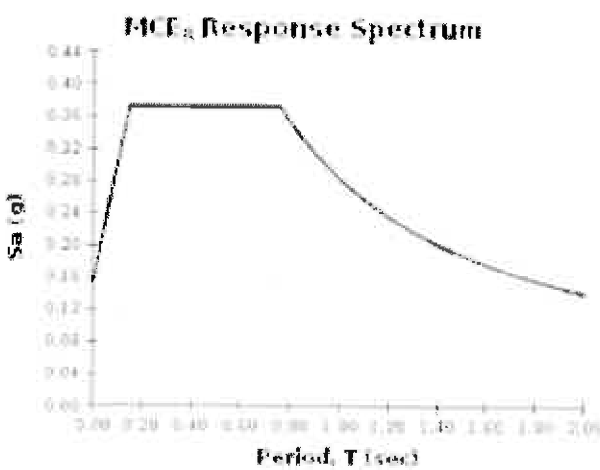
User–Specified Input

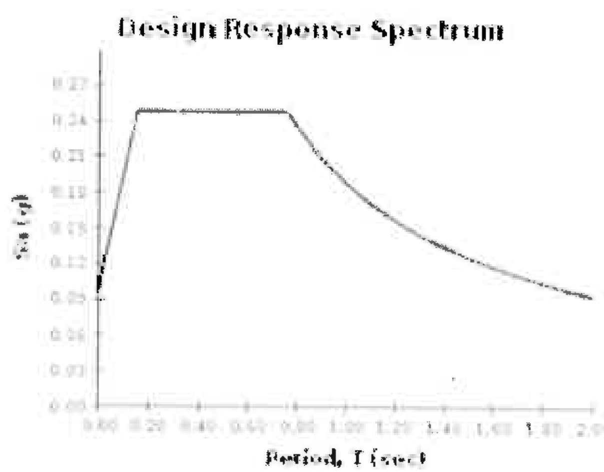
Report Title	Topok Fri December 19, 2014 13:32:10 UTC
Building Code Reference Document	2012 International Building Code (which utilizes USGS hazard data available in 2008)
Site Coordinates	34.71399°N, 114.51483°W
Site Soil Classification	Site Class D – "Stiff Soil"
Risk Category	IV (e.g. essential facilities)

USGS–Provided Output

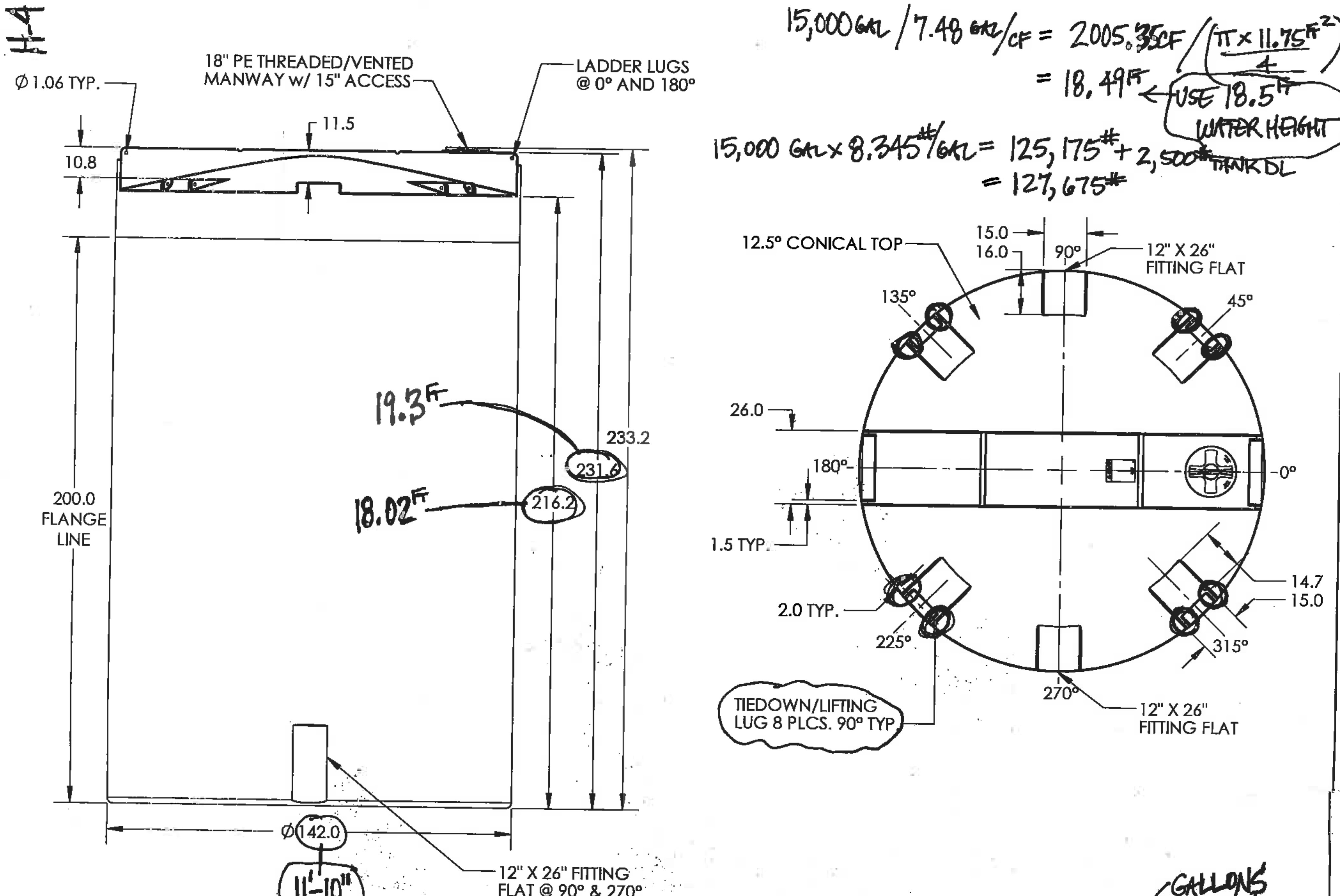
S_S =	0.232 g	S_{MS} =	0.372 g	S_{DS} =	0.248 g
S_1 =	0.122 g	S_{M1} =	0.282 g	S_{D1} =	0.188 g

For information on how the SS and S1 values above have been calculated from probabilistic (risk-targeted) and deterministic ground motions in the direction of maximum horizontal response, please return to the application and select the "2009 NEHRP" building code reference document.





H-4



*ALL EXTERNAL PIPING MUST BE INDEPENDENTLY SUPPORTED.
*ONLY BASE FITTINGS TO BE LEFT INSTALLED AT TIME OF SHIPMENT PER SII PROCEDURE.
*Consult Snyder's Guidelines for Use and Installation prior to delivery. Available on-line at http://www.snyderindustriestanks.com/Technical
*DIMENSIONS ARE IN INCHES, NOMINAL, & SUBJECT TO CHANGE WITHOUT NOTICE.
*DIMENSIONS ON ROTATIONAL MOLDED PARTS ARE SUBJECT TO A ± 3% TOLERANCE.

DO NOT SCALE	DRAWN BY	DATE		TITLE	REVISION
STATUS: Released	ETS	07/25/	SNYDER INDUSTRIES, INC. 4700 Fremont Street Lincoln, NE 68504 (402) 467-5221 www.snydernet.com	ASM TK 15000 VDT X 142 (GALLONS)	A SHEET 1 OF 1
© SNYDER INDUSTRIES INC.				PART NO. 5370000N__01	ENG. ID. D001074

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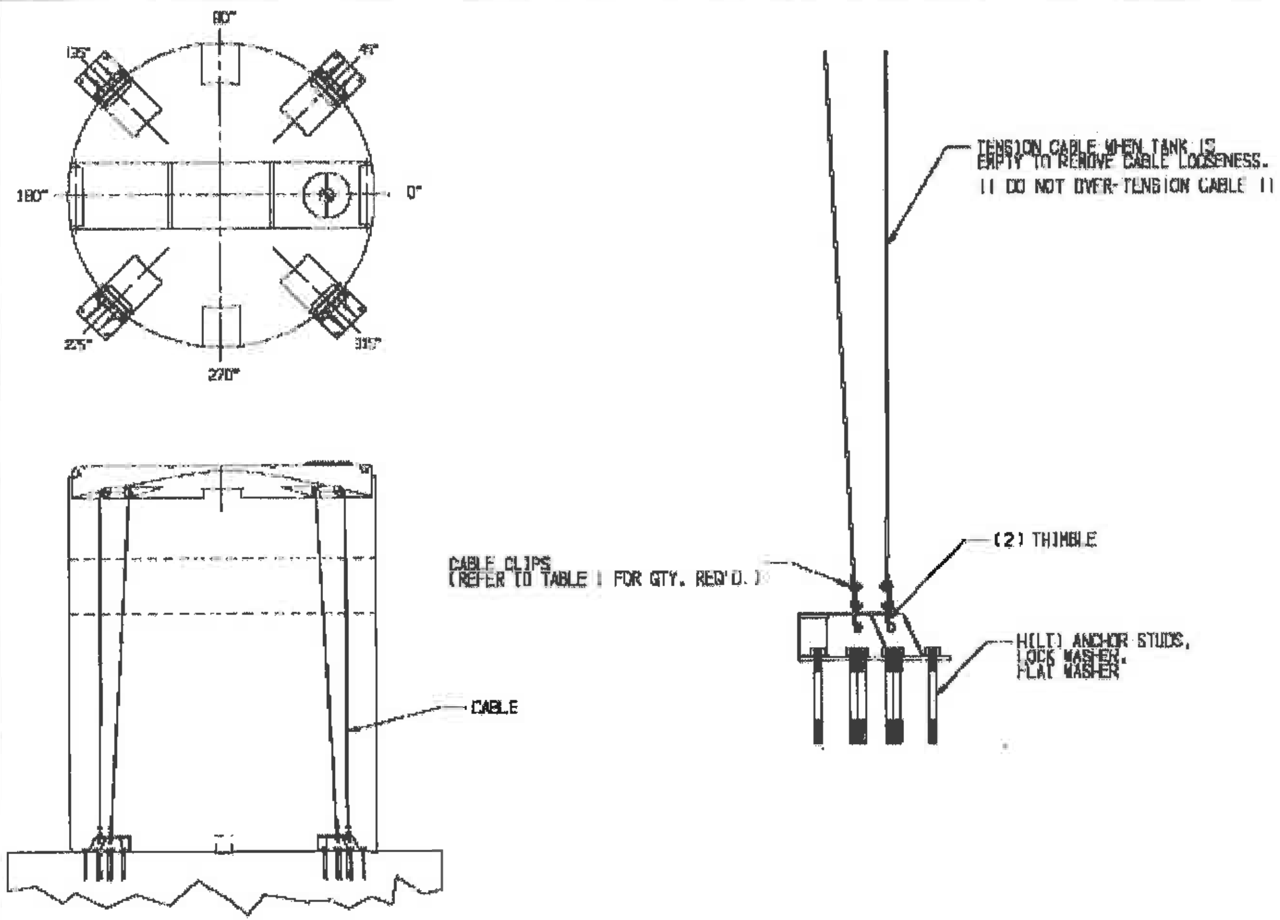

CODES:
CBC 2010
IBC 2009
ASCE 7-05
AISC 13TH EDITION

SEISMIC DESIGN:
Zip Code = 92701, Site class D - Fa=1.0, Fv=1.5,
Ss = 1.4, S1 = 0.5, I = 1.5, R = 3.0
Fp=(Vi*Wi+Vc*Wc/(Wi+Wc*SS)) = 0.445 W

WIND DESIGN:
IBC/CBC - 150 MPH
Qz = 0.00256Kz*Kzt*Kd*V^2I = 58.14 PSF
(Kz = 0.85, Kzt = 1.0, Kd = 0.95, I = 1.25)

GENERAL:
1. ALL CONSTRUCTION SHALL MEET LOCAL BUILDING CODE REQUIREMENTS AND BE APPROVED BY THE BUILDING OFFICIAL.
2. THESE GUIDELINES HAVE BEEN PROVIDED TO SPECIFY THE RESTRAINT RECOMMENDATIONS FOR SNYDER INDUSTRY BULK STORAGE TANKS.

CONCRETE:
1. CONCRETE SHALL HAVE A MINIMUM DESIGN AS PER DRAWING REFERENCED IN SPECIFICATION CHART BELOW.
2. CONCRETE PAD DESIGN SHOULD BE REVIEWED AND APPROVED BY THE BUILDING OFFICIAL BASED ON SPECIFIC APPLICATION AS OTHER DESIGN PARAMETERS ARE POSSIBLE DEPENDING UPON SITE CONDITIONS.

STRUCTURAL STEEL:
1. ALL STRUCTURAL STEEL COMPONENTS SHALL BE NEW AND OF BASIC OPEN HEARTH PROCESS STEEL CONFORMING TO ALL APPLICABLE REQUIREMENTS OF ASTM A36 (STRUCTURAL STEEL FOR BRIDGES AND BUILDINGS - Fy = 36,000 PSI.).
2. ALL ARC WELDING ELECTRODES SHALL CONFORM TO ASTM A233 FOR STEEL ARC WELDING ELECTRODES. ELECTRODES SHALL BE AS RECOMENDED BY THE MANUFACTURES FOR THE POSITIONS AND OTHER CONDITIONS OF ACTUAL USE. WELDING SHALL CONFORM TO REQUIREMENTS OF AMERICAN WELDING SOCIETY AWS D1.1.
3. ALL SHARP EDGES AND CORNERS SHALL BE REMOVED ON ALL STRUCTURAL STEEL COMPONENTS.
4. CABLES TO BE 7X19 STRANDED CORE CONSTRUCTION SIZED PER CHART MATERIAL TO BE SPECIFIED BY CUSTOMER ORDER (MINIMUM BREAKING STRENGTH EQUAL TO OR GREATER THAN 304 SS RATING).
5. ANCHOR BOLTS TO BE HILTI ADHESIVE ANCHORS, MODEL HIT-RE 500-SD WITH SIZE, MATERIAL, AND EMBEDMENT AS SPECIFIED PER SPECIFICATION CHART BELOW.
ALL OTHER FASTENER MATERIALS MUST CORRESPOND TO THE TYPE OF ANCHOR SELECTED.

H-4A

Lotycz, Matt

From:	O'Brien, Maureen
Sent:	Wednesday, December 10, 2014 5:03 PM
To:	Lotycz, Matt
Cc:	Eckel, Caroline H.; Baxter, Jonathan; Sidoti, John
Subject:	RE: Utility Pad DWG File
Attachments:	15,000 gal snyder tank.PDF; Generator Dimensional drawing 2 adv7853.pdf; Diesel Generator g5373.pdf; Generator Dimensional drawing 1 adv7853.pdf; cooper pad mount transformer.pdf; seismic restraint.JPG

Here is the cut sheet and seismic info for the 15.000 gal FSW (Now: fire suppression water) tank. The seismic info is for all of the snyder tanks, this was all I could find from Snyder on the website. I can ask for more if you need it.

I've also attached the cutsheets for the transformer and generator. I pulled the dimensions for each directly from these sheets, so they should be accurate.

Andy is updating the utility pad right now to add some more space in between the tanks so I will send you the updated dwg file as soon as I receive it.

Let me know if you need anything else!

Thanks,
Maureen

From: Sidoti, John
Sent: Wednesday, December 10, 2014 3:51 PM
To: Lotycz, Matt
Cc: Eckel, Caroline H.; O'Brien, Maureen; Baxter, Jonathan
Subject: RE: Utility Pad DWG File

I'm ok with where the panels sit right now—at this point there is nothing in front of them (on the north side of the pad). We would have 4' required in front of them, which we appear to have.

John

John Sidoti, PE | Electrical Engineer | john.sidoti@arcadis-us.com

ARCADIS U.S., Inc. | 222 South Main St., Suite 300 | Akron, OH, 44308
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Connect with us! www.arcadis-us.com | LinkedIn | Twitter | Facebook

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Please consider the environment before printing this email.

From: Lotycz, Matt
Sent: Wednesday, December 10, 2014 4:48 PM
To: O'Brien, Maureen; Baxter, Jonathan
Cc: Sidoti, John; Eckel, Caroline H.
Subject: RE: Utility Pad DWG File

Maureen and Jon – Couple of questions:

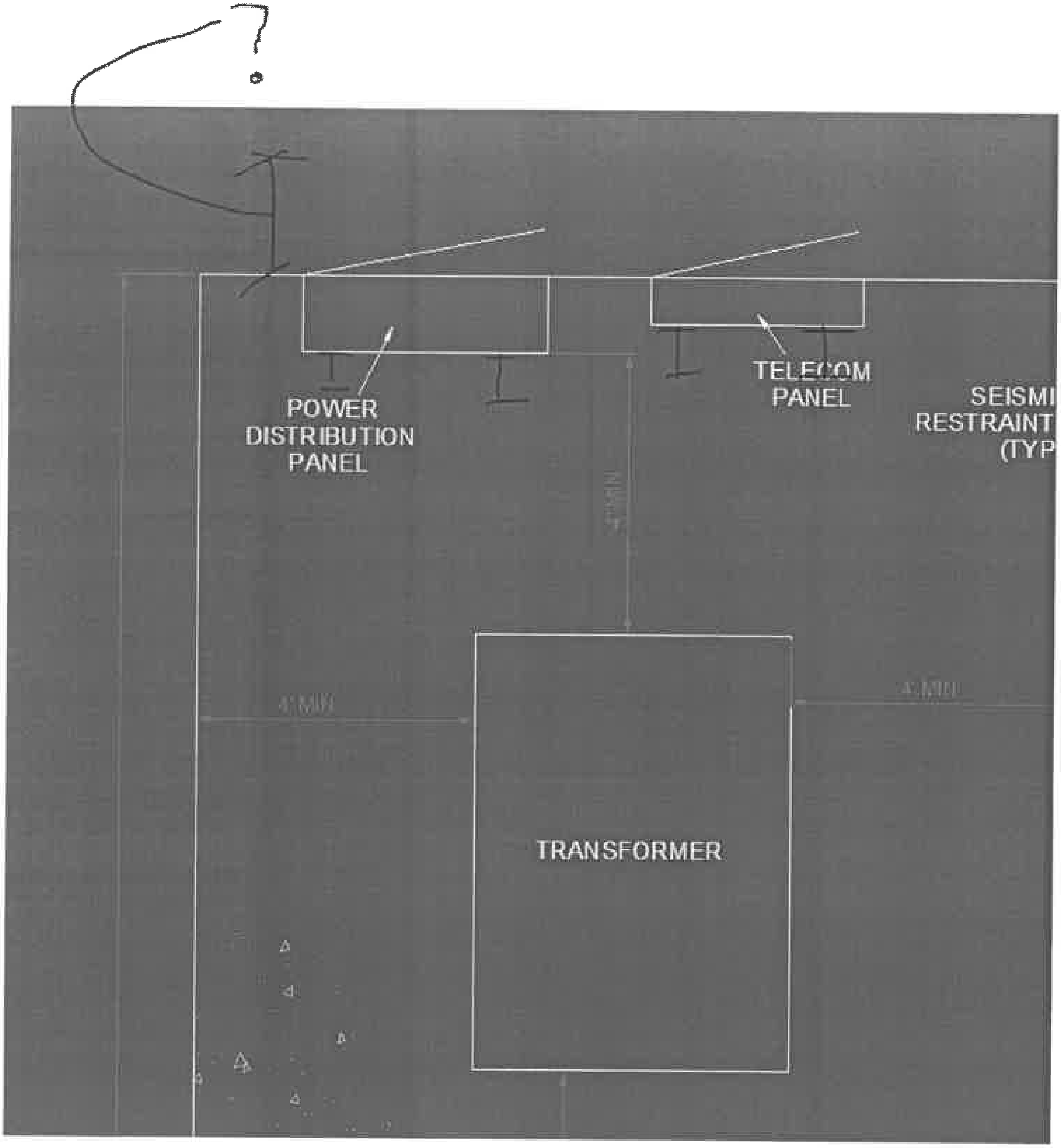
1. Just wanted to confirm if you are ok with the Power Distribution Panel and Telecom Panel sitting at the very edge of the Pad? I wasn't sure if you wanted 3'-0" of distance around (to the top side of those panels) those panels for "ease of maintenance (see attached screen image below).
2. Are all the tanks, pumps, transformer and generator all shown to scale per cutsheets?

Maureen and/or Carol - Can you get me a cutsheet on the 15,000 Fire Water Tank and Bladder tank by tomorrow morning. Need plan view size, section view, seismic anchorage and hold-downs and total weight. The only tank info I have received to date is the 5000 gal tanks from Caroline. Thanks.

John S - Can you get me a cutsheet on the transformer and generator by tomorrow morning. Need plan view size and weight.

Let me know as I will be getting started on this tomorrow. Thanks.

Matt



From: O'Brien, Maureen
Sent: Wednesday, December 10, 2014 4:37 PM
To: Lotycz, Matt
Cc: Baxter, Jonathan
Subject: Fw: Utility Pad DWG File

Utility Pad to use as an xref.

Let me know if you need anything else!

Thanks,
Maureen

From: Andy Wottrich <awottrich@eticeng.com>
Sent: Wednesday, December 10, 2014 3:35 PM
To: O'Brien, Maureen
Subject: RE: Utility Pad DWG File

Here you go...

Andy Wottrich
Corporate Support - CAD/Graphics Manager
awottrich@eticeng.com
www.eticeng.com
ETIC Engineering, Inc.
2285 Morello Ave.
Pleasant Hill, CA 94523
Tel: 925-602-4710 x2140
Fax: 925-602-4720
Mobile: 925-285-1075

From: O'Brien, Maureen [mailto:Maureen.O'Brien@arcadis-us.com]
Sent: Wednesday, December 10, 2014 1:28 PM
To: Andy Wottrich
Cc: Brent Searcy; Baxter, Jonathan; Lotycz, Matt
Subject: Utility Pad DWG File

Hi Andy,

We are looking to use the dwg of the utility pad as an xref for a structural drawing. Can you please send that our way?

Thank you!
Maureen

Maureen O'Brien | Remediation Specialist | Maureen.O'Brien@arcadis-us.com

ARCADIS U.S., Inc. | 126 N. Jefferson St., Suite 400 | Milwaukee, WI 53202
T: 414.277.6205
www.arcadis-us.com

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Reference:G:\Project\RC000753.0008\Dept\Structural\MathCAD\Seismic Calculations\Arcadis_Units.mcd(R)

Topok, California 15,000 Gal Tank Seismic Loads

References

American Institute of Steel Construction
AISC 13th edition construction manual.
AISC 360-05 Steel structure design specification.
American Society of Civil Engineers
ASCE 7-10
California Building Code
CBC 2013
USGS Seismic Design Maps -
http://earthquake.usgs.gov/hazards/designmaps/usdesign.php
Earthquake Hazard Program - Seismic Design Maps and Tools for Buildings
Ground Motion Parameter Calculator - Version 3.0.1, last updated 12 July 2012.
Performance Pipe
First Edition - Field Handbook, August 2009, Chevron Phillips Chemical Co.
American Water Works Association
AWWA D103-09 - Bolted Carbon Steel Tanks For Water Storage

Goal of this package of calculations

This set of calculations has been performed for the following purposes:

1. To calculate seismic response coefficients (C_s) that can be applied to 15,000 Gal tank operational weights to determine lateral load effects on anchorage due to seismic events.

Summary of Findings:

1. Calculations use ASCE 7-10 and AWWA D103-09 as two methods in determining seismic response coefficients (C_s).

Determine Acceleration Coefficients

Zip code of work: [redacted] Use with USGS ground motion calculator

$S_1 := 0.120$ $S_s := 0.23($

From ASCE 7, chapter 11 (below):

11.4.2 Site Class. Based on the site soil properties, the site shall be classified as Site Class A, B, C, D, E, or F in accordance with Chapter 20. Where the soil properties are not known in sufficient detail to determine the site class, Site Class D shall be used unless the authority having jurisdiction or geotechnical data determines Site Class E or F soils are present at the site.

Use Site Class "D"

ASCE 7-10 Table 11.4-2

Use

$F_v := 2.4$

ASCE 7-10 Table 11.4-1

Use

$F_a := 1.6$

$S_{DS} := \frac{2}{3} \cdot F_a \cdot S_s$ $S_{DS} = 0.25$

$S_{D1} := \frac{2}{3} \cdot F_v \cdot S_1$ $S_{D1} = 0.19$

Determine Seismic Design Category

ASCE 7-10 Table 11.6-1 & 2 SDC "C" for Sds and "D" for Sd1 ...nce occupancy IV $I_E := 1.5$

Analysis based on AWWA D103-09: Ground Supported Flat Bottom Tanks

See attached AWWA Standard

$D := 11.83ft$ Tank Diameter $V := 15000gal$ Tank Capacity

$$H := \frac{4 \cdot V}{\pi \cdot D^2}$$ Fluid height in Tank $H = 18.24\,ft$

$$T_c := 2 \cdot \pi \cdot \sqrt{\frac{D}{3.68 \cdot g \cdot \tanh\left(3.68 \cdot \frac{H}{D}\right)}}$$ $T_c = 1.99\,s$ First mode of sloshing wave period AWWA EQ 14-18

$T_L := 8s$ AWWA Figure 17 $T_s := \frac{S_{D1}}{S_{DS}} = 0.78$ s $C_t := .02$ $x := .75$

$T_a := C_t \cdot H^x$ $T_i := T_a$ $T_i = 0.145$ s

$0 < T_i < T_s$ $S_{ai} := S_{DS}$ per AWWA 14.2.8.6.1 $S_{ai} = 0.25$ ---Use

FYI T.s < T.i <T.L $S_{ai2} := \frac{S_{DS}}{T_i} = 1.69$ ▮ > ▮ = ▮ $S_{DS} = 0.25$ ---Use

$R_i := 3$ per AWWA table 6, Impulsive component of mechanically anchored tanks

$R_c := 1.5$ per AWWA table 6, Convective component of mechanically anchored tanks

$$A_i := \max\left(\frac{S_{ai} \cdot I_E}{1.4 \cdot R_i}, \frac{0.36 \cdot S_1 \cdot I_E}{R_i}\right)$$ $A_i = 0.09$ impulsive acceleration

$T_c < T_L$ $S_{ac} := \frac{1.5 \cdot S_{D1} \cdot 1s}{T_c}$ $S_{ac} = 0.15$ ▮ < ▮ $S_{DS} = 0.25$ AWWA EQ 14-12

$$A_c := \frac{S_{ac} \cdot I_E}{1.4 \cdot R_c}$$ $A_c = 0.1$ Convective acceleration

Use this value (Controls)

$C_{sAWWA} := \sqrt{A_i^2 + A_c^2}$ $C_{sAWWA} = 0.14$ Check this value against ASCE 7-10 per Chapter 15

Load analysis of Ground Supported Tanks containing Liquid: ASCE 7-10

Refer to ASCE 7-10, chapter 15

From 15.4.1b of ASCE 7

Non-building structures shall be designed in compliance with Sections 15.5 and 15.6 to resist minimum seismic lateral forces that are not less the requirements of Section 12.8 with the following additions and exceptions identified in 15.4.1-1 & 2.

Table 15.4-2 - Structures not similar to buildings

For Flat bottom tanks, Bolted Steel, see Design and Detailing Requirements of 15.7 $R := 3.0$ Mechanically anchored tank. See Table on next sheet.

Determine Fundamental Period of Tank:

$D = 11.83\text{ft}$ Tank Diameter

$V = 15000\text{gal}$ Tank Capacity

$H = 18.24\text{ft}$ Fluid height in Tank

$T := T_c$ $T = 1.99\text{s}$ Tank Period

$S_1 = 0.12$ $I_E = 1.5$ $R = 3$

Per ASCE 7-05 15.4.1.2 $C_{smin1} := .044 S_{DS} \cdot I_E = 0.02$ ASCE 7 EQ 15.4-1

which is greater than 0.03 MIN

$C_{smin2} := \dfrac{0.8 \cdot S_1}{\frac{R}{I_E}}$ $C_{smin2} = 0.05$ ASCE 7 EQ 15.4-2 Not Applicable

because $S_1 = 0.12$ $<$ $S_{1a} := 0.6$

$T_a := T \cdot \dfrac{1}{s}$ $T_a = 1.99$

From Section 12.8 ASCE 7-10 $C_s := \dfrac{S_{DS}}{\frac{R}{I_E}}$ $C_s = 0.12$

$R = 3$ $T_L := 12$ $C_{smax} := \dfrac{S_{D1}}{T_a \cdot \frac{R}{I_E}}$ $C_{smax} = 0.05$ ignore

Min Base Shear Force to foundation per 12.8 $V := C_s \cdot W$ $V = 0.12W$

Controlling Seismic Response Coefficient is Cs =0.14 of AWWA D103

$W_i := 127.675kip$ Operating Weight of EQ Tank (tank DL and water)

From Section 12.8 ASCE 7-10 $V := C_{sAWWA} \cdot W_i = 17.32 \cdot kip$

ASCE 7-10 Section 15.7.6

$(0 < T_i < T_s)$ $(S_{ai} := S_{DS})$ per ASCE 7-10 Eq 15.7-7 $(S_{ai}) = 0.25$

$T_c < T_L$ $S_{ac} := \frac{1.5 \cdot S_{D1} \cdot 1s}{T_c}$ per ASCE 7-10 Eq 15.7-10

$S_{ac} = 0.15$ $<$ $1.5x$ $S_{DS} = 0.25$

$W_i := 127.675kip$ Operating Weight of EQ Tank (tank DL and water)

$V_i := \frac{(S_{ai} \cdot W_i)}{\left(\frac{R}{I_E}\right)} = 15661.47\,lbf$ per ASCE 7-10 Eq 15.7-5

$W_c := 25.14kip$ Weight of Effective Mass of First Mode of Sloshing

$V_c := \frac{(S_{ac} \cdot I_E \cdot W_c)}{1.5} = 3645.5\,lbf$ per ASCE 7-10 Eq 15.7-6

Sesimic Base Shear = $V_t := \left(V_i^2 + V_c^2\right)^{0.5} = 16.08 \cdot kip$

Sum of the squares per ASCE 7-10 Section 15.7.6.1-e

Sliding Resistance (un-anchored) per ASCE 7-10 Eq 15.7-14

$V_t < W_t \tan(30deg)$ $W_t := 127.65kip$ $\tan(30deg) = 0.58$

$V_t = 16.08 \cdot kip$ $<$ $W_t \tan(30deg) = 73.7 \cdot kip$ OK

Job Title: Topok, CA - 15,000 Gal Fire Water Tank

Design of Water Storage Tanks in Seismic Regions

$I_E := 1.5$	*SEISMIC IMPORTANCE FACTOR*
$F_a := 1.6$	*SHORT PERIOD SITE COEFFICIENT*
$F_v := 2.4$	*LONG PERIOD SITE COEFFICIENT*
$S_s := 0.230$	*MAPPED MAX. CONSIDERED EARTHQUAKE SPECTRAL RESPONSE ACCELERATION AT 0.2 SEC PERIOD FOR SITE CLASS B*
$S_1 := 0.120$	*MAPPED MAX. CONSIDERED EARTHQUAKE SPECTRAL RESPONSE AT 1-SEC PERIOD FOR SITE CLASS B*
$S_{MS} := F_a \cdot S_s = 0.37$	*MAXIMIMUM CONSIDERED EARTHQUAKE SPECTRAL RESPONSE ACCELERATION AT 0.2 SEC PERIOD*
$S_{M1} := F_v \cdot S_1 = 0.29$	*MAXIMUM CONSIDERED EARTHQUAKE SPECTRAL RESPONSE ACCELERATION AT 1 SEC PERIOD*
$U := \frac{2}{3}$	*SCALING FACTOR TO SCALE THE MAX. CONSIDERED EARTHQUAKE RESPONSE ACCELERATION TO THE DESIGN RESPONSE ACCELERATION*
$S_{DS} := U \cdot S_{MS} = 0.25$	*DESIGN EARTHQUAKE SPECTRAL RESPONSE ACCELERATION AT 0.2-SEC PERIOD*
$S_{D1} := U \cdot S_{M1} = 0.19$	*DESIGN EARTHQUAKE SPECTRAL RESPONSE ACCELERATION AT 1-SEC PERIOD*

$T_s := \frac{S_{D1}}{S_{DS}} = 0.78$

$T_i := 0.145$ $T_L := 8$

$$S_{ai} := \begin{cases} S_{DS} & \text{if } 0 \le T_i \le T_s \\ \left(\frac{S_{D1}}{T_i}\right) & \text{if } T_s \le T_i \le T_L \\ \frac{T_L \cdot S_{D1}}{T_i^2} & \text{otherwise} \end{cases}$$

DESIGN SPECTRAL RESPONSE ACCELERATION FOR IMPULSIVE COMPONENTS AT THE NATURAL FREQUENCY OF THE STRUCTURE

$S_{ai} = 0.25$

$K := 1.5$

DAMPING SCALING FACTOR

$D := 11.83ft$ $Volume := 15000gal$ $H := \frac{4 \cdot Volume}{\pi \cdot D^2} = 18.24 \cdot ft$ $H_{tank} := 18.24ft$

$$T_c := \frac{1}{s} \cdot 2 \cdot \pi \cdot \sqrt{\frac{D}{3.68 \cdot g \cdot \tanh\left(\frac{3.68 \cdot H}{D}\right)}} = 1.99$$

$$S_{ac} := \begin{cases} \frac{K \cdot S_{D1}}{T_c} & \text{if } T_c \le T_L \\ \frac{K \cdot T_L \cdot S_{D1}}{T_c^2} & \text{otherwise} \end{cases}$$

DESIGN SPECTRAL RESPONSE ACCELERATION FOR THE CONVECTIVE COMPONENT AT THE FIRST MODE SLOSHING WAVE PERIOD

$S_{ac} = 0.15$

$R_i := 3$ $R_c := 1.5$ $G := 1.0$ *SPECIFIC GRAVITY OF WATER*

Mechanically-Anchored

$$A_i := \max\left[\left(\frac{S_{ai}\cdot I_E}{1.4\cdot R_i}\right),\left(\frac{0.36\cdot S_1\cdot I_E}{R_i}\right)\right] = 0.09$$

IMPULSIVE DESIGN ACCELERATION

$$A_c := \frac{S_{ac}\cdot I_E}{1.4\cdot R_c} = 0.1 \qquad \frac{D}{H} = 0.65 > 1.33$$

CONVECTIVE DESIGN ACCELERATION

$$W_t := 62.4\text{pcf}\cdot G\cdot H\cdot\left(\frac{\pi\cdot D^2}{4}\right) = 125.13\cdot\text{kip}$$

TOTAL WEIGHT OF TANK CONTENTS

$$W_c := 0.230\cdot\frac{D}{H}\cdot\tanh\left(3.67\cdot\frac{H}{D}\right)\cdot W_t = 18.66\cdot\text{kip}$$

WEIGHT OF EFFECTIVE MASS OF FIRST MODE OF SLOSHING

$$W_i := \begin{cases} \dfrac{\tanh\left(\dfrac{0.866\cdot D}{H}\right)}{\left(\dfrac{0.866\cdot D}{H}\right)}\cdot W_t & \text{if } \dfrac{D}{H} \geq 1.333 \\ W_t\left(1.0 - \dfrac{0.218\cdot D}{H}\right) & \text{otherwise} \end{cases}$$

WEIGHT OF EFFECTIVE MASS OF TANK CONTENTS THAT MOVES WITH TANK SHELL

$$W_i = 107.44\cdot\text{kip}$$

$$X_i := \begin{cases} 0.375\cdot H & \text{if } \dfrac{D}{H} \geq 1.333 \\ \left(0.5 - \dfrac{0.094\cdot D}{H}\right)\cdot H & \text{otherwise} \end{cases}$$

HEIGHT FROM BOTTOM OF SHELL TO CENTROID OF LATERAL SEISMIC FORCE APPLIED THROUGH THE IMPULSIVE WEIGHT

$$X_i = 8.01\cdot\text{ft}$$

$$X_c := \left[1.0 - \frac{\cosh\left(\dfrac{3.67\cdot H}{D}\right) - 1}{\left(\dfrac{3.67\cdot H}{D}\right)\cdot\sinh\left(\dfrac{3.67\cdot H}{D}\right)}\right]\cdot H = 15.04\cdot\text{ft}$$

HEIGHT FROM BOTTOM OF SHELL TO THE CENTROID OF LATERAL SEISMIC FORCE APPLIED TO THE EFFECTIVE CONVECTIVE WEIGHT

$$X_s := 0.5\cdot H_{tank} = 9.12\cdot\text{ft}$$

HEIGHT FROM BOTTOM OF SHELL TO CENTER OF MASS OF TANK

$W_s := 1.7kip$

$W_r := 400lbf$

$H_t := H_{tank} = 18.24 \cdot ft$

$$M_s := \sqrt{\left[A_i \cdot \left(W_s \cdot X_s + W_r \cdot H_t + W_i \cdot X_i\right)\right]^2 + \left(A_c \cdot W_c \cdot X_c\right)^2}$$

$M_s = 82.68 \cdot ft \cdot kip$

DESIGN OVERTURNING MOMENT AT THE BOTTOM OF THE SHELL CAUSED BY HORIZONTAL DESING ACCELERATION

WEIGHT OF TANK BOTTOM

$W_f := 400lbf$

$$X_{cmf} := \left[1.0 - \frac{\cosh\left(\frac{3.67 \cdot H}{D}\right) - 1.937}{\left(\frac{3.67 \cdot H}{D}\right) \sinh\left(\frac{3.67 \cdot H}{D}\right)}\right] \cdot H = 15.06 \cdot ft$$

HEIGHT FROM BOTTOM OF SHELL TO THE CENTROID OF THE EFFECTIVE CONVECTIVE WEIGHT ADIJUSTED TO FOR VARYING BOTTOM PRESSURES

$$V_F := \sqrt{\left[A_i \cdot \left(W_s + W_r + W_f + W_i\right)\right]^2 + \left[\left(A_c \cdot W_c\right)^2\right]}$$

$V_F = 9.82 \cdot kip$

DESIGN SHEAR AT THE TOP OF THE FOUNDATION DUE TO HORIZONTAL DESIGN ACCELERATION

$M_s = 82.68 \cdot ft \cdot kip$

DESIGN OVERTURNING MOMENT AT TOP OF THE FOUNDATION FOR TANKS SUPPORTED BY RINGWALL FOUNDATIONS

$$X_{imf} := \begin{cases} 0.375 \cdot \left[1.0 + 1.333 \left(\dfrac{0.866 \cdot \frac{D}{H}}{\tanh\left(\frac{0.866 \cdot D}{H}\right)} - 1.0 \right)\right] \cdot H & \text{if } \dfrac{D}{H} \geq 1.333 \\ \left[\left(0.50 + 0.06 \dfrac{D}{H}\right) H\right] & \text{otherwise} \end{cases}$$

$X_{imf} = 9.83 \cdot ft$

$$M_{mf} := \sqrt{\left[A_i \cdot \left(W_s \cdot X_s + W_r \cdot H_t + W_i \cdot X_{imf}\right)\right]^2 + \left(A_c \cdot W_c \cdot X_{cmf}\right)^2}$$

$M_{mf} = 98.93 \cdot ft \cdot kip$ *DESIGN OVERTURNING MOMENT AT TOP OF THE FOUNDATION FOR TANKS SUPPORTED BY MAT FOUNDATIONS*

OVERTURNING RATIO

$w_t := 45.7 plf$

the equations may not be meant to include units? as below

$G := 1 \quad t_b := .375 \quad F_y := 36000 \quad H := 18 \quad D := 11.83$

$w_L := 7.9 \cdot t_b \cdot \sqrt{(F_y \cdot H \cdot G)} = 2384.77 \qquad W_{Lmax} := 1.28 \cdot H \cdot D \cdot G = 272.56$

Therefore $w_{Luse} := 272.56 plf$

$A_v := 0.14 \cdot S_{DS} = 0.03$

$$J := \frac{M_s}{\left[D^2 \cdot \left[w_t \cdot (1 - .4 \cdot A_v) + w_{Luse}\right]\right]} = \blacksquare \cdot ft^2 \qquad 1.859 \blacksquare > \blacksquare \quad 0.785$$

Therefore, there is shell uplift due to overturning moment and the tank needs to be anchored into the slab

SLIDING CHECK

$$V_{allow} := \tan(30°) \cdot (W_s + W_r + W_i + W_c) \cdot (1 - 0.4 A_v) = 73 \cdot kip \qquad \blacksquare > \blacksquare \quad V_F = 9.82 \cdot kip$$

Therefore, allowable lateral shear is greater than design shear at the top of the foundation due to horizontal design acceleration V.F and therefore a self-anchored tank is acceptable

(15,000 GAL TANK CON'T)

WIND LOADS = $q_z = 0.00256\, K_z K_{zt} K_d V^2 = 28.30$ psf FACT

- K_z: 0.88 ~ 18 FT TABLE 29.3-1
- K_{zt}: FIGURE 26.8-1 (1.0)
- K_d: 0.95 ROUND - TABLE 26.6-1
- V: 115 mph

ASCE 7-10 CHAPT 29 - WIND LOADS ON OTHER STRUCTURES - MWFRS

$F = q_z G C_f A_f = (28.3\text{ psf})(0.85)(0.73)(11.83^F \times 19.3^F) = 4.01^K$ FACT   (G = 0.85)

FIGURE 29.5-1 ~ $D\sqrt{q_z} = 62.9 > 2.5$, $h/D = 1.63$, ROUGH, $C_f = 0.73$

LOAD COMBINATIONS (ASCE 7-10 - 2.4 ALLOWABLE & 2.3 FACTORED)

(2.4 ALLOWABLE LOADS)

(5) D + F + 0.7E → $(1.0 + 0.14 S_{DS})D + F + 0.7E$ =   (1,034; D = 2500#; F = 125,175#; 0.7 × 17.32K →)

= 127,760# ↓ & 12.12K → @ 18.5F/2 ARM

(7) 0.6D + 0.6W → 0.6(2500#)↓ + 0.6(4010#) →

= 1500# ↓ & 2406# → @ 19.3F/2 ARM

(8) 0.6D + 1.0F + 0.7E → $(0.6 - 0.14 S_{DS})D + 1.0F + 0.7E$

0.565D

= 126.59K ↓ & 12.12K → @ 18.5F/2 ARM

(2.3 FACTORED LOADS)

(5) 1.2D + 1.0F + 1.0E → $(1.2 + 0.2 S_{DS})D + 1.0F + 1.0E$ (1.249)

⇒ 128.28K ↓ & 17.32K → @ 18.5F/2 ARM

(6) 0.9D + 1.0W → 0.9(2500#)↓ + 1.0(4010#) →

2250# ↓ & 4010# →

(7) 0.9D + 0.9F + 1.0E → $[(0.9 - 0.2 S_{DS})D + F]$ CONSERV + 1.0E   (0.851)

= 110.78K ↓ & 17.32K @ 18.5FT/2 ARM

ARCADIS

SUBJECT: TOPOK- UTILITY PAD

JOB NO:

BY: MSL DATE: 12/19/14

CHKD: DATE:

PAGE H-8

SHEET 1

BEARING CAPACITY ~15,000 GAL TANK

- ASSUME 1'-2" THICK SLAB
- ASSUME 13'-2" SQ SLAB

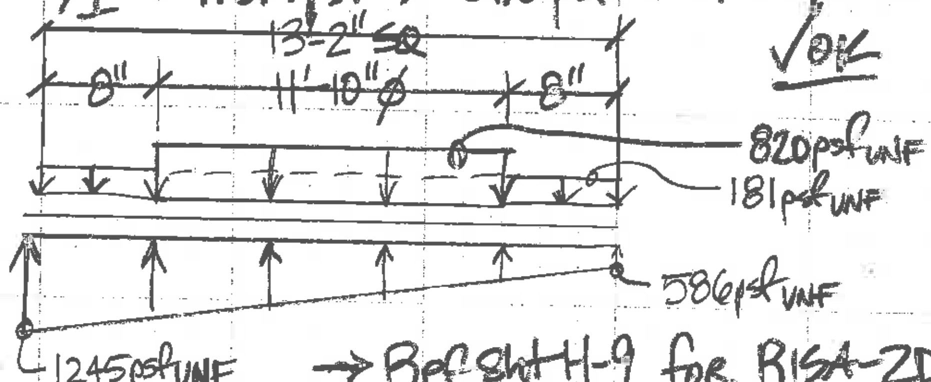
→ TANK FULL ~ (D+F+0.7E) = 127.76K ↓ & 12.12K →

- $M_{OT} = 12.12^K \rightarrow \times \left(\frac{18.5^{FT}}{2} + 1'\text{-}2''\right) = 126.25^{K\cdot FT}_{UNF}$ (10.42FT ARM)
- $\Sigma P = 127.76^K + [(13'\text{-}2'' SQ)^2 \times 1.167' \times 150 pcf \times 1.034] = 159.14^K \downarrow$
- $A = 173.37 FT^2$, $y = 6.584^{FT}$, $I = \frac{bh^3}{12} = 2504.76 FT^4$
- $q = P/A + \frac{My}{I} = 918 psf +/- 332 psf \rightarrow 1,245 ksf$ OR $0.586 ksf$

1500 psf ≥ NET ALLOWABLE √OK

→ TANK EMPTY (0.6D+0.6W)

- $M_{OT} = 2406^{\#} \times \left(\frac{19.3^{FT}}{2}\right)_{ARM} = 23.22^{K\cdot FT}$
- $\Sigma P = 1500^{\#} + (13.167 ft^2 \times 1.167^{FT} \times 150 pcf \times 0.6) = 19.71^K$
- $q = P/A +/- My/I = 113.7 psf +/- 61.0 psf \rightarrow 174.7 psf$ OR $52.7 psf$ √OK

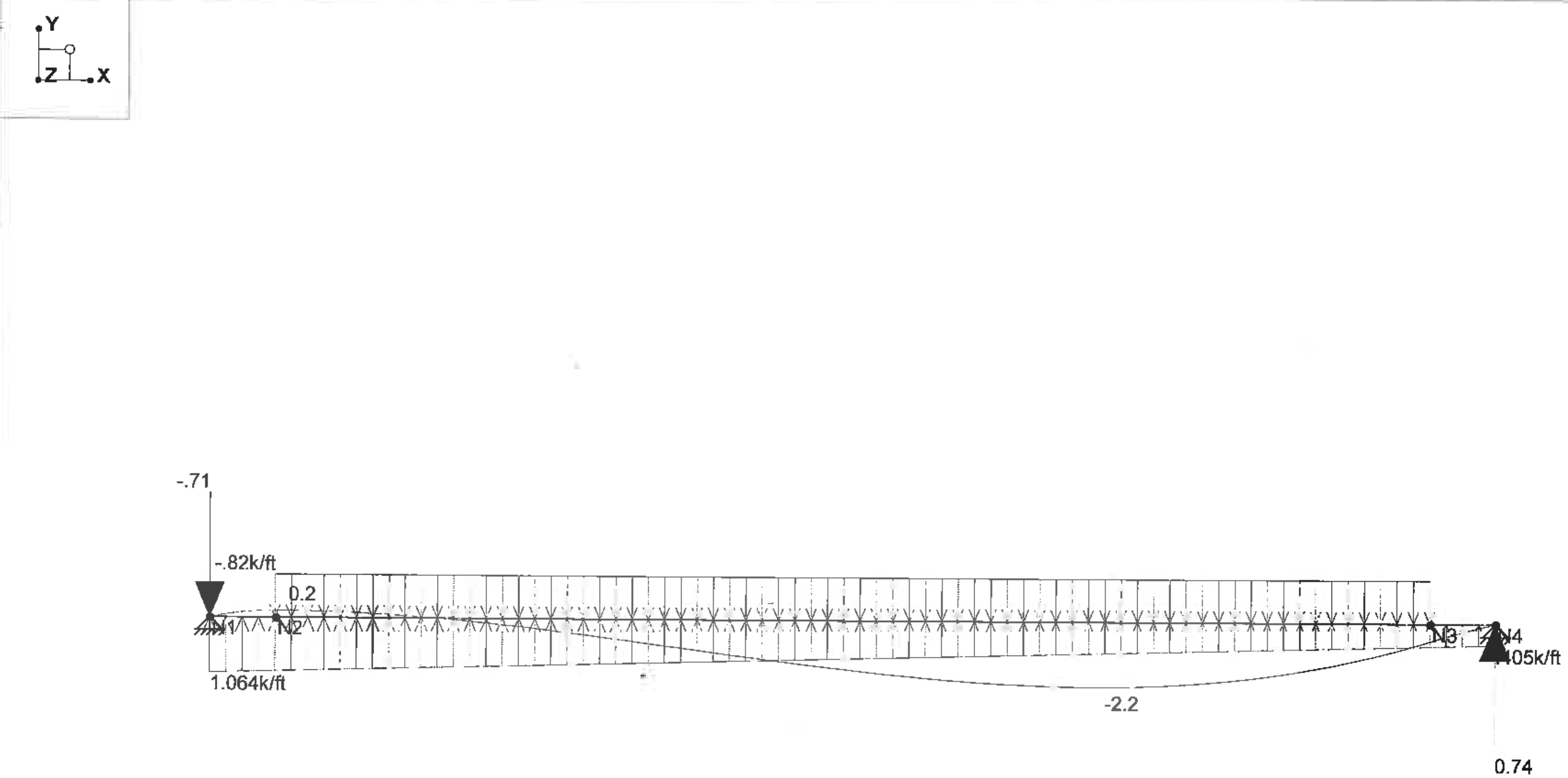


→ Ref Sht H-9 for RISA-2D
– CANtilever on 8" extensions ok by inspection

12.086K ~ 586psf = 7.716K
1245-586 4.3385
12.054
10.80K ↓ = 4.339 + 5.338
9.703 = 9.677K

AGM Form 30 12-01

H-9



Loads: LC 1, unf
Results for LC 1, unf
Member Bending Moments (k-ft)
Y-direction Reaction units are k and k-ft

SK - 2
Dec 19, 2014 at 1:18 PM
15000gallontankfoundation.r2d

Joint Coordinates and Temperatures

	Label	X [ft]	Y [ft]	Temp [F]
1	N1	0	0	0
2	N2	.67	0	0
3	N3	12.5	0	0
4	N4	13.167	0	0

Joint Boundary Conditions

	Joint Label	X [k/in]	Y [k/in]	Rotation[k-ft/rad]	Footing
1	N2				
2	N3				
3	N1	Reaction	Reaction		
4	N4	Reaction	Reaction		

Member Distributed Loads (BLC 1 : unf)

	Member Label	Direction	Start Magnitude[k/ft,F]	End Magnitude[k/ft,F]	Start Location[ft,%]	End Location[ft,%]
1	M1	Y	1.245	.586	0	%100
2	M1	Y	-.181	-.181	0	%100
3	M1	Y	-.82	-.82	.667	12.5

Load Combinations

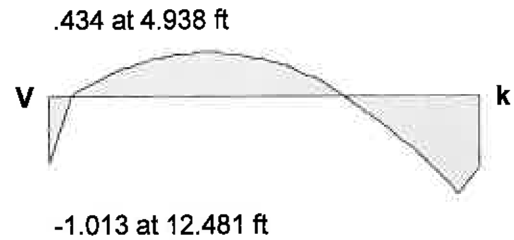
	Description	Sol...	PD...	SR...	BLC	Factor	BLC	Factor	BLC	Factor	BLC	Factor	BLC	Factor	BLC	Factor	BLC	Factor	BLC	Factor
1	unf	Yes			1	1														

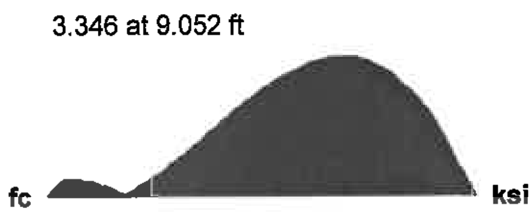
Load Combination Design

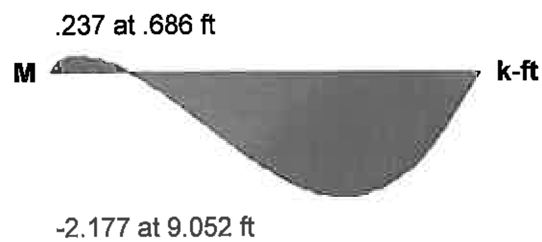
	Description	ASIF	CD	ABIF	Service	Hot Rolled	Cold Form...	Wood	Concrete	Masonry	Footings	Aluminum
1	unf					Yes	Yes	Yes	Yes	Yes	Yes	Yes

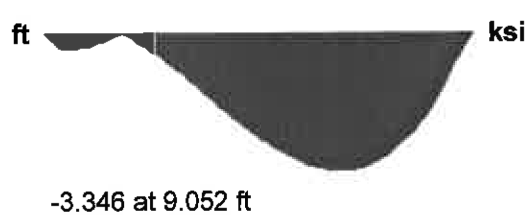
Beam: ***M1***

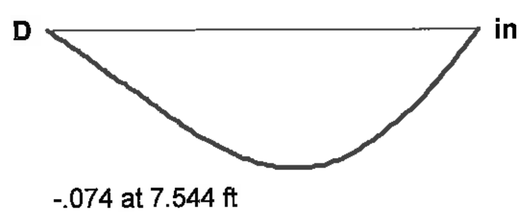
Shape: **W8x10**
Material: **A36 Gr.36**
Length: **13.167 ft**
I Joint: **N1**
J Joint: **N4**
LC 1: unf
Code Check: **No Calc**
Report Based On 97 Sections











AISC 14th(360-10): ASD Code Check

Direct Analysis Method

- P-Delta analysis required for all AISC 360-10 Load Combinations -

Max Defl Ratio **L/2140**

~ BY INSPECTION ~ 1'-2" THICK W/ #5 @ 10" c/c (@ 3" COVER BOT & 2" COVER TOP) IS SUFFICIENT FOR $M_{UNF} = 2.18^{K \cdot FT}$ & $V_{UNF} = 1.01$ (d = 10.1", d = 11.1")

~ ACI 350 T&S SHRINK REQ'S ~ POURS OF 33' & 30'

$$A_{S\,REQ'D} = \frac{0.004bh}{2\ \text{FACES}} = 0.34\ \text{IN}^2/\text{FT} < \#5 @ 10" c/c\ (A_s = 0.37\ \text{IN}^2/\text{FT})$$

~ GRAVITY LOADS = $127.76^K \downarrow / \left(\frac{\pi \times 11.83 FT^2}{4}\right) = 1162\ psf < 1325\ psf$ ✓OK

1500 psf − (1.167' × 150 pcf)

TANK ANCHORAGE

(4) − 3/4"Ø ADHESIVE ANCHORS (1 PER CLIP ANGLE)

$V_{REQ'D} = 12.12^K / 4\ \text{ANCHORS} = 3.03^K_{UNF},\ 4.33^K_{ACI}$

• LC#8 UNF ~ 0.6DHF + 0.7E (SEISMIC) → $M_{OT} = 12.12^K \times \left(\frac{18.5 FT}{2}\right)_{ARM} = 112.11^{K \cdot FT}_{UNF}$

$M_{RES} = 126.59^K \times \left(\frac{11.83 FT}{2}\ \text{TANK Ø}\right) = 748.99^K_{UNF}$

∴ $M_R > M_{OT}$ ~ NO TENSION IN ANCHORS $FS_{OVERTURNING} = 6.7 > 1.5$ ✓OK

• LC#7 ~ 0.6D + 0.6W (WIND) → $M_{OT} = 2.406^K \times \left(\frac{19.3 FT}{2}\right)_{ARM} = 23.22^{K \cdot FT}$

$M_{RES} = 1500^{\#} \times \left(\frac{11.83 FT}{2}\right) = 8.87^{K \cdot FT}$

~ SINCE $M_{OT} > M_{RES}$ ~ TENSION IN ANCHORS

$$T_{REQ'D} = \frac{(M_{OT} \times 1.5\ SF) - M_{RES}}{2\ \text{TENSION} \times 11.83 FT} = 2.19^K_{UNF} \times \left(\frac{1.0W}{0.6W}\right)$$

$= 3.66^K_{ACI}$ REQ'D IN (2) − 3/4"Ø HILTI SD-500 ADHESIVE ANCHORS

PER TENSION CABLE STRAP

$$V_{REQ'D} = \frac{2.406^K}{4\ \text{ANCHORS}} = 0.60^K_{UNF},\ 1.01^K_{ACI}$$ ← 4 CLIP ANGLES (1) 3/4"Ø ADHESIVE ANCHOR PER CLIP ANGLE

(TANK ANCHORAGE CON'T)

- LC#7 – 0.9D+0.9F+1.0E = 110.78^K ↓ & 17.32^K @ $\frac{18.5^F}{2}$ ARM
  - $V_{DES} = \frac{17.32^K}{4 \text{ ANCHORS}} = \underline{4.33^K_{ACI}}$ ← (1) 3/4"ø ADHESIVE ANCHOR PER 4 CLIP ANGLES
  - $M_{OT} = 17.32^K \times \left(\frac{18.5^F}{2}\right)_{ARM} = 160.2^{K \cdot F}$
  - $M_{RES} = 110.78^K \times \frac{11.83^F}{2} = 655.4^{K \cdot F}$ ~ FS = 4.09 > 1.5 ✓OK

~ NO TENSION IN ANCHORS

H-12

Company:	ARCADIS	Page:	1
Specifier:	Matt Lotycz	Project:	Topok, CA PG&E - HQ
Address:		Sub-Project I Pos. No.:	HQ Utility Pad
Phone I Fax:	|	Date:	12/22/2014
E-Mail:			

Specifier's comments: 15,000 Gal Tank Anchorage - Max Wind Uplift with shear

1 Input data

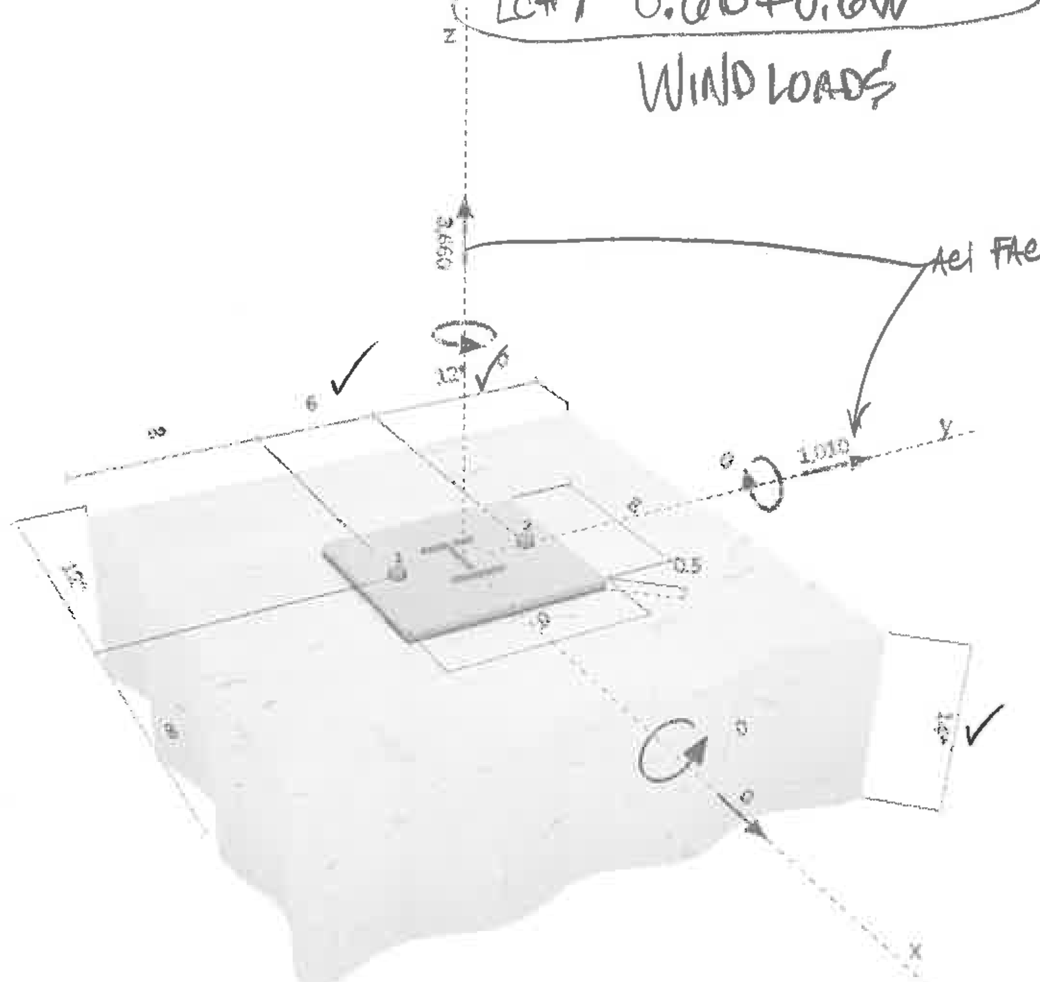
Anchor type and diameter:	**HIT-RE 500-SD + HAS 3/4**
Effective embedment depth:	$h_{ef,act}$ = 10.000 in. ($h_{ef,limit}$ = - in.)
Material:	5.8
Evaluation Service Report:	ESR-2322
Issued I Valid:	2/1/2014 | 4/1/2016
Proof:	design method ACI 318-11 / Chem
Stand-off installation:	e_b = 0.000 in. (no stand-off); t = 0.500 in.
Anchor plate:	l_x x l_y x t = 8.000 in. x 9.000 in. x 0.500 in.; (Recommended plate thickness: not calculated)
Profile:	S shape (AISC); (L x W x T x FT) = 3.000 in. x 2.330 in. x 0.170 in. x 0.260 in.
Base material:	cracked concrete, 4000, f_c' = 4000 psi; h = 14.000 in., Temp. short/long: 130/110 °F
Installation:	hammer drilled hole, installation condition: dry
Reinforcement:	tension: condition B, shear: condition B; no supplemental splitting reinforcement present edge reinforcement: > No. 4 bar

SAME CAPACITY FOR 316SST

Geometry [in.] & Loading [lb, in.lb]

LC#7 0.6D+0.6W

WIND LOADS



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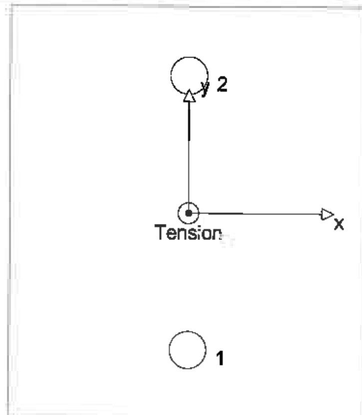
2 Load case/Resulting anchor forces

Load case: Design loads

Anchor reactions [lb]
Tension force: (+Tension, -Compression)

Anchor	Tension force	Shear force	Shear force x	Shear force y
1	1830	505	0	505
2	1830	505	0	505

max. concrete compressive strain: - [‰]
max. concrete compressive stress: - [psi]
resulting tension force in (x/y)=(0.000/0.000): 3660 [lb]
resulting compression force in (x/y)=(0.000/0.000): 0 [lb]



3 Tension load

	Load N_{ua} [lb]	Capacity ϕN_n [lb]	Utilization $\beta_N = N_{ua}/\phi N_n$	Status
Steel Strength*	1830	15762	12	OK
Bond Strength**	3660	7917	47	OK
Sustained Tension Load Bond Strength*	N/A	N/A	N/A	N/A
Concrete Breakout Strength**	3660	20566	18	OK

* anchor having the highest loading **anchor group (anchors in tension)

3.1 Steel Strength

N_{sa} = ESR value refer to ICC-ES ESR-2322
$\phi N_{steel} \geq N_{ua}$ ACI 318-11 Table D.4.1.1

Variables

n	$A_{se,N}$ [in.^{2}]	f_{uta} [psi]
1	0.33	72500

Calculations

N_{sa} [lb]
24250

Results

N_{sa} [lb]	ϕ_{steel}	ϕN_{sa} [lb]	N_{ua} [lb]
24250	0.650	15762	1830

Company:	ARCADIS	Page:	3
Specifier:	Matt Lotycz	Project:	Topok, CA PG&E - HQ
Address:		Sub-Project I Pos. No.:	HQ Utility Pad
Phone I Fax:	|	Date:	12/22/2014
E-Mail:			

3.2 Bond Strength

$N_{ag} = \left(\frac{A_{Na}}{A_{Na0}}\right) \psi_{ec1,Na}\, \psi_{ec2,Na}\, \psi_{ed,Na}\, \psi_{cp,Na}\, N_{ba}$ — ACI 318-11 Eq. (D-19)

$\phi\, N_{ag} \geq N_{ua}$ — ACI 318-11 Table D.4.1.1

A_{Na} = see ACI 318-11, Part D.5.5.1, Fig. RD.5.5.1(b)

$A_{Na0} = (2\, c_{Na})^2$ — ACI 318-11 Eq. (D-20)

$c_{Na} = 10\, d_a \sqrt{\frac{\tau_{uncr}}{1100}}$ — ACI 318-11 Eq. (D-21)

$\psi_{ec,Na} = \left(\frac{1}{1 + \frac{e_N}{c_{Na}}}\right) \leq 1.0$ — ACI 318-11 Eq. (D-23)

$\psi_{ed,Na} = 0.7 + 0.3 \left(\frac{c_{a,min}}{c_{Na}}\right) \leq 1.0$ — ACI 318-11 Eq. (D-25)

$\psi_{cp,Na} = MAX\left(\frac{c_{a,min}}{c_{ac}}, \frac{c_{Na}}{c_{ac}}\right) \leq 1.0$ — ACI 318-11 Eq. (D-27)

$N_{ba} = \lambda_a \cdot \tau_{k,c} \cdot \kappa_{bond} \cdot \pi \cdot d_a \cdot h_{ef}$ — ACI 318-11 Eq. (D-22)

Variables

$\tau_{k,c,uncr}$ [psi]	d_a [in.]	h_{ef} [in.]	$c_{a,min}$ [in.]	$\tau_{k,c}$ [psi]
715	0.750	10.000	12.000	345

$e_{c1,N}$ [in.]	$e_{c2,N}$ [in.]	c_{ac} [in.]	κ_{bond}	λ_a
0.000	0.000	17.469	1.00	1.000

Calculations

c_{Na} [in.]	A_{Na} [in.^{2}]	A_{Na0} [in.^{2}]	$\psi_{ed,Na}$
6.019	217.17	144.93	1.000

$\psi_{ec1,Na}$	$\psi_{ec2,Na}$	$\psi_{cp,Na}$	N_{ba} [lb]
1.000	1.000	1.000	8129

Results

N_{ag} [lb]	ϕ_{bond}	$\phi\, N_{ag}$ [lb]	N_{ua} [lb]
12180	0.650	7917	3660

3.3 Concrete Breakout Strength

$N_{cbg} = \left(\frac{A_{Nc}}{A_{Nc0}}\right) \psi_{ec,N}\, \psi_{ed,N}\, \psi_{c,N}\, \psi_{cp,N}\, N_b$ — ACI 318-11 Eq. (D-4)

$\phi\, N_{cbg} \geq N_{ua}$ — ACI 318-11 Table D.4.1.1

A_{Nc} see ACI 318-11, Part D.5.2.1, Fig. RD.5.2.1(b)

$A_{Nc0} = 9\, h_{ef}^2$ — ACI 318-11 Eq. (D-5)

$\psi_{ec,N} = \left(\frac{1}{1 + \frac{2\, e_N}{3\, h_{ef}}}\right) \leq 1.0$ — ACI 318-11 Eq. (D-8)

$\psi_{ed,N} = 0.7 + 0.3 \left(\frac{c_{a,min}}{1.5 h_{ef}}\right) \leq 1.0$ — ACI 318-11 Eq. (D-10)

$\psi_{cp,N} = MAX\left(\frac{c_{a,min}}{c_{ac}}, \frac{1.5 h_{ef}}{c_{ac}}\right) \leq 1.0$ — ACI 318-11 Eq. (D-12)

$N_b = k_c\, \lambda_a \sqrt{f'_c}\, h_{ef}^{1.5}$ — ACI 318-11 Eq. (D-6)

Variables

h_{ef} [in.]	$e_{c1,N}$ [in.]	$e_{c2,N}$ [in.]	$c_{a,min}$ [in.]	$\psi_{c,N}$
10.000	0.000	0.000	12.000	1.000

c_{ac} [in.]	k_c	λ_a	f'_c [psi]
17.469	17	1.000	4000

Calculations

A_{Nc} [in.^{2}]	A_{Nc0} [in.^{2}]	$\psi_{ec1,N}$	$\psi_{ec2,N}$	$\psi_{ed,N}$	$\psi_{cp,N}$	N_b [lb]
891.00	900.00	1.000	1.000	0.940	1.000	34000

Results

N_{cbg} [lb]	$\phi_{concrete}$	$\phi\, N_{cbg}$ [lb]	N_{ua} [lb]
31640	0.650	20566	3660

Input data and results must be checked for agreement with the existing conditions and for plausibility!
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4 Shear load

	Load V_{ua} [lb]	Capacity ϕV_n [lb]	Utilization $\beta_V = V_{ua}/\phi V_n$	Status
Steel Strength*	505	8730	6	OK
Steel failure (with lever arm)*	N/A	N/A	N/A	N/A
Pryout Strength (Bond Strength controls)**	1010	17052	6	OK
Concrete edge failure in direction y+**	1010	13147	8	OK

* anchor having the highest loading **anchor group (relevant anchors)

4.1 Steel Strength

$V_{sa} = (n\ 0.6\ A_{se,V}\ f_{uta})$ refer to ICC-ES ESR-2322

$\phi V_{steel} \geq V_{ua}$ ACI 318-11 Table D.4.1.1

Variables

n	$A_{se,V}$ [in.^{2}]	f_{uta} [psi]	$(n\ 0.6\ A_{se,V}\ f_{uta})$ [lb]
1	0.33	72500	14550

Calculations

V_{sa} [lb]
14550

Results

V_{sa} [lb]	ϕ_{steel}	ϕV_{sa} [lb]	V_{ua} [lb]
14550	0.600	8730	505

4.2 Pryout Strength (Bond Strength controls)

$V_{cpg} = k_{cp}\left[\left(\frac{A_{Na}}{A_{Na0}}\right)\psi_{ec1,Na}\ \psi_{ec2,Na}\ \psi_{ed,Na}\ \psi_{cp,Na}\ N_{ba}\right]$ ACI 318-11 Eq. (D-41)

$\phi V_{cpg} \geq V_{ua}$ ACI 318-11 Table (D.4.1.1)

A_{Na} see ACI 318-11, Part D.5.5.1, Fig. RD.5.5.1(b)

$A_{Na0} = (2\ c_{Na})^2$ ACI 318-11 Eq. (D-20)

$c_{Na} = 10\ d_a \sqrt{\frac{\tau_{uncr}}{1100}}$ ACI 318-11 Eq. (D-21)

$\psi_{ec,Na} = \left(\frac{1}{1 + \frac{e_N}{c_{Na}}}\right) \leq 1.0$ ACI 318-11 Eq. (D-23)

$\psi_{ed,Na} = 0.7 + 0.3\left(\frac{c_{a,min}}{c_{ac}}\right) \leq 1.0$ ACI 318-11 Eq. (D-25)

$\psi_{cp,Na} = \mathrm{MAX}\left(\frac{c_{a,min}}{c_{ac}}, \frac{c_{Na}}{c_{ac}}\right) \leq 1.0$ ACI 318-11 Eq. (D-27)

$N_{ba} = \lambda_a \cdot \tau_{k,c} \cdot \kappa_{bond} \cdot \pi \cdot d_a \cdot h_{ef}$ ACI 318-11 Eq. (D-22)

Variables

k_{cp}	$\tau_{k,c,uncr}$ [psi]	d_a [in.]	h_{ef} [in.]	$c_{a,min}$ [in.]	$\tau_{k,c}$ [psi]
2	715	0.750	10.000	12.000	345

$e_{c1,N}$ [in.]	$e_{c2,N}$ [in.]	c_{ac} [in.]	κ_{bond}	λ_a
0.000	0.000	17.469	1.00	1.000

Calculations

c_{Na} [in.]	A_{Na} [in.^{2}]	A_{Na0} [in.^{2}]	$\psi_{ed,Na}$
6.019	217.17	144.93	1.000

$\psi_{ec1,Na}$	$\psi_{ec2,Na}$	$\psi_{cp,Na}$	N_{ba} [lb]
1.000	1.000	1.000	8129

Results

V_{cpg} [lb]	$\phi_{concrete}$	ϕV_{cpg} [lb]	V_{ua} [lb]
24360	0.700	17052	1010

Input data and results must be checked for agreement with the existing conditions and for plausibility!
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Specifier: Matt Lotycz
Address:
Phone I Fax: |
E-Mail:

4.3 Concrete edge failure in direction y+

$V_{cbg} = \left(\frac{A_{Vc}}{A_{Vc0}}\right) \psi_{ec,V}\ \psi_{ed,V}\ \psi_{c,V}\ \psi_{h,V}\ \psi_{parallel,V}\ V_b$ ACI 318-11 Eq. (D-31)

$\phi\ V_{cbg} \geq V_{ua}$ ACI 318-11 Table D.4.1.1

A_{Vc} see ACI 318-11, Part D.6.2.1, Fig. RD.6.2.1(b)

$A_{Vc0} = 4.5\ c_{a1}^2$ ACI 318-11 Eq. (D-32)

$\psi_{ec,V} = \left(\frac{1}{1 + \frac{2e_V}{3c_{a1}}}\right) \leq 1.0$ ACI 318-11 Eq. (D-36)

$\psi_{ed,V} = 0.7 + 0.3\left(\frac{c_{a2}}{1.5c_{a1}}\right) \leq 1.0$ ACI 318-11 Eq. (D-38)

$\psi_{h,V} = \sqrt{\frac{1.5c_{a1}}{h_a}} \geq 1.0$ ACI 318-11 Eq. (D-39)

$V_b = 9\ \lambda_a\ \sqrt{f'_c}\ c_{a1}^{1.5}$ ACI 318-11 Eq. (D-34)

Variables

c_{a1} [in.]	c_{a2} [in.]	e_{cV} [in.]	$\psi_{c,V}$	h_a [in.]
12.000	12.000	0.000	1.200	14.000

l_e [in.]	λ_a	d_a [in.]	f'_c [psi]	$\psi_{parallel,V}$
6.000	1.000	0.750	4000	1.000

Calculations

A_{Vc} [in.^{2}]	A_{Vc0} [in.^{2}]	$\psi_{ec,V}$	$\psi_{ed,V}$	$\psi_{h,V}$	V_b [lb]
420.00	648.00	1.000	0.900	1.134	23662

Results

V_{cbg} [lb]	$\phi_{concrete}$	$\phi\ V_{cbg}$ [lb]	V_{ua} [lb]
18781	0.700	13147	1010

5 Combined tension and shear loads

β_N	β_V	ζ	Utilization $\beta_{N,V}$ [%]	Status
0.462	0.077	5/3	30	OK

$\beta_{NV} = \beta_N^{\zeta} + \beta_V^{\zeta} <= 1$

6 Warnings

- Load re-distributions on the anchors due to elastic deformations of the anchor plate are not considered. The anchor plate is assumed to be sufficiently stiff, in order not to be deformed when subjected to the loading!
- Condition A applies when supplementary reinforcement is used. The Φ factor is increased for non-steel Design Strengths except Pullout Strength and Pryout strength. Condition B applies when supplementary reinforcement is not used and for Pullout Strength and Pryout Strength. Refer to your local standard.
- Design Strengths of adhesive anchor systems are influenced by the cleaning method. Refer to the INSTRUCTIONS FOR USE given in the Evaluation Service Report for cleaning and installation instructions
- Checking the transfer of loads into the base material and the shear resistance are required in accordance with ACI 318 or the relevant standard!
- Installation of Hilti adhesive anchor systems shall be performed by personnel trained to install Hilti adhesive anchors. Reference ACI 318-11, Part D.9.1

Fastening meets the design criteria!

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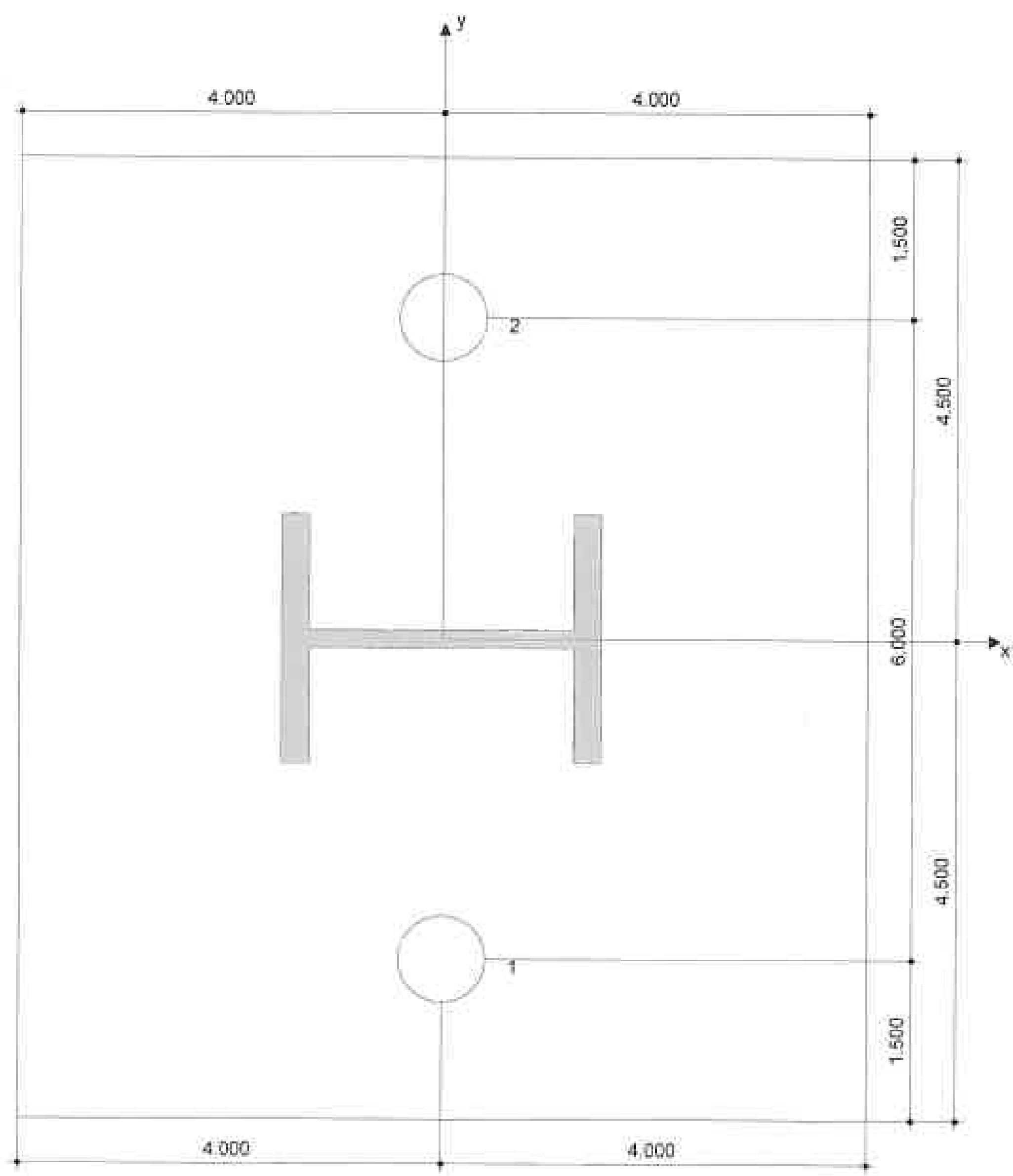
Specifier:	Matt Lotycz	Project:	Topok, CA PG&E - HQ
Address:		Sub-Project I Pos. No.:	HQ Utility Pad
Phone I Fax:	|	Date:	12/22/2014
E-Mail:			

7 Installation data

Anchor plate, steel: -
Profile: S shape (AISC); 3.000 x 2.330 x 0.170 x 0.260 in.
Hole diameter in the fixture: d_f = 0.813 in.
Plate thickness (input): 0.500 in.
Recommended plate thickness: not calculated
Cleaning: Premium cleaning of the drilled hole is required

Anchor type and diameter: HIT-RE 500-SD + HAS 3/4
Installation torque: 1200.000 in.lb
Hole diameter in the base material: 0.875 in.
Hole depth in the base material: 10.000 in.
Minimum thickness of the base material: 11.750 in.



Coordinates Anchor in.

Anchor	x	y	c_{-x}	c_{+x}	c_{-y}	c_{+y}
1	0.000	-3.000	12.000	-	-	18.000
2	0.000	3.000	12.000	-	-	12.000

Input data and results must be checked for agreement with the existing conditions and for plausibility!
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- You must take all necessary and reasonable steps to prevent or limit damage caused by the Software. In particular, you must arrange for the regular backup of programs and data and, if applicable, carry out the updates of the Software offered by Hilti on a regular basis. If you do not use the AutoUpdate function of the Software, you must ensure that you are using the current and thus up-to-date version of the Software in each case by carrying out manual updates via the Hilti Website. Hilti will not be liable for consequences, such as the recovery of lost or damaged data or programs, arising from a culpable breach of duty by you.

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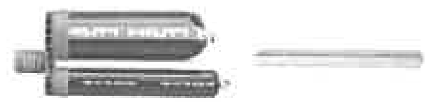
Specifier:		Project:	Topok, CA PG&E - HQ
Address:		Sub-Project I Pos. No.:	HQ Utility Pad
Phone I Fax:	|	Date:	12/22/2014
E-Mail:			

Specifier's comments: 15,000 Gal Tank Anchorage - Max Seismic Shear

1 Input data



Anchor type and diameter:	HIT-RE 500-SD + HAS B7 3/4
Effective embedment depth:	$h_{ef,act}$ = 10.000 in. ($h_{ef,limit}$ = - in.)
Material:	ASTM A 193 Grade B7
Evaluation Service Report:	ESR-2322
Issued I Valid:	2/1/2014 | 4/1/2016
Proof:	design method ACI 318-11 / Chem
Stand-off installation:	e_b = 0.000 in. (no stand-off); t = 0.500 in.
Anchor plate:	l_x x l_y x t = 8.000 in. x 9.000 in. x 0.500 in.; (Recommended plate thickness: not calculated)
Profile:	S shape (AISC); (L x W x T x FT) = 3.000 in. x 2.330 in. x 0.170 in. x 0.260 in.
Base material:	cracked concrete, 4000, f_c' = 4000 psi; h = 14.000 in., Temp. short/long: 130/110 °F
Installation:	hammer drilled hole, installation condition: dry
Reinforcement:	tension: condition B, shear: condition B; no supplemental splitting reinforcement present edge reinforcement: ≥ No. 4 bar ✓
Seismic loads (cat. C, D, E, or F)	Tension load: yes (D.3.3.4.3 (d)) ✓ Shear load: yes (D.3.3.5.3 (c))

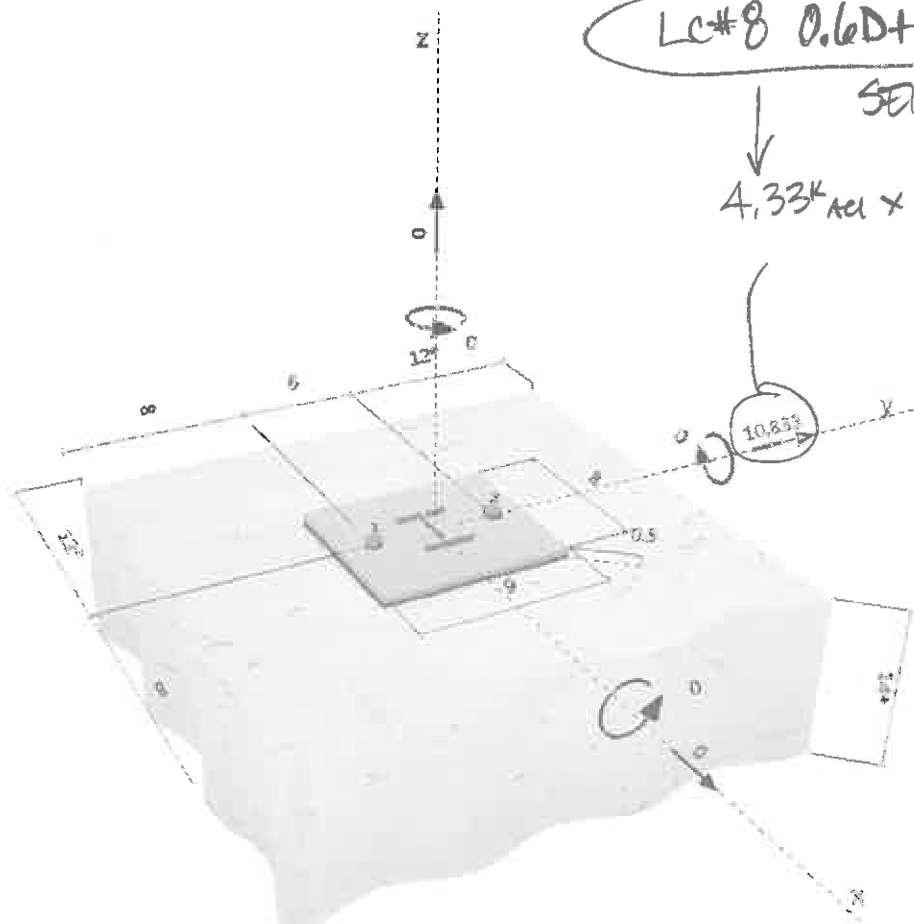
FYI 316SST ~ SAME CAPACITY

Geometry [in.] & Loading [lb, in.lb]

LC#8 0.6D+1.0F+0.7E

SEISMIC LOADS

4.33K ACI x 2.5 Ω OVERSTRENGTH



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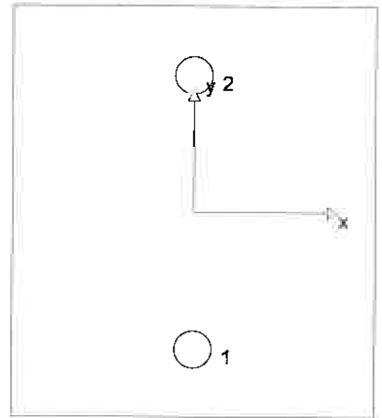
2 Load case/Resulting anchor forces

Load case: Design loads

Anchor reactions [lb]
Tension force: (+Tension, -Compression)

Anchor	Tension force	Shear force	Shear force x	Shear force y
1	0	5417	0	5417
2	0	5417	0	5417

max. concrete compressive strain: - [‰]
max. concrete compressive stress: - [psi]
resulting tension force in (x/y)=(0.000/0.000): 0 [lb]
resulting compression force in (x/y)=(0.000/0.000): 0 [lb]



3 Tension load

	Load N_{ua} [lb]	Capacity ϕN_n [lb]	Utilization $\beta_N = N_{ua}/\phi N_n$	Status
Steel Strength*	N/A	N/A	N/A	N/A
Bond Strength**	N/A	N/A	N/A	N/A
Sustained Tension Load Bond Strength*	N/A	N/A	N/A	N/A
Concrete Breakout Strength**	N/A	N/A	N/A	N/A

* anchor having the highest loading **anchor group (anchors in tension)

Input data and results must be checked for agreement with the existing conditions and for plausibility!
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4 Shear load

	Load V_{ua} [lb]	Capacity ϕV_n [lb]	Utilization $\beta_V = V_{ua}/\phi V_n$	Status
Steel Strength*	5417	11414	48	OK
Steel failure (with lever arm)*	N/A	N/A	N/A	N/A
Pryout Strength (Bond Strength controls)**	10833	11084	98	OK
Concrete edge failure in direction y+**	10833	13147	83	OK

* anchor having the highest loading **anchor group (relevant anchors)

4.1 Steel Strength

$V_{sa} = \alpha_{V,seis}\,(n\ 0.6\ A_{se,V}\ f_{uta})$ refer to ICC-ES ESR-2322

$\phi\ V_{steel} \geq V_{ua}$ ACI 318-11 Table D.4.1.1

Variables

n	$A_{se,V}$ [in.^{2}]	f_{uta} [psi]	$\alpha_{V,seis}$	$(n\ 0.6\ A_{se,V}\ f_{uta})$ [lb]
1	0.33	125000	0.700	25086

Calculations

$V_{sa,eq}$ [lb]
17560

Results

$V_{sa,eq}$ [lb]	ϕ_{steel}	$\phi\ V_{sa}$ [lb]	V_{ua} [lb]
17560	0.650	11414	5417

4.2 Pryout Strength (Bond Strength controls)

$V_{cpg} = k_{cp}\left[\left(\frac{A_{Na}}{A_{Na0}}\right)\psi_{ec1,Na}\ \psi_{ec2,Na}\ \psi_{ed,Na}\ \psi_{cp,Na}\ N_{ba}\right]$ ACI 318-11 Eq. (D-41)

$\phi\ V_{cpg} \geq V_{ua}$ ACI 318-11 Table (D.4.1.1)

A_{Na} see ACI 318-11, Part D.5.5.1, Fig. RD.5.5.1(b)

$A_{Na0} = (2\ c_{Na})^2$ ACI 318-11 Eq. (D-20)

$c_{Na} = 10\ d_a\sqrt{\frac{\tau_{uncr}}{1100}}$ ACI 318-11 Eq. (D-21)

$\psi_{ec,Na} = \left(\frac{1}{1+\frac{e_N}{c_{Na}}}\right) \leq 1.0$ ACI 318-11 Eq. (D-23)

$\psi_{ed,Na} = 0.7 + 0.3\left(\frac{c_{a,min}}{c_{ac}}\right) \leq 1.0$ ACI 318-11 Eq. (D-25)

$\psi_{cp,Na} = \mathrm{MAX}\left(\frac{c_{a,min}}{c_{ac}}, \frac{c_{Na}}{c_{ac}}\right) \leq 1.0$ ACI 318-11 Eq. (D-27)

$N_{ba} = \lambda_a \cdot \tau_{k,c} \cdot \alpha_{N,seis} \cdot \kappa_{bond} \cdot \pi \cdot d_a \cdot h_{ef}$ ACI 318-11 Eq. (D-22)

Variables

k_{cp}	$\tau_{k,c,uncr}$ [psi]	d_a [in.]	h_{ef} [in.]	$c_{a,min}$ [in.]	$\tau_{k,c}$ [psi]
2	715	0.750	10.000	12.000	345

$e_{c1,N}$ [in.]	$e_{c2,N}$ [in.]	c_{ac} [in.]	κ_{bond}	λ_a	$\alpha_{N,seis}$
0.000	0.000	17.469	1.00	1.000	0.650

Calculations

c_{Na} [in.]	A_{Na} [in.^{2}]	A_{Na0} [in.^{2}]	$\psi_{ed,Na}$
6.019	217.17	144.93	1.000

$\psi_{ec1,Na}$	$\psi_{ec2,Na}$	$\psi_{cp,Na}$	N_{ba} [lb]
1.000	1.000	1.000	5284

Results

V_{cpg} [lb]	$\phi_{concrete}$	$\phi_{seismic}$	$\phi_{nonductile}$	$\phi\ V_{cpg}$ [lb]	V_{ua} [lb]
15834	0.700	1.000	1.000	11084	10833

Input data and results must be checked for agreement with the existing conditions and for plausibility!
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4.3 Concrete edge failure in direction y+

$V_{cbg} = \left(\frac{A_{Vc}}{A_{Vc0}}\right) \psi_{ec,V}\, \psi_{ed,V}\, \psi_{c,V}\, \psi_{h,V}\, \psi_{parallel,V}\, V_b$ ACI 318-11 Eq. (D-31)

$\phi\, V_{cbg} \geq V_{ua}$ ACI 318-11 Table D.4.1.1

A_{Vc} see ACI 318-11, Part D.6.2.1, Fig. RD.6.2.1(b)

$A_{Vc0} = 4.5\, c_{a1}^2$ ACI 318-11 Eq. (D-32)

$\psi_{ec,V} = \left(\frac{1}{1 + \frac{2e_V'}{3c_{a1}}}\right) \leq 1.0$ ACI 318-11 Eq. (D-36)

$\psi_{ed,V} = 0.7 + 0.3\left(\frac{c_{a2}}{1.5c_{a1}}\right) \leq 1.0$ ACI 318-11 Eq. (D-38)

$\psi_{h,V} = \sqrt{\frac{1.5c_{a1}}{h_a}} \geq 1.0$ ACI 318-11 Eq. (D-39)

$V_b = 9\, \lambda_a \sqrt{f'_c}\, c_{a1}^{1.5}$ ACI 318-11 Eq. (D-34)

Variables

c_{a1} [in.]	c_{a2} [in.]	e_{cV} [in.]	$\psi_{c,V}$	h_a [in.]
12.000	12.000	0.000	1.200	14.000

l_e [in.]	λ_a	d_a [in.]	f'_c [psi]	$\psi_{parallel,V}$
6.000	1.000	0.750	4000	1.000

Calculations

A_{Vc} [in.^{2}]	A_{Vc0} [in.^{2}]	$\psi_{ec,V}$	$\psi_{ed,V}$	$\psi_{h,V}$	V_b [lb]
420.00	648.00	1.000	0.900	1.134	23662

Results

V_{cbg} [lb]	$\phi_{concrete}$	$\phi_{seismic}$	$\phi_{nonductile}$	$\phi\, V_{cbg}$ [lb]	V_{ua} [lb]
18781	0.700	1.000	1.000	13147	10833

5 Warnings

- Load re-distributions on the anchors due to elastic deformations of the anchor plate are not considered. The anchor plate is assumed to be sufficiently stiff, in order not to be deformed when subjected to the loading!
- Condition A applies when supplementary reinforcement is used. The Φ factor is increased for non-steel Design Strengths except Pullout Strength and Pryout strength. Condition B applies when supplementary reinforcement is not used and for Pullout Strength and Pryout Strength. Refer to your local standard.
- Design Strengths of adhesive anchor systems are influenced by the cleaning method. Refer to the INSTRUCTIONS FOR USE given in the Evaluation Service Report for cleaning and installation instructions
- Checking the transfer of loads into the base material and the shear resistance are required in accordance with ACI 318 or the relevant standard!
- An anchor design approach for structures assigned to Seismic Design Category C, D, E or F is given in ACI 318-11 Appendix D, Part D.3.3.4.3 (a) that requires the governing design strength of an anchor or group of anchors be limited by ductile steel failure. If this is NOT the case, the connection design (tension) shall satisfy the provisions of Part D.3.3.4.3 (b), Part D.3.3.4.3 (c), or Part D.3.3.4.3 (d). The connection design (shear) shall satisfy the provisions of Part D.3.3.5.3 (a), Part D.3.3.5.3 (b), or Part D.3.3.5.3 (c).
- Part D.3.3.4.3 (b) / part D.3.3.5.3 (a) requires that the attachment the anchors are connecting to the structure be designed to undergo ductile yielding at a load level corresponding to anchor forces no greater than the controlling design strength. Part D.3.3.4.3 (c) / part D.3.3.5.3 (b) waives the ductility requirements and requires that the anchors shall be designed for the maximum tension / shear that can be transmitted to the anchors by a non-yielding attachment. Part D.3.3.4.3 (d) / part D.3.3.5.3 (c) waives the ductility requirements and requires the design strength of the anchors to equal or exceed the maximum tension / shear obtained from design load combinations that include E, with E increased by Ω_0.
- Installation of Hilti adhesive anchor systems shall be performed by personnel trained to install Hilti adhesive anchors. Reference ACI 318-11, Part D.9.1

Fastening meets the design criteria!

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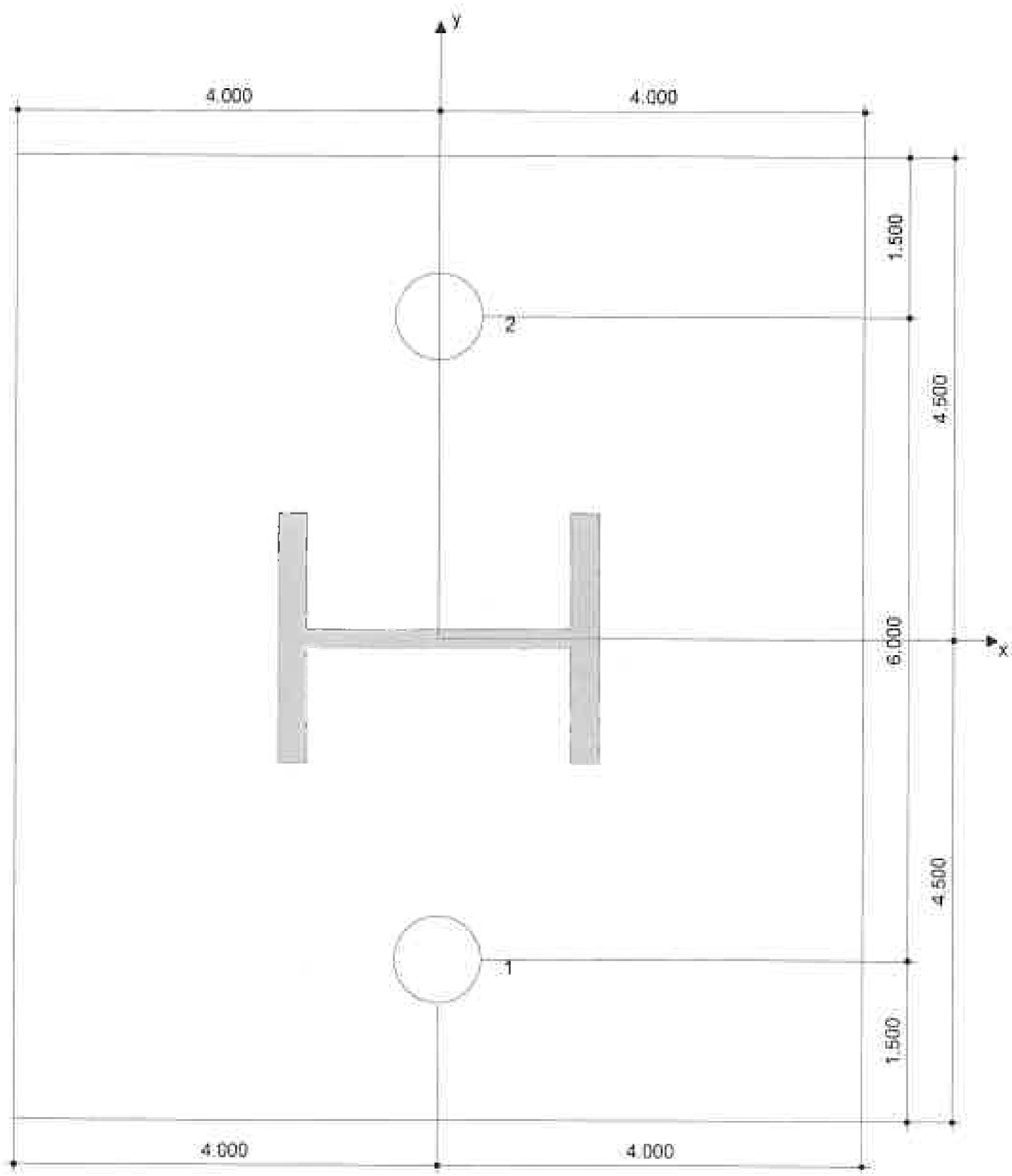
Phone I Fax:		Date:	12/22/2014
E-Mail:			

6 Installation data

Anchor plate, steel: -
Profile: S shape (AISC); 3.000 x 2.330 x 0.170 x 0.260 in.
Hole diameter in the fixture: d_f = 0.813 in.
Plate thickness (input): 0.500 in.
Recommended plate thickness: not calculated
Cleaning: Premium cleaning of the drilled hole is required

Anchor type and diameter: HIT-RE 500-SD + HAS B7 3/4
Installation torque: 1200.000 in.lb
Hole diameter in the base material: 0.875 in.
Hole depth in the base material: 10.000 in.
Minimum thickness of the base material: 11.750 in.



Coordinates Anchor in.

Anchor	x	y	c_{-x}	c_{+x}	c_{-y}	c_{+y}
1	0.000	-3.000	12.000	-	-	18.000
2	0.000	3.000	12.000	-	-	12.000

Input data and results must be checked for agreement with the existing conditions and for plausibility!
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- You must take all necessary and reasonable steps to prevent or limit damage caused by the Software. In particular, you must arrange for the regular backup of programs and data and, if applicable, carry out the updates of the Software offered by Hilti on a regular basis. If you do not use the AutoUpdate function of the Software, you must ensure that you are using the current and thus up-to-date version of the Software in each case by carrying out manual updates via the Hilti Website. Hilti will not be liable for consequences, such as the recovery of lost or damaged data or programs, arising from a culpable breach of duty by you.

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5,000 GAL WATER TANKS

- REF SHT H-15 FOR TANK INFO
- REF SHT H-16 FOR TANK SEISMIC LOADS

  AWWA D103 ~ $V_{SEISMIC} = 6.46^K \rightarrow$

  ASCE 7-10 – 15.7.6 ~ $V_{SEISMIC} = 6.8^K \rightarrow$

- REF SHT H-6 AWWA D103 ~ $V_{SEISMIC} = 3.3^K \rightarrow$

  $M_{SEISMIC} = 21.89^{K \cdot FT}$

  ~ ANCHORAGE REQ'D FOR OVERTURNING

- ASCE 7-10 15.4.2 RIGID – NON BLDG STRUCTURE (PER 15.7.6.1 – a)

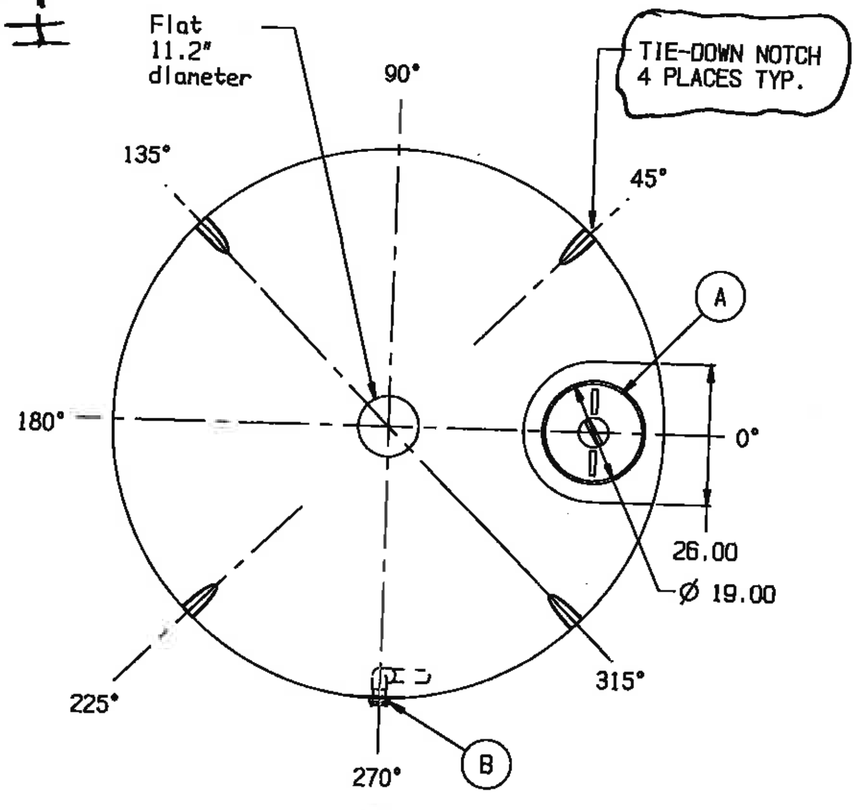
  $V = 0.30 S_{DS} W I_e = 0.30(0.245)(42{,}995^{\#})(1.5) = 4.738^K \rightarrow$

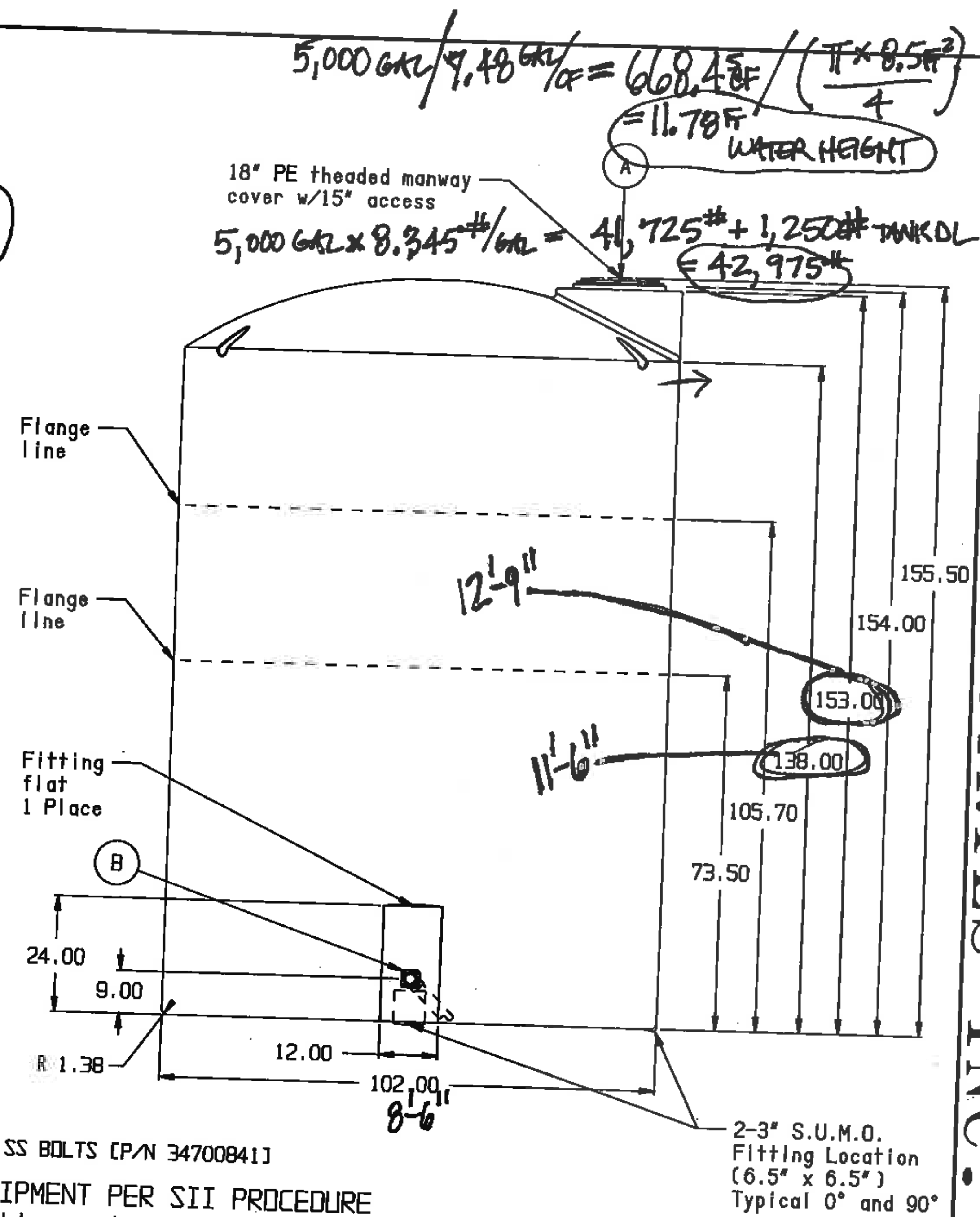
USE

$M_{SEISMIC} = 6.8^K \times (11.78^F / 2) = 40.05^{K \cdot F}$

WATER

H-15





- 18" PE THREADED-VENTED MANWAY W/15" ACCESS [P/N 34700087]
- 2" PP DBL FLANGED BOLTED LONG SIPHON TUBE ASSY W/EPDM GASKETS & SS BOLTS [P/N 34700841]

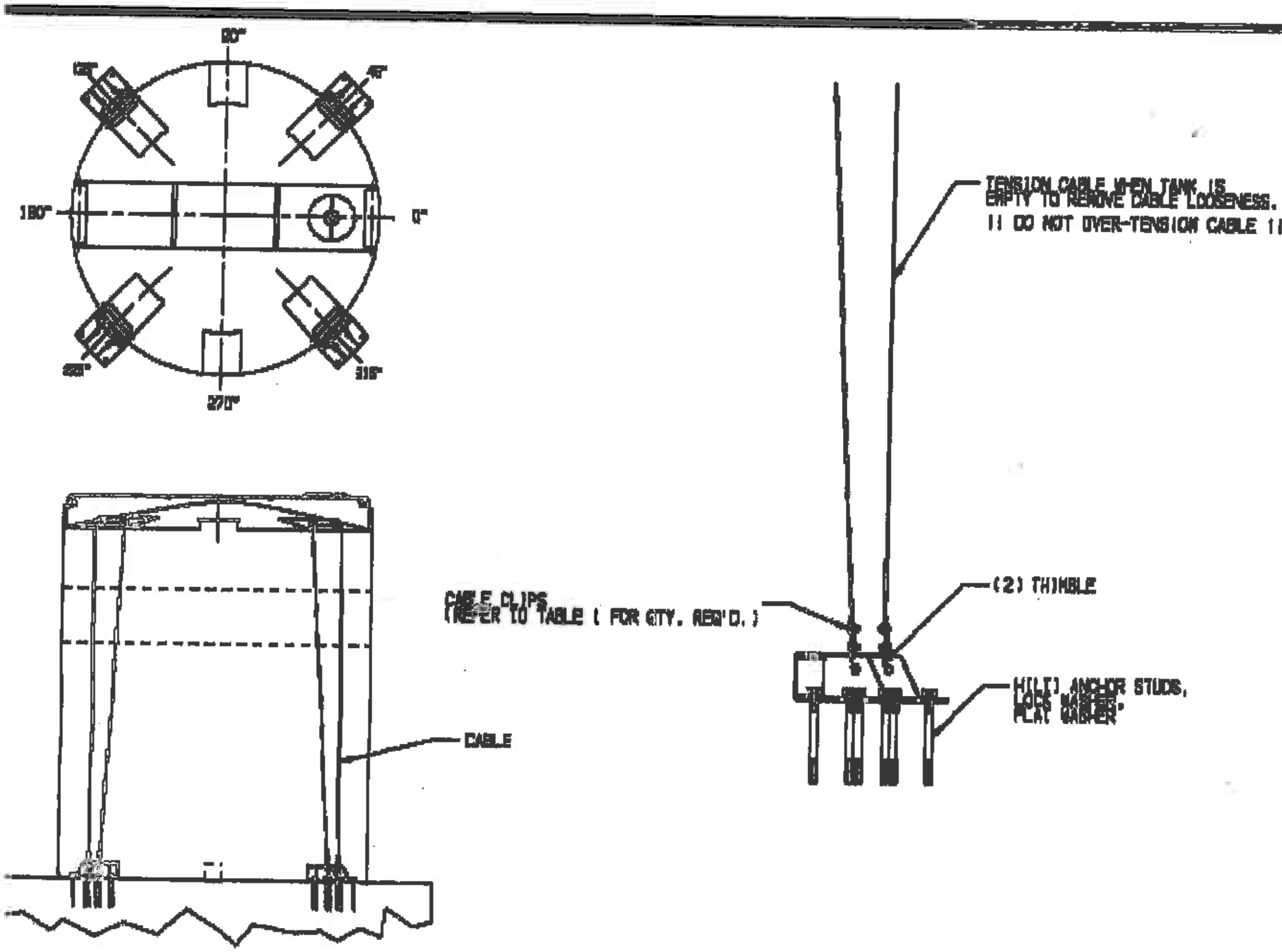
BASE FITTINGS TO BE LEFT INSTALLED AT TIME OF SHIPMENT PER SII PROCEDURE
Consult Snyder's Guidelines for Use and Installation prior to delivery.
Available on-line at www.snydernet.com

(all dimensions in inches)

5,000 GALLON FLAT BOTTOM TANK

SNYDER INDUSTRIES INC.

PART # TANK:	1002000W94302 (P) HDLPE/NAT/1.0 SPGR
REF#: 0000	02/08/06



CODES:
CBC 2010
IBC 2009
ASCE 7.05
AISC 13TH EDITION

SEISMIC DESIGN:
Zip Code = 92701, Site class D - Fa=1.0, Fv=1.5,
Ss = 1.4, S1 = 0.5, I = 1.5, R = 3.0
Fp=(Vi*Wi+Vc*Wc/(We+Wc*SG) = 0.445 W

WIND DESIGN:
IBC/CBC - 150 MPH
Qz = 0.00256KzKztKdV^2I = 58.14 PSF
(Kz = 0.85, Kzt = 1.0, Kd = 0.85, I = 1.25)

GENERAL:
1. ALL CONSTRUCTION SHALL MEET LOCAL BUILDING CODE REQUIREMENTS AND BE APPROVED BY THE BUILDING OFFICIAL.
2. THESE GUIDELINES HAVE BEEN PROVIDED TO SPECIFY THE RESTRAINT RECOMMENDATIONS FOR SNYDER INDUSTRY BULK STORAGE TANKS.

CONCRETE:
1. CONCRETE SHALL HAVE A MINIMUM DESIGN AS PER DRAWING REFERENCED IN SPECIFICATION CHART BELOW.
2. CONCRETE PAD DESIGN SHOULD BE REVIEWED AND APPROVED BY THE BUILDING OFFICIAL BASED ON SPECIFIC APPLICATION AS OTHER DESIGN PARAMETERS ARE POSSIBLE DEPENDING UPON SITE CONDITIONS.

STRUCTURAL STEEL:
1. ALL STRUCTURAL STEEL COMPONENTS SHALL BE NEW AND OF BASIC OPEN HEARTH PROCESS STEEL CONFORMING TO ALL APPLICABLE REQUIREMENTS OF ASTM A36 (STRUCTURAL STEEL FOR BRIDGES AND BUILDINGS - Fy = 36,000 PSI.).
2. ALL ARC WELDING ELECTRODES SHALL CONFORM TO ASTM A233 FOR STEEL ARC WELDING ELECTRODES. ELECTRODES SHALL BE AS RECOMENDED BY THE MANUFACTURES FOR THE POSITIONS AND OTHER CONDITIONS OF ACTUAL USE. WELDING SHALL CONFORM TO REQUIREMENTS OF AMERICAN WELDING SOCIETY AWS D121.
3. ALL SHARP EDGES AND CORNERS SHALL BE REMOVED ON ALL STRUCTURAL STEEL COMPONENTS.
4. CABLES TO BE 7X19 STRANDED CORE CONSTUCTION SIZED PER CHART. MATERIAL TO BE SPECIFIED BY CUSTOMER ORDER (MINIMUM BREAKING STRENGTH EQUAL TO OR GREATER THAN 304 SS RATING).
5. ANCHOR BOLTS TO BE HILTI ADHESIVE ANCHORS, MODEL HIT-RE 500-SD WITH SIZE, MATERIAL, AND EMBEDMENT AS SPECIFIED PER SPECIFICATION CHART BELOW.
ALL OTHER FASTENER MATERIALS MUST CORRESPOND TO THE TYPE OF ANCHOR SELECTED.

Lotycz, Matt

From: Eckel, Caroline H.
Sent: Tuesday, November 18, 2014 3:10 PM
To: Lotycz, Matt
Subject: Moabi

Hey Matt,

Are you designing the pad for the water storage tanks? VOID

Right now I am looking at two tanks, 10' in diameter, 11' tall, cylindrical. About 5000 gallons in each. They will be piped together so maybe 7 or so feet between them.

I will also have a packaged skid with the booster pumps on it (I don't know the size yet) and a bladder tank (waiting on size from Brian).

Caroline Eckel, PE | Engineer | caroline.eckel@arcadis-us.com

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www.arcadis-us.com

ARCADIS, Imagine the result

Please consider the environment before printing this email.

Lotycz, Matt

From: Eckel, Caroline H
Sent: ~~Friday, November 21, 2014 3:31 PM~~
To: Lotycz, Matt
Subject: FW: Topock CHQ 5000gal Tank Specs
Attachments: seismic restraint.JPG; 5000 gal snyder tank.pdf

Seismic info

From: O'Brien, Maureen
Sent: Friday, November 21, 2014 11:35 AM
To: Eckel, Caroline H.
Cc: Baxter, Jonathan
Subject: Topock CHQ 5000gal Tank Specs

Hi Caroline,

Please find attached the specifications for the 5000 gal tanks needed for the CHQ. The .jpg file is the info for their seismic restraints.

Let me know if you have any questions.

Thank you!
Maureen

Maureen O'Brien | Remediation Specialist | Maureen.O'Brien@arcadis-us.com

ARCADIS U.S., Inc. | 126 N. Jefferson St., Suite 400 | Milwaukee, WI 53202
T: 414.277.6205
www.arcadis-us.com

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H-16

Reference:G:\Project\RC000753.0008\Dept\Structural\MathCAD\Seismic Calculations\Arcadis_Units.mcd(R)

Topok, California 5,000 Gal Tank Seismic Loads

References

American Institute of Steel Construction
AISC 13th edition construction manual.
AISC 360-05 Steel structure design specification.
American Society of Civil Engineers
ASCE 7-10
California Building Code
CBC 2013
USGS Seismic Design Maps -
http://earthquake.usgs.gov/hazards/designmaps/usdesign.php
Earthquake Hazard Program - Seismic Design Maps and Tools for Buildings
Ground Motion Parameter Calculator - Version 3.0.1, last updated 12 July 2012.
Performance Pipe
First Edition - Field Handbook, August 2009, Chevron Phillips Chemical Co.
American Water Works Association
AWWA D103-09 - Bolted Carbon Steel Tanks For Water Storage

Goal of this package of calculations

This set of calculations has been performed for the following purposes:

1. To calculate seismic response coefficients (C_s) that can be applied to 5,000 Gal tank operational weights to determine lateral load effects on anchorage due to seismic events.

Summary of Findings:

1 Calculations use ASCE 7-10 and AWWA D103-09 as two methods in determining seismic response coefficients (C_s).

Determine Acceleration Coefficients

Zip code of work: [redacted]

$S_1 := 0.120$ $S_s := 0.230$ Use with USGS ground motion calculator

From ASCE 7, chapter 11 (below):

11.4.2 Site Class. Based on the site soil properties, the site shall be classified as Site Class A, B, C, D, E, or F in accordance with Chapter 20. Where the soil properties are not known in sufficient detail to determine the site class, Site Class D shall be used unless the authority having jurisdiction or geotechnical data determines Site Class E or F soils are present at the site.

Use Site Class "D"

ASCE 7-10 Table 11.4-2

Use

$F_v := 2.4$

ASCE 7-10 Table 11.4-1

Use

$F_a := 1.6$

$S := \frac{2}{3} \cdot F_a \cdot S_s$ $S_{DS} = 0.25$ ✓

$:= \frac{2}{3} \cdot F_v \cdot S_1$ $S_{D1} = 0.19$ ✓

Determine Seismic Design Category

ASCE 7-10 Table 11.6-1 & 2 SDC "C" for Sds and "D" for Sd1 Since occupancy IV $I_E := 1.5$

Analysis based on AWWA D103-09: Ground Supported Flat Bottom Tanks

See attached AWWA Standard

$D := 8.5ft$ ✓ Tank Diameter $V := 5000gal$ ✓ Tank Capacity

$H := \frac{4 \cdot V}{\pi \cdot D^2}$ Fluid height in Tank $H = 11.78ft$ ✓

$T_c := 2 \cdot \pi \cdot \sqrt{\frac{D}{3.68 \cdot g \cdot \tanh\left(3.68 \cdot \frac{H}{D}\right)}}$ $T_c = 1.68s$ First mode of sloshing wave period AWWA EQ 14-18

$T_L := 8s$ AWWA Figure 17 $T_s := \frac{S_{D1}}{S_{DS}} = 0.78$ s $C_t := .02$ $x := .75$

$T_a := C_t \cdot H^x$ $T_i := T_a$ $T_i = 0.145$ s

$0 < T_i < T_s$ $S_{ai} := S_{DS}$ per AWWA 14.2.8.6.1 $S_{ai} = 0.25$ ---Use

FYI T.s < T.i <T.L $S_{ai2} := \frac{S_{DS}}{T_i} = 1.69$ ▮ > ▮ = ▮ $S_{DS} = 0.25$ ---Use

$R_i := 3$ per AWWA table 6, Impulsive component of mechanically anchored tanks

$R_c := 1.5$ per AWWA table 6, Convective component of mechanically anchored tanks

$A_i := \max\left(\frac{S_{ai} \cdot I_E}{1.4 \cdot R_i}, \frac{0.36 \cdot S_1 \cdot I_E}{R_i}\right)$ $A_i = 0.09$ impulsive acceleration

$T_c < T_L$ $S_{ac} := \frac{1.5 \cdot S_{D1} \cdot 1s}{T_c}$ $S_{ac} = 0.17$ ▮ < ▮ $S_{DS} = 0.25$ AWWA EQ 14-12

$A_c := \frac{S_{ac} \cdot I_E}{1.4 \cdot R_c}$ $A_c = 0.12$ Convective acceleration

Use this value (Controls)

$C_{sAWWA} := \sqrt{A_i^2 + A_c^2}$ $C_{sAWWA} = 0.15$ Check this value against ASCE 7-10 per Chapter 15 ✓

Load analysis of Ground Supported Tanks containing Liquid: ASCE 7-10

Refer to ASCE 7-10, chapter 15

From 15.4.1b of ASCE 7

Non-building structures shall be designed in compliance with Sections 15.5 and 15.6 to resist minimum seismic lateral forces that are not less the requirements of Section 12.8 with the following additions and exceptions identified in 15.4.1-1 & 2.

Table 15.4-2 - Structures not similar to buildings

For Flat bottom tanks, Bolted Steel, see Design and Detailing Requirements of 15.7 $R := 3.0$ Mechanically anchored tank. See Table on next sheet.

Determine Fundamental Period of Tank:

$D = 8.5 ft$ Tank Diameter

$V = 5000 gal$ Tank Capacity

$H = 11.78 ft$ Fluid height in Tank

$T := T_c$ $T = 1.68 s$ Tank Period

$S_1 = 0.12$ $I_E = 1.5$ $R = 3$

Per ASCE 7-05 15.4.1.2 $C_{smin1} := .044 S_{DS} \cdot I_E = 0.02$ ASCE 7 EQ 15.4-1
which is greater than 0.03 MIN

$C_{smin2} := \frac{0.8 \cdot S_1}{\frac{R}{I_E}}$ $C_{smin2} = 0.05$ ASCE 7 EQ 15.4-2 Not Applicable

because $S_1 = 0.12 < S_{1a} := 0.6$

$T_a := T \cdot \frac{1}{s}$ $T_a = 1.68$

From Section 12.8 ASCE 7-10 $C_s := \frac{S_{DS}}{\frac{R}{I_E}}$ $C_s = 0.12$ ✓

$R = 3$ $T_L := 12$ $C_{smax} := \frac{S_{D1}}{T_a \cdot \frac{R}{I_E}}$ $C_{smax} = 0.06$ Ignore

Min Base Shear Force to foundation per 12.8 $V := C_s \cdot W$ $V = 0.12W$

Controlling Seismic Response Coefficient is Cs =0.15 of AWWA D103 ✓

$W_i := 42.975kip$ Operating Weight of EQ Tank (tank DL and water)

From Section 12.8 ASCE 7-10 $V := C_{sAWWA} \cdot W_i = 6.46 \cdot kip$ ✓

ASCE 7-10 Section 15.7.6

$(0 < T_i < T_s)$ $(S_{ai} := S_{DS})$ per ASCE 7-10 Eq 15.7-7 $(S_{ai}) = 0.25$

$T_c < T_L$ $S_{ac} := \frac{1.5 \cdot S_{D1} \cdot 1s}{T_c}$ per ASCE 7-10 Eq 15.7-10

$S_{ac} = 0.17$ $<$ $1.5x$ $S_{DS} = 0.25$

$W_i := 42.975kip$ ✓ Operating Weight of EQ Tank (tank DL and water)

$$V_i := \frac{(S_{ai} \cdot W_i)}{\left(\frac{R}{I_E}\right)} = 5271.6\,lbf$$ per ASCE 7-10 Eq 15.7-5

$W_c := 25.14kip$ Weight of Effective Mass of First Mode of Sloshing

$$V_c := \frac{(S_{ac} \cdot I_E \cdot W_c)}{1.5} = 4300.6\,lbf$$ per ASCE 7-10 Eq 15.7-6

Sesimic Base Shear = $V_t := \left(V_i^2 + V_c^2\right)^{0.5} = 6.8 \cdot kip$ ✓

Sum of the squares per ASCE 7-10 Section 15.7.6.1-e

Sliding Resistance (un-anchored) per ASCE 7-10 Eq 15.7-14

$V_t < W_t \tan(30deg)$ $W_t := 42.975kip$ $\tan(30deg) = 0.58$

$V_t = 6.8 \cdot kip$ $<$ $W_t \tan(30deg) = 24.81 \cdot kip$ OK

Job Title: Topok, CA - 5,000 Gal Fire Water Tank

Design of Water Storage Tanks in Seismic Regions

$I_E := 1.5$	*SEISMIC IMPORTANCE FACTOR*
$F_a := 1.6$	*SHORT PERIOD SITE COEFFICIENT*
$F_v := 2.4$	*LONG PERIOD SITE COEFFICIENT*
$S_s := 0.230$	*MAPPED MAX. CONSIDERED EARTHQUAKE SPECTRAL RESPONSE ACCELERATION AT 0.2 SEC PERIOD FOR SITE CLASS B*
$S_1 := 0.120$	*MAPPED MAX. CONSIDERED EARTHQUAKE SPECTRAL RESPONSE AT 1-SEC PERIOD FOR SITE CLASS B*
$S_{MS} := F_a \cdot S_s = 0.37$	*MAXIMIMUM CONSIDERED EARTHQUAKE SPECTRAL RESPONSE ACCELERATION AT 0.2 SEC PERIOD*
$S_{M1} := F_v \cdot S_1 = 0.29$	*MAXIMUM CONSIDERED EARTHQUAKE SPECTRAL RESPONSE ACCELERATION AT 1 SEC PERIOD*
$U := \frac{2}{3}$	*SCALING FACTOR TO SCALE THE MAX. CONSIDERED EARTHQUAKE RESPONSE ACCELERATION TO THE DESIGN RESPONSE ACCELERATION*
$S_{DS} := U \cdot S_{MS} = 0.25$	*DESIGN EARTHQUAKE SPECTRAL RESPONSE ACCELERATION AT 0.2-SEC PERIOD*
$S_{D1} := U \cdot S_{M1} = 0.19$	*DESIGN EARTHQUAKE SPECTRAL RESPONSE ACCELERATION AT 1-SEC PERIOD*

$T_s := \frac{S_{D1}}{S_{DS}} = 0.78$

$T_i := 0.145$ ✓ $T_L := 8$ ✓

$$S_{ai} := \begin{cases} S_{DS} & \text{if } 0 \le T_i \le T_s \\ \left(\frac{S_{D1}}{T_i}\right) & \text{if } T_s \le T_i \le T_L \\ \frac{T_L \cdot S_{D1}}{T_i^2} & \text{otherwise} \end{cases}$$

DESIGN SPECTRAL RESPONSE ACCELERATION FOR IMPULSIVE COMPONENTS AT THE NATURAL FREQUENCY OF THE STRUCTURE

$S_{ai} = 0.25$

$K := 1.5$

DAMPING SCALING FACTOR

$D := 8.5ft$ ✓ $Volume := 5000gal$ ✓ $H := \frac{4 \cdot Volume}{\pi \cdot D^2} = 11.78 \cdot ft$ $H_{tank} := 11.78ft$ ✓

$$T_c := \frac{1}{s} \cdot 2 \cdot \pi \cdot \sqrt{\frac{D}{3.68 \cdot g \cdot \tanh\left(\frac{3.68 \cdot H}{D}\right)}} = 1.68$$

$$S_{ac} := \begin{cases} \frac{K \cdot S_{D1}}{T_c} & \text{if } T_c \le T_L \\ \frac{K \cdot T_L \cdot S_{D1}}{T_c^2} & \text{otherwise} \end{cases}$$

DESIGN SPECTRAL RESPONSE ACCELERATION FOR THE CONVECTIVE COMPONENT AT THE FIRST MODE SLOSHING WAVE PERIOD

$S_{ac} = 0.17$

$R_i = 3$ √ $R_c = 1.5$ √ $G := 1.0$ *SPECIFIC GRAVITY OF WATER*

Mechanically-Anchored

$$A_i := \max\left[\left(\frac{S_{ai} \cdot I_E}{1.4 \cdot R_i}\right), \left(\frac{0.36 \cdot S_1 \cdot I_E}{R_i}\right)\right] = 0.09$$

IMPULSIVE DESIGN ACCELERATION

$$A_c := \frac{S_{ac} \cdot I_E}{1.4 \cdot R_c} = 0.12 \qquad \frac{D}{H} = 0.72 \; > \; 1.33$$

CONVECTIVE DESIGN ACCELERATION

$$W_t := 62.4\text{pcf} \cdot G \cdot H \cdot \left(\frac{\pi \cdot D^2}{4}\right) = 41.71 \cdot \text{kip}$$

TOTAL WEIGHT OF TANK CONTENTS

$$W_c := 0.230 \cdot \frac{D}{H} \cdot \tanh\left(3.67 \cdot \frac{H}{D}\right) \cdot W_t = 6.92 \cdot \text{kip}$$

WEIGHT OF EFFECTIVE MASS OF FIRST MODE OF SLOSHING

$$W_i := \begin{cases} \dfrac{\tanh\left(\dfrac{0.866 \cdot D}{H}\right)}{\left(\dfrac{0.866 \cdot D}{H}\right)} \cdot W_t & \text{if } \dfrac{D}{H} \geq 1.333 \\ W_t \left(1.0 - \dfrac{0.218 \cdot D}{H}\right) & \text{otherwise} \end{cases}$$

WEIGHT OF EFFECTIVE MASS OF TANK CONTENTS THAT MOVES WITH TANK SHELL

$$W_i = 35.15 \cdot \text{kip}$$

$$X_i := \begin{cases} 0.375 \cdot H & \text{if } \dfrac{D}{H} \geq 1.333 \\ \left(0.5 - \dfrac{0.094 \cdot D}{H}\right) \cdot H & \text{otherwise} \end{cases}$$

HEIGHT FROM BOTTOM OF SHELL TO CENTROID OF LATERAL SEISMIC FORCE APPLIED THROUGH THE IMPULSIVE WEIGHT

$$X_i = 5.09 \cdot \text{ft}$$

$$X_c := \left[1.0 - \frac{\cosh\left(\dfrac{3.67 \cdot H}{D}\right) - 1}{\left(\dfrac{3.67 \cdot H}{D}\right) \cdot \sinh\left(\dfrac{3.67 \cdot H}{D}\right)}\right] \cdot H = 9.49 \cdot \text{ft}$$

HEIGHT FROM BOTTOM OF SHELL TO THE CENTROID OF LATERAL SEISMIC FORCE APPLIED TO THE EFFECTIVE CONVECTIVE WEIGHT

$$X_s := 0.5 \cdot H_{tank} = 5.89 \cdot \text{ft}$$

HEIGHT FROM BOTTOM OF SHELL TO CENTER OF MASS OF TANK

$W_s := 0.85\text{kip}$ ✓

$W_r := 200\text{lbf}$ ✓

$H_t := H_{tank} = 11.78 \cdot \text{ft}$

$$M_s := \sqrt{\left[A_i \cdot \left(W_s \cdot X_s + W_r \cdot H_t + W_i \cdot X_i\right)\right]^2 + \left(A_c \cdot W_c \cdot X_c\right)^2}$$

$M_s = 18.19 \cdot \text{ft} \cdot \text{kip}$

DESIGN OVERTURNING MOMENT AT THE BOTTOM OF THE SHELL CAUSED BY HORIZONTAL DESING ACCELERATION

$W_f := 200\text{lbf}$ ✓

WEIGHT OF TANK BOTTOM

$$X_{cmf} := \left[1.0 - \frac{\cosh\left(\frac{3.67 \cdot H}{D}\right) - 1.937}{\left(\frac{3.67 \cdot H}{D}\right)\sinh\left(\frac{3.67 \cdot H}{D}\right)}\right] \cdot H = 9.52 \cdot \text{ft}$$

HEIGHT FROM BOTTOM OF SHELL TO THE CENTROID OF THE EFFECTIVE CONVECTIVE WEIGHT ADIJUSTED TO FOR VARYING BOTTOM PRESSURES

$$V_F := \sqrt{\left[A_i \cdot \left(W_s + W_r + W_f + W_i\right)\right]^2 + \left[\left(A_c \cdot W_c\right)^2\right]}$$

$V_F = 3.3 \cdot \text{kip}$

DESIGN SHEAR AT THE TOP OF THE FOUNDATION DUE TO HORIZONTAL DESIGN ACCELERATION

$M_s = 18.19 \cdot ft \cdot kip$

DESIGN OVERTURNING MOMENT AT TOP OF THE FOUNDATION FOR TANKS SUPPORTED BY RINGWALL FOUNDATIONS

$$X_{imf} := \begin{cases} 0.375 \cdot \left[1.0 + 1.333\left(\frac{0.866 \cdot \frac{D}{H}}{\tanh\left(\frac{0.866 \cdot D}{H}\right)} - 1.0\right)\right] \cdot H & \text{if } \frac{D}{H} \geq 1.333 \\ \left[\left(0.50 + 0.06\frac{D}{H}\right)H\right] & \text{otherwise} \end{cases}$$

$X_{imf} = 6.4 \cdot ft$

$$M_{mf} := \sqrt{\left[A_i \cdot \left(W_s \cdot X_s + W_r \cdot H_t + W_i \cdot X_{imf}\right)\right]^2 + \left(A_c \cdot W_c \cdot X_{cmf}\right)^2}$$

$M_{mf} = 21.89 \cdot ft \cdot kip$ *DESIGN OVERTURNING MOMENT AT TOP OF THE FOUNDATION FOR TANKS SUPPORTED BY MAT FOUNDATIONS*

OVERTURNING RATIO

$w_t := 45.7plf$ ✓

the equations may not be meant to include units? as below

$G := 1$ $t_b := .375$ $F_y := 36000$ $H := 11.5$ ✓ $D := 8.5$ ✓

$w_L := 7.9 \cdot t_b \cdot \sqrt{(F_y \cdot H \cdot G)} = 1906.16$ $W_{Lmax} := 1.28 \cdot H \cdot D \cdot G = 125.12$

Therefore $w_{Luse} := 125.12plf$

$A_v := 0.14 \cdot S_{DS} = 0.03$

$$J := \frac{M_s}{\left[D^2 \cdot \left[w_t \cdot (1 - .4 \cdot A_v) + w_{Luse}\right]\right]} = \blacksquare \cdot ft^2$$

$1.479 > 0.785$ ✓

Therefore, there is shell uplift due to overturning moment and the tank needs to be anchored into the slab

SLIDING CHECK

$V_{allow} := \tan(30°) \cdot (W_s + W_r + W_i + W_c) \cdot (1 - 0.4A_v) = 24.55 \cdot kip > V_F = 3.3 \cdot kip$ ✓

Therefore, allowable lateral shear is greater than design shear at the top of the foundation due to horizontal design acceleration V.F and therefore a self-anchored tank is acceptable

(5,000 GAL TANK CON'T)

WIND LOADS = $q_z = 0.00256 K_z K_{zt} K_d V^2 = 27.30$ psf FACT

- K_z: 0.85 < 15 FT TABLE 29.3-1
- K_d: 0.95 ROUND - TABLE 26.6-1
- K_{zt}: FIGURE 26.8-1 (1.0)
- V: 115 mpH

ASCE 7-10 CHAPT 29 - WIND LOADS ON OTHER STRUCTURES - MWFRS

$F = q_z G C_f A_f = (27.3\text{psf})(0.85)(0.71)(8.5^{F} \times 12.75^{F}) = 1.79^{K}$ FACT (G = 0.85)

FIGURE 29.5-1 ~ $D\sqrt{q_z} = 44.4 > 2.5$, $h/D = 1.50$, ROUGH, $C_f = 0.71$

LOAD COMBINATIONS (ASCE 7-10 - 2.4 ALLOWABLE & 2.3 FACTORED)

→ (2.4 ALLOWABLE LOADS)

(5) $D + F + 0.7E \rightarrow (1.0 + 0.14S_{DS})D + F + 0.7E =$

(1.034; D = 1250#; F = 41,725#; 0.7E = 0.7 × 6.80K →)

$= 43{,}018\#\downarrow$ & $4.76^{K}\rightarrow$ @ 11.78F/2 ARM

(7) $0.6D + 0.6W \rightarrow 0.6(1250\#)\downarrow + 0.6(1790\#)\rightarrow$

$= 750\#\downarrow$ & $1074\#\rightarrow$ @ 12.75F/2 ARM

(8) $0.6D + 1.0F + 0.7E \rightarrow (0.6 - 0.14S_{DS})D + 1.0F + 0.7E$

0.565D

$= 42.43^{K}\downarrow$ & $4.76^{K}\rightarrow$ @ 11.78F/2 ARM

→ (2.3 FACTORED LOADS)

(5) $1.2D + 1.0F + 1.0E \rightarrow (1.2 + 0.2S_{DS})D + 1.0F + 1.0E$ (1.249)

$\Rightarrow 43.29^{K}\downarrow$ & $6.80^{K}\rightarrow$ @ 11.78F/2 ARM

(6) $0.9D + 1.0W \rightarrow 0.9(1250\#)\downarrow + 1.0(1790\#)\rightarrow$

$1125\#\downarrow$ & $1790\#\rightarrow$

(7) $0.9D + 0.9F + 1.0E \rightarrow [(0.9 - 0.2S_{DS})D + F]_{\text{CONSERV}} + 1.0E$

0.851

$= 36.57^{K}\downarrow$ & 6.80^{K} @ 11.78F/2 ARM

BEARING CAPACITY ~ 5,000 GAL TANK

- ASSUME 1'-2" THICK SLAB
- ASSUME 9'-10" SQ SLAB

→ TANK FULL ~ (D + F + 0.7E) = 43.02^K ↓ & 4.76^K →

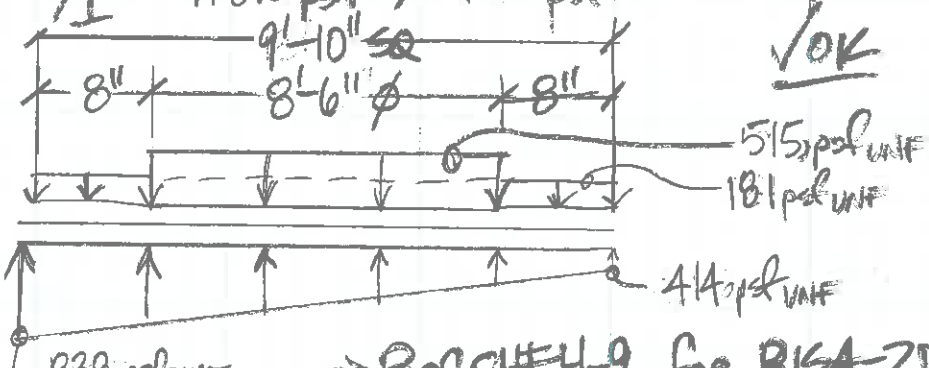
- $M_{OT} = 4.76^K \rightarrow \times \left(\frac{11.78\,FT}{2} + 1'\text{-}2"\right) = 33.59$ K·FT UNF ↻
  7.06 FT ARM
- $\Sigma P = 43.018^K + \left[(9'\text{-}10"\ SQ)^2 \times 1.167' \times 150\,pcf \times 1.034\right] = 60.52^K$ ↓
- $A = 96.69\ FT^2,\ y = 4.92\ FT,\ I = \frac{bh^3}{12} = 779.14\ FT^4$
- $q = P/A + \frac{My}{I} = 626\ psf \pm 212\ psf \rightarrow 838$ ksf OR 414 ksf

  1500 psf > NET ALLOWABLE ✓OK

→ TANK EMPTY (0.6D + 0.6W)

- $M_{OT} = 1074^{\#} \times \left(\frac{12.75\,FT}{2}\right)_{ARM} = 6.85$ K·FT
- $\Sigma P = 1250^{\#} + (9.83\ FT^2 \times 1.167\ FT \times 150\,pcf \times 0.6) = 11.41^K$
- $q = P/A \pm My/I = 118.0\ psf \pm 43.3\ psf \rightarrow 161.3$ psf OR 74.7 psf

  ✓OK



→ Ref SHT H-9 for RISA-2D SINCE those loads & footprints are larger

6.157^K ~ 414 psf = 4.07^K
838 − 414 = 2.085^K
6.156^K

~ BY INSPECTION ~ 1'-2" THICK W/ #5@10" o/c (@3" COVER BOT & 2" COVER TOP) IS SUFFICIENT FOR $M_{UNF} = 2.18^{K\cdot FT}$ & $V_{UNF} = 1.01^K$
d = 10.1"
Ld = 11.1"

~ ACI 350 T&S SHRINK REQ'S ~ POURS OF 33' & 30'

$$A_{S\,REQ'D} = \frac{0.0046h}{2\ FACES} = 0.34\ IN^2/FT < \#5@10" o/c\ (A_S = 0.37\ IN^2/FT)$$

~ GRAVITY LOADS = $43.02^K \downarrow / \left(\frac{\pi \times 8.5\ FT^2}{4}\right) = 758\ psf < 1325\ psf$ ✓OK
1500 psf − (1.167' × 150 pcf)

TANK ANCHORAGE

SHT H-22 → (4) - 3/4" ⌀ ADHESIVE ANCHORS (1 PER CLIP ANGLE)

• LC#8 UNF ~ 0.6D+F + 0.7E → (SEISMIC)

$V_{REQ'D} = 4.76^K / 4\ ANCHORS = 1.19^K_{UNF},\ 1.70^K_{ACI}$

$M_{OT} = 4.76^K \times \left(\frac{11.78\ FT}{2}\right)_{ARM} = 28.04^{K\cdot FT}_{UNF}$

$M_{RES} = 42.43^K \times \left(\frac{8.5\ FT_{TANK\,\phi}}{2}\right) = 180.33^{K\cdot FT}_{UNF}$

∴ $M_R > M_{OT}$ ~ NO TENSION IN ANCHORS $FS_{OVERTURNING} = 6.43 > 1.5$ ✓OK

• LC#7 ~ 0.6D + 0.6W → (WIND)

$M_{OT} = 1.074^K \times \left(\frac{12.75\ FT}{2}\right)_{ARM} = 6.847\ K\cdot FT$

$M_{RES} = 750\# \times \left(\frac{12.75\ FT}{2}\right) = 4.78\ K\cdot FT$

~ SINCE $M_{OT} > M_{RES}$ ~ TENSION IN ANCHORS

$$T_{REQ'D} = \frac{(M_{OT} \times 1.5\ SF) - M_{RES}}{TENSION \times 8.5\ FT} = 0.646^K_{UNF} \times \left(\frac{1.0W}{0.6W}\right)$$

$= 1.08^K_{ACI}$ REQ'D IN (2) - 3/4" ⌀ HILTI SD-500 ADHESIVE ANCHORS PER TENSION CABLE STRAP

*Ref SHT H-12 FOR HILTI PROFIS FOR MORE CONSTRAINING LOADS $T_{ACI} = 3.66^K \uparrow$, $V_{ACI} = 1.01^K \rightarrow$

$V_{REQ'D} = \frac{1.074^K}{4\ ANCHORS} = 0.27^K_{UNF},\ 0.45^K_{ACI}$ ← 4 CLIP ANGLES (1) 3/4" ⌀ ADHESIVE ANCHOR PER CLIP ANGLE

(TANK ANCHORAGE CON'T)

- LC#7 – 0.9D+0.9F+1.0E = 36.57K↓ & 6.80K @ $\frac{11.78FT}{2}$ ARM
  - $V_{DES} = \frac{6.80K}{4 \text{ ANCHORS}} = \underline{1.70K_{ACH}}$ ← (1) 3/4"ø ADHESIVE ANCHOR PER 4 CLIPANGLES
  - $M_{OT} = 6.80K \times \left(\frac{11.78FT}{2}\right)_{ARM} = 40.05K\cdot FT$
  - $M_{RES} = 36.57K \times \frac{8.5FT}{2} = 155.4\ K\cdot FT$ ~ FS = 3.88 > 1.5 ✓OK
  - ~NO TENSION IN ANCHORS

* REF SHT H-13 FOR MORE CONSTRAINING SHEAR LOAD = 4.33K/ACH IN (1) 3/4"ø ADHESIVE ANCHOR

H-22

www.hilti.us

Profis Anchor 2.4.8

Company:	ARCADIS	Page:	1
Specifier:	Matt Lotycz	Project:	Topok, CA PG&E - HQ
Address:		Sub-Project I Pos. No.:	HQ Utility Pad
Phone I Fax:	|	Date:	12/22/2014
E-Mail:			

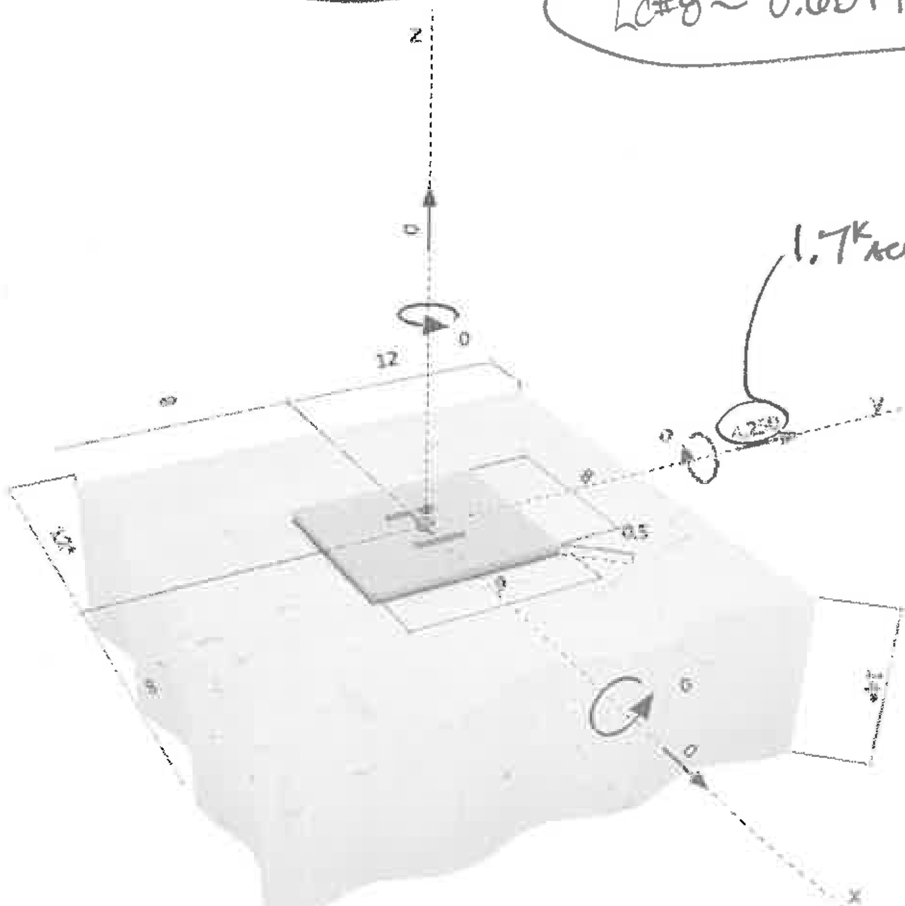
Specifier's comments: 5,000 Gal Tank Anchorage - Max Seismic shear

1 Input data

Anchor type and diameter:	**HIT-RE 500-SD + HAS B7 3/4**
Effective embedment depth:	$h_{ef,act}$ = 10.000 in. ($h_{ef,limit}$ = - in.)
Material:	ASTM A 193 Grade B7 — SAME CAPACITY FOR 316 SST
Evaluation Service Report:	ESR-2322
Issued I Valid:	2/1/2014 | 4/1/2016
Proof:	design method ACI 318-11 / Chem
Stand-off installation:	e_b = 0.000 in. (no stand-off); t = 0.500 in.
Anchor plate:	l_x x l_y x t = 8.000 in. x 9.000 in. x 0.500 in.; (Recommended plate thickness: not calculated)
Profile:	S shape (AISC); (L x W x T x FT) = 3.000 in. x 2.330 in. x 0.170 in. x 0.260 in.
Base material:	cracked concrete, 4000, f_c' = 4000 psi; h = 14.000 in., Temp. short/long: 130/110 °F
Installation:	hammer drilled hole, installation condition: dry
Reinforcement:	tension: condition B, shear: condition B; no supplemental splitting reinforcement present edge reinforcement: > No. 4 bar
Seismic loads (cat. C, D, E, or F)	Tension load: yes (D.3.3.4.3 (d)) Shear load: yes (D.3.3.5.3 (c))

Geometry [in.] & Loading [lb, in.lb]

LC#8 ~ 0.6D+1.0F+0.7E → SEISMIC → 1.7K ACI x Ω = 2.5 OVERSTRENGTH



Input data and results must be checked for agreement with the existing conditions and for plausibility!
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Company:	ARCADIS	Page:	2
Specifier:	Matt Lotycz	Project:	Topok, CA PG&E - HQ
Address:		Sub-Project I Pos. No.:	HQ Utility Pad
Phone I Fax:	|	Date:	12/22/2014
E-Mail:			

2 Load case/Resulting anchor forces

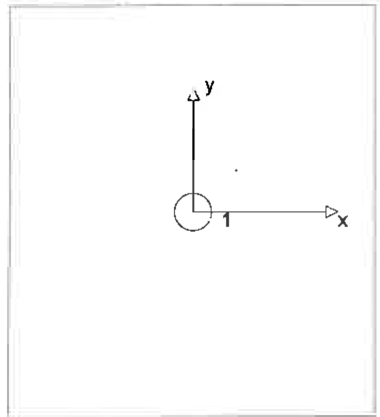
Load case: Design loads

Anchor reactions [lb]

Tension force: (+Tension, -Compression)

Anchor	Tension force	Shear force	Shear force x	Shear force y
1	0	4250	0	4250

max. concrete compressive strain: - [‰]
max. concrete compressive stress: - [psi]
resulting tension force in (x/y)=(0.000/0.000): 0 [lb]
resulting compression force in (x/y)=(0.000/0.000): 0 [lb]



3 Tension load

	Load N_{ua} [lb]	Capacity ϕN_n [lb]	Utilization $\beta_N = N_{ua}/\phi N_n$	Status
Steel Strength*	N/A	N/A	N/A	N/A
Bond Strength**	N/A	N/A	N/A	N/A
Sustained Tension Load Bond Strength*	N/A	N/A	N/A	N/A
Concrete Breakout Strength**	N/A	N/A	N/A	N/A

* anchor having the highest loading **anchor group (anchors in tension)

Input data and results must be checked for agreement with the existing conditions and for plausibility!
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Company:	ARCADIS	Page:	3
Specifier:	Matt Lotycz	Project:	Topok, CA PG&E - HQ
Address:		Sub-Project I Pos. No.:	HQ Utility Pad
Phone I Fax:	|	Date:	12/22/2014
E-Mail:			

4 Shear load

	Load V_{ua} [lb]	Capacity ϕV_n [lb]	Utilization $\beta_V = V_{ua}/\phi V_n$	Status
Steel Strength*	4250	11414	38	OK
Steel failure (with lever arm)*	N/A	N/A	N/A	N/A
Pryout Strength (Bond Strength controls)**	4250	7397	58	OK
Concrete edge failure in direction y+**	4250	13147	33	OK

* anchor having the highest loading **anchor group (relevant anchors)

4.1 Steel Strength

$V_{sa} = \alpha_{V,seis} (n\ 0.6\ A_{se,V}\ f_{uta})$ refer to ICC-ES ESR-2322

$\phi\ V_{steel} \geq V_{ua}$ ACI 318-11 Table D.4.1.1

Variables

n	$A_{se,V}$ [in.^{2}]	f_{uta} [psi]	$\alpha_{V,seis}$	$(n\ 0.6\ A_{se,V}\ f_{uta})$ [lb]
1	0.33	125000	0.700	25086

Calculations

$V_{sa,eq}$ [lb]
17560

Results

$V_{sa,eq}$ [lb]	ϕ_{steel}	$\phi\ V_{sa}$ [lb]	V_{ua} [lb]
17560	0.650	11414	4250

4.2 Pryout Strength (Bond Strength controls)

$V_{cp} = k_{cp}\left[\left(\frac{A_{Na}}{A_{Na0}}\right) \psi_{ed,Na}\ \psi_{p,Na}\ N_{a0}\right]$ ACI 318-11 Eq. (D-40)

$\phi\ V_{cp} \geq V_{ua}$ ACI 318-11 Table (D.4.1.1)

A_{Na} see ACI 318-11, Part D.5.5.1, Fig. RD.5.5.1(b)

$A_{Na0} = (2\ c_{Na})^2$ ACI 318-11 Eq. (D-20)

$c_{Na} = 10\ d_a \sqrt{\frac{\tau_{uncr}}{1100}}$ ACI 318-11 Eq. (D-21)

$\psi_{ec,Na} = \left(\frac{1}{1 + \frac{e_N}{c_{Na}}}\right) \leq 1.0$ ACI 318-11 Eq. (D-23)

$\psi_{ed,Na} = 0.7 + 0.3 \left(\frac{c_{a,min}}{c_{ac}}\right) \leq 1.0$ ACI 318-11 Eq. (D-25)

$\psi_{cp,Na} = \text{MAX}\left(\frac{c_{a,min}}{c_{ac}}, \frac{c_{Na}}{c_{ac}}\right) \leq 1.0$ ACI 318-11 Eq. (D-27)

$N_{ba} = \lambda_a \cdot \tau_{k,c} \cdot \alpha_{N,seis} \cdot \kappa_{bond} \cdot \pi \cdot d_a \cdot h_{ef}$ ACI 318-11 Eq. (D-22)

Variables

k_{cp}	$\tau_{k,c,uncr}$ [psi]	d_a [in.]	h_{ef} [in.]	$c_{a,min}$ [in.]	$\tau_{k,c}$ [psi]
2	715	0.750	10.000	12.000	345

$e_{c1,N}$ [in.]	$e_{c2,N}$ [in.]	c_{ac} [in.]	κ_{bond}	λ_a	$\alpha_{N,seis}$
0.000	0.000	17.469	1.00	1.000	0.650

Calculations

c_{Na} [in.]	A_{Na} [in.^{2}]	A_{Na0} [in.^{2}]	$\psi_{ed,Na}$
6.019	144.93	144.93	1.000

$\psi_{ec1,Na}$	$\psi_{ec2,Na}$	$\psi_{cp,Na}$	N_{ba} [lb]
1.000	1.000	1.000	5284

Results

V_{cp} [lb]	$\phi_{concrete}$	$\phi_{seismic}$	$\phi_{nonductile}$	$\phi\ V_{cp}$ [lb]	V_{ua} [lb]
10568	0.700	1.000	1.000	7397	4250

Input data and results must be checked for agreement with the existing conditions and for plausibility!
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4.3 Concrete edge failure in direction y+

$V_{cb} = \left(\frac{A_{Vc}}{A_{Vc0}}\right) \psi_{ed,V}\ \psi_{c,V}\ \psi_{h,V}\ \psi_{parallel,V}\ V_b$ — ACI 318-11 Eq. (D-30)

$\phi\ V_{cb} \geq V_{ua}$ — ACI 318-11 Table D.4.1.1

A_{Vc} see ACI 318-11, Part D.6.2.1, Fig. RD.6.2.1(b)

$A_{Vc0} = 4.5\ c_{a1}^2$ — ACI 318-11 Eq. (D-32)

$\psi_{ec,V} = \left(\frac{1}{1 + \frac{2e_V}{3c_{a1}}}\right) \leq 1.0$ — ACI 318-11 Eq. (D-36)

$\psi_{ed,V} = 0.7 + 0.3\left(\frac{c_{a2}}{1.5c_{a1}}\right) \leq 1.0$ — ACI 318-11 Eq. (D-38)

$\psi_{h,V} = \sqrt{\frac{1.5c_{a1}}{h_a}} \geq 1.0$ — ACI 318-11 Eq. (D-39)

$V_b = 9\ \lambda_a \sqrt{f'_c}\ c_{a1}^{1.5}$ — ACI 318-11 Eq. (D-34)

Variables

c_{a1} [in.]	c_{a2} [in.]	e_{cV} [in.]	$\psi_{c,V}$	h_a [in.]
12.000	12.000	0.000	1.200	14.000

l_e [in.]	λ_a	d_a [in.]	f'_c [psi]	$\psi_{parallel,V}$
6.000	1.000	0.750	4000	1.000

Calculations

A_{Vc} [in.^{2}]	A_{Vc0} [in.^{2}]	$\psi_{ec,V}$	$\psi_{ed,V}$	$\psi_{h,V}$	V_b [lb]
420.00	648.00	1.000	0.900	1.134	23662

Results

V_{cb} [lb]	$\phi_{concrete}$	$\phi_{seismic}$	$\phi_{nonductile}$	$\phi\ V_{cb}$ [lb]	V_{ua} [lb]
18781	0.700	1.000	1.000	13147	4250

5 Warnings

- Load re-distributions on the anchors due to elastic deformations of the anchor plate are not considered. The anchor plate is assumed to be sufficiently stiff, in order not to be deformed when subjected to the loading!
- Condition A applies when supplementary reinforcement is used. The Φ factor is increased for non-steel Design Strengths except Pullout Strength and Pryout strength. Condition B applies when supplementary reinforcement is not used and for Pullout Strength and Pryout Strength. Refer to your local standard.
- Design Strengths of adhesive anchor systems are influenced by the cleaning method. Refer to the INSTRUCTIONS FOR USE given in the Evaluation Service Report for cleaning and installation instructions
- Checking the transfer of loads into the base material and the shear resistance are required in accordance with ACI 318 or the relevant standard!
- An anchor design approach for structures assigned to Seismic Design Category C, D, E or F is given in ACI 318-11 Appendix D, Part D.3.3.4.3 (a) that requires the governing design strength of an anchor or group of anchors be limited by ductile steel failure. If this is NOT the case, the connection design (tension) shall satisfy the provisions of Part D.3.3.4.3 (b), Part D.3.3.4.3 (c), or Part D.3.3.4.3 (d). The connection design (shear) shall satisfy the provisions of Part D.3.3.5.3 (a), Part D.3.3.5.3 (b), or Part D.3.3.5.3 (c).
- Part D.3.3.4.3 (b) / part D.3.3.5.3 (a) requires that the attachment the anchors are connecting to the structure be designed to undergo ductile yielding at a load level corresponding to anchor forces no greater than the controlling design strength. Part D.3.3.4.3 (c) / part D.3.3.5.3 (b) waives the ductility requirements and requires that the anchors shall be designed for the maximum tension / shear that can be transmitted to the anchors by a non-yielding attachment. Part D.3.3.4.3 (d) / part D.3.3.5.3 (c) waives the ductility requirements and requires the design strength of the anchors to equal or exceed the maximum tension / shear obtained from design load combinations that include E, with E increased by Ω_0.
- Installation of Hilti adhesive anchor systems shall be performed by personnel trained to install Hilti adhesive anchors. Reference ACI 318-11, Part D.9.1

Fastening meets the design criteria!

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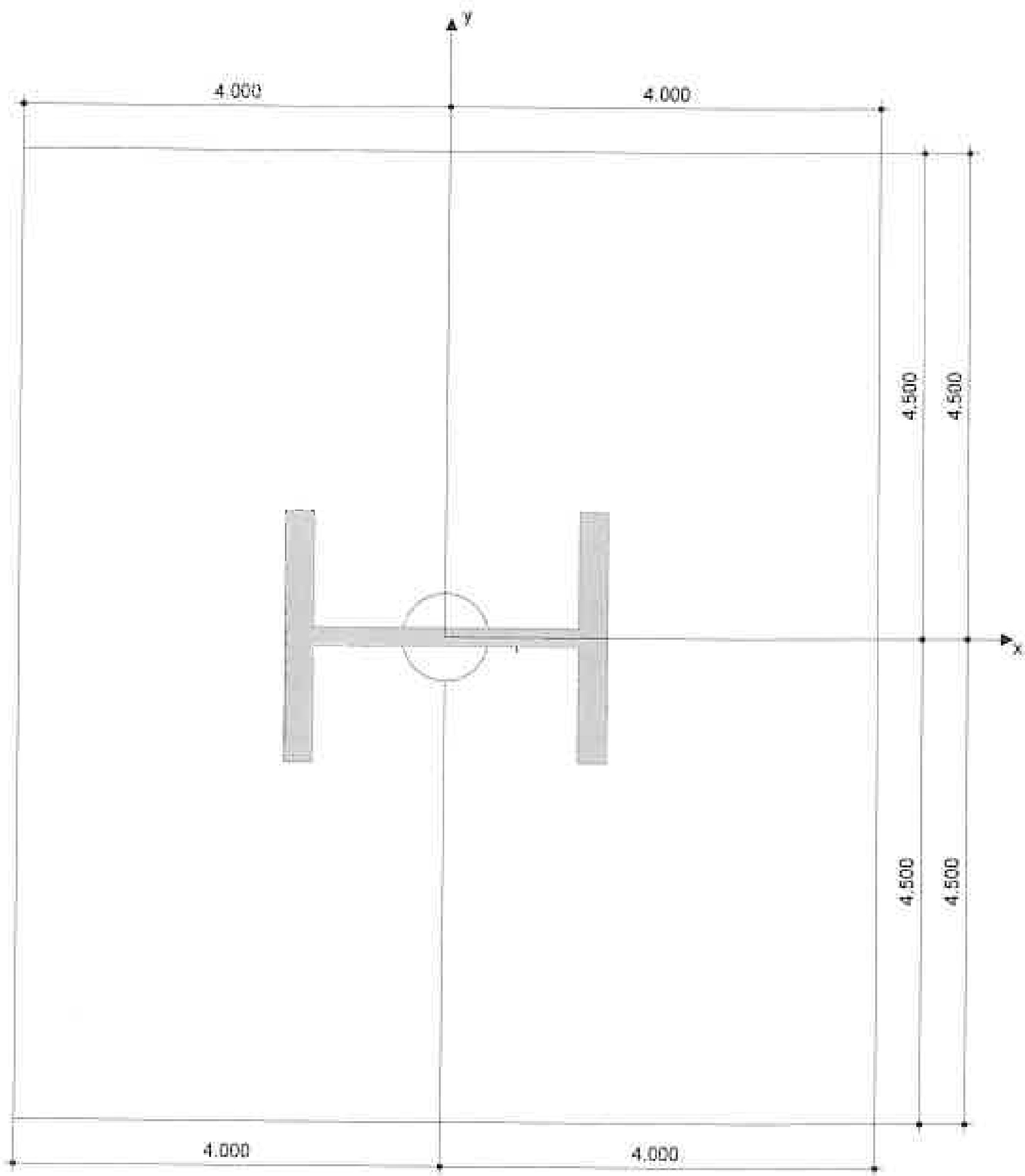
Company:	ARCADIS	Page:	5
Specifier:	Matt Lotycz	Project:	Topok, CA PG&E - HQ
Address:		Sub-Project I Pos. No.:	HQ Utility Pad
Phone I Fax:	|	Date:	12/22/2014
E-Mail:			

6 Installation data

Anchor plate, steel: -
Profile: S shape (AISC); 3.000 x 2.330 x 0.170 x 0.260 in.
Hole diameter in the fixture: d_f = 0.813 in.
Plate thickness (input): 0.500 in.
Recommended plate thickness: not calculated
Cleaning: Premium cleaning of the drilled hole is required

Anchor type and diameter: HIT-RE 500-SD + HAS B7 3/4
Installation torque: 1200.000 in.lb
Hole diameter in the base material: 0.875 in.
Hole depth in the base material: 10.000 in.
Minimum thickness of the base material: 11.750 in.



Coordinates Anchor in.

Anchor	x	y	c_{-x}	c_{+x}	c_{-y}	c_{+y}
1	0.000	0.000	12.000	-	-	12.000

Input data and results must be checked for agreement with the existing conditions and for plausibility!
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Company: ARCADIS
Specifier: Matt Lotycz
Address:
Phone I Fax: |
E-Mail:

7 Remarks; Your Cooperation Duties

- Any and all information and data contained in the Software concern solely the use of Hilti products and are based on the principles, formulas and security regulations in accordance with Hilti's technical directions and operating, mounting and assembly instructions, etc., that must be strictly complied with by the user. All figures contained therein are average figures, and therefore use-specific tests are to be conducted prior to using the relevant Hilti product. The results of the calculations carried out by means of the Software are based essentially on the data you put in. Therefore, you bear the sole responsibility for the absence of errors, the completeness and the relevance of the data to be put in by you. Moreover, you bear sole responsibility for having the results of the calculation checked and cleared by an expert, particularly with regard to compliance with applicable norms and permits, prior to using them for your specific facility. The Software serves only as an aid to interpret norms and permits without any guarantee as to the absence of errors, the correctness and the relevance of the results or suitability for a specific application.
- You must take all necessary and reasonable steps to prevent or limit damage caused by the Software. In particular, you must arrange for the regular backup of programs and data and, if applicable, carry out the updates of the Software offered by Hilti on a regular basis. If you do not use the AutoUpdate function of the Software, you must ensure that you are using the current and thus up-to-date version of the Software in each case by carrying out manual updates via the Hilti Website. Hilti will not be liable for consequences, such as the recovery of lost or damaged data or programs, arising from a culpable breach of duty by you.

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ELECTRICAL GENERATOR w/ ENCLOSURE & FUEL TANK

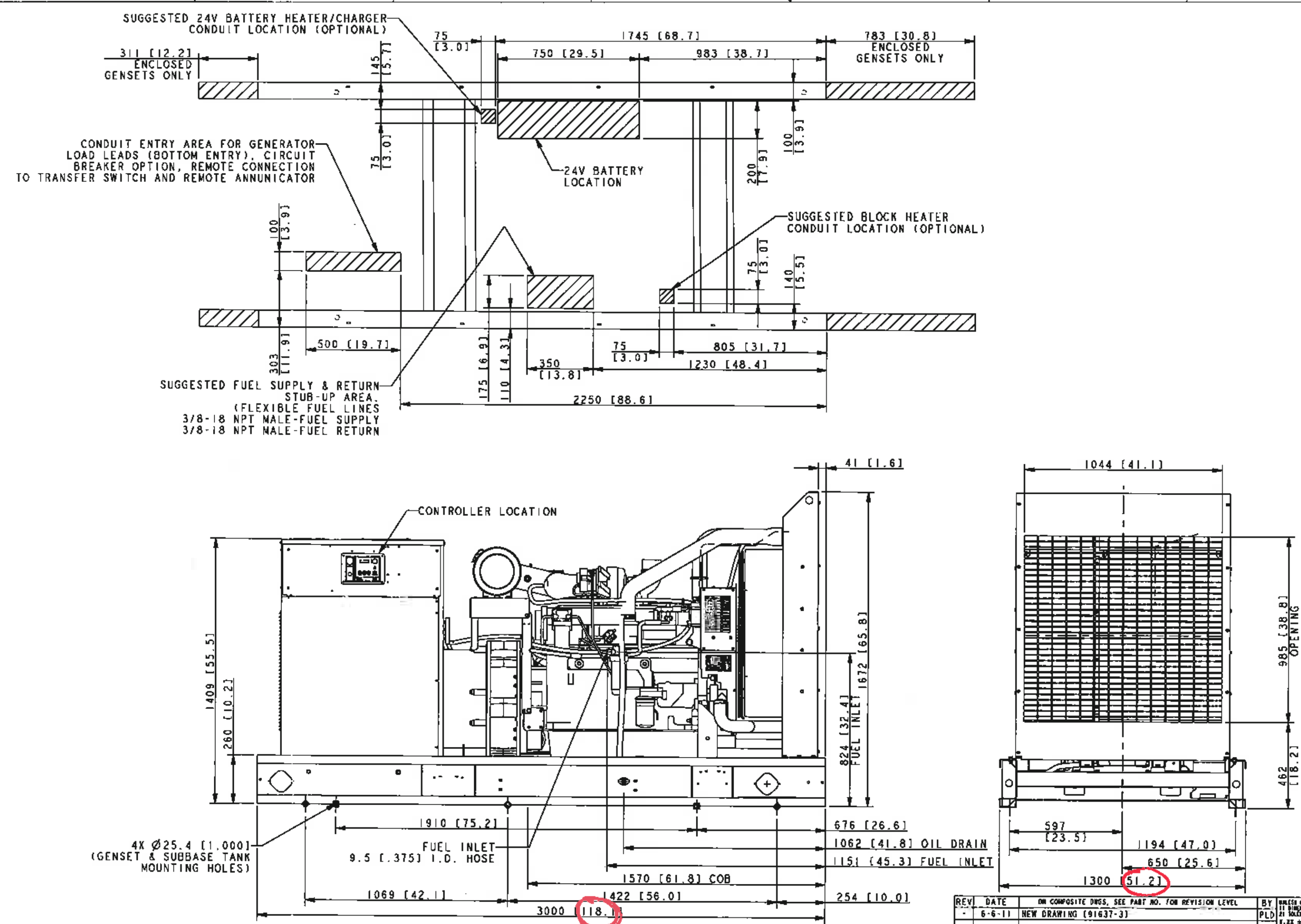
- REF SHT H-24 FOR GENERATOR → 4240# (ON 2 STEEL SKID BEAMS @ 48" o/c × 9'-10" LONG × 4'-3 1/8")
- REF SHT H-25 FOR ENCLOSURE → 13'-5" × 4'-4 1/2" → 1290#
  - FUEL TANK → 13'-5" × 4'-3 1/8" → 2926# (758 GAL)

TOTAL LOAD = 8456# / (4'-3 1/8" × 9'-10")
= 202 psf < 1325 psf NET ALLOWABLE ✓OK

→ BY INSPECTION, 1'-2" THICK w/ #5 @ 10" o/c EF/EW (3" COVER BOT & 2" COVER TOP) IS SUFFICIENT TO SPAN MINIMAL LOADS B/W 4'-0" c/c STEEL SKID BEAMS

→ ANCHORAGE BY GENERATOR MFG

H-24



■ 4X25.4 [1.0] STANDARD MOUNTING
◆ 6X22.2 [0.88] IBC MOUNTING

INSTALLATION NOTE
IF SUBBASE FUEL TANK AND/OR SOUND HOUSING IS USED, REFER TO SUBBASE FUEL TANK ADV TO DETERMINE MOUNTING LOCATIONS.

NOTES:
1) WHEN SUBBASE TANK IS USED, CONDUIT MUST BE LOCATED OUTSIDE OF TANK AREA OR IN STUB-UP AREA FOR SUBBASE TANK. REFER TO SUBBASE ADV.
2) DIMENSIONS IN [] ARE ENGLISH EQUIVALENTS.
3) IF AN ENCLOSURE IS USED, THE FUEL LINE MUST BE STUBBED UP FROM DIRECTLY UNDER THE UNIT OR BROUGHT IN FROM THE END OF THE SKID. REFER TO ENCLOSURE ADV.
4) MAXIMUM WET WEIGHT OF GENSET: 1923 KG [4240 LBS]
5) IF IBC CERTIFICATION IS REQUIRED SEE SEISMIC ADV FOR INSTALLATION INSTRUCTIONS.

200 MODEL, 4UA9, 4UA13 RECONNECTABLE IMPROVED MOTOR STARTING (IMS) RECONNECTABLE AND 600V ALTERNATORS JOHN DEERE 6068HF TIER III

REV	DATE	ON COMPOSITE DWGS, SEE PART NO. FOR REVISION LEVEL	BY
-	6-6-11	NEW DRAWING [91637-3]	PLD

APPROVALS		DATE
DRAWN	PLD	6-6-11
CHECKED	PLD	6-6-11
APPROVED	GDF	6-6-11

KOHLER CO. METRIC | PRO-E
POWER SYSTEMS, KOHLER, WI 53044 U.S.A.
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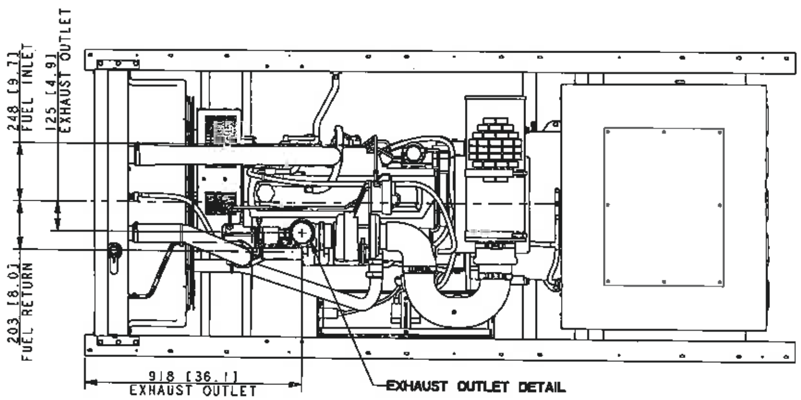
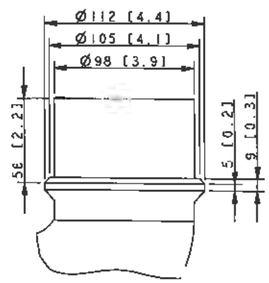
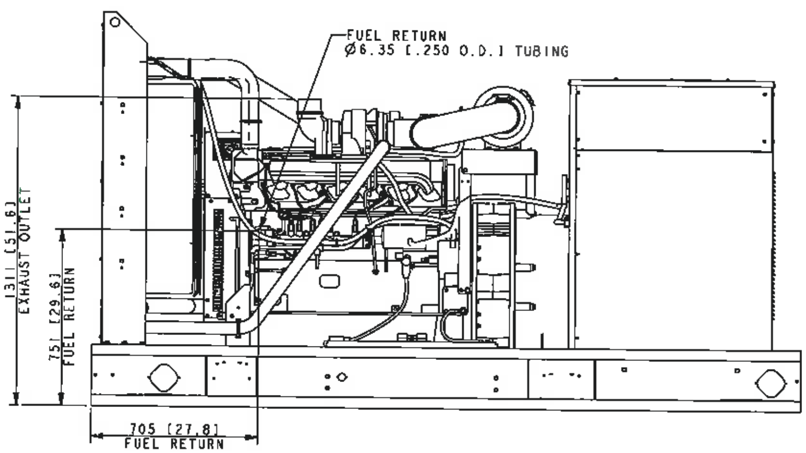
TITLE: DIMENSION PRINT, 200 MODEL
SCALE 0.10 | SHEET 1 of 2
DWG NO. ADV-8185 | D





EXHAUST OUTLET DETAIL
SCALE 0.60



200 MODEL 4UA9, 4UA13 RECONNECTABLE
IMPROVED MOTOR STARTING (IMS) RECONNECTABLE
AND 600V ALTERNATORS
JOHN DEERE 6068HF TIER III

REV	DATE	ON COMPOSITE DWGS, SEE PART NO. FOR REVISION LEVEL	BY
-	6-6-11	NEW DRAWING [91637-3]	PLD

UNLESS OTHERWISE SPECIFIED - 1) DIMENSIONS ARE IN MILLIMETERS 2) TOLERANCES ARE: X.XX ± X.X ± X ± ANGLES ±

SURFACE FINISH MAX.

THIRD ANGLE PROJECTION

APPROVALS		DATE
DRAWN	PLD	6-6-11
CHECKED	PLD	6-6-11
APPROVED	GDF	6-6-11

KOHLER CO. METRIC | PRO-E

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SCALE 0.10 | CAD NO. | SHEET 2 of 2

DWG NO. ADV-8185 | D

Model: **200REOZJF**

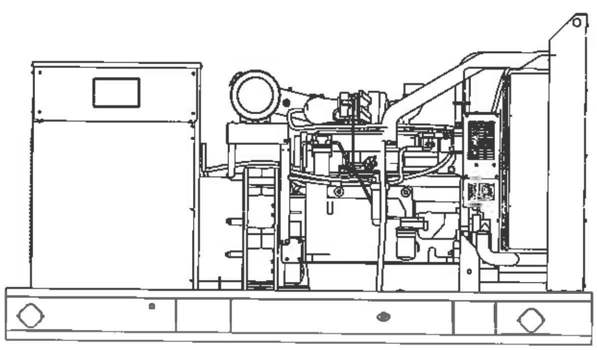
KOHLER. Power Systems

208-600 V **Diesel**

Tier 3 EPA-Certified for Stationary Emergency Applications

Ratings Range

		60 Hz
Standby:	kW	168-200
	kVA	210-250
Prime:	kW	158-180
	kVA	198-225



Generator Set Ratings

Alternator	Voltage	Ph	Hz	130°C Rise Standby Rating kW/kVA	Amps	105°C Rise Prime Rating kW/kVA	Amps
4S13X	120/208	3	60	184/230	639	173/216	600
	127/220	3	60	194/243	636	180/225	590
	120/240	3	60	184/230	553	173/216	520
	139/240	3	60	200/250	601	180/225	541
	220/380	3	60	168/210	319	158/198	300
	277/480	3	60	200/250	301	180/225	271
4UA9	120/208	3	60	200/250	694	180/225	625
	127/220	3	60	200/250	656	180/225	590
	120/240	3	60	200/250	601	180/225	541
	139/240	3	60	200/250	601	180/225	541
	220/380	3	60	200/250	380	180/225	342
	277/480	3	60	200/250	301	180/225	271
	347/600	3	60	200/250	241	180/225	217
4UA13	120/208	3	60	200/250	694	180/225	625
	127/220	3	60	200/250	656	180/225	590
	120/240	3	60	200/250	601	180/225	541
	139/240	3	60	200/250	601	180/225	541
	220/380	3	60	200/250	380	180/225	342
	277/480	3	60	200/250	301	180/225	271
	347/600	3	60	200/250	241	180/225	217

RATINGS: All three-phase units are rated at 0.8 power factor. All single-phase units are rated at 1.0 power factor. *Standby Ratings:* The standby rating is applicable to varying loads for the duration of a power outage. There is no overload capability for this rating. *Prime Power Ratings:* At varying load, the number of generator set operating hours is unlimited. A 10% overload capacity is available for one hour in twelve. Ratings are in accordance with ISO-8528-1 and ISO-3046-1. For limited running time and continuous ratings, consult the factory. Obtain technical information bulletin (TIB-101) for ratings guidelines, complete ratings definitions, and site condition derates. The generator set manufacturer reserves the right to change the design or specifications without notice and without any obligation or liability whatsoever.

Standard Features

- Kohler Co. provides one-source responsibility for the generating system and accessories.
- The generator set and its components are prototype-tested, factory-built, and production-tested.
- The 60 Hz generator set offers a UL 2200 listing.
- The generator set accepts rated load in one step.
- The 60 Hz generator set meets NFPA 110, Level 1, when equipped with the necessary accessories and installed per NFPA standards.
- A one-year limited warranty covers all systems and components. Two- and five-year extended warranties are also available.
- Alternator features:
  - The unique Fast-Response™ X excitation system delivers excellent voltage response and short-circuit capability using a rare-earth, permanent magnet (PM)-excited alternator.
    (4S13X alternator)
  - The unique Fast-Response™ II excitation system delivers excellent voltage response and short-circuit capability using a permanent magnet (PM)-excited alternator.
    (4UA9 and 4UA13 alternators)
  - The brushless, rotating-field alternator has broadrange reconnectability.
- Other features:
  - Kohler designed controllers for guaranteed system integration and remote communication. See Controllers on page 3.
  - The low coolant level shutdown prevents overheating (standard on radiator models only).
  - Integral vibration isolation eliminates the need for under-unit vibration spring isolators.
  - Multiple circuit breaker configurations.

Alternator Specifications

Specifications	Alternator
Manufacturer	Kohler
Type	4-Pole, Rotating-Field
Exciter type	Brushless, Permanent-Magnet
Leads: quantity, type	
4SX, 4UA	12, Reconnectable
Voltage regulator	Solid State, Volts/Hz
Insulation:	NEMA MG1
Material	Class H
Temperature rise	130°C, Standby
Bearing: quantity, type	1, Sealed
Coupling	Flexible Disc
Amortisseur windings	Full
Voltage regulation, no-load to full-load	Controller Dependent
One-step load acceptance	100% of Rating
Unbalanced load capability	100% of Rated Standby Current

- NEMA MG1, IEEE, and ANSI standards compliance for temperature rise and motor starting.
- Sustained short-circuit current of up to 300% of the rated current for up to 10 seconds.
- Sustained short-circuit current enabling downstream circuit breakers to trip without collapsing the alternator field.
- Self-ventilated and dripproof construction.
- Vacuum-impregnated windings with fungus-resistant epoxy varnish for dependability and long life.
- Superior voltage waveform from a two-thirds pitch stator and skewed rotor.

Specifications		Alternator
Peak motor starting kVA:		(35% dip for voltages below)
480 V	4S13X (12 lead)	570
480 V	4UA9 (12 lead)	700
480 V	4UA13 (12 lead)	960

Application Data

Engine

Engine Specifications	
Manufacturer	John Deere
Engine model	6068HFG85
Engine type	4-Cycle, Turbocharged, Charge Air-Cooled
Cylinder arrangement	6 Inline
Displacement, L (cu. in.)	6.8 (415)
Bore and stroke, mm (in.)	106 x 127 (4.19 x 5.00)
Compression ratio	17.0:1
Piston speed, m/min. (ft./min.)	457 (1500)
Main bearings: quantity, type	7, Replaceable Insert
Rated rpm	1800
Max. power at rated rpm, kWm (BHP)	235 (315)
Cylinder head material	Cast Iron
Crankshaft material	Forged Steel
Valve material:	
Intake	Chromium-Silicon Steel
Exhaust	Stainless Steel
Governor: type, make/model	JDEC Electronic L14 Denso HP3
Frequency regulation, no-load to full-load	Isochronous
Frequency regulation, steady state	±0.25%
Frequency	Fixed
Air cleaner type, all models	Dry

Exhaust

Exhaust System	
Exhaust manifold type	Dry
Exhaust flow at rated kW, m³/min. (cfm)	42.8 (1510)
Exhaust temperature at rated kW, dry exhaust, °C (°F)	527 (980)
Maximum allowable back pressure, kPa (in. Hg)	Min. 4 (1.2) Max. 10 (3.0)
Exhaust outlet size at engine hookup, mm (in.)	98 (3.86)

Engine Electrical

Engine Electrical System	
Battery charging alternator:	24 Volt
Ground (negative/positive)	Negative
Volts (DC)	24
Ampere rating	45
Starter motor rated voltage (DC)	24
Battery, recommended cold cranking amps (CCA):	
Quantity, CCA rating each	Two, 950
Battery voltage (DC)	12

Fuel

Fuel System	
Fuel supply line, min. ID, mm (in.)	11.0 (0.44)
Fuel return line, min. ID, mm (in.)	6.0 (0.25)
Max. lift, fuel pump: type, m (ft.)	Mechanical, 1.8 (6.0)
Max. fuel flow, Lph (gph)	92.7 (24.5)
Max. return line restriction, kPa (in. Hg)	20 (5.9)
Fuel prime pump	Manual
Fuel filter	
Primary	30 Microns
Secondary	2 Microns @ 98% Efficiency
Water Separator	Yes
Recommended fuel	#2 Diesel

Lubrication

Lubricating System	
Type	Full Pressure
Oil pan capacity, L (qt.)	32.5 (34.4)
Oil pan capacity with filter, L (qt.)	33.4 (35.3)
Oil filter: quantity, type	1, Cartridge
Oil cooler	Water-Cooled

Application Data

Cooling

Radiator System	
Ambient temperature, °C (°F) *	50 (122)
Engine jacket water capacity, L (gal.)	11.3 (3.0)
Radiator system capacity, including engine, L (gal.)	27.6 (7.3)
Engine jacket water flow, Lpm (gpm)	230.9 (61)
Heat rejected to cooling water at rated kW, dry exhaust, kW (Btu/min.)	94.2 (5360)
Heat rejected to air charge cooler at rated kW, dry exhaust, kW (Btu/min.)	56.1 (3190)
Water pump type	Centrifugal
Fan diameter, including blades, mm (in.)	787 (31)
Fan, kWm (HP)	8.6 (11.5)
Max. restriction of cooling air, intake and discharge side of radiator, kPa (in. H_2O)	0.125 (0.5)

* Enclosure with enclosed silencer reduces ambient temperature capability by 5°C (9°F).

Operation Requirements

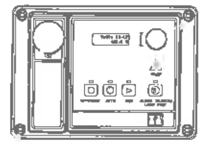
Air Requirements	
Radiator-cooled cooling air, m^3/min. (scfm)‡	368.1 (13000)
Combustion air, m^3/min. (cfm)	17.6 (620)
Heat rejected to ambient air:	
Engine, kW (Btu/min.)	46.9 (2670)
Alternator, kW (Btu/min.)	18.5 (1050)

‡ Air density = 1.20 kg/m^3 (0.075 lbm/ft^3)

Fuel Consumption

Diesel, Lph (gph) at % load	Standby Rating	
100%	58.0	(15.3)
75%	43.3	(11.4)
50%	31.4	(8.3)
25%	19.7	(5.2)
Diesel, Lph (gph) at % load	**Prime Rating**	
100%	50.1	(13.2)
75%	36.1	(9.5)
50%	25.7	(6.8)
25%	16.6	(4.4)

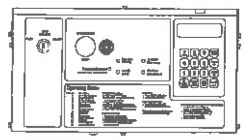
Controllers



Decision-Maker® 3000 Controller
Provides advanced control, system monitoring, and system diagnostics for optimum performance and compatibility.

- Digital display and menu control provide easy local data access
- Measurements are selectable in metric or English units
- Remote communication thru a PC via network or serial configuration
- Controller supports Modbus® protocol
- Integrated hybrid voltage regulator with ±0.5% regulation
- Built-in alternator thermal overload protection
- NFPA 110 Level 1 capability

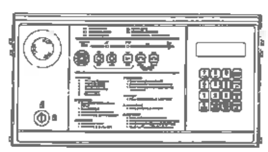
Refer to G6-100 for additional controller features and accessories.



Decision-Maker® 550 Controller
Provides advanced control, system monitoring, and system diagnostics with remote monitoring capabilities.

- Digital display and keypad provide easy local data access
- Measurements are selectable in metric or English units
- Remote communication thru a PC via network or modem configuration
- Controller supports Modbus® protocol
- Integrated voltage regulator with ±0.25% regulation
- Built-in alternator thermal overload protection
- NFPA 110 Level 1 capability

Refer to G6-46 for additional controller features and accessories.



Decision-Maker® 6000 Paralleling Controller
Provides advanced control, system monitoring, and system diagnostics with remote monitoring capabilities for paralleling multiple generator sets.

- Paralleling capability with first-on logic, synchronizer, kW and kVAR load sharing, and protective relays
- Digital display and keypad provide easy local data access
- Measurements are selectable in metric or English units
- Remote communication thru a PC via network or modem configuration
- Controller supports Modbus® protocol
- Integrated voltage regulator with ±0.25% regulation
- Built-in alternator thermal overload protection
- NFPA 110 Level 1 capability

Refer to G6-107 for additional controller features and accessories.

KOHLER CO., Kohler, Wisconsin 53044 USA
Phone 920-457-4441, Fax 920-459-1646
For the nearest sales and service outlet in the US and Canada, phone 1-800-544-2444
KOHLERPower.com

Kohler Power Systems
Asia Pacific Headquarters
7 Jurong Pier Road
Singapore 619159
Phone (65) 6264-6422, Fax (65) 6264-6455

Standard Features

- Alternator Protection
- Battery Rack and Cables
- Customer Connection (standard with Decision-Maker® 6000 controller only)
- Local Emergency Stop Switch
- Oil Drain Extension
- Operation and Installation Literature

Available Options

Approvals and Listings

- ❑ California OSHPD Approval
- ❑ CSA Approval
- ❑ IBC Seismic Certification
- ❑ UL 2200 Listing

Enclosed Unit

- ❑ Sound Enclosure (with enclosed critical silencer)
- ❑ Weather Enclosure (with enclosed critical silencer)

Open Unit

- ❑ Exhaust Silencer, Critical (kit: PA-354809)
- ❑ Flexible Exhaust Connector, Stainless Steel

Fuel System

- ❑ Flexible Fuel Lines
- ❑ Fuel Pressure Gauge
- ❑ Subbase Fuel Tanks

Controller

- ❑ Common Failure Relay
- ❑ Communication Products and PC Software
- ❑ Customer Connection (Decision-Maker® 550 controller only)
- ❑ Decision-Maker® Paralleling System (DPS) (Decision-Maker® 6000 controller only)
- ❑ Dry Contact (isolated alarm) (Decision-Maker® 550 and 6000 controllers only)
- ❑ Input/Output Module (Decision-Maker® 3000 controller only)
- ❑ Remote Emergency Stop Switch
- ❑ Remote Serial Annunciator Panel
- ❑ Run Relay

Cooling System

- ❑ Block Heater, 1800 W, 90-120 V, 1 Ph
- ❑ Block Heater, 2000 W, 190-240 V, 1 Ph
  Recommended for ambient temperatures below 0°C (32°F)
- ❑ Radiator Duct Flange

Electrical System

- ❑ Alternator Strip Heater
- ❑ Battery
- ❑ Battery Charger, Equalize/Float Type
- ❑ Battery Heater
- ❑ Line Circuit Breaker (NEMA type 1 enclosure)
- ❑ Line Circuit Breaker with Shunt Trip (NEMA type 1 enclosure)

Paralleling System

- ❑ Manual Speed Adjust

Miscellaneous

- ❑ Air Cleaner, Heavy Duty
- ❑ Air Cleaner Restriction Indicator
- ❑ Certified Test Report
- ❑ Crankcase Emissions Canister
- ❑ Engine Fluids Added
- ❑ Rated Power Factor Testing
- ❑ Rodent Guards

Literature

- ❑ General Maintenance
- ❑ NFPA 110
- ❑ Overhaul
- ❑ Production

Warranty

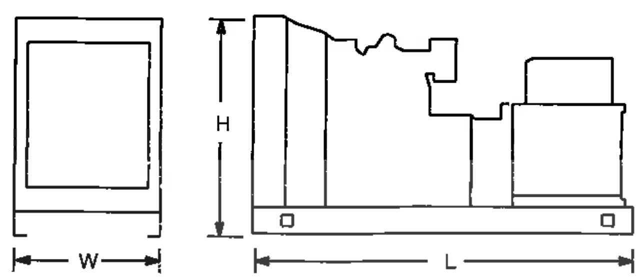
- ❑ 2-Year Basic
- ❑ 5-Year Basic
- ❑ 5-Year Comprehensive

Other Options

- ❑ ______________________
- ❑ ______________________
- ❑ ______________________
- ❑ ______________________
- ❑ ______________________

Dimensions and Weights

Overall Size, L x W x H, mm (in.):	3000 x 1300 x 1672 (118.1 x 51.2 x 65.8)
Weight (radiator model), wet, kg (lb.):	1923 (4240)



NOTE: This drawing is provided for reference only and should not be used for planning installation. Contact your local distributor for more detailed information.

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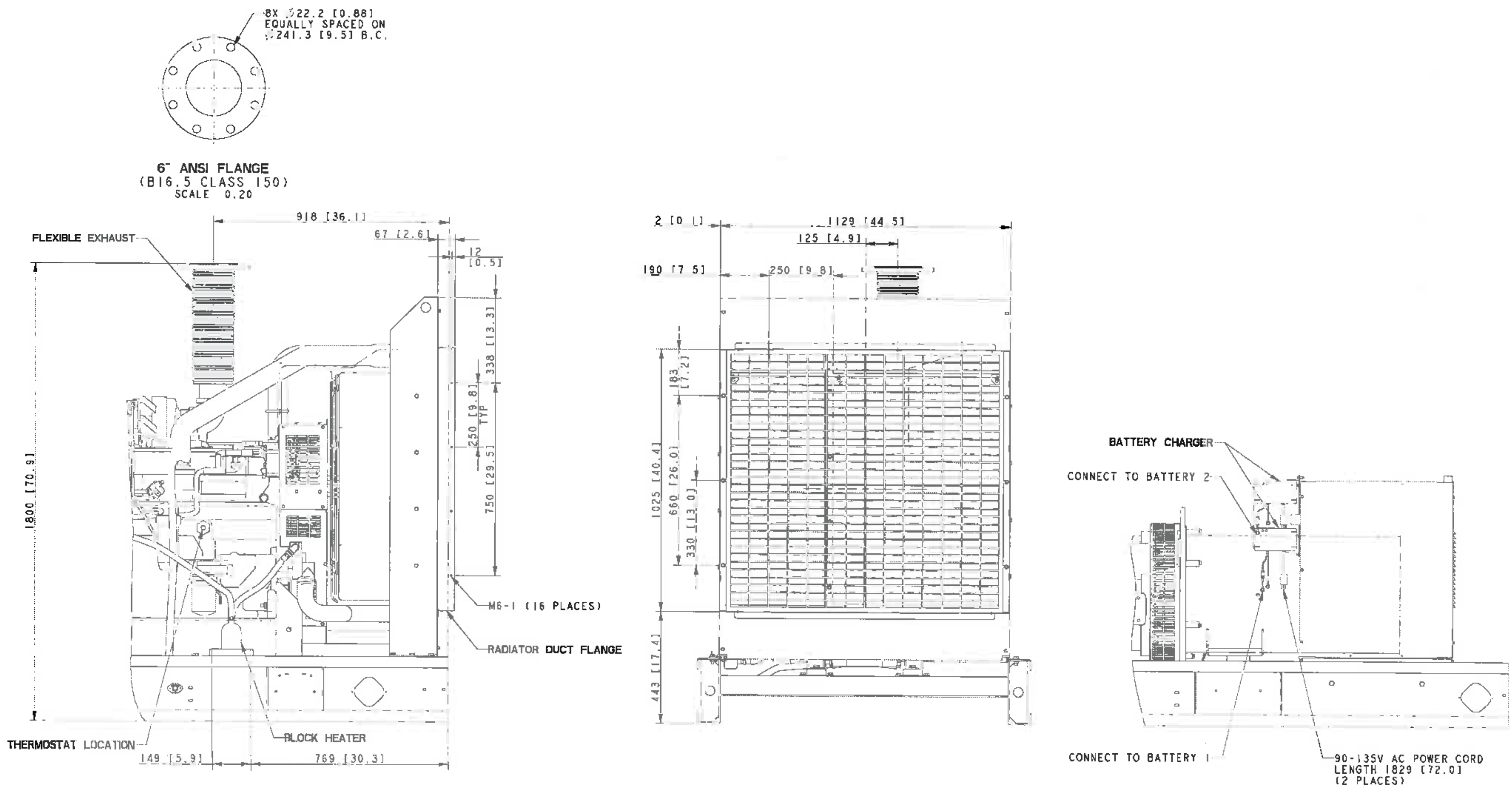

NOTE: DIMENSIONS IN [] ARE ENGLISH EQUIVALENTS

REV	DATE	ON COMPOSITE DWGS, SEE PART NO. FOR REVISION LEVEL	BY
-	12-4-09	NEW DRAWING [8825T-4]	DJV

180 MODEL 4S15
200 MODEL 4UA9 & 4UA13
RECONNECTABLE
IMPROVED MOTOR STARTING (IMS) RECONN., & 600V ALTERNATORS
JOHN DEERE 6068HF TIER III

UNLESS OTHERWISE SPECIFIED: 1) DIMENSIONS ARE IN MILLIMETERS 2) TOLERANCES ARE: X.XX ± 0.25, X.X ± 1.0, X ± 1.5, ANGLES ± 0° 30' — SURFACE FINISH MAX.

THIRD ANGLE PROJECTION

APPROVALS		DATE
DRAWN	DJV	12-4-09
CHECKED	CWF	12-4-09
APPROVED	JDZ	12-4-09

KOHLER CO. METRIC | PRO-E

POWER SYSTEMS, KOHLER, WI 53044 U.S.A.

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TITLE: DIMENSION PRINT, ACCESSORY, 180-200 JD

SCALE 0.14 | SHEET 1 of 1

DWG NO. ADV-7853 | D

H-25

Lotycz, Matt

From:	O'Brien, Maureen
Sent:	Wednesday, December 10, 2014 5:26 PM
To:	Lotycz, Matt; Baxter, Jonathan
Cc:	Sidoti, John; Eckel, Caroline H.
Subject:	RE: Utility Pad DWG File
Attachments:	Generator housing drawing adv7854.pdf; Generator tank drawing adv7859.pdf; Generator enclosure and tank g6099.pdf

Forgot to include the enclosure/sub base fuel tank cut sheets for the generator. I will make sure Andy updates to these dimensions.

Sorry about that!

From: Lotycz, Matt
Sent: Wednesday, December 10, 2014 3:48 PM
To: O'Brien, Maureen; Baxter, Jonathan
Cc: Sidoti, John; Eckel, Caroline H.
Subject: RE: Utility Pad DWG File

Maureen and Jon – Couple of questions:

1. Just wanted to confirm if you are ok with the Power Distribution Panel and Telecom Panel sitting at the very edge of the Pad? I wasn't sure if you wanted 3'-0" of distance around (to the top side of those panels) those panels for "ease of maintenance (see attached screen image below).
2. Are all the tanks, pumps, transformer and generator all shown to scale per cutsheets?

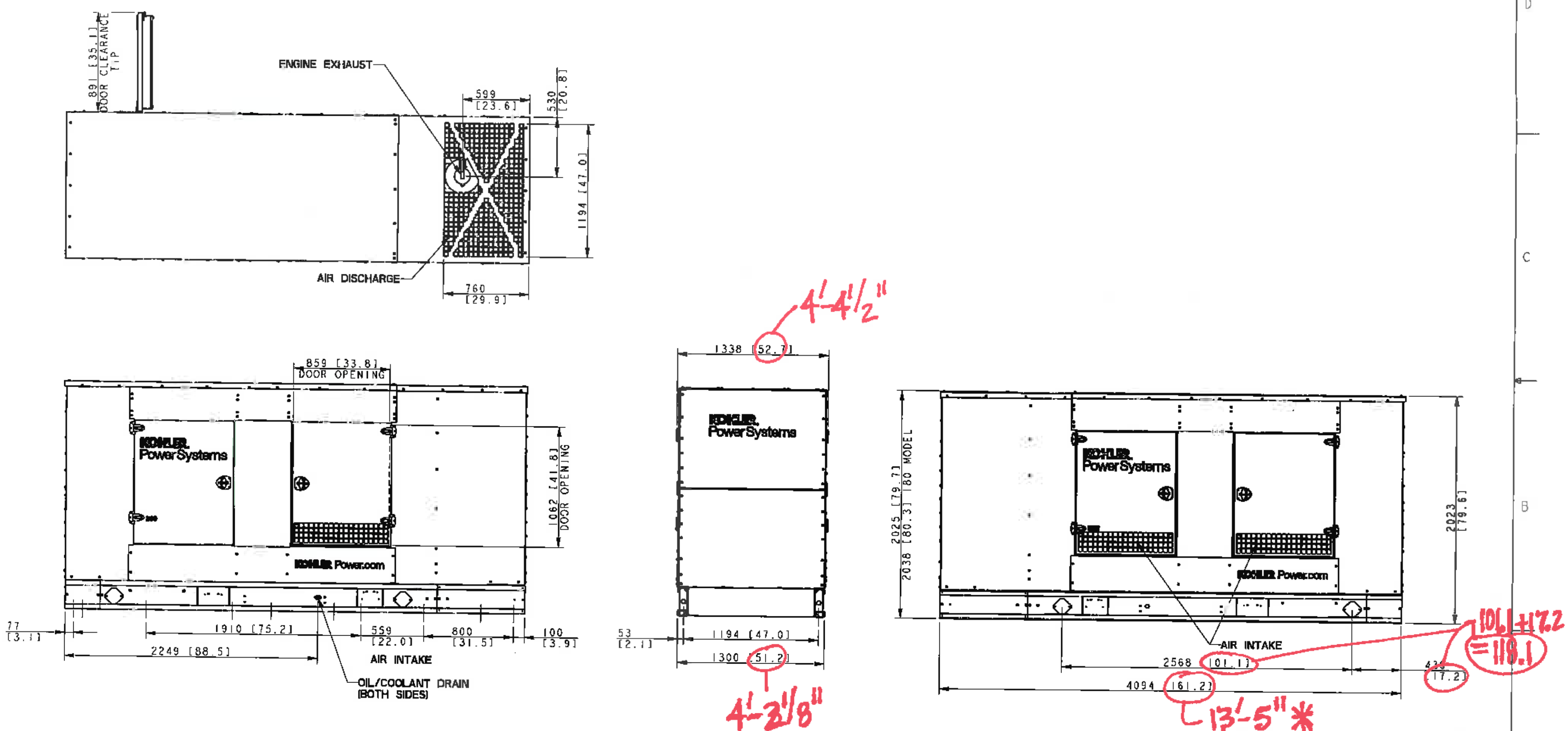
Maureen and/or Carol - Can you get me a cutsheet on the 15,000 Fire Water Tank and Bladder tank by tomorrow morning. Need plan view size, section view, seismic anchorage and hold-downs and total weight. The only tank info I have received to date is the 5000 gal tanks from Caroline. Thanks.

John S - Can you get me a cutsheet on the transformer and generator by tomorrow morning. Need plan view size and weight.

Let me know as I will be getting started on this tomorrow. Thanks.

Matt

MODEL	ENCLOSURE WEIGHT KG [LBS]
STEEL WEATHER	494 [1090]
STEEL SOUND	585 [1290]
ALUMINUM SOUND	300 [660]



DIMENSIONS IN [ ] ARE INCH EQUIVALENTS

NOTE:
ENCLOSURE ONLY MOUNTS TO SKID
FOR STEP-UP ACCESS DURING INSTALLATION THE REAR ENCLOSURE PANEL SHOULD BE REMOVED

180 MODEL 4S15, 4S12X, 4S13X
200 MODEL 4UA9, 4UA13, 4S13X
RECONNECTABLE
IMPROVE MOTOR STARTING (IMS) RECONNECTABLE
& 600V ALTERNATORS
6068HF435 JOHN DEERE TIER III

REV	DATE	ON COMPOSITE DWGS, SEE PART NO. FOR REVISION LEVEL	BY
G	10-31-12	SHEET 2 WAS SHEET, ADDED SHEET 1 [CT28612]	CEK
H	2-5-13	(A-1) 1-3 WAS 1-2, SEE SHEET 3 [CT32174]	SAH

APPROVALS		DATE
DRAWN	DJV	2-11-10
CHECKED	CWF	2-11-10
APPROVED	RJD	2-11-10

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POWER SYSTEMS, KOHLER, WI 53044 U.S.A.

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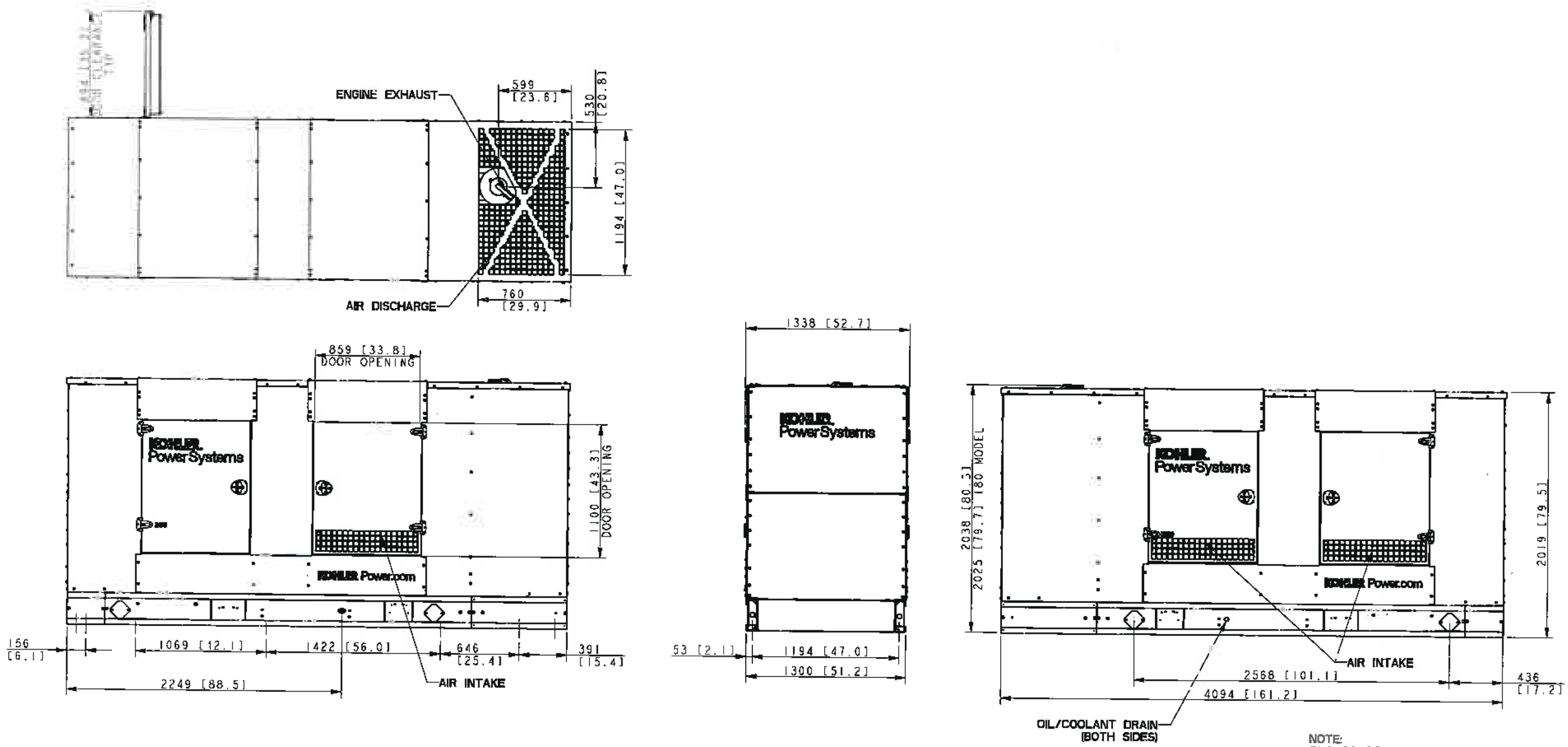
DIMENSION PRINT, ENCLOSURE 180-200 JD

SCALE 0.06

ADV-7854 D

MODEL	ENCLOSURE WEIGHT KG (LBS)
STEEL WEATHER	494 [1090]
STEEL SOUND	585 [1290]
ALUMINUM SOUND	300 [660]



NOTE:
ENCLOSURE ONLY MOUNTS TO SKID.

FOR STUB-UP ACCESS DURING INSTALLATION THE REAR ENCLOSURE PANEL SHOULD BE REMOVED

DIMENSIONS IN [ ] ARE INCH EQUIVALENTS

IBC/OSHPD ENCLOSURE

180 MODEL 4S15, 4S12X, 4S13Y
200 MODEL 4UA9, 4UA13, 4S13X
RECONNECTABLE
IMPROVE MOTOR STARTING (IMS) RECONNECTABLE
& 600V ALTERNATORS
6068HF485 JOHN DEERE TIER III

REV	DATE	ON COMPOSITE DWGS, SEE PART NO. FOR REVISION LEVEL	BY
C	6-20-11	(A-1) STUB-UP NOTE ADDED [91752]	SJM
D	12-15-11	(C-2) 494 [1090] WAS 363 [800], 585 [1290] WAS 386 [850] AND 300 [660] WAS 238 [525] [92432]	GFR
E	2-7-12	(A-4) 180 & 200 MODEL NOTE UPDATED [92681]	PKD
F	9-18-12	(B-4) 2065 WAS 2128 [CT24079]	SJM
G	10-31-12	SHEET 2 WAS SHEET 1, ADDED SHEET 1 [CT28612]	CEK
H	2-5-13	(A-1) 2-3 WAS 2-2, SEE SHEET 3 [CT32174]	SAM

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN MILLIMETERS. TOLERANCES ARE: X.XX ± 0.25, X.X ± 1.0, X ± 1.5, ANGLES ± 0° 30'

APPROVALS		DATE
DRAWN	DJV	2-11-10
CHECKED	CWF	2-11-10
APPROVED	RJD	2-11-10

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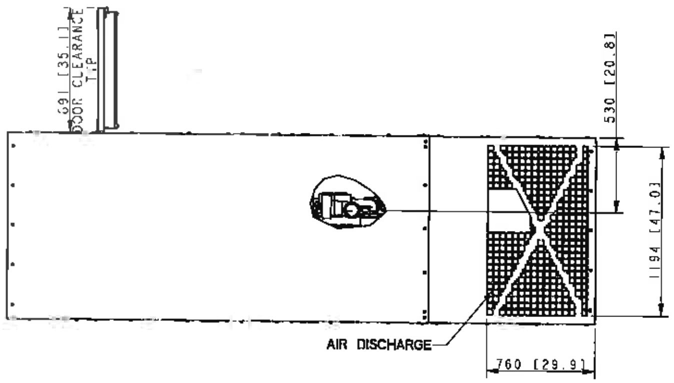
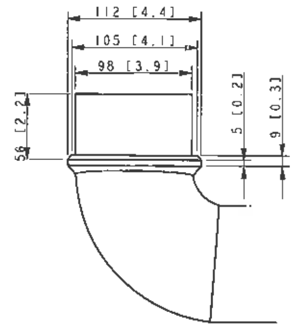
TITLE: DIMENSION PRINT, ENCLOSURE 180-200 JD

SCALE 0.06 SHEET 2 of 3

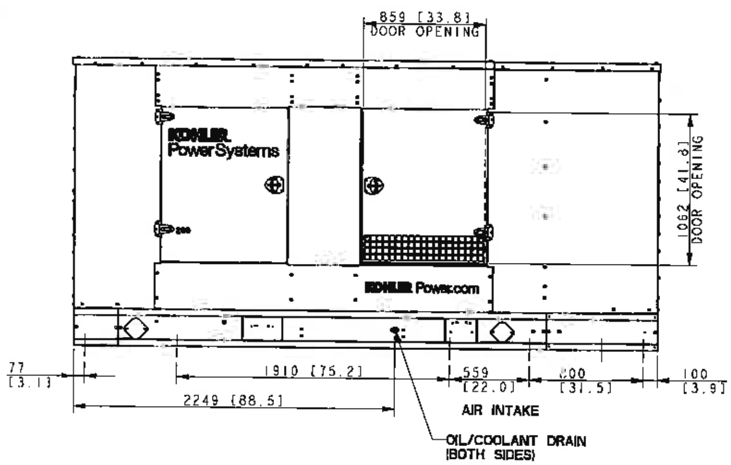
ADV-7854 D

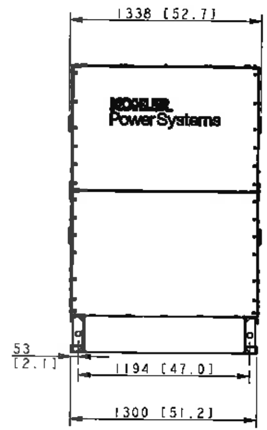
MODEL	ENCLOSURE WEIGHT KG [LBS]
STEEL WEATHER	448 [990]
STEEL SOUND	539 [1190]
ALUMINUM SOUND	254 [560]

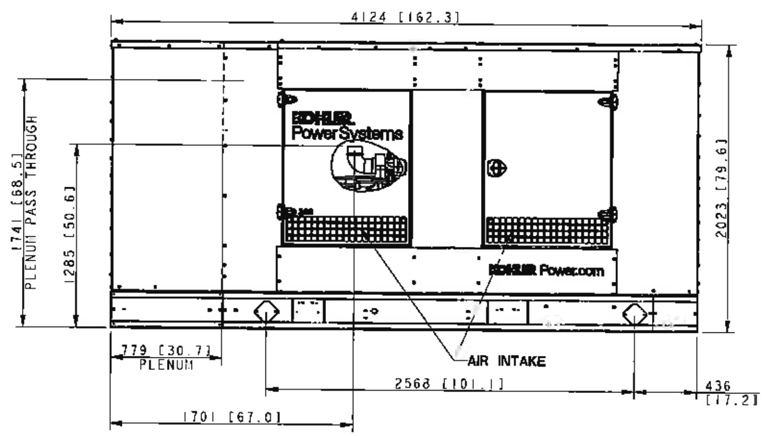




EXHAUST OUTLET
SCALE 0.500







CA AQMD READY ENCLOSURES (NO SILENCER)

DIMENSIONS IN [ ] ARE INCH EQUIVALENTS

NOTE:
ENCLOSURE ONLY MOUNTS TO SHIP
FOR STUB-UP ACCESS DURING INSTALLATION THE REAR ENCLOSURE PANEL SHOULD BE REMOVED.

180 MODEL 4S15, 4S12X, 4S13X
200 MODEL 4UA9, 4UA13, 4S13X
RECONNECTABLE
IMPROVE MOTOR STARTING (IMS) RECONNECTABLE
& 600V ALTERNATORS
6068HF485 JOHN DEERE TIER III

REV	DATE	ON COMPOSITE DWGS. SEE PART NO. FOR REVISION LEVEL	BY
H	2-5-13	SHEET 3 AND AQMA MODEL ADDED [GT32174]	SAM

UNLESS OTHERWISE SPECIFIED - 1) DIMENSIONS ARE IN MILLIMETERS 2) TOLERANCES ARE: X.XX ± 0.25, X.X ± 1.0, X ± 1.5, ANGLES ± 0° 30'

APPROVALS		DATE
DRAWN	SAM	2-5-13
CHECKED	KEM	2-5-13
APPROVED	KEM	2-5-13

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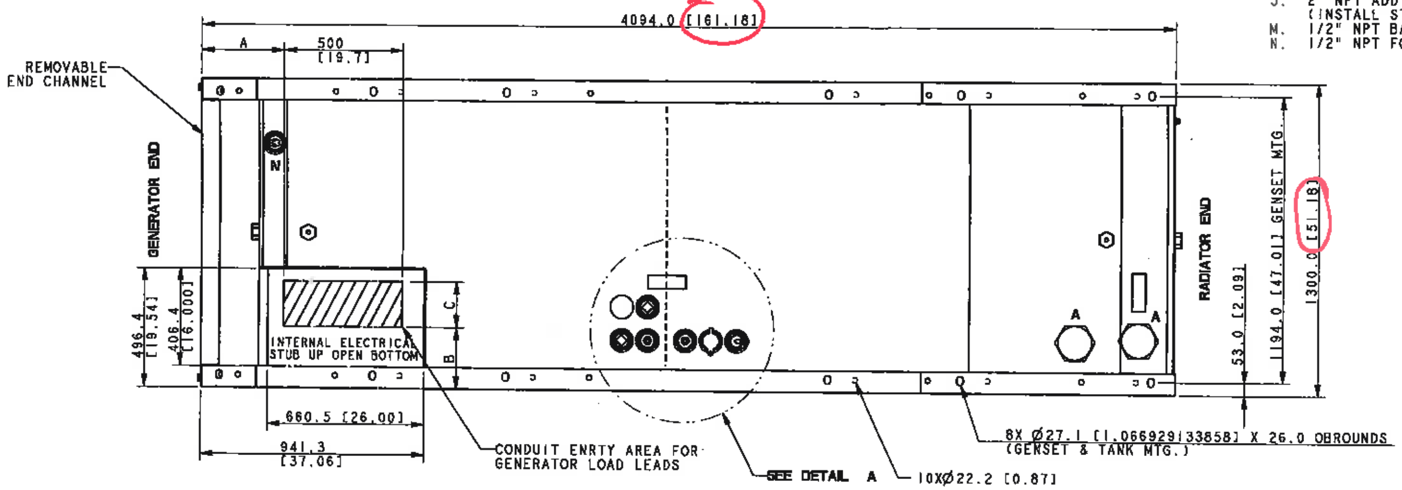
TITLE: DIMENSION PRINT, ENCLOSURE 180-200 JD
SCALE 0.06 SHEET 3 of 3
ADV-7854 D

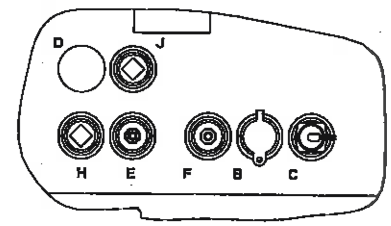
MODEL	CAPACITY		WEIGHT		HEIGHT		E-Vent	
	LITERS	GAL	KG	LBS	MM	IN	SIZE (IN)	QTY
180/200kW	1514	400	933	2057	482.6	19.0	4.0	2.0
180/200kW	2871	758	1327	2926	889.0	35.0	5.0	2.0

13'-5" *

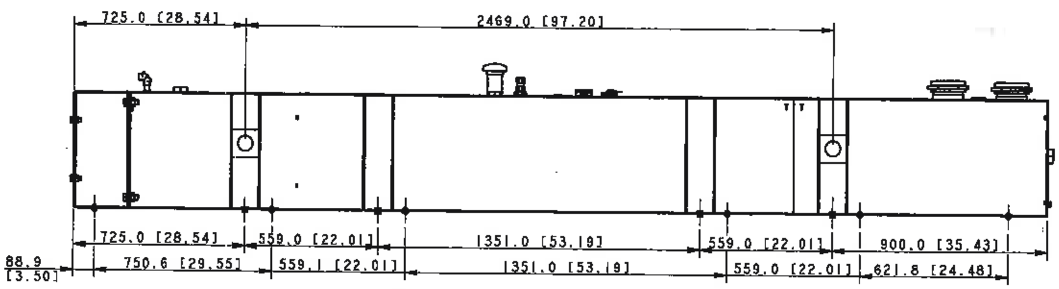
TANK FITTINGS:

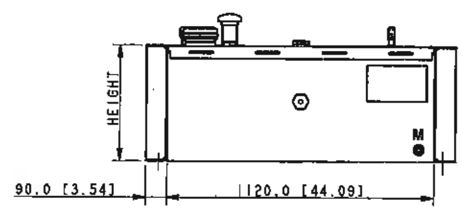
A. 'A' NPT EMERGENCY VENT FITTING PER NFPA 30 WITH VENT CAPS
B. 2" NPT FUEL FILL FITTING WITH LOCKABLE CAP
C. 2" NPT FUEL LEVEL GAUGE FITTING
D. 2" NORMAL VENT FITTING WITH MUSHROOM VENT CAP AND 5" RISER
E. 2" NPT FITTING FOR REMOVABLE ENGINE SUPPLY DIP TUBE (3/8" NPT FEMALE WITH CHECK VALVE)
F. 2" NPT FITTING FOR REMOVABLE FUEL RETURN DIP TUBE (3/8" NPT FEMALE)
H. 2" NPT FOR LOW LEVEL SWITCH (SET AT 50% FULL, SILICONE PACKED)
J. 2" NPT ADDITIONAL FITTING FOR OPTIONAL ACCESSORY (INSTALL STEEL 2" NPT PIPE PLUG)
M. 1/2" NPT BASIN DRAIN (INSTALL STEEL 1/2" NPT PIPE PLUG)
N. 1/2" NPT FOR FUEL IN BASIN SWITCH (INSTALL STEEL 1/2" NPT PIPE PLUG)





DETAIL A
SCALE 0.200





■ 8XØ25.4 [1.0] STANDARD MOUNTING
◆ 12XØ22.2 [0.88] IBC MOUNTING

STANDARD TANK

180 MODEL 60HZ 4S15, 4S12X & 4S13X
200 MODEL 4UA9, 4UA13 & 4S13X
RECONNECTABLE
IMPROVED MOTOR STARTING (IMS) &
600V ALTERNATOR
JOHN DEERE 6068HF485, TIER III

GENSET	A	B	C
180KW	571 [22.5]	310 [12.2]	90 [3.5]
200KW	561 [22.1]	195 [7.7]	100 [3.9]

REV	DATE	ON COMPOSITE DWGS, SEE PART NO. FOR REVISION LEVEL	BY
B	11-16-10	(A-8,A-7,A-6,A-5,A-4) 88.9,750.6,559.1,1351.0, 12X2Ø2.2,559.0,621.8 ADDED [90633]	JOEL
C	6-29-11	SEE SHEET 2 [91839]	KMP
D	12-1-11	VIEWS UPDATED [92417-4]	PKD
E	2-7-12	(A-4) 180 & 200 MODEL NOTE UPDATED, SEE SHEET 2 [92881]	PKD
F	08-11-14	(A-4) STANDARD TANK NOTE ADDED & SEE SHEET 2 [CT89102]	PAS

UNLESS OTHERWISE SPECIFIED - 1) DIMENSIONS ARE IN MILLIMETERS 2) TOLERANCES ARE: ANGLES ± 0° 30' SURFACE FINISH MAX.

THIRD ANGLE PROJECTION

APPROVALS		DATE
DRAWN	PKD	1-20-10
CHECKED	AJD	1-20-10
APPROVED	AJD	1-20-10

KOHLER CO. METRIC PRO-E
POWER SYSTEMS, KOHLER, WI 53044 U.S.A.

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TITLE: DIMENSION PRINT

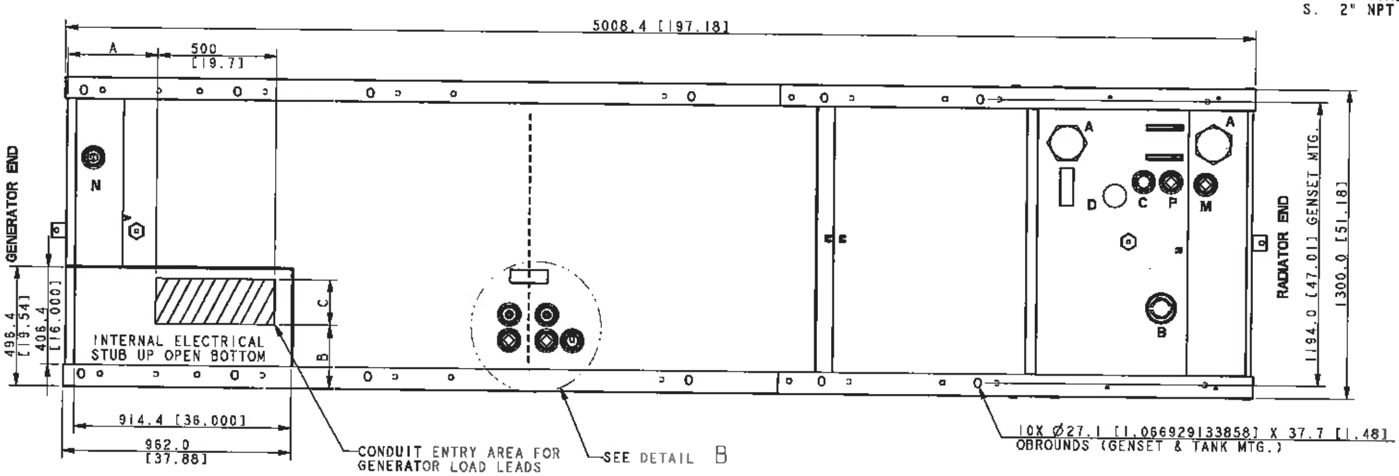
SCALE 0.16 SHEET 1 of 2

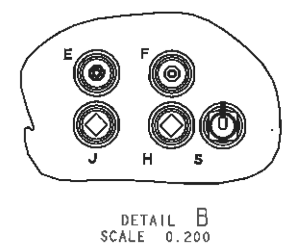
DWG NO. ADV-7859 D

MODEL	CAPACITY		WEIGHT		HEIGHT		E-Vent	
	LITERS	GAL	KG	LBS	MM	IN	SIZE (IN)	QTY
180/200kW	1576	416	1234	2721	457.2	18.0	4.0	2.0
180/200kW	2896	765	1560	3440	762.0	30.0	5.0	2.0

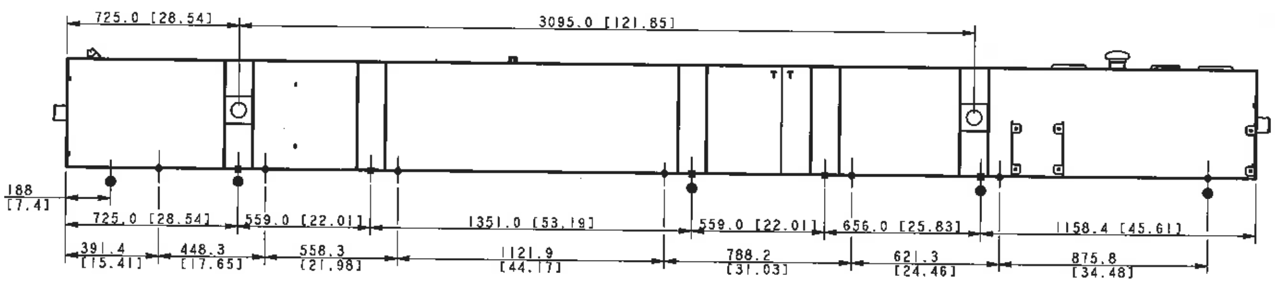
TANK FITTINGS:

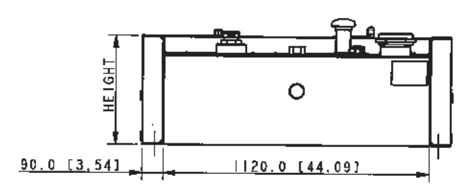
A. 'A' NPT EMERGENCY VENT FITTING PER NFPA 30 WITH VENT CAPS
B. 4" NPT FUEL FILL FTTING WITH LOCKABLE CAP AND RISER. PLUG & SHIP WITH TANK NI NBOX ATTACHED TO TANK
C. 2" NPT FUEL LEVEL GAUGE FITING
D. 2" NPT NORMAL VENT FITTING WITH MUSHROOM VENT CAP AND 5" RISER.
E. 2" NPT FITTING FOR REMOVABLE ENGINE SUPPLY DIP TUBE (3/8" NPT FEMALE WITH CHECK VALVE)
F. 2" NPT FITTING FOR REMOVABLE FUEL RETURN DIP TUBE (3/8" NPT FEMALE)
H. 2" NPT FOR LOW LEVEL SWITCH (SET AT 50% FULL, SILICONE PACKED)
J. 2" NPT ADDITIONAL FITTING FOR OPTIONAL ACCESSORY (INSTALL 2" NPT PIPE PLUG)
M. 2" NPT BASIN DRAIN (PLUGGED
N. 2" NPT FOR FUEL IN BASIN SWITCH
P. 2" NPT ADDITIONAL FITTING FOR OTPIONAL ACCESORY (INSTALL 2" NPT PIPE PLUG)
S. 2" NPT FUEL LEVEL GAUGE FITTING WITH SENDER





DETAIL B
SCALE 0.200





■ 10XØ25.4 [1.0] STANDARD MOUNTING
◆ 14XØ22.2 [0.88] IBC MOUNTING
● 10XØ25.4 [1.0] BOTTOM BEAM MOUNTING

GENSET	A	B	C
180KW	571 [22.5]	310 [12.2]	90 [3.5]
200KW	561 [22.1]	195 [7.7]	100 [3.9]

STATE TANK
180 MODEL 60HZ 4S15, 4S12X & 4S13X
200 MODEL 4UA9, 4UA13 & 4S13X
RECONNECTABLE
IMPROVED MOTOR STARTING (IMS) &
600V ALTERNATOR
JOHN DEERE 6068HF485, TIER III

REV	DATE	ON COMPOSITE DWGS, SEE PART NO. FOR REVISION LEVEL	BY
B	11-16-10	(A-8,A-7,A-6,A-5,A-4) 391.4,448.3,558.3,1121.9 788.2,621.3,875.8 ADDED [90633]	JOEL
C	6-29-11	(A-8) 188[7.4] ADDED, (A-6) 10X25.4 ADDED [91839]	KMP
D	12-1-11	VIEWS UPDATED [82417-4]	PKD
E	2-7-12	(A-4) 180 & 200 MODEL NOTE UPDATED, SEE SHEET 1 [92681]	PKD
F	08-11-14	(A-4) STATE TANK NOTE ADDED & SEE SHEET 1 [CT89102]	PAS

UNLESS OTHERWISE SPECIFIED - 1) DIMENSIONS ARE IN MILLIMETERS 2) TOLERANCES ARE:
X.XX ± 0.25
X.X ± 1.0
X ± 1.5
ANGLES ± 0° 30'
SURFACE FINISH MAX.

THIRD ANGLE PROJECTION

APPROVALS		DATE
DRAWN	PKD	1-20-10
CHECKED	AJD	1-20-10
APPROVED	AJD	1-20-10

KOHLER CO. METRIC | PRO-E
POWER SYSTEMS, KOHLER, WI 53044 U.S.A.
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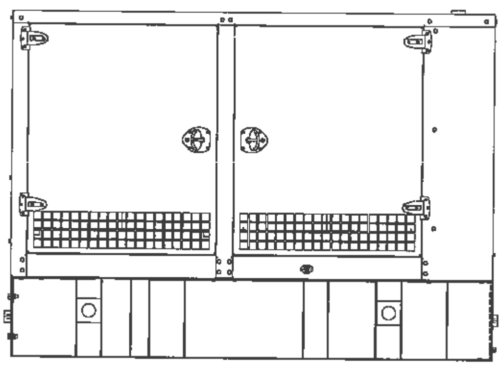
TITLE
DIMENSION PRINT

SCALE 0.10 | CAD NO. | SHEET 2 of 2
DWG NO. ADV-7859 D

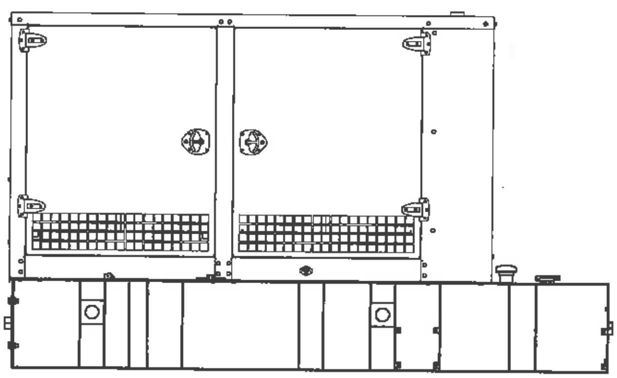
KOHLER. Power Systems

Weather/Sound Enclosure and Subbase Fuel Tank Package

ISO 9001 KOHLER POWER SYSTEMS NATIONALLY REGISTERED



Enclosure with Standard Subbase Fuel Tank



Enclosure with State Code Subbase Fuel Tank

Available Approvals and Listings

- ☐ UL 2200 Listing
- ☐ CSA Certified
- ☐ IBC Seismic Certification
- ☐ California OSHPD Approval
- ☐ cUL Listing (fuel tanks only)

NOTE: Some models may have limited third-party approvals, see your local distributor for details.

Applicable to the following:
20-40REOZJC
50/60REOZJD
80/100/150/180/200REOZJF
125/180REOZJG
40/50/230-275REOZJE
300REOZJ

Weather Enclosure Standard Features

- Internal-mounted silencer and flexible exhaust connector.
- Lift base or tank-mounted, steel construction with hinged doors.
- Fade-, scratch-, and corrosion-resistant Kohler® Power Armor™ cream beige automotive-grade textured finish.
- Enclosure has four large access doors which allow for easy maintenance.
- Lockable, flush-mounted door latches.
- Vertical air inlet and outlet discharge to redirect air and reduce noise.
- Certified to withstand 241 kph (150 mph) wind load rating.

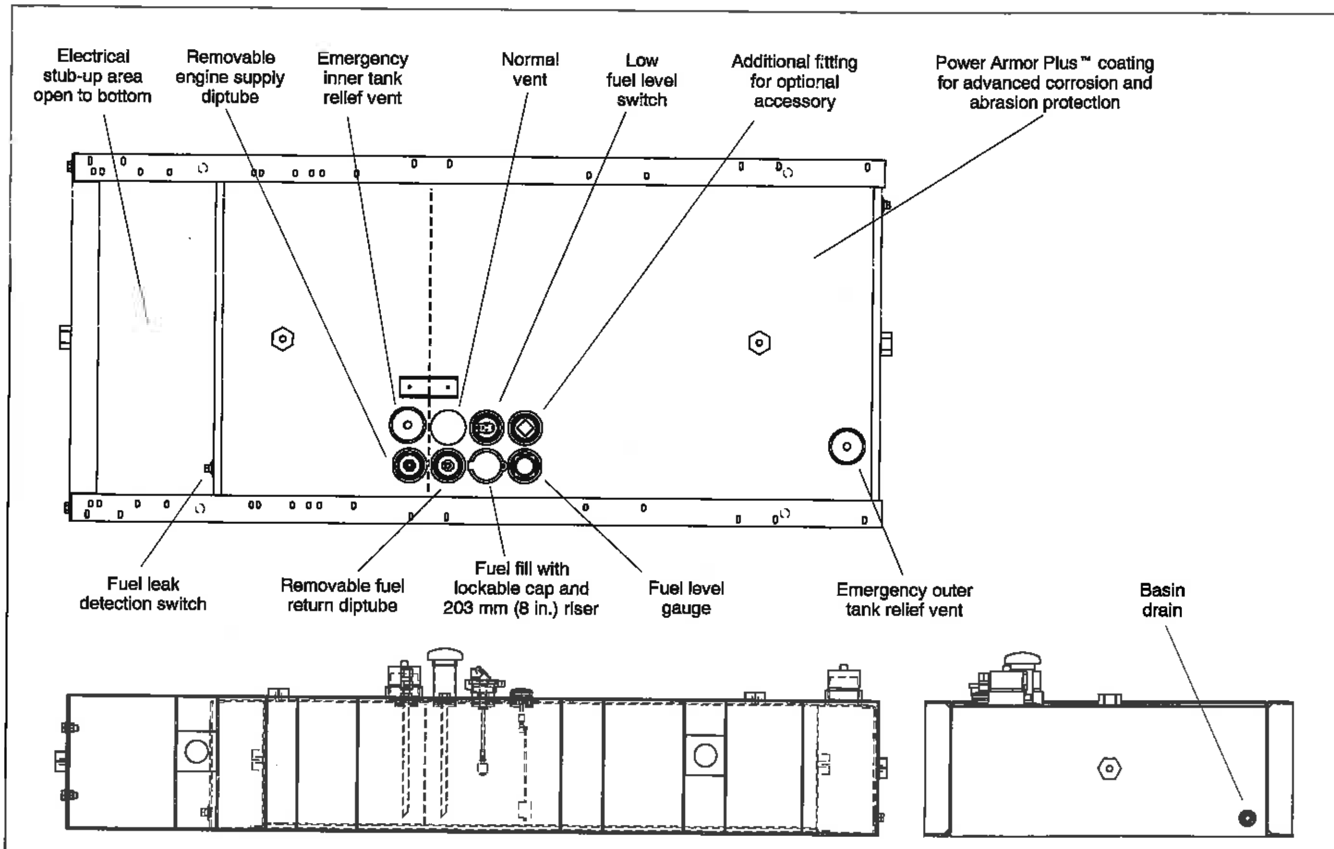
Sound Enclosure Standard Features

- Includes all of the weather enclosure features with the addition of acoustic insulation material.
- Lift base or tank-mounted, steel or aluminum construction with hinged doors. Aluminum enclosures are recommended for high humidity and/or high salt/ coastal regions.
- Acoustic insulation that meets UL 94 HF1 flammability classification and repels moisture absorption.
- Sound attenuated enclosure that uses up to 51 mm (2 in.) of acoustic insulation.

Subbase Fuel Tank Features

- The fuel tank has a Power Armor Plus™ textured epoxy-based rubberized coating.
- The above-ground rectangular secondary containment tank mounts directly to the generator set, below the generator set skid (subbase).
- Both the inner and outer tanks have emergency relief vents.
- Flexible fuel lines are provided with subbase fuel tank selection.
- The secondary containment generator set base tank meets UL 142 tank requirements. The inner (primary) tank is sealed inside the outer (secondary) tank. The outer tank contains the fuel if the inner tank leaks or ruptures.
- State tanks with varying capacities are an available option. Florida Dept. of Environmental Protection (FDEP) File No. EQ-634 approved.

Subbase Fuel Tank



Note: 20-40REOZJC models shown, other models are similar. Refer to the respective ADV drawings for details.

Standard Subbase Fuel Tank Features

- Extended operation. Usable tank capacity offers full load standby operation of up to 72 hours.
- Power Armor Plus™ textured epoxy-based rubberized coating that creates an ultra-thick barrier between the tank and harsh environmental conditions like humidity, saltwater, and extreme temperatures, and provides advanced corrosion and abrasion protection.
- UL listed. Secondary containment generator set base tank meeting UL 142 requirements.
- NFPA compliant. Designed to comply with the installation standards of NFPA 30 and NFPA 37.
- Integral external lift lugs. Enables crane with spreader-bar lifting of the complete package (empty tank, mounted generator set, and enclosure) to ensure safety.
- Emergency pressure relief vents. Vents ensure adequate venting of the inner and outer tank under extreme pressure and/or emergency conditions.
- Normal vent with cap. Vent is raised above lockable fuel fill.
- Low fuel level switch. Annunciates a 50% low fuel level condition at generator set control.
- Leak detection switch. Annunciates a contained primary tank fuel leak condition at generator set control.
- Electrical stub-up.

Enclosure and Subbase Fuel Tank Specifications

Fuel Tank Capacity, L (gal.)	Est. Fuel Supply Hours at 60 Hz with Full Load, Nominal/Actual	Enclosure and Subbase Fuel Tank					Fuel Tank Height, mm (in.)	Sound Pressure at 60 Hz with Full Load at 7 m (23 ft.), Weather/Sound dB(A)
		Max. Dimensions, mm (in.)			Max. Weight, kg (lb.) *			
		Length	Width	Height	With Steel Enclosure	With Aluminum Enclosure		
20REOZJC without IBC Seismic Certification								
No Tank	0	2320 (91.3)	1077 (42.4)	1438 (56.6)	943 (2080)	830 (1830)	152 (6)	78/65
295 (78)	24/41			1722 (67.8)	1167 (2572)*	1053 (2322)*	305 (12)	
424 (112)	36/58			1824 (71.8)	1201 (2647)*	1087 (2397)*	406 (16)	
621 (164)	48/86			1976 (77.8)	1251 (2759)*	1138 (2509)*	559 (22)	
20REOZJC with IBC Seismic Certification								
No Tank	0	2320 (91.3)	1077 (42.4)	1384 (54.6)	943 (2080)	830 (1830)	100 (4)	78/65
295 (78)	24/41			1671 (65.8)	1272 (2806)*	1159 (2556)*	254 (10)	
428 (113)	36/59			1773 (69.8)	1321 (2913)*	1208 (2663)*	358 (14)	
625 (165)	48/86			1925 (75.8)	1393 (3073)*	1280 (2823)*	508 (20)	
20REOZJC with State Code Fuel Tank†								
439 (116)	24/61	2896 (114)	1077 (42.4)	1671 (65.8)	1362 (3003)*	1249 (2753)*	358 (14)	78/65
556 (147)	48/77			1849 (72.8)	1459 (3217)*	1346 (2967)*	432 (17)	
958 (253)	72/133			2103 (82.8)	1514 (3338)*	1401 (3088)*	686 (27)	
30REOZJC without IBC Seismic Certification								
No Tank	0	2320 (91.3)	1077 (42.4)	1438 (56.6)	1007 (2220)	894 (1970)	152 (6)	78/65
295 (78)	24/27			1722 (67.8)	1230 (2712)*	1117 (2462)*	305 (12)	
424 (112)	36/40			1824 (71.8)	1264 (2787)*	1151 (2537)*	406 (16)	
621 (164)	48/58			1976 (77.8)	1315 (2899)*	1202 (2649)*	559 (22)	
30REOZJC with IBC Seismic Certification								
No Tank	0	2320 (91.3)	1077 (42.4)	1384 (54.6)	1007 (2220)	894 (1970)	100 (4)	78/65
295 (78)	24/27			1671 (65.8)	1336 (2946)*	1223 (2696)*	254 (10)	
428 (113)	36/40			1773 (69.8)	1385 (3053)*	1271 (2803)*	358 (14)	
625 (165)	48/58			1925 (75.8)	1457 (3213)*	1344 (2963)*	508 (20)	
30REOZJC with State Code Fuel Tank†								
439 (116)	24/41	2896 (114)	1077 (42.4)	1671 (65.8)	1424 (3139)*	1311 (2889)*	358 (14)	78/65
556 (147)	48/52			1849 (72.8)	1521 (3353)*	1408 (3103)*	432 (17)	
958 (253)	72/90			2103 (82.8)	1576 (3474)*	1463 (3224)*	686 (27)	
40REOZJC without IBC Seismic Certification								
No Tank	0	2320 (91.3)	1077 (42.4)	1438 (56.6)	966 (2130)	853 (1880)	152 (6)	78/65
424 (112)	24/32			1824 (71.8)	1223 (2697)*	1110 (2447)*	406 (16)	
621 (164)	48/48			1976 (77.8)	1274 (2809)*	1161 (2559)*	559 (22)	
946 (250)	72/73			2230 (87.8)	1555 (3429)*	1442 (3179)*	813 (32)	
40REOZJC with IBC Seismic Certification								
No Tank	0	2320 (91.3)	1077 (42.4)	1384 (54.6)	966 (2130)	853 (1880)	100 (4)	78/65
428 (113)	24/33			1773 (69.8)	1344 (2963)*	1231 (2713)*	358 (14)	
625 (165)	48/48			1925 (75.8)	1416 (3123)*	1303 (2873)*	508 (20)	
958 (253)	72/74			2179 (85.8)	1736 (3826)*	1622 (3576)*	762 (30)	
40REOZJC with State Code Fuel Tank†								
439 (116)	24/34	2896 (114)	1077 (42.4)	1671 (65.8)	1451 (3199)*	1338 (2949)*	358 (14)	78/65
958 (253)	48/74			2103 (82.8)	1575 (3472)*	1462 (3222)*	686 (27)	

Note: Data in table is for reference only, refer to the respective ADV drawings for details.

Note: Refer to TIB-114 for generator set sound data.

* Max. weight includes the generator set (wet) using the largest alternator option, enclosure with acoustic insulation added, silencer, and tank (no fuel).

† State code fuel tank specifications (height and weight) include I-beam option.

Fuel Tank Capacity, L (gal.)	Est. Fuel Supply Hours at 60 Hz with Full Load, Nominal/Actual	Enclosure and Subbase Fuel Tank					Fuel Tank Height, mm (in.)	Sound Pressure at 60 Hz with Full Load at 7 m (23 ft.), Weather/ Sound dB(A)
		Max. Dimensions, mm (in.)			Max. Weight, kg (lb.) *			
		Length	Width	Height	With Steel Enclosure	With Aluminum Enclosure		
80REOZJF without IBC Seismic Certification								
No Tank	0	2821 (111.1)	1156 (45.5)	1575 (62)	1483 (3269)	1351 (2979)	152 (6)	83/69
791 (209)	24/30			1930 (76)	1766 (3894)*	1635 (3604)*	508 (20)	
1317 (348)	48/50			2235 (88)	1882 (4150)*	1751 (3860)*	813 (32)	
80REOZJF with IBC Seismic Certification								
No Tank	0	2821 (111.1)	1156 (45.5)	1525 (60)	1483 (3269)	1351 (2979)	102 (4)	83/69
757 (200)	24/28			1880 (74)	1851 (4080)*	1719 (3790)*	457 (18)	
1313 (347)	48/50			2185 (86)	2108 (4647)*	1976 (4357)*	762 (30)	
80REOZJF with State Code Fuel Tank†								
814 (215)	24/31	3400 (133.9)	1156 (45.5)	1855 (73)	1996 (4400)*	1864 (4110)*	432 (17)	83/69
1571 (415)	48/60			2185 (86)	2236 (4929)*	2104 (4639)*	762 (30)	
100REOZJF without IBC Seismic Certification								
No Tank	0	2821 (111.1)	1156 (45.5)	1575 (62)	1592 (3510)	1461 (3220)	152 (6)	82/69
791 (209)	24/25			1930 (76)	1875 (4134)*	1744 (3844)*	508 (20)	
1696 (448)	48/54	3400 (133.9)		2235 (88)	2070 (4564)*	1939 (4274)*	813 (32)	
100REOZJF with IBC Seismic Certification								
No Tank	0	2821 (111.1)	1156 (45.5)	1525 (60)	1592 (3510)	1461 (3220)	102 (4)	82/69
757 (200)	24/24			1880 (74)	1960 (4320)*	1828 (4030)*	457 (18)	
1699 (449)	48/54	3400 (133.9)		2185 (86)	2345 (5170)*	2214 (4880)*	762 (30)	
100REOZJF with State Code Fuel Tank†								
814 (215)	24/26	3400 (133.9)	1156 (45.5)	1855 (73)	2105 (4641)*	1974 (4351)*	432 (17)	82/69
1571 (415)	48/50			2185 (86)	2345 (5170)*	2214 (4880)*	762 (30)	
125REOZJG								
No Tank	0	3532 (139.0)	1153 (45.4)	1753 (69)	1651 (3632)	1515 (3333)	0 (0)	87/73
1128 (298)	24/30			2236 (88)	2400 (5280)*	2264 (4981)*	483 (19)	
2207 (583)	48/58			2667 (105)	2751 (6052)*	2615 (5753)*	914 (36)	
125REOZJG with State Code Fuel Tank†								
1196 (316)	24/31	4414 (173.8)	1153 (45.4)	2236 (88)	2382 (5240)*	2446 (4941)*	483 (19)	87/73
2252 (595)	48/60			2591 (102)	2654 (5839)*	2500 (5511)*	838 (33)	
150REOZJF								
No Tank	0	3532 (139.0)	1153 (45.4)	1753 (69)	1860 (4101)	1724 (3800)	0 (0)	86/75
1128 (298)	24/25			2236 (88)	2609 (5752)*	2473 (5452)*	483 (19)	
2207 (583)	48/49			2667 (105)	2960 (6526)*	2824 (6226)*	914 (36)	
150REOZJF with State Code Fuel Tank†								
1196 (316)	24/27	4414 (173.8)	1153 (45.4)	2236 (88)	2591 (5712)*	2455 (5412)*	483 (19)	86/75
2252 (595)	48/50			2591 (102)	2890 (6361)*	2727 (6012)*	838 (33)	

Note: Data in table is for reference only, refer to the respective ADV drawings for details.

Note: Refer to TIB-114 for generator set sound data.

* Max. weight includes the generator set (wet) using the largest alternator option, enclosure with acoustic insulation added, silencer, and tank (no fuel).

† State code fuel tank specifications (height and weight) include I-beam option.

Enclosure and Subbase Fuel Tank Specifications (continued)

300REOZJ

No Tank	0	4121 (162.3)	1338 (52.7)	2157 (84.9)	2835 (6250)	2722 (6000)	0 (0)	89/75
2067 (546)	24/24			2735 (107.7)	3770 (8311)*	3656 (8061)*	838 (33)	

300REOZJ with State Code Fuel Tank†

2101 (555)	24/25	5009 (197.2)	1338 (52.7)	2792 (109.9)	4076 (8987)*	3963 (8737)*	635 (25)	89/75
4065(1074)	48/48	5588 (220.0)		3071 (120.9)	4644 (10238)*	4530 (9988)*	914 (36)	

Note: Data in table is for reference only, refer to the respective ADV drawings for details.

Note: Refer to TIB-114 for generator set sound data.

* Max. weight includes the generator set (wet) using the largest alternator option, enclosure with acoustic insulation added, silencer, and tank (no fuel).

† State code fuel tank specifications (height and weight) include I-beam option.

TRANSFORMER

- REF SHT H-27 FOR TRANSFORMER MFG DATA
  - ↳ 6'-2" x 4'-6" @ 3160# → 114 psf < 1325 psf NET ALLOWABLE ✓OK
- → BY INSPECTION, 1'-2" THICK w/ #5 @ 10" o/c EF/EW (3" COVER BOT & 2" COVER TOP) IS SUFFICIENT TO HANDLE UNIFORM LOADS.
- → TRANSFORMER ANCHORAGE BY EQUIP MFG

POTABLE WATER PUMP & BLADDER TANK

- REF SHT H-28 FOR PUMP/BLADDER TANK SKID INFO
  - ↳ 9'-0" x 5'-0" → BLADDER TANK – 158 GAL x 8.34#/GAL
    + 200# TANK DL
    TOTAL = 1518# x 2 ← FOR PUMP/PIPING & SKID
    ↳ 3035# / (9' x 5')
    = 67.5 psf < 1325 psf NET ALLOWABLE ✓OK
- → W/ (2) STEEL BEAMS @ 5'-0" C/C

H-27

Three-phase pad-mounted PEAK™ transformer

General

PEAK™ transformers from Eaton's Cooper Power Systems represent the next generation of transformer design, and with two distinct product offerings there is a PEAK transformer to fit your needs. The first PEAK transformer option is a 75 °C average winding rise (AWR) design that offers users a smaller and lighter footprint than today's 65 °C AWR transformers. This design is ideal for applications with size, weight, and dimensional constraints. The second PEAK transformer option is a 65/75 °C AWR design that offers users sustained overload capacity while maintaining IEEE Std C57.91™-2011 standard per unit life requirements. This design offers customers flexibility in transformer sizing by offering the ability to accommodate future load growth without oversizing relative to current load, or the ability to meet periods of peak demand without oversizing based on continuous load.

With both PEAK product offerings being comprised of thermally upgraded kraft paper and Envirotemp™ FR3™ dielectric fluid, all PEAK transformers offer customers a high temperature insulation system that is fully compatible with the new IEEE® standard for transformers using high-temperature insulation systems, IEEE Std C57.154™-2012 standard. In addition, all PEAK transformers provide the high fire point and environmental benefits of Envirotemp™ FR3™ fluid. PEAK transformers are available in various designs and configurations to match almost every application.

Cooper Power Systems
by EATON

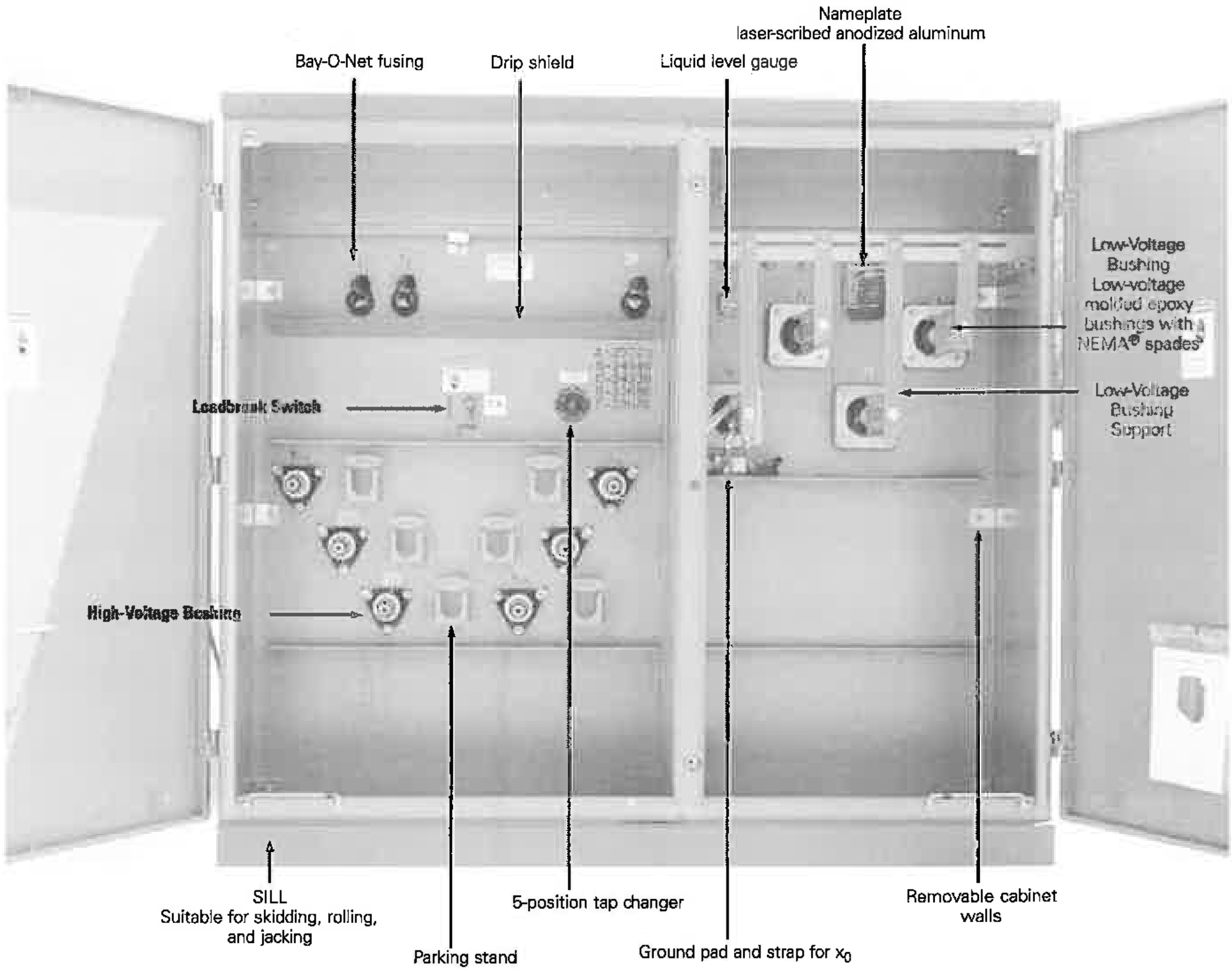


Figure 1. Three-phase pad-mounted PEAK transformer.

Table 1. Product scope

Type	Three-Phase, 50 or 60 Hz, 75 °C Rise and 65 °C/75 °C
Fluid Type	Only Envirotemp™ FR3™ fluid
Coil Configuration	2-winding or 4-winding or 3-winding (Low-High-Low), 3-winding (Low-Low-High)
Size	45 – 12,000 kVA
Primary Voltage	2,400 – 46,000 V
Secondary Voltage	208Y/120 V to 14,400 V
Specialty Designs	Inverter/Rectifier Bridge
	K-Factor (up to K-19)
	Solar/Wind Designs
	Differential Protection
	Seismic Applications (including OSHPD)
	Hardened Data Center
	UL® Listed & Label and Classified
	Factory Mutual (FM) Approved®

Table 2. Three-Phase Ratings

Three-Phase 50 or 60 Hz
kVA Available[1]: 45, 75, 112.5, 150, 225, 300, 500, 750, 1000, 1500, 2000, 2500, 3000, 3750, 5000, 7500, 10000, 12000

[1]Transformers are available in the standard ratings and configurations shown or can be customized to meet specific needs.

Table 3. Audible Sound Levels

Self-Cooled, Two Winding kVA Rating	NEMA® TR-1 Average Decibels (dB)
45-500	56
501-700	57
701-1000	58
1001-1500	60
1501-2000	61
2001-2500	62
2501-3000	63
3001-4000	64
4001-5000	65
5001-6000	66
6001-7500	67
7501-12000	68

Table 4. Insulation Test Levels

KV Class	Induced Test 180 or 400 Hz 7200 Cycle	kV BIL Distribution	Applied Test 60 Hz (kV)
1.2	Twice Rated Voltage	30	10
2.5		45	15
5		60	19
8.7		75	26
15		95	34
25 (grd Y Only)		125	40
25		150	50
34.5 (grd Y Only)		125	40
34.5		150	70

Table 5. Temperature Rise Ratings 0-3300 Feet (0-1000 meters)

	Unit Rating (Temperature Rise Winding)	
	75 °C	65/75 °C
Ambient Temperature Max.	40 °C	40 °C
Ambient Temperature 24 Hour Average	30 °C	30 °C
Temperature Rise Hotspot	90 °C	90 °C

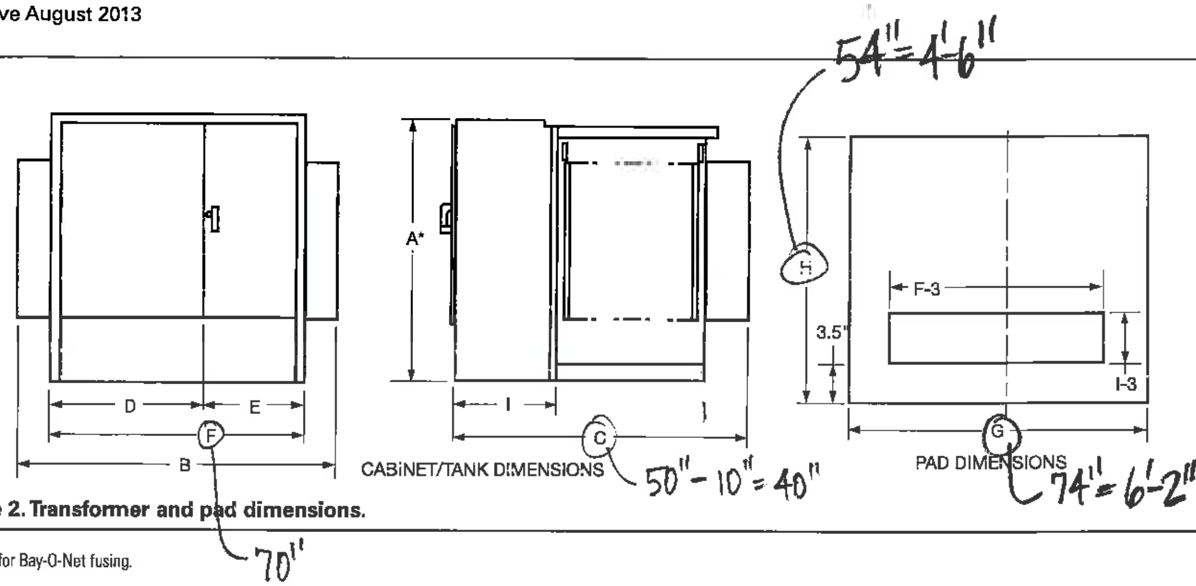


Figure 2. Transformer and pad dimensions.

* Add 9" for Bay-O-Net fusing.

Table 6. Fluid-Filled—Aluminum Windings 65 °C Rise[1]

kVA	A	B	C	D	E	F	G	H	I	GALLONS	WEIGHT
45	50	66	40	41	25	66	70	44	20	102	1990
75	50	66	40	41	25	66	70	44	20	102	1990
112.5	50	66	40	41	25	66	70	44	20	108	2150
150	50	66	41	41	25	66	70	45	20	115	2330
225	50	71	50	41	30	71	75	54	20	127	2810
300	50	71	50	41	30	71	75	54	20	136	3200
500	50	79	52	41	30	71	83	56	20	170	4200
750	64	82	56	41	30	71	86	60	20	242	5390
1000	64	82	59	41	30	71	86	63	20	305	7120
1500	64	76	90	42	29	71	80	94	24	356	9980
2000	72	76	90	42	29	71	80	94	24	520	11079
2500	72	79	97	42	29	71	83	101	24	550	13340
3000	84	88	98	49	29	78	92	102	24	625	14820
3750	84	88	103	49	29	78	92	107	24	671	17640
5000	84	99	108	50	30	80	103	112	24	910	21750
7500	94	100	108	48	48	96	104	112	24	1017	25100
10000	94	100	120	48	48	96	104	124	24	1500	38900

[1] Weights, gallons of fluid, and dimensions are for reference only and not for construction. Please contact Eaton's Cooper Power Systems for exact dimensions.

* Add 9" for Bay-O-Net fusing.

Table 7. Fluid-Filled—Aluminum Windings 75 °C Rise[1]

kVA	A	B	C	D	E	F	G	H	I	GALLONS	WEIGHT
45	50	66	40	41	25	66	70	44	20	102	1990
75	50	66	40	41	25	66	70	44	20	102	1990
112.5	50	66	40	41	25	66	70	44	20	104	2150
150	50	66	40	41	25	66	70	44	20	106	2310
225	50	70	40	41	29	70	74	44	20	120	2710
300	50	70	50	41	29	70	74	54	20	132	3160
500	50	70	53	41	29	70	74	57	20	168	4090
750	64	70	57	41	29	70	74	61	20	237	5300
1000	64	70	58	41	29	70	74	62	20	284	6650
1500	64	71	64	42	29	71	75	68	24	347	9840
2000	64	71	68	42	29	71	75	72	24	393	10790
2500	64	71	91	42	29	71	75	95	24	406	13300
3000	72	71	108	42	29	71	75	112	24	559	14560
3750	72	78	102	46	32	78	82	106	24	634	17440
5000	84	85	112	47	38	85	89	116	24	755	20645
7500	84	88	120	48	40	88	92	124	24	890	23060
10000	84	88	130	48	40	88	92	134	24	990	27300

[1] Weights, gallons of fluid, and dimensions are for reference only and not for construction. Please contact Eaton's Cooper Power Systems for exact dimensions.

* Add 9" for Bay-O-Net fusing.

Standard features

Connections and neutral configurations

- Delta-Wye: Low voltage neutral shall be a fully insulated X0 bushing with removable ground strap.
- Grounded Wye-Wye: High voltage neutral shall be internally tied to the low voltage neutral and brought out as the H0X0 bushing in the secondary compartment with a removable ground strap.
- Delta-Delta: Transformer shall be provided without a neutral bushing.
- Wye-Wye: High voltage neutral shall be brought out as the H0 bushing in the primary compartment and the low voltage neutral shall be brought as the X0- bushing in the secondary compartment.
- Wye-Delta: High voltage neutral shall be brought out as the H0 bushing in the primary compartment. No ground strap shall be provided (line to line rated fusing is required).

High and low voltage bushings

- 200 A bushing wells (15, 25, 35 kV)
- 200 A, 35 kV large Interface
- 600 A (15, 25, 35 kV) integral bushings (dead-front)
- Electrical-grade wet-process porcelain bushings (live-front)

Tank/cabinet features

- Bolted cover for tank access (45-1750 kVA)
- Welded cover with hand hole (2000-12,000 kVA)
- Three-point latching door for security
- Removable sill for easy installation
- Lifting lugs (4)
- Stainless steel cabinet hinges and mounting studs
- Steel divider between HV and LV compartment
- 20" deep cabinet (45-1000 kVA)
- 24" deep cabinet (1500-7500 kVA)
- 30" deep cabinet (34.5/19.92 kV)
- Pentahead captive bolt
- Stainless steel 1-hole ground pads (45-500 kVA)
- Stainless steel 2-hole ground pads (750-10,000 kVA)
- Parking stands

Valves/plugs

- One-inch upper filling plug
- One-inch drain plug (45-500 kVA)
- One-inch combination drain valve with sampling device in low voltage compartment (750-12,000 kVA)
- Automatic pressure relief valve

Nameplate

- Laser-scribed anodized aluminum nameplate

Figure 3. Drain valve with sampler.

Figure 4. Automatic pressure relief valve.

Figure 5. Liquid level gauge.

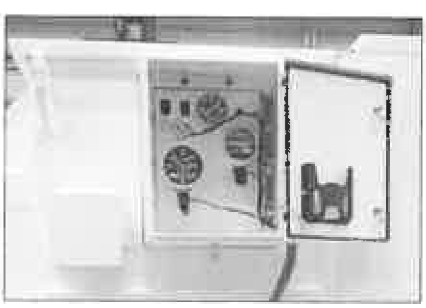


Figure 6. External Gauges.

Figure 7. External visible break with gauges.

Optional features

High and low voltage bushings

- 200 A (15, 25 kV) bushing inserts
- 200 A (15, 25 kV) feed thru inserts
- 200 A (15, 25 kV) (HTN) bushing wells with removable studs
- High-voltage 600 A (15, 25, 35 kV) deadbreak one-piece bushings
- Low-voltage 6-, 8-holes spade
- Low-voltage 12-, 16-, 20-holes spade (750-2500 kVA)
- Low-voltage bushing supports

Tank/cabinet features

- Stainless steel tank base and cabinet
- Stainless steel tank base, cabinet sides and sill
- 100% stainless steel unit
- Service entrance (2 inch) in sill or cabinet side
- Touch-up paint (domestic)
- Copper ground bus bar
- Kirk-Key provisions
- Nitrogen blanket
- Bus duct cutout

Special designs

- Triplex
- High Altitude
- K-Factors
- Step-up
- Critical application
- Modulation transformers
- Seismic applications (including California Office of Statewide Health Planning and Development, OSHPD)

Switches

- 100 A, 150 A, 300 A tap-changers
- Dual-voltage switch
- One, two, or three On/Off loadbreak switches
- 4-position loadbreak V-blade switch or T-blade switch
- Delta-wye switch
- 3-position V-blade selector switch
- Visible break with VFI interrupter interlock
- External visible break (15, 25, and 35 kV, up to 3 MVA)
- External visible break with gauges (15, 25, and 35 kV, up to 3 MVA)

Gauges and devices

- Liquid level gauge (optional contacts)
- Pressure vacuum gauge (optional contacts and bleeder)
- Dial-type thermometer (optional alarm contacts)
- Cover-mounted pressure relief device
- Ground connectors
- Hexhead captive bolt
- Breaker mounting provisions
- External gauges in padlockable box

Overcurrent protection

- Cartridge fusing in series with a partial-range under-oil ELSP current-limiting fuse (above 23 kV)
- MagneX™ interrupter with ELSP current-limiting fuse
- Visible break window
- Fuse/switch interlock

Valves/plugs

- Drain/sampling valve in high-voltage compartment
- Globe-type upper fill valve

Overvoltage protection

- Distribution-, intermediate-, or station-class surge arresters
- Elbow arresters (for dead-front connections)

Metering/fan/control

- Full metering package
- Metering socket
- NEMA® 4 control box (optional stainless steel)
- NEMA® 7 control box (explosion proof)
- Fan packages

Testing

- Customer test witness
- Customer final inspection
- Zero sequence impedance test
- Heat Run Test
- ANSI® Impulse Test
- Audible Sound Level Test
- RIV (Corona) Test
- Dissolved Gas Analysis (DGA) Test
- 8- or 24-Hour Leak Test

Coatings (Paint)

- ANSI® bell green
- ANSI® #61 light gray
- ANSI® #70 sky gray
- Special paint (available per request)

Nameplate

- Stainless steel nameplate

Decals and labels

- High-voltage warning signs
- Mr. Ouch decal
- Bi-lingual warning
- DOE compliant
- Customer stock code
- Customer stenciling
- Shock and arc flash warning decal
- Non-PCB decal

Construction

Core

The three-legged, step-lap mitered core construction is manufactured using a high-quality cutting machine. For maximum efficiency, cores are precisely stacked, virtually eliminating gaps in the corner joints.

Five-legged wound core or shell-type triplex designs are used for wye-wye connected transformers, and other special transformer designs.

Cores are manufactured with precision cut, burr-free, grain-oriented silicon steel. Many grades of core steel are available for optimizing core loss efficiency.

Coils

Pad-mounted transformers feature a rectangular coil configuration with wire-wound, high-voltage primaries and sheet-wound secondaries. The design minimizes axial stress developed by short circuits and provides for magnetic balancing of tap connections.

Coils are wound using the highest quality winding machines providing exacting tension control and conductor placement for superior short-circuit strength and maximum efficiency.

Extra mechanical strength is provided by diamond pattern, epoxy-coated paper insulation, used throughout the coil, with additional epoxy at heavy stress points. The diamond pattern distribution of the epoxy and carefully arranged ducts, provide a network of passages through which cooling fluid can freely circulate.

Coil assemblies are heat-cured under calculated hydraulic pressure to ensure performance against short-circuit forces.

Core and coil assemblies

Pad-mounted transformer core and coil assemblies are braced with heavy steel ends to prevent the rectangular coil from distorting under short-circuit conditions. Plates are clamped in place using presses, and welded or bolted to form a solid core and coil assembly. Core and coil assemblies exceed ANSI® and IEEE® requirements for short-circuit performance. Due to the rigidity of the design, impedance shift after short-circuit is comparable to that of circular wound assemblies.

Tanks

Transformer tanks are designed for high strength and ease of handling, installation, and maintenance. Tanks are welded using precision-cut, hot rolled, pickled and oiled steel. They are sealed to protect the insulating fluid and other internal components.

Transformer tanks are pressure-tested to withstand 7 psig without permanent distortion and 15 psig without rupture.

Tank finish

An advanced multi-stage finishing process exceeds the IEEE Std C57.12.28™-2005 standard. The eight-stage pre-treatment process assures coating adhesion and retards corrosion. It converts tank surfaces to a nonmetallic, water insoluble iron phosphate coating.

The paint method consists of two distinct layers of paint. The first is an epoxy primer (E-coat) layer which provides a barrier against moisture, salt and corrosives. The two-component urethane final coat seals and adds ultraviolet protection.

Vacuum processing

Transformers are dried and filled with filtered insulating fluid under vacuum, while secondary windings are energized. Coils are heated to drive out moisture, ensuring maximum penetration of fluid into the coil insulation system.

Insulating fluid

Transformers from Eaton's Cooper Power Systems are available with Envirotemp™ FR3™ fluid. The highly refined fluids are tested and degassed to assure a chemically inert product with minimal acid ions. Special additives minimize oxygen absorption and inhibit oxidation. To ensure high dielectric strength, the fluid is re-tested for dryness and dielectric strength, refiltered, heated, dried, and stored under vacuum before being added to the completed transformer.

Eaton's Cooper Power Systems transformers filled with Envirotemp™ FR3™ fluid enjoy unique fire safety, environmental, electrical, and chemical advantages, including insulation life extending properties.

A bio-based, sustainable, natural ester dielectric coolant, Envirotemp™ FR3™ fluid quickly and thoroughly biodegrades in the environment and is non-toxic per acute aquatic and oral toxicity tests.

Building for Environmental and Economic Sustainability (BEES) total life cycle assessment software, utilized by the US Dept. of Commerce, reports its overall environmental performance impact score at 1/4th that reported for mineral oil. Envirotemp™ FR3™ fluid has also earned the EPA Environmental Technology Verification of transformer materials.

With a fire point of 360 °C, Envirotemp™ FR3™ fluid is FM Approved® and Underwriters Laboratories (UL®) Classified "Less-Flammable" per NEC® Article 450-23, fitting the definition of a Listed Product per NEC®.

FM APPROVED

c UL US LISTED

Special application transformers

Data center transformer

With focus rapidly shifting from simply maximizing uptime and supporting demand to improving energy utilization, the data center industry is continually looking for methods to increase its energy efficiency and reliability. Utilizing cutting edge technology, Eaton's Cooper Power Systems Envirotran™ Hardened Data Center (HDC) transformers are the solution. Designed with special attention given to surge protection, HDC liquid-filled transformers provide superior performance under the harshest electrical environments. Contrary to traditional dry-type units, HDC transformers provide unsurpassed reliability, overloadability, operational life, efficiency, thermal loading and installed footprint. These Eaton's Cooper Power Systems units have reliably served more than 100 MW of critical data center capacity for a total of more than 6,000,000 hours without an hour of downtime caused by a thermal or short-circuit coil failure.

The top priority in data center operations is uninterrupted service. Envirotran HDC transformers from Eaton's Cooper Power Systems, having substantially higher levels of insulation, are less susceptible to voltage surges. Eaton's Cooper Power Systems has experienced zero failures due to switching transients. The ANSI® and IEEE® standard impulse withstand ratings are higher for liquid-filled transformers, making them less susceptible to insulation failure. The Envirotran HDC transformer provides ultimate protection by increasing the BIL rating one level higher than standard liquid-filled transformer ratings. The cooling system of liquid-filled transformers provides better protection from severe overloads—overloads that can lead to significant loss of life or failure.

Data center design typically includes multiple layers of redundancy, ensuring maximum uptime for the critical IT load. When best in class transformer manufacturing lead times are typically weeks, not days, an unexpected transformer failure will adversely affect the facility's reliability and profitability. Therefore, the ability to determine the electrical and mechanical health of a transformer can reduce the probability of costly, unplanned downtime. Routine diagnostic tests, including key fluid properties and dissolved gas analysis (DGA), can help determine the health of a liquid-filled transformer. Although sampling is not required for safe operation, it will provide the user with valuable information, leading to scheduled repair or replacement, and minimizing the duration and expense of an outage. With a dry-type transformer, there is no reliable way to measure the health or likelihood of an impending failure.

Solar transformer

As a result of the increasing number of states that are adopting aggressive Renewable & Alternative Energy Portfolio Standards, the solar energy market is growing—nearly doubling year over year. Eaton's Cooper Power Systems, a key innovator and supplier in this expanding market, is proud to offer Envirotran transformers specifically designed for Solar Photovoltaic medium-voltage applications. Eaton's Cooper Power Systems is working with top solar photovoltaic developers, integrators and inverter manufacturers to evolve the industry and change the way we distribute power.

In accordance with this progressive stance, every Eaton's Cooper Power Systems Envirotran Solar transformer is filled with non-toxic, biodegradable Envirotemp™ FR3™ dielectric fluid, made from renewable seed oils. On top of its biodegradability, Envirotemp™ FR3™ fluid substantially extends the life of the transformer insulation, saving valuable resources. What better way to distribute green power than to use a green transformer. In fact, delaying conversion to Envirotran transformers places the burden of today's environmental issues onto tomorrow's generations. Eaton's Cooper Power Systems can help you create a customized transformer, based on site specific characteristics including: temperature profile, site altitude, solar profile and required system life. Some of the benefits gained from this custom rating include:

- Reduction in core losses
- Improved payback on investment
- Reduction in footprint
- Improved fire safety
- Reduced environmental impact

For the solar photovoltaic industry, Eaton's Cooper Power Systems is offering standard step up transformers and dual secondary designs, including 4-winding, 3-winding (Low-High-Low) and 3-winding (Low-Low-High) designs.

Wind transformer

Eaton's Cooper Power Systems is offering custom designs for renewable energy power generation. Eaton's Cooper Power Systems manufactures Generator Step-Up (GSU) transformers for installation at the base of every wind turbine. Additionally, grounding transformers are available for wind power generation.

DOE efficiency

The United States Department of Energy (DOE) has mandated efficiency values for most liquid type, medium voltage transformers. As a result, all applicable Eaton's Cooper Power Systems transformers are designed to meet or exceed the standard efficiency values per DOE 2010; Final Ruling, 10 CFR Part 431.

K-Factor transformer

With a drastic increase in the use of ferromagnetic devices, arcing devices, and electric power converters, higher frequency loads have increased significantly. This harmonic loading has the potential to generate higher heat levels within a transformer's windings and leads by as much as 300%. Harmonic loading has the potential to induce premature failure in standard-design distribution transformers.

In addition to standard UL® "K-Factor" ratings, transformers can be designed to customer-provided specifications detailing precise loading scenarios. Onsite measurements of magnitude and frequency, alongside harmonic analysis of the connected load can be performed by Eaton's Cooper Power Systems engineers or a third party consultant. These field measurements are used to determine exact customer needs and outline the transformer specifications.

Eaton's Cooper Power Systems will design harmonic-resistant transformers that will be subjected to the unique harmonic loads. These units are designed to maintain normal temperature rise under harmonic, full-load conditions. Standard UL® "K-Factor" designs can result in unnecessary costs when the "next-highest" K-Factor must be selected for a calculated design factor. To save the customer these unnecessary costs, Eaton's Cooper Power Systems can design the transformer to the specific harmonic spectrum used in the application. K-factor transformers from Eaton's Cooper Power Systems are filled with mineral oil or Envirotemp™ FR3™ fluid and enjoy the added benefits of dielectric cooling such as higher efficiencies than dry-type transformers.

Modulation transformer

Bundled with an Outboard Modulation Unit (OMU) and a Control and Receiving Unit (CRU), a Modulation Transformer Unit (MTU) is designed to remotely achieve two way communication.

The use of an MTU reduces travel time and expense versus traditional meter reading performed by high voltage electricians. Additionally, with MTU it is possible to manage and evaluate energy consumption data, providing reduced metering costs and fewer tenant complaints.

An MTU utilizes existing utility infrastructure, therefore eliminating the need to engineer and construct a dedicated communication network.

Figure 8. Modular transformer.

Inverter/rectifier bridge

Eaton's Cooper Power Systems complements its range of applications for transformers by offering dual winding designs. These designs are intended for connection to 12-pulse rectifier bridges.

Product attributes

To set us apart from other transformer manufactures, Eaton's Cooper Power Systems includes the following guarantees with every three-phase pad-mounted transformer.

Engineered to order (ETO)

Providing the customer with a well developed, cost-effective solution is the number one priority at Eaton's Cooper Power Systems. Using customer specifications, Eaton's Cooper Power Systems will work with the customer from the beginning to the end to develop a solution to fit their needs. Whether it is application specific, site specific, or a uniquely specified unit, Eaton's Cooper Power Systems will provide transformers with the best in class value and performance, saving the customer time and money.

Made in the U.S.A.

Eaton's Cooper Power Systems three-phase pad-mounted transformers are produced right here in the United States of America. Our manufacturing facilities are positioned strategically for rapid shipment of products. Furthermore, should the need arise, Eaton's Cooper Power Systems has a broad network of authorized service repair shops throughout the United States.

Superior paint performance

Protecting transformers from nature's elements worldwide, Eaton's Cooper Power Systems E-coat system provides unrivaled transformer paint life, and exceeds IEEE Std C57.12.28™-2005 and IEEE C57.12.29™-2005 standards. In addition to the outside of the unit, each transformer receives a gray E-coat covering in the interior of the tank and cabinet, providing superior rust resistance and greater visibility during service.

If the wide range of standard paint selections does not suit the customer's needs, Eaton's Cooper Power Systems will customize the paint color to meet their requirements.

Rectangular coil design

Eaton's Cooper Power Systems utilizes a rectangular coil design. This winding technique results in a smaller overall unit footprint as well as reducing the transformer weight. The smaller unit size does not hinder the transformer performance in the least. Units have proven short circuit withstand capabilities up to 12 MVA.

Testing

Eaton's Cooper Power Systems performs routing testing on each transformer manufactured including the following tests:

- **Insulation Power Factor:** This test verifies that vacuum processing has thoroughly dried the insulation system to required limits.
- **Ratio, Polarity, and Phase Relation:** Assures correct winding ratios and tap voltages; checks insulation of HV and LV circuits. Checks entire insulation system to verify all live-to-ground clearances.
- **Resistance:** This test verifies the integrity of internal high-voltage and low-voltage connections; provides data for loss upgrade calculations.
- **Applied Potential:** Applied to both high-voltage and low-voltage windings, this test stresses the entire insulation system to verify all live-to-ground clearances.
- **Induced Potential:** 3.46 times normal plus 1000 volts for reduced neutral designs.
- **Loss Test:** These design verification tests are conducted to assure that guaranteed loss values are met and that test values are within design tolerances. Tests include no-load loss and excitation current along with impedance voltage and load loss.
- **Leak Test:** Pressurizing the tank to 7 psig assures a complete seal, with no weld or gasket leaks, to eliminate the possibility of moisture infiltration or fluid oxidation.

Design performance tests

The design performance tests include the following:

- **Temperature Rise:** Our automated heat run facility ensures that any design changes meet ANSI® and IEEE® temperature rise criteria.
- **Audible Sound Level:** Ensures compliance with NEMA® requirements.
- **Lightning Impulse:** To assure superior dielectric performance, this test consists of one reduced wave, two chopped waves and one full wave in sequence, precisely simulating the harshest conditions.

Thomas A Edison Research and Test Facility

We are constantly striving to introduce new innovations to the transformer industry, bringing you the highest quality transformer for the lowest cost. Eaton's Cooper Power Systems Transformer Products are ISO 9001 compliant, emphasizing process improvement in all phases of design, manufacture, and testing. We have invested millions of dollars in the Thomas A. Edison Technical Center, our premier research facility in Franksville, Wisconsin affirming our dedication to introducing new innovations and technologies to the transformer industry. Headquarters for the Systems Engineering group of Eaton's Cooper Power Systems, this research facility is fully available for use by our customers to utilize our advanced electrical and chemical testing labs.

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H-28

Lotycz, Matt

From:	Eckel, Caroline H.
Sent:	Friday, December 12, 2014 2:44 PM
To:	Lotycz, Matt
Subject:	RE: California Remediation Project - Arcadis

The preliminary drawing shows the whole package pump station that we will be using on site. Pumps and panel and bladder tank are all enclosed together. The bladder tank is item 4 on the key, 158 gallons. It will go on the utility pad, along with the water supply tanks. Do you have that layout of the pad?

From: Lotycz, Matt
Sent: Friday, December 12, 2014 2:38 PM
To: Eckel, Caroline H.
Subject: RE: California Remediation Project - Arcadis

Caroline - Not sure what all this is. Do we have other stuff on the Utility pad from this cutsheet you gave me, or just the bladder tank. If just the bladder tank from this info, please email a cutsheet just on the bladder tank. Thanks.

If it is easier to call me, feel free.

Matt

From: Eckel, Caroline H.
Sent: Friday, December 12, 2014 2:33 PM
To: Lotycz, Matt
Subject: FW: California Remediation Project - Arcadis

This is what we have on the water system.

The pressure range is going to change to 50-70.

We haven't gotten the revision for this yet.

If this isn't enough on the bladder tank, I will request a specific cut sheet on it.

I think it will be part of the "package".

From: David Sabatka [mailto:djs-sda@sbcglobal.net]
Sent: Thursday, December 11, 2014 12:00 PM
To: Eckel, Caroline H.
Subject: Fw: California Remediation Project - Arcadis

Caroline:

Take a look at this package system that may be close to what you might consider for your project. We could make some slight modifications, such as utilizing an air conditioning unit or proper ventilation in lieu of the heating unit shown. Let me know what you think and then we can proceed further with final details and some pricing.

Dave Sabatka, P.E.

Sabatka, Davis & Associates, Inc.

4620 Indianola Ave.
Columbus, OH 43215

p: 614-447-8989
c: 614-214-0795
email: djs-sda@sbcglobal.net

----- Forwarded Message -----
From: Craig Dickinson <cdickinson@pattersonpumps.com>
To: Dave Sabatka <djs-sda@sbcglobal.net>
Sent: Wednesday, December 3, 2014 3:08 PM
Subject: California Remediation Project - Arcadis

See attached drawing from a project that we built previously. It was constant speed and had standard check valves. As long as they don't mind the pressure swings between 40-60 PSI then this will work. If they want constant pressure, we will need to add either pressure reducing valves or variable speed drives. In this size, they would cost about the same.

Craig Dickinson
Flo-Pak Integrated Municipal Systems
Patterson Pump Company
Phone: (706) 297-2837
Email: cdickinson@pattersonpumps.com

Lotycz, Matt

From: Eckel, Caroline H.
Sent: Friday, December 12, 2014 2:33 PM
To: Lotycz, Matt
Subject: FW: California Remediation Project - Arcadis
Attachments: CR10-4.pdf; Preliminary Drawing.pdf

This is what we have on the water system.

The pressure range is going to change to 50-70.

We haven't gotten the revision for this yet.

If this isn't enough on the bladder tank, I will request a specific cut sheet on it.

I think it will be part of the "package".

From: David Sabatka [mailto:djs-sda@sbcglobal.net]
Sent: Thursday, December 11, 2014 12:00 PM
To: Eckel, Caroline H.
Subject: Fw: California Remediation Project - Arcadis

Caroline:

Take a look at this package system that may be close to what you might consider for your project. We could make some slight modifications, such as utilizing an air conditioning unit or proper ventilation in lieu of the heating unit shown. Let me know what you think and then we can proceed further with final details and some pricing.

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Columbus, OH 43215

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To: Dave Sabatka <djs-sda@sbcglobal.net>
Sent: Wednesday, December 3, 2014 3:08 PM
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Craig Dickinson
Flo-Pak Integrated Municipal Systems
Patterson Pump Company
Phone: (706) 297-2837
Email: cdickinson@pattersonpumps.com

Lotycz, Matt

From: Eckel, Caroline H.
Sent: Friday, December 12, 2014 4:16 PM
To: Lotycz, Matt
Subject: Pump enclosure

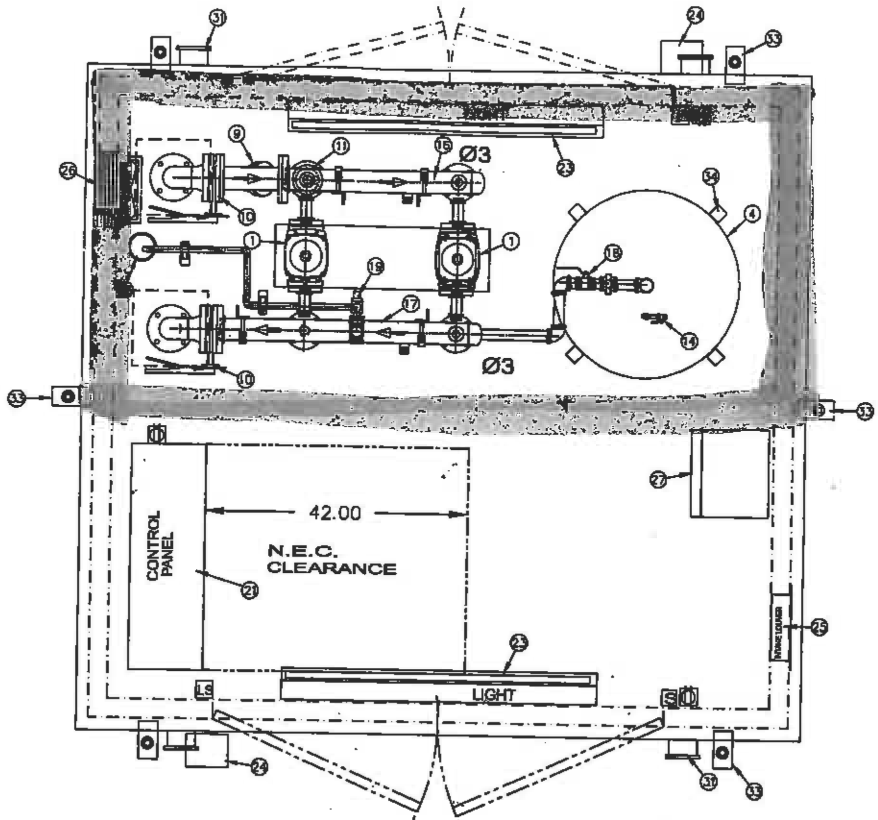
FYI - Jon asked about eliminating the enclosure and changing the footprint to 5'x9', I don't think that will be a problem. Although I forwarded the question on to the manufacturer.

Caroline Eckel, PE | Engineer | caroline.eckel@arcadis-us.com

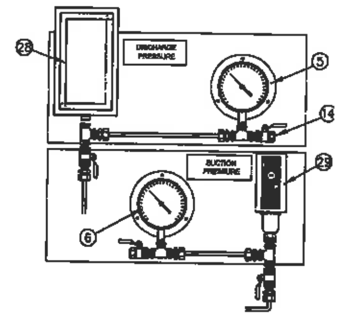
ARCADIS U.S., Inc. | One SeaGate, Suite 700 | Toledo, Ohio 43604
M: 419 392 1479 | T: 419 213 1615 | F: 419 473 2108
www.arcadis-us.com

ARCADIS, Imagine the result

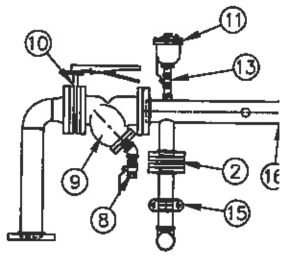
Please consider the environment before printing this email.



PLAN ELEVATION

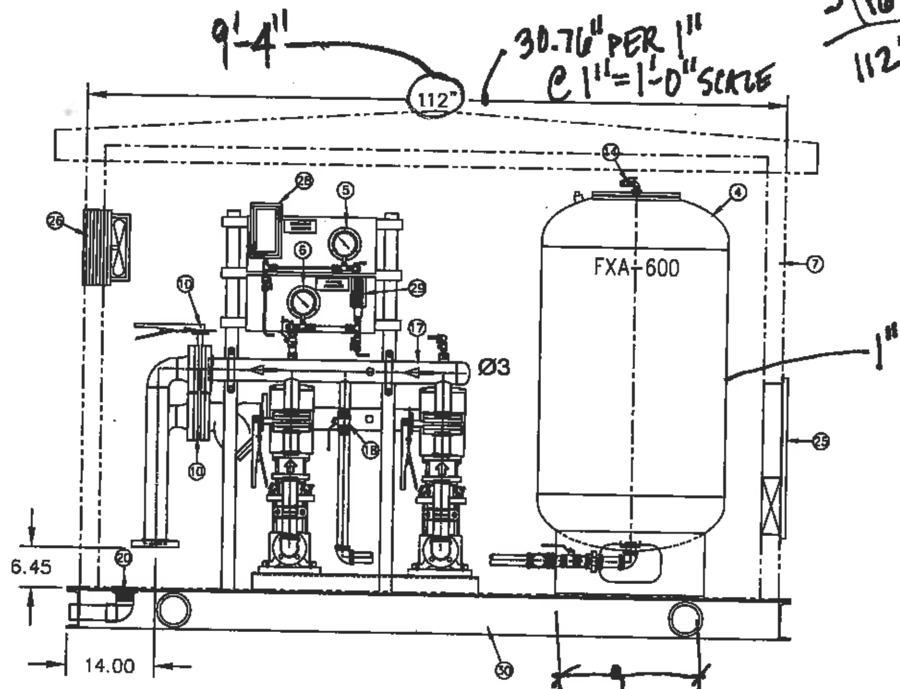


PRESSURE GAUGE DETAIL



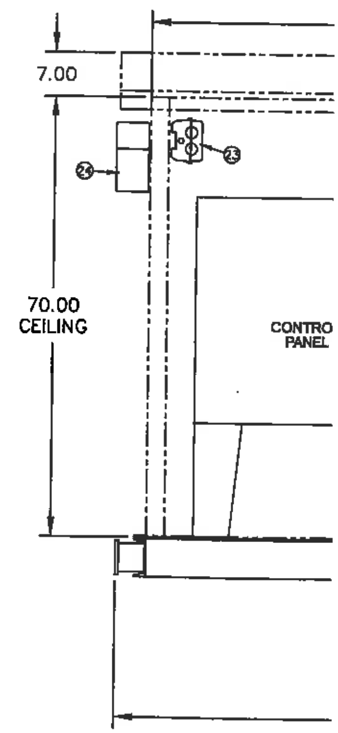
SUCTION HEADER DE

$$\frac{3\left(\frac{10.25}{16}\right)''}{112''} = \frac{12.5/16''}{x}$$



FRONT ELEVATION

CTRL PANEL NOT SHOWN FOR CLARITY



ARCADIS

SUBJECT: TOPOK-WORKSHOP BLDG

JOB NO:

BY: MSL DATE: 12/24/14

CHKD: MSL DATE: 1/8/15

PAGE I-1

SHEET 1

WORKSHOP BLDG

- REF SHT I-2 FOR BUILDING PLAN & SECTION
- REF SHT I-3 FOR CBC 2013/IBC 2012 WIND & SEISMIC LOADS
- DEAD LOADS:
  - WALLS
    - WALL PANEL = 1.5 psf (24 GA METAL WALL PANEL)
    - LINER = 1.5 psf
    - INSULATION = 1 psf
    - GIRTS 10#/ft / 5ft o/c = 2 psf

    TOTAL = 6 psf
  - ROOF
    - ROOF PANEL = 1.5 psf (24 GA STANDING SEAM ROOF PANEL)
    - LINER = 1.5 psf
    - INSULATION = 1 psf
    - PURLINS 10#/ft / 4ft o/c = 2.5 psf
    - SOLAR PANEL = ~~10~~ 5 psf (B-12, 13 & 14)
    - COLLATERAL = 5 psf

    TOTAL = 16.5 psf ✓ — MAX

    TOTAL = 4 psf ✓ — MIN (NO SOLAR PANELS, NO LINER, 0.5 psf SS → METAL)

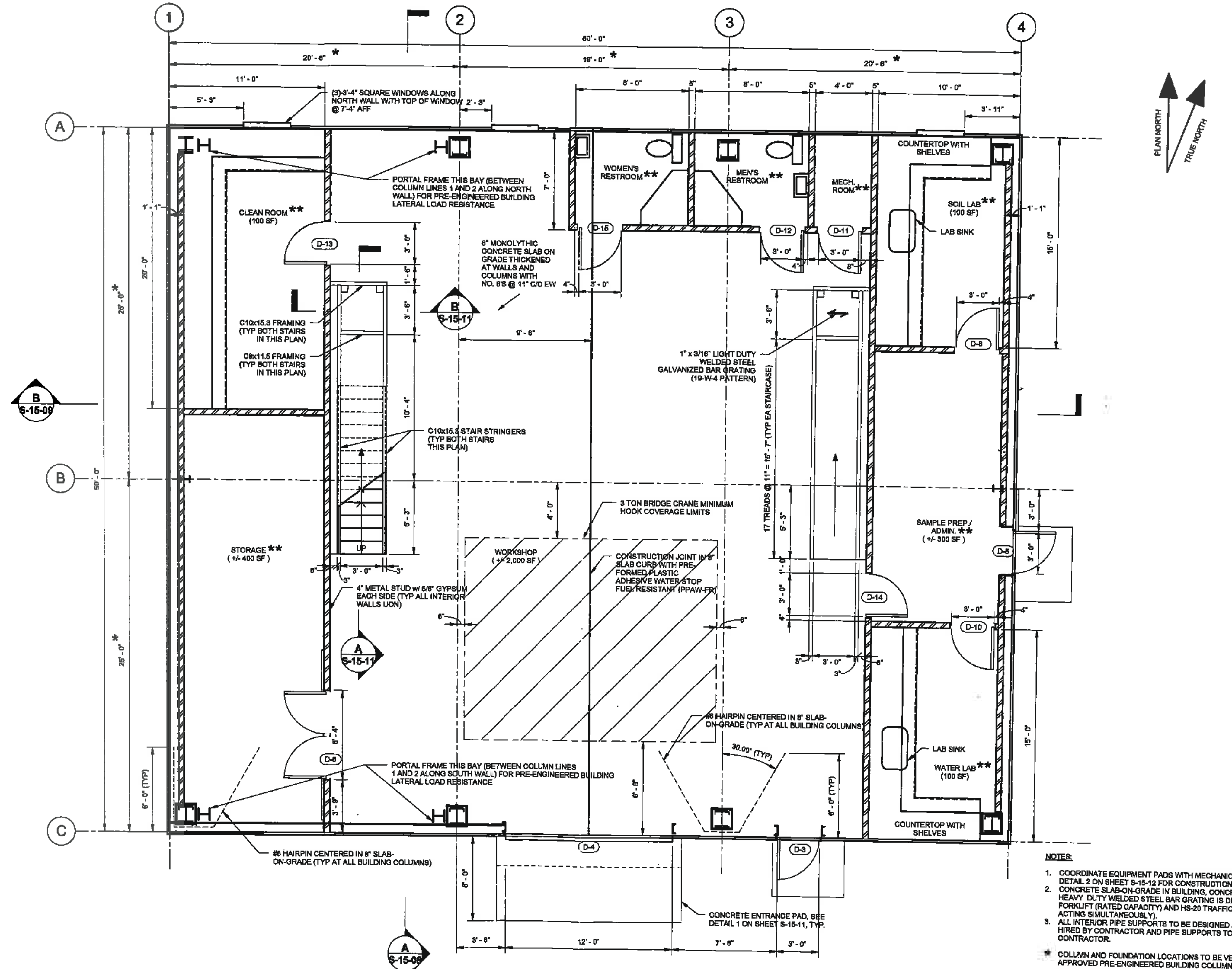
- REF SHT I-2A FOR BRIDGE CRANE INFO – 3 TON LIFTING LOAD = 6,000#
  - RUNWAY BEAMS = 100#/F
  - BRIDGE/TROLLEY DEAD LOAD = 2570#
  - MAX WHEEL LOAD = 4,000# (×2 @ 5'-11" o/c)

    ↳ (6,000# LIFTING × 1.25 / 2 WHEELS) + (490# TROLLEY / 2 WHEELS) + (2080# BRIDGE / 4 WHEELS)

    = 4515# ✓ OK

AGM Form 30 12-01

I-2



FINISH FLOOR PLAN
1/4" = 1'-0"

NOTES:

1. COORDINATE EQUIPMENT PADS WITH MECHANICAL DRAWINGS. SEE DETAIL 2 ON SHEET S-15-12 FOR CONSTRUCTION REQUIREMENTS.
2. CONCRETE SLAB-ON-GRADE IN BUILDING, CONCRETE RAMPS, AND HEAVY DUTY WELDED STEEL BAR GRATING IS DESIGNED FOR 3 TON FORKLIFT (RATED CAPACITY) AND HS-20 TRAFFIC LOADS (LOADS NOT ACTING SIMULTANEOUSLY).
3. ALL INTERIOR PIPE SUPPORTS TO BE DESIGNED BY CALIFORNIA P.E. HIRED BY CONTRACTOR AND PIPE SUPPORTS TO BE PORVIDED BY CONTRACTOR.

* COLUMN AND FOUNDATION LOCATIONS TO BE VERIFIED PER APPROVED PRE-ENGINEERED BUILDING COLUMN LOCATIONS.

** 1/2" PLYWOOD SHEATHING FASTENED TO TOP OF METAL ROOF DECK (1.5B DECK 22 GA) w/ 6" METAL STUD JOISTS AT 16" C/C (TYP ALL INTERIOR ROOMS) (MAX LIVE LOAD RATING = 50 PSF)

- DRAFT -
NOT FOR CONSTRUCTION

ARCADIS

No.	Date	DESCRIPTION	GM/SPEC	DWN	CHKD	SUPV	APVD BY
0	12/30/14	SUPPLEMENTAL PRE-FINAL (90%) DESIGN SUBMITTAL		CMW	MSL	JB	RAK

REVISIONS

APPROVED BY	
SO	
SUPV	JB
DSGN	MSL
DWN	CMW
CHKD	MSL
OK	RAK
DATE	12/30/14
SCALES	NONE or AS SHOWN

TOPOCK GROUNDWATER REMEDIATION PROJECT

WORKSHOP BUILDING FINISH FLOOR PLAN

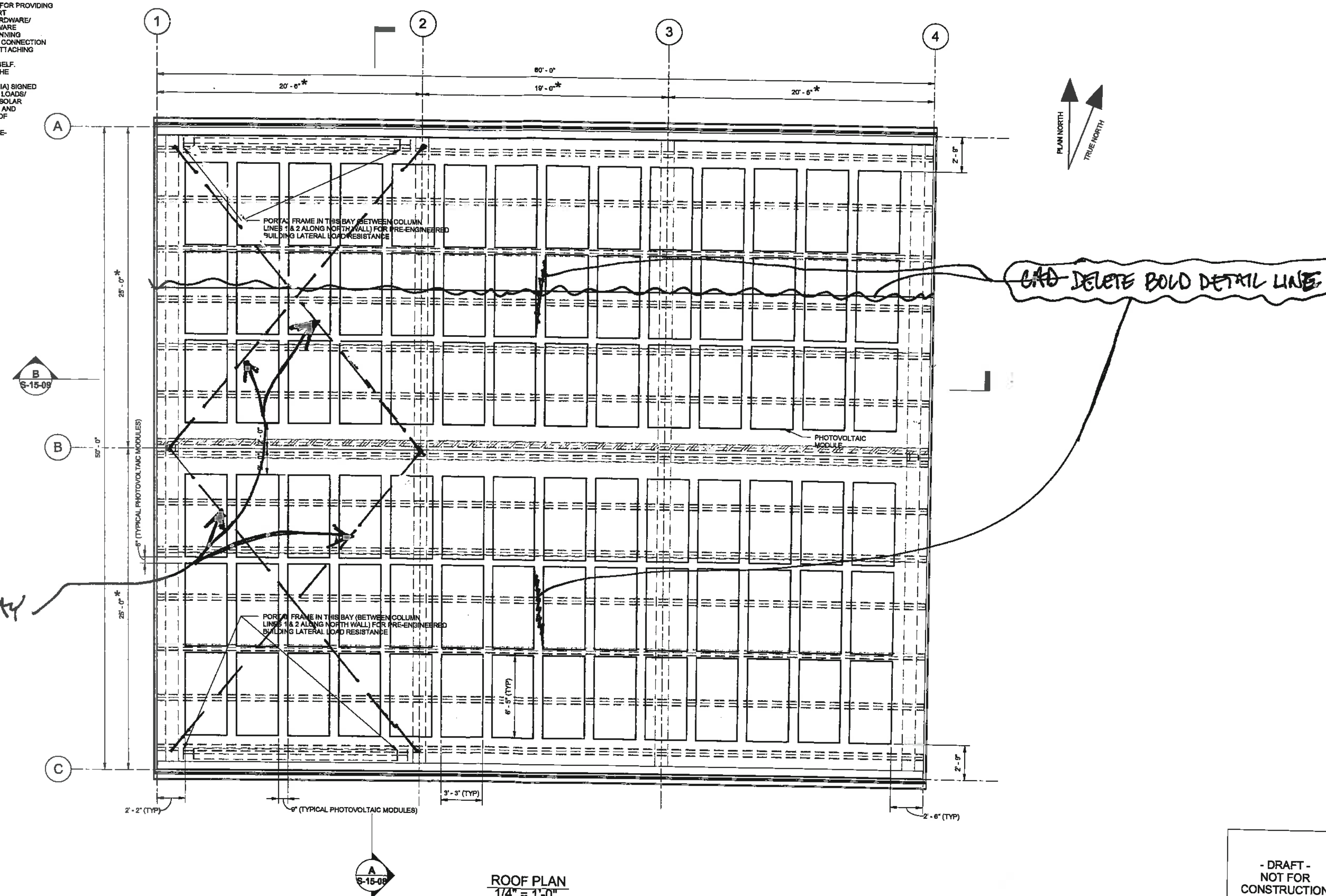
GAS TRANSMISSION & DISTRIBUTION
PACIFIC GAS AND ELECTRIC COMPANY
SAN FRANCISCO, CALIFORNIA

MICROFILM
BILL OF MATL
DWG LIST
SUPSDS
SUPSD BY
SHEET NO. of SHEETS
S-15-06
REV

PHOTOVOLTAIC (PV) SOLAR PANEL NOTES:

1. PV SOLAR PANEL UNITS ARE TO BE PROVIDED ON TOP OF THE METAL ROOF DECK OF THE WORKSHOP BUILDING. THE PV SOLAR PANEL UNIT MANUFACTURER IS RESPONSIBLE FOR THE FOLLOWING:
   A. THE PV SOLAR PANEL UNIT MANUFACTURER IS RESPONSIBLE FOR PROVIDING AND DESIGNING ALL ITEMS (PV SOLAR PANELS/PANEL SUPPORT FRAMING/ROOF CLIPS (ATTACHING TO METAL ROOF DECK)/HARDWARE/ ETC.). THIS INCLUDES THE STRUCTURAL FRAMING AND HARDWARE ATTACHING TO THE BACK OF THE PV SOLAR PANELS AND SPANNING TO EACH ROOF CLIP (ATTACHING TO METAL ROOF DECK), THE CONNECTION OF THE PV SOLAR PANEL UNIT FRAMING TO THE ROOF CLIP (ATTACHING TO METAL ROOF DECK), AND THE ROOF CLIP AND ITS BOLTED/WELDED CONNECTION TO THE METAL DECK ROOF ITSELF.
   B. THE PV SOLAR PANEL UNIT MANUFACTURER MUST PROVIDE THE FOLLOWING:
      1. SUBMIT P.E. (REGISTERED IN THE STATE OF CALIFORNIA) SIGNED AND SEALED DETAILS/DESIGN CALCULATIONS/DESIGN LOADS/ (DEAD/LIVE/SEISMIC/WIND LOADS) ACTING ON THE PV SOLAR PANEL UNITS, PANEL SUPPORT FRAMING, ROOF CLIPS AND ITS BOLTED/WELDED CONNECTION TO THE METAL ROOF DECK, AND HARDWARE.

* COLUMN AND FOUNDATION LOCATIONS TO BE VERIED PER APPROVED PRE-ENGINEERED BUILDING COLUMN LOCATIONS.



NOTES:

1. NORTH SIDE PHOTOVOLTAICS MOUNTED AT 10 DEGREE TILT TOWARD SOUTH.

ROOF PLAN
1/4" = 1'-0"

- DRAFT -
NOT FOR CONSTRUCTION

ARCADIS

No.	Date	DESCRIPTION	GM/SPEC	DWN	CHKD	SUPV	APVD BY
0	12/30/14	SUPPLEMENTAL PRE-FINAL (90%) DESIGN SUBMITTAL		CMW	MSL	JB	RAK

REVISIONS

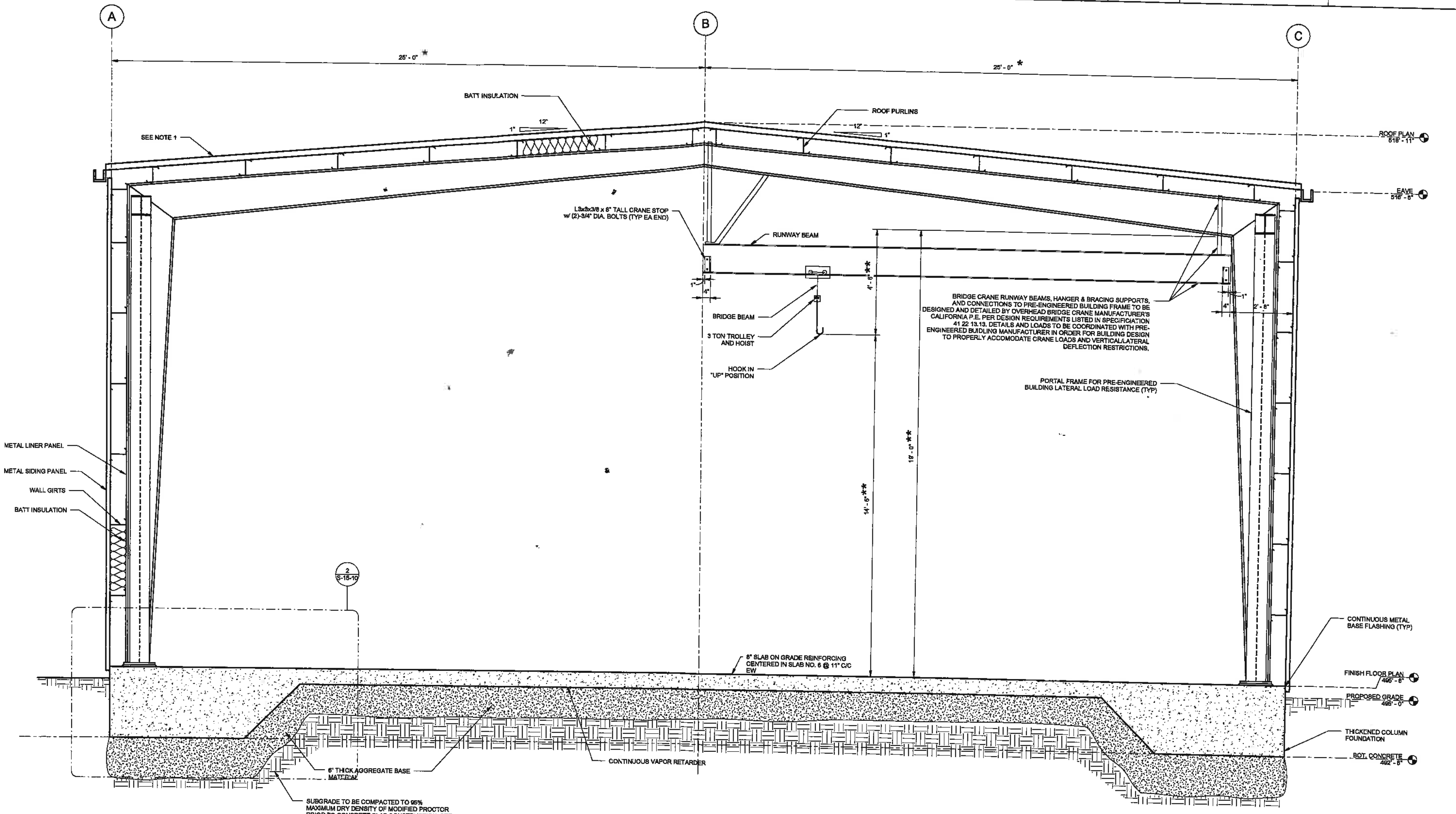
SO	
SUPV	JB
DSGN	MSL
DWN	CMW
CHKD	MSL
OK	RAK
DATE	12/30/14
SCALES	NONE or AS SHOWN

TOPOCK GROUNDWATER REMEDIATION PROJECT

WORKSHOP BUILDING ROOF PLAN

GAS TRANSMISSION & DISTRIBUTION
PACIFIC GAS AND ELECTRIC COMPANY
SAN FRANCISCO, CALIFORNIA

MICROFILM
BILL OF MATL
DWG LIST
SUPSDS
SUPSD BY
SHEET NO. of SHEETS
S-15-07 REV



(A) TYPICAL FRAME
1/2" = 1'-0"

NOTES:

1. PHOTOVOLTAIC MODULES NOT SHOW FOR CLARITY.

* COLUMN AND FOUNDATION LOCATIONS TO BE VERIFIED PER APPROVED PRE-EINGEERED BUILDING COLUMN LOCATIONS.

** HEIGHT FROM TOP OF FLOOR TO BOTTOM OF FRAME RAFTER BEAM TO BE VERIFIED TO ACHIEVE MINIMUM 14'-6" HOOK CLEARANCE HEIGHT FROM FLOOR

- DRAFT -
NOT FOR CONSTRUCTION

ARCADIS

No.	Date	DESCRIPTION	GM/SPEC	DWN	CHKD	SUPV	APVD BY
0	12/30/14	SUPPLEMENTAL PRE-FINAL (90%) DESIGN SUBMITTAL		CMW	MSL	JB	RAK

REVISIONS

APPROVED BY	
SUPV	JB
DSGN	MSL
DWN	CMW
CHKD	MSL
OK	RAK
DATE	12/30/14
SCALES	NONE or AS SHOWN

TOPOCK GROUNDWATER REMEDIATION PROJECT

WORKSHOP BUILDING
SECTION-TYPICAL FRAME

GAS TRANSMISSION & DISTRIBUTION
PACIFIC GAS AND ELECTRIC COMPANY
SAN FRANCISCO, CALIFORNIA

MICROFILM
BILL OF MATL
DWG LIST
SUPSDS
SUPSD BY
SHEET NO. of SHEETS
S-15-08
REV

12/22/2014 3:40:36 PM

I-2A

Lotycz, Matt

From: Dan Yeakey <dyeakey@dearborncrane.com>
Sent: Friday, November 14, 2014 10:32 AM
To: Lotycz, Matt
Subject: Crane quote 171881
Attachments: 171881-Crane Quote.pdf; Drawing.pdf

Matt

Please review the attached quote and crane drawings. We look forward to the opportunity to discuss this project with you. Please contact me with questions or comments.
Sincerely,
Dan Yeakey
Dearborn Overhead Crane
P: 574-208-6864
F: 574-208-6864
Visit us at:
www.DearbornCrane.com
OVER 60 YEARS OF LIFTING EXPECTATIONS!
https://plus.google.com/102203654753437148752/about?gl=US&hl=en-US

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www.DearbornCrane.com

DEARBORN OVERHEAD CRANE
1133 East Fifth Street
Mishawaka, IN 46544
Phone 1-574-259-2444
24 Hours 1-800-272-6358

*** Cover Sheet ***

To: Matt Lotycz
Company: Arcadis
Email:

From: Dan Yeakey

Quote#: 171881

Date: 11/14/14
Pages (including this page): 6
Comments: Bridge Crane

Dearborn Overhead Crane
Since 1947

DESIGN SPECIFICATIONS

Material design and safety features, based on service classification, will conform to the following listed specifications and codes where applicable and appropriate:

Crane Manufacturers Association of America, Inc., CMAA 70-74, Latest Edition
American National Standard, B30.11-1980 "Underhung Cranes"
American National Standard, ANSI-B30.16 "Overhead Hoist"
Hoist Manufacturers Institute – Specification HMI 100-74
Manual of Steel Construction, Latest Edition
National Electrical Code – Latest Edition
Specification for Welding Industrial & Mill Cranes ANSI/AWS D 14.1 – 1997

www.DearbornCrane.com

DEARBORN OVERHEAD CRANE
1133 East Fifth Street
Mishawaka, IN 46544
Phone 1-574-259-2444
24 Hours 1-800-272-6358

11/14/14

Proposal No. 171881

ATTN: Matt Lotycz
Arcadis

Email:

SUBJECT: Bridge Crane

We first would like to thank you for the opportunity to provide a quote on this valued project. We are pleased to quote the following;

SCOPE

One 3 ton under running, single girder crane per attached specifications. Our quote includes all crane and hoist components, runways, 4 conductor runway electrification, engineering, fabrication, painting.

PRICING

Item Description	Material		
3 ton under running, single girder crane	17000		
Runways	2000		
4 Bar Runway Electrification System	500		
Totals:	**$19,500.00**		

- Add Remote Radio System $960 installed per crane
- Please add sales tax where applicable
- Freight not included

We hope the above information and enclosures are sufficient to answer any questions you might have regarding this equipment. Should there be any further questions please feel free to call. We would welcome the opportunity to further discuss our proposal with you.
DEARBORN has been a manufacturer of cranes since 1947. DEARBORN is the only regional crane manufacturer that not only builds cranes but also has a full time field service crew that repairs all brands of cranes. We also rebuild cranes as well as provide annual OSHA inspections.

Price quoted is subject to increase to cover any applicable sales or use tax which we are required by law to pay or collect as a result of this transaction. We reserve the right to correct any stenographic errors.
Terms: 35% down payment, 55% prior to delivery 10% net 30 (pending credit approval.)
Due to the volatile steel market, all quotations must be confirmed prior to acceptance of order.

Delivery: 6 weeks after receipt of signed approval drawings and Purchase Order

F.O.B.: Origin, Mishawaka, IN

Attached Bid Notes are an integral part of this proposal.

Quoted By: DJY

Ordered by:	
Total Amount:	
PO Number:	

Respectfully submitted,

Dan Yeakey

Dan Yeakey, DEARBORN CRANE & ENGINEERING CO.

www.DearbornCrane.com
DEARBORN OVERHEAD CRANE
1133 East Fifth Street
Mishawaka, IN 46544
Phone 1-574-259-2444
24 Hours 1-800-272-6358

Crane Specifications

Quote No: 171881 **Date:** 11/14/14
Customer: Arcadis
Attention: Matt Lotycz

Crane Data

Crane type	under running, single girder	**# of Cranes**	1
Capacity	3 Tons	**Operation**	Indoors
Span	20'- 0"	**Power**	460/3/60
Lift	14'- 2"	**Reeving**	2/1
Hoist	3 ton wire rope	**Control Encl.**	NEMA 12
Whl Load	4000 lbs.	**Crane Rating**	CMAA C
Br. Endtr.	5'- 10 7/8" wheel base	**Operation type**	Sliding P.B.
Configuration	single girder	**Control Voltage**	110V
Girder Type	standard wide-flange	**Cross Conductors**	Festooned
Walkway	N/A	**Paint**	Yellow
Standard items	2 speed hoist , Weight Watcher Load Cell, Trolley Brake, Trolley Bumpers, Hoist Geared Upper and Lower Limit, Bridge Travel Slow Down Limit Switch, Trolley VFD Control, Bridge VFD Control, Warning Horn, Hoist Inspection Test Record, Wire Rope Certification, Hook Forging Certificate		

Runway Data

Runway type	W14x43	**Runway Conductors**	4 bar Conductor system
Length	25'	**Runway Collectors**	Tandum Spring Shoe type
Supports	Bolted connection every 25' directly to building headers		

Electrical Data

Drive	Motor Type	Speed (FPM)	Brakes
Hoist	Crane Duty	20/3.3 two speed	DC Disc
Trolley	Crane Duty	65 variable	DC Disc
Bridge	Crane Duty	100 variable	DC Disc

CMAA CRANE MANUFACTURERS ASSOCIATION OF AMERICA, INC. ISA D&B BBB HMI HOIST MANUFACTURERS INSTITUTE MATERIAL HANDLING INDUSTRY OF AMERICA

DEARBORN OVERHEAD CRANE
1133 East Fifth Street
Mishawaka, IN 46544
Phone 1-574-259-2444
24 Hours 1-800-272-6358

Bid Notes

The following bid notes are included as an integral part of the quote. Variances and/or exceptions may affect the final price of this equipment.

- Dearborn installation is computed on a straight time basis. Installation requested to be done outside normal working hours may require overtime charges. Pricing also assumes all work is done in a continuous fashion with a single "Start up and Shut down". Additional charges may be incurred if Dearborn is required to pull off the job and restart later.
- Dearborn cannot accept responsibility for any existing support or building structures.
- Proper sizing, location, alignment to CMAA recommendations, and spacing of Runways, columns, support steel and/or ASCE rail is responsibility of others **where Dearborn does not supply these items.**
- Design and supply of material for any concrete work is *not* included unless otherwise called out in quotation.
- All material factory painted using manufacturers standard paint with field paint touch up, by Dearborn.
- Temporary electric power for lighting and welders by others. **Dearborn uses Gas welders as a standard**
- Removal of any obstruction in crane path, by others. **Exception only if agreed to in advance in writing with Dearborn**
- Disposal of leaded paint chips, asbestos, or any other hazardous material which may need to be removed during the crane installation will be the responsibility of the owner.
- Handling and storage of materials due to delays by customer may result in additional charges.
- A complete Operating & Maintenance manual with appropriate spare parts list is included.
- All installation prices assume a clear work area with concrete floors in place. Delays and/or extra time incurred by the field crews due to inaccessibility to work area will be billed at then current rates for men and equipment .**Exception only if agreed to in advance in writing with Dearborn** .
- Adequate headroom above the bridge crane must be available to allow the boom of the mobile crane to set the crane and hoist. **Exception only if agreed to in advance in writing with Dearborn** .
- A fused disconnect and power from source to the disconnect and from disconnect to conductor bar is by others. Current taps and connection at the conductor bar is provided by Dearborn.
- Any permits required, by others.
- Basic operator orientation, including one session of approximately ½ hour at time of installation, is included. A more comprehensive operator and OSHA training is available on request.
- "Testing" in the scope section refers to 'No Load' Testing which tests all functions of equipment. Full Load Testing with test weights is available as described on the Load Testing Policy page.
- Limitation of liability: seller shall have no liability to buyer with respect to the sale of products or provision of services hereunder for lost profits or for special, consequential, exemplary or incidental damages of any kind.
- Warranty: Dearborn Overhead Crane provides a full 10 year warranty on all structural components of the crane (and runway system where supplied by Dearborn Overhead Crane). All mechanical and electrical components (such as hoists, end trucks, electrification, attachments, etc.) are supplied with a limited ONE year warranty on material only. Warranty period begins on the date of crane commissioning and signed acceptance by the customer.

OPTIONAL EQUIPMENT AVAILABLE:

- **RADIO CONTROL**
- **ANTI-COLLISION FEATURE**
- **WARNING DEVICES**
- **CRANE LIGHTS**
- **ADJUSTABLE FREQUENCY DRIVES**
- **OUTDOOR APPLICATIONS**
- **WALKWAYS AND/OR SERVICE PLATFORMS**

  (Means to access the above option is not included, but available)
- **SPECIAL PAINT**
- **BELOW HOOK DEVICES (C-HOOKS, MAGNETS, SLINGS, ETC)**

DEARBORN will provide the right combination of PERFORMANCE, RELIABILITY and VALUE, all at the right price. We not only build and install the highest quality cranes; we also have a full time field service crew that repairs all brands of cranes. DEARBORN also provides annual service contracts for those customers who depend on their equipment for critical production needs or who want to be sure their equipment is always in top working order and OSHA inspections are being done in a timely fashion.

www.DearbornCrane.com

DEARBORN OVERHEAD CRANE
1133 East Fifth Street
Mishawaka, IN 46544
Phone 1-574-259-2444
24 Hours 1-800-272-6358

Load Testing Advisory

1) Current specifications regarding the load tests of Overhead Crane Systems

ANSI B30.11 requires the following;
11-2.2.2 Rated Load Test
(a) Prior to initial use, all new, extensively repaired, and altered equipment shall be tested and inspected by, or under the direction of, an appointed or authorized person, and a written report should be furnished by such person, confirming the load rating of the system. The load rating should no be more than 80% of the maximum load sustained during the test.

OSHA 1910.179 Paragraph K2 states the following;
Rated load test.
Test loads shall not be more than 125% of the rated load unless otherwise recommended by the manufacturer. The test reports ***shall*** be placed on file where readily available to appointed personnel.

2) Definitions

Hoist
A machinery unit that is used for lifting and lowering a load.
Crane
A bridging structure that spans two or more runways and provides traversing motion.
Runway
The rails, beams, brackets and framework on which the crane operates.

3) Dearborn Overhead Crane Load Testing Offer (Maximum crane capacity of 10ton)

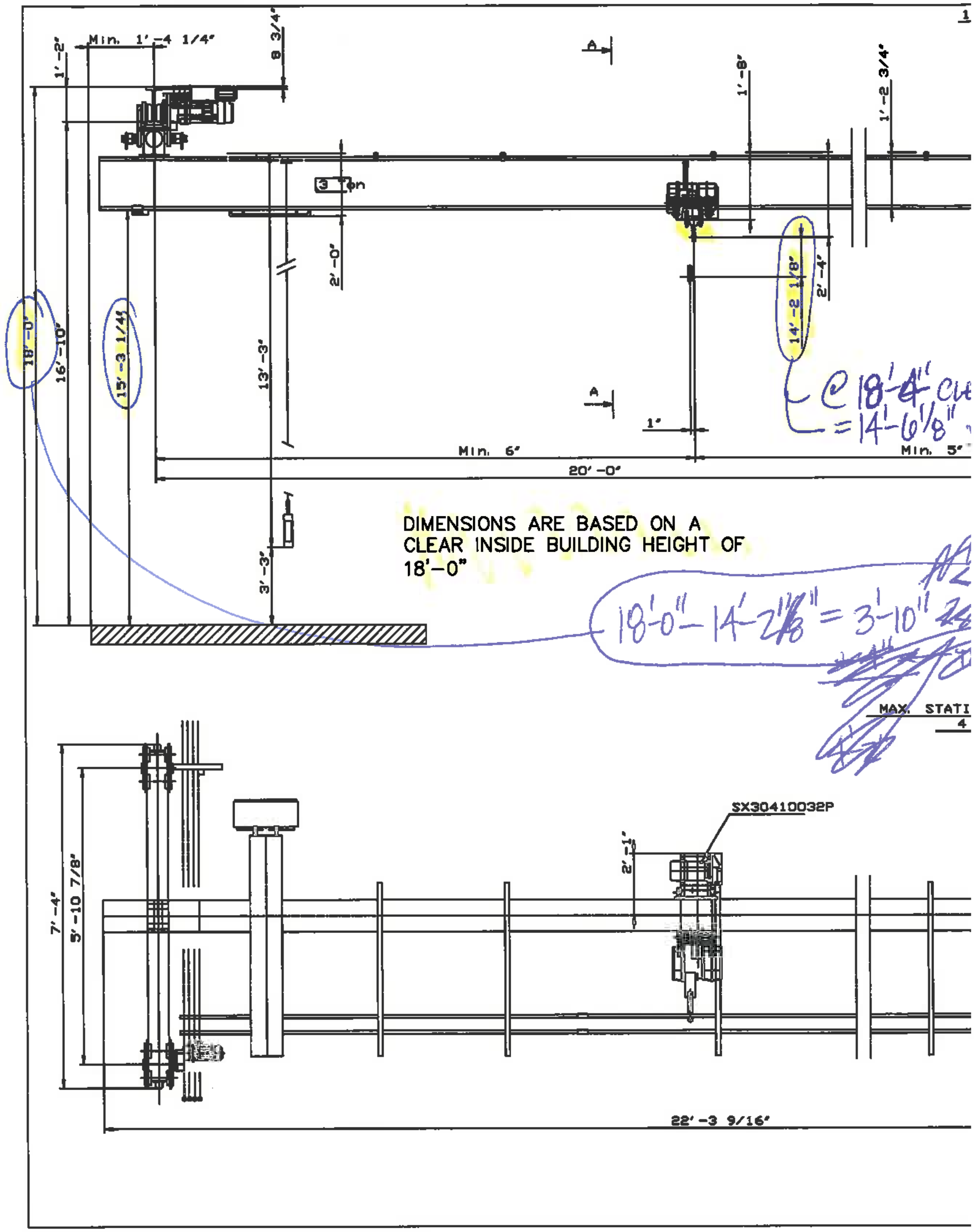
It therefore is our opinion, that it is the owner's responsibility to load test the overhead bridge crane ***system***. The "system" consists of the hoist, crane, runways, columns and footings. To test the "system", requires that the full system be in place and therefore must occur after the completion of the crane installation. Although it is hoist industry practice to load test every hoist prior to shipping, this practice does not preclude the requirement for the full load testing upon commissioning of the full hoist, crane and runway system.

As a service to our customers, DOC offers to provide this load test free of charge to the purchaser of a Dearborn Crane. To take advantage of this **free** offer, **ALL** the following criteria is required.

1. Dearborn Must be contracted to install the crane and will perform this load test during the normal installation time period
2. The customer must provide a full capacity test load** to be used for testing purposes. This load must be 125% of the rated capacity of the crane.
3. The load must be of reliable weight, and be easily accessible and in the immediate area of the crane to be tested. The weight of the load should be certifiable. If certification of the load is not practical, DOC can provide a scale to weigh the load for a small fee.
4. All necessary rigging** must be provided by the customer.
5. The load and rigging must be provided while DOC is on site for the installation. (If the customer cannot provide the required materials during the normal installation period, but still would like to have a Certified Load Test performed, a crew can be provided on a time and material basis.)

Upon completion of the test, a temporary hand written certificate will be supplied to the owner, so that there is no possible exposure to the owner of not have proper documentation. The official Load Test Certificate to following within 2 weeks. Also, a copy will remain on file at Dearborn.

** Dearborn Overhead Crane is not responsible for any damage that may occur to either the test weights or the rigging used.



1
Min. 1'-4 1/4"
8 3/4"
1'-2"
A
1'-8"
1'-2 3/4"
3 Ton
2'-0"
2'-4"
14'-2 1/8"
18'-0"
16'-10"
15'-3 1/4"
13'-3"
@ 18'-4" CL
= 14'-6 1/8"
1"
Min. 6"
Min. 5"
20'-0"
DIMENSIONS ARE BASED ON A
CLEAR INSIDE BUILDING HEIGHT OF
18'-0"
3'-3"
18'-0" - 14'-2 1/8" = 3'-10"
MAX. STATI
4
SX30410032P
2'-1"
7'-4"
5'-10 7/8"
22'-3 9/16"

STRUCTURAL CALCULATIONS

FOR

Topok

Needles, CA

Code Search

Code: International Building Code 2012

Occupancy:

Occupancy Group = U Utility & Miscellaneous

Risk Category & Importance Factors:

Risk Category =	II √
Wind factor =	1.00
Snow factor =	1.00 √
Seismic factor =	1.00

Type of Construction:

Fire Rating:

Roof =	0.0 hr
Floor =	0.0 hr

Building Geometry:

Roof angle (θ)	1.00 / 12	4.8 deg √
Building length (L)	60.0 ft √	
Least width (B)	50.0 ft √	
Mean Roof Ht (h)	22.8 ft √	
Parapet ht above grd	0.0 ft	
Minimum parapet ht	0.0 ft	

Live Loads:

Roof
0 to 200 sf: 20 psf
200 to 600 sf: 24 - 0.02Area, but not less than 12 psf
over 600 sf: 12 psf

Floor:

Typical Floor	50 psf
Partitions	15 psf
Corridors above first floor	80 psf
Lobbies & first floor corridors	100 psf
Balconies (exterior)	50 psf

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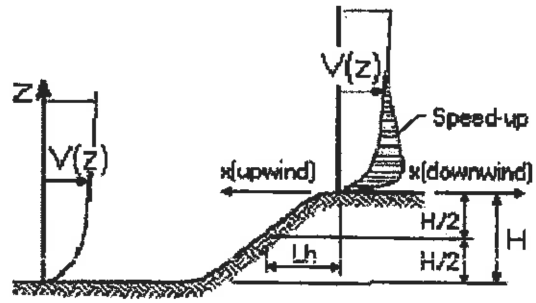
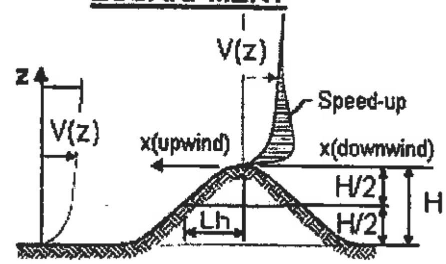
Wind Loads :

Ultimate Wind Speed	110 mph √
Directionality (Kd)	0.85 √
Exposure Category	C √
Enclosure Classif.	Partially Enclosed √
Internal pressure	+/-0.55 √
Kh case 1	0.927 √
Kh case 2	0.927
Type of roof	Gable



ESCARPMENT



2D RIDGE or 3D AXISYMMETRICAL HILL

Topographic Factor (Kzt)

Topography		Flat
Hill Height	(H)	80.0 ft
Half Hill Length (Lh)		100.0 ft
Actual H/Lh	=	0.80
Use H/Lh	=	0.50
Modified Lh	=	160.0 ft
From top of crest: x =		50.0 ft
Bldg up/down wind?		downwind

H/Lh= 0.50	K_1 =	0.000
x/Lh = 0.31	K_2 =	0.792
z/Lh = 0.14	K_3 =	1.000

At Mean Roof Ht:

$Kzt = (1+K_1K_2K_3)^2 =$ 1.00 √

Gust Effect Factor

h =	22.8 ft
B =	50.0 ft
/z (0.6h) =	15.0 ft

Flexible structure if natural frequency < 1 Hz (T > 1 second).
However, if building h/B < 4 then probably rigid structure (rule of thumb).
h/B = 0.46 Rigid structure

G = 0.85 Using rigid structure default √

Rigid Structure

ē =	0.20
ℓ =	500 ft
z_{min} =	15 ft
c =	0.20
g_Q, g_v =	3.4
L_z =	427.1 ft
Q =	0.91
I_z =	0.23
G =	0.88 use G = 0.85

Flexible or Dynamically Sensitive Structure

Natural Frequency (η_1) =	0.0 Hz				
Damping ratio (β) =	0				
/b =	0.65				
/α =	0.15				
Vz =	92.9				
N_1 =	0.00				
R_n =	0.000				
R_h =	28.282	η =	0.000	h =	22.8 ft
R_B =	28.282	η =	0.000		
R_L =	28.282	η =	0.000		
g_R =	0.000				
R =	0.000				
G =	0.000				

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Enclosure Classification

Test for Enclosed Building: A building that does not qualify as open or partially enclosed.

Test for Open Building: All walls are at least 80% open.
Ao ≥ 0.8Ag

Test for Partially Enclosed Building:

	Input			Test
Ao	166.0	sf	Ao ≥ 1.1Aoi	YES
Ag	1275.0	sf	Ao > 4' or 0.01Ag	YES
Aoi	77.5	sf	Aoi / Agi ≤ 0.20	YES
Agi	3400.0	sf		

Building IS Partially Enclosed ✓

Conditions to qualify as Partially Enclosed Building. Must satisfy all of the following:

- Ao ≥ 1.1Aoi
- Ao > smaller of 4' or 0.01 Ag
- Aoi / Agi ≤ 0.20

Where:
Ao = the total area of openings in a wall that receives positive external pressure.
Ag = the gross area of that wall in which Ao is identified.
Aoi = the sum of the areas of openings in the building envelope (walls and roof) not including Ao.
Agi = the sum of the gross surface areas of the building envelope (walls and roof) not including Ag.

Reduction Factor for large volume partially enclosed buildings (Ri) :

If the partially enclosed building contains a single room that is unpartitioned , the internal pressure coefficient may be multiplied by the reduction factor Ri.

Total area of all wall & roof openings (Aog):	0 sf
Unpartitioned internal volume (Vi) :	0 cf
Ri =	1.00

Altitude adjustment to constant 0.00256 (caution - see code) :

Altitude = 0 feet
Constant = 0.00256

Average Air Density = 0.0765 lbm/ft^3

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1ft HIGH BUT OK

Wind Loads - MWFRS all h (Enclosed/partially enclosed only)

Kh (case 2) =	0.93	h =	22.8 ft	GCpi =	+/-0.55
Base pressure (q_h) =	**24.4 psf**	ridge ht =	24.9 ft	G =	0.85
Roof Angle (θ) =	4.8 deg	L =	60.0 ft	z for qi :	22.8 ft
Roof tributary area - (h/2)*L:	684 sf	B =	50.0 ft	qi =	24.4 psf for positive internal pressures
(h/2)*B:	570 sf				

Ultimate Wind Surface Pressures (psf)

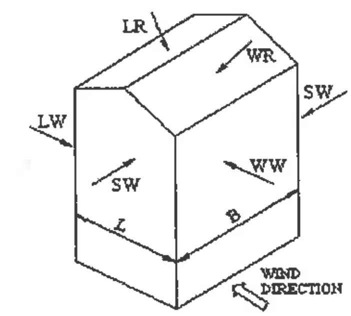
Surface	Wind Normal to Ridge B/L = 0.83 h/L = 0.46				Wind Parallel to Ridge L/B = 1.20 h/L = 0.38				
	Cp	q_hGC_p	w/+q_iGC_{pi}	w/-q_hGC_{pi}	Dist.*	Cp	q_hGC_p	w/ +q_iGC_{pi}	w/ -q_hGC_{pi}
Windward Wall (WW)	0.80	16.6	see table below			0.80	16.6	see table below	
Leeward Wall (LW)	-0.50	-10.4	-23.8	3.1		-0.46	-9.5	-23.0	3.9
Side Wall (SW)	-0.70	-14.5	-27.9	-1.1		-0.70	-14.5	-27.9	-1.1
Leeward Roof (LR)		**				Included in windward roof			
Windward Roof: 0 to h/2*	-0.90	-18.7	-32.1	-5.2	0 to h/2*	-0.90	-18.7	-32.1	-5.2
h/2 to h*	-0.90	-18.7	-32.1	-5.2	h/2 to h*	-0.90	-18.7	-32.1	-5.2
h to 2h*	-0.50	-10.37	-23.80	3.05	h to 2h*	-0.50	-10.4	-23.8	3.1
> 2h*	-0.30	-6.22	-19.65	7.20	> 2h*	-0.30	-6.2	-19.7	7.2

**Roof angle < 10 degrees. Therefore, leeward roof is included in windward roof pressure zones.

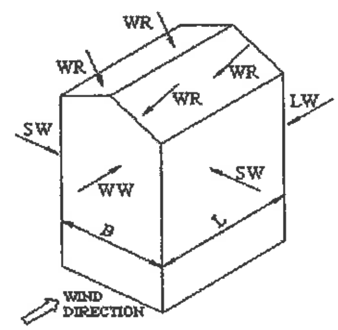
*Horizontal distance from windward edge

Windward Wall Pressures at "z" (psf)

	z	Kz	Kzt	Windward Wall q_zGC_p	w/+q_iGC_{pi}	w/-q_hGC_{pi}	Combined WW + LW Normal to Ridge	Parallel to Ridge
	0 to 15'	0.85	1.00	15.2	1.8	28.6	25.6	24.7
	20.0 ft	0.90	1.00	16.1	2.7	29.6	26.5	25.7
h=	22.8 ft	0.93	1.00	16.6	3.2	30.0	27.0	26.1
ridge =	24.9 ft	0.94	1.00	16.9	3.5	30.3	27.3	26.5



WIND NORMAL TO RIDGE



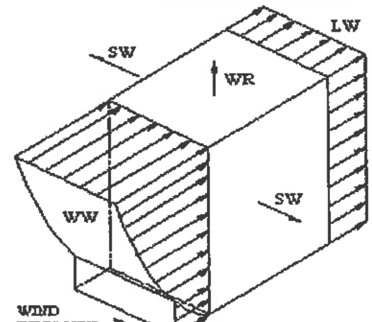
WIND PARALLEL TO RIDGE

NOTE:
See figure in ASCE7 for the application of full and partial loading of the above wind pressures. There are 4 different loading cases.

Parapet

z	Kz	Kzt	qp (psf)
0.0 ft	0.85	1.00	0.0

Windward parapet: 0.0 psf (GCpn = +1.5)
Leeward parapet: 0.0 psf (GCpn = -1.0)



TYPICAL WIND LOADING

Windward roof overhangs (add to windward roof pressure) : 16.6 psf (upward)

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Wind Loads - MWFRS h≤60' (Low-rise Buildings) Enclosed/partially enclosed only

Kz = Kh (case 1) = 0.93
Base pressure (qh) = **24.4 psf** > 20psf MIN PG&E DESIGN CRITERIA
GCpi = +/-0.55

Edge Strip (a) = 5.0 ft
End Zone (2a) = 10.0 ft
Zone 2 length = 25.0 ft

Wind Pressure Coefficients

Surface	CASE A GCpf	CASE A θ = 4.8 deg w/-GCpi	CASE A w/+GCpi	CASE B GCpf	CASE B w/-GCpi	CASE B w/+GCpi
1	0.40	0.95 ✓	-0.15	-0.45	0.10	-1.00
2	-0.69	-0.14 ✓	-1.24 ✓	-0.69	-0.14	-1.24
3	-0.37	0.18 ✓	-0.92 ✓	-0.37	0.18	-0.92
4	-0.29	0.26	-0.84 ✓	-0.45	0.10	-1.00
5	-0.45	0.10	-1.00	0.40	0.95	-0.15
6	-0.45	0.10	-1.00	-0.29	0.26	-0.84
1E	0.61	1.16	0.06	-0.48	0.07	-1.03
2E	-1.07	-0.52	-1.62	-1.07	-0.52	-1.62
3E	-0.53	0.02	-1.08	-0.53	0.02	-1.08
4E	-0.43	0.12	-0.98	-0.48	0.07	-1.03
5E				0.61	1.16	0.06
6E				-0.43	0.12	-0.98

Ultimate Wind Surface Pressures (psf)

Surface	CASE A w/-GCpi	CASE A w/+GCpi	CASE B w/-GCpi	CASE B w/+GCpi
1	23.2	-3.7	2.4	-24.4
2	-3.4	-30.3	-3.4	-30.3
3	4.4	-22.5	4.4	-22.5
4	6.3	-20.5	2.4	-24.4
5	2.4	-24.4	23.2	-3.7
6	2.4	-24.4	6.3	-20.5
1E	28.3	1.5	1.7	-25.1
2E	-12.7	-39.5	-12.7	-39.5
3E	0.5	-26.4	0.5	-26.4
4E	2.9	-23.9	1.7	-25.1
5E			28.3	1.5
6E			2.9	-23.9

19,125^F INTERIOR FRAME TRIB CONTROLS

10,88^F END FRAME TRIB AREA

Parapet
Windward parapet = 0.0 psf (GCpn = +1.5)
Leeward parapet = 0.0 psf (GCpn = -1.0)

Windward roof overhangs = 17.1 psf (upward) add to windward roof pressure

Horizontal MWFRS Simple Diaphragm Pressures (psf)
Transverse direction (normal to L)
Interior Zone: Wall 16.8 psf ✓
Roof -7.8 psf **
End Zone: Wall 25.4 psf
Roof -13.2 psf **

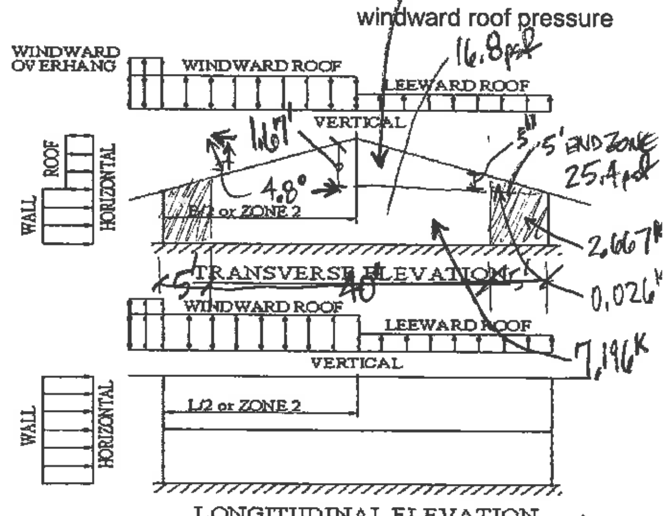
51.2% ↑ THAN INTERIOR

Longitudinal direction (parallel to L)
Interior Zone: Wall 16.8 psf
End Zone: Wall 25.4 psf

** NOTE: Total horiz force shall not be less than that determined by neglecting roof forces (except for MWFRS moment frames).

The code requires the MWFRS be designed for a min ultimate force of 16 psf multiplied by the wall area plus an 8 psf force applied to the vertical projection of the roof.

ASCE 7-10 SECTION 27.4.7



$(0.279^K + 7.196^K + 2.667^K + 0.026^K) \times 2$
$= 1.0W \Rightarrow 20.34^K \times 0.6$
$= 12.20^K$

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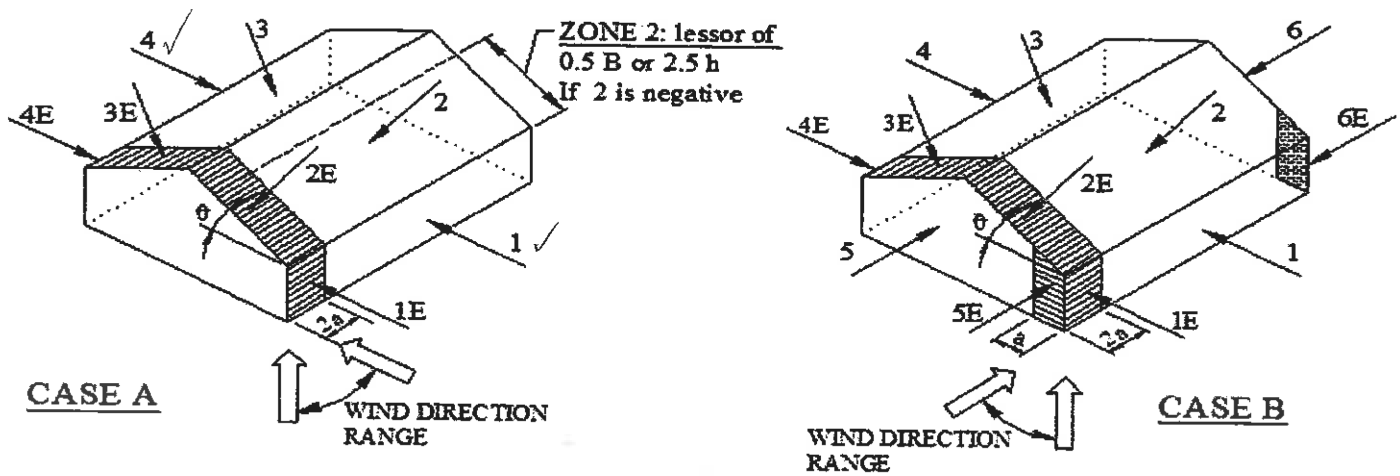
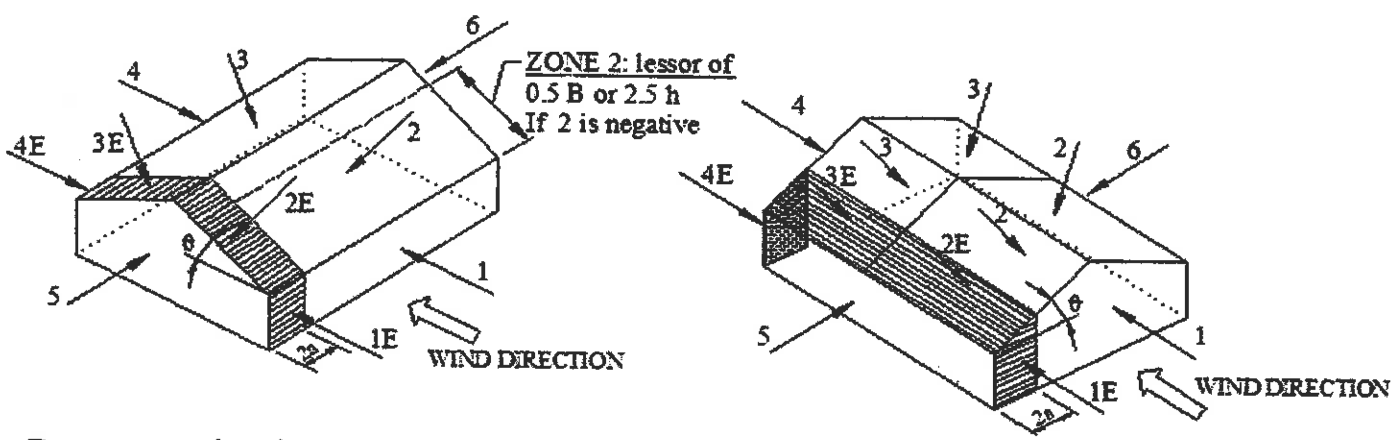
Location of MWFRS Wind Pressure Zones



NOTE: Torsional loads are 25% of zones 1 - 6. See code for loading diagram.

ASCE 7 -99 and ASCE 7-10 (& later)



Transverse Direction

Longitudinal Direction

NOTE: Torsional loads are 25% of zones 1 - 4. See code for loading diagram.

ASCE 7 -02 and ASCE 7-05

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Wind Loads - Components & Cladding : h <= 60'

Ultimate Wind Pressures

Kh (case 1) =	0.93 ✓		h =	22.8 ft ✓
Base pressure (qh) =	**24.4 psf**		a =	5.0 ft ✓
Minimum parapet ht =	0.0 ft		GCpi =	+/-0.55 ✓
Roof Angle (θ) =	4.8 deg			
Type of roof =	Gable			

Roof

	GCp +/- GCpi			Surface Pressure (psf)			**User input**	
Area	10 sf	50 sf	100 sf	10 sf	50 sf	100 sf	25 sf	75 sf
Negative Zone 1	-1.55	-1.48	-1.45	-37.8	-36.1	-35.4	-36.9	-35.7
Negative Zone 2	-2.35	-1.86	-1.65	-57.4	-45.4	-40.3	-50.6	-42.4
Negative Zone 3	-3.35	-2.16	-1.65	-81.8	-52.8	-40.3	-65.3	-45.5
Positive All Zones	0.85	0.78	0.75	20.7	19.0	18.3	19.8	18.6
Overhang Zone 1&2	-1.70	-1.63	-1.60	-41.5	-39.8	-39.1	-40.5	-39.4
Overhang Zone 3	-2.80	-1.40	-0.80	-68.3	-34.2	-19.5	-48.9	-25.6

Overhang pressures in the table above assume an internal pressure coefficient (Gcpi) of 0.0
Overhang soffit pressure equals adjacent wall pressure minus internal pressure of -13.4 / 13.4 psf

Parapet

qp = 0.0 psf

CASE A = pressure towards building (pos)
CASE B = pressure away from bldg (neg)

	Surface Pressure (psf)			**User input**
Solid Parapet Pressure	10 sf	100 sf	500 sf	40 sf
CASE A : Interior zone:	0.0	0.0	0.0	0.0
Corner zone:	0.0	0.0	0.0	0.0
CASE B : Interior zone:	0.0	0.0	0.0	0.0
Corner zone:	0.0	0.0	0.0	0.0

Walls

	GCp +/- GCpi			Surface Pressure (psf)			**User input**	
Area	10 sf	100 sf	500 sf	10 sf	100 sf	500 sf	50 sf	200 sf
Negative Zone 4	-1.54	-1.38	-1.27	-37.6	-33.7	-31.0	-34.9	-32.5
Negative Zone 5	-1.81	-1.49	-1.27	-44.2	-36.4	-31.0	-38.8	-34.1
Positive Zone 4 & 5	1.45	1.29	1.18	35.4	31.5	28.8	32.7	30.3

Note: GCp reduced by 10% due to roof angle <= 10 deg.

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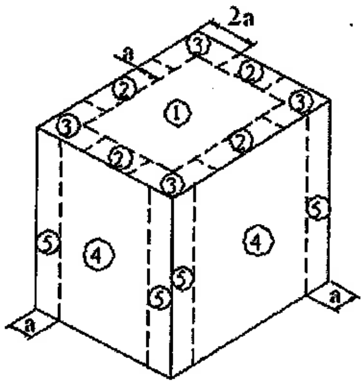
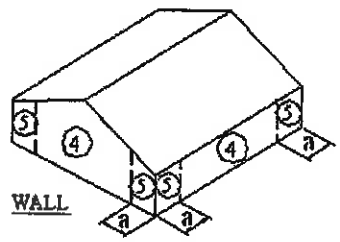
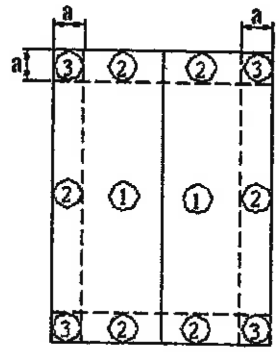
Location of C&C Wind Pressure Zones



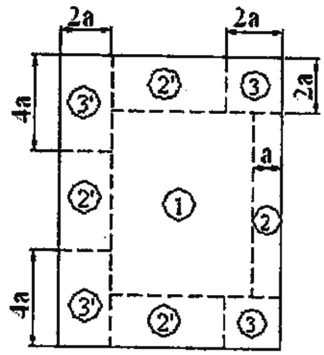
Roofs w/ θ ≤ 10°
and all walls
h > 60'



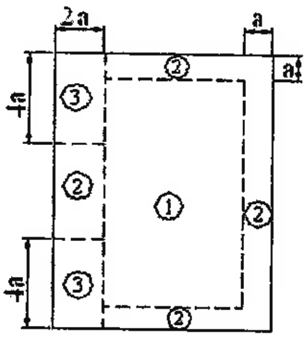
Walls h ≤ 60'
& alt design h<90'



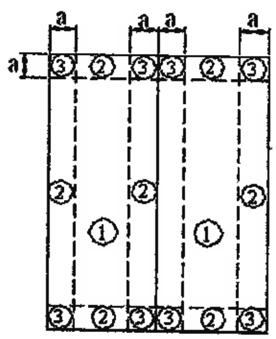
Gable, Sawtooth and
Multispan Gable θ ≤ 7 degrees &
Monoslope ≤ 3 degrees
h ≤ 60' & alt design h<90'



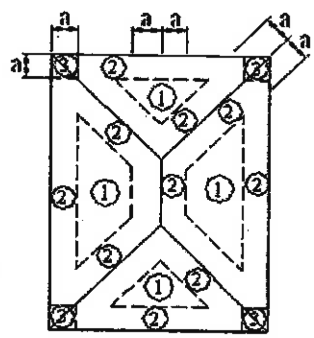
Monoslope roofs
3° < θ ≤ 10°
h ≤ 60' & alt design h<90'



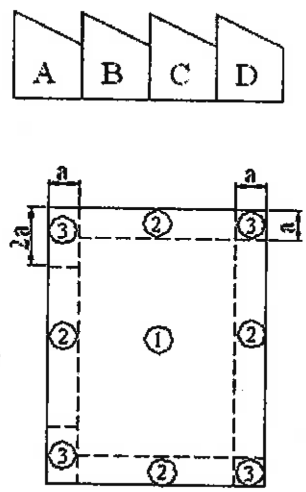
Monoslope roofs
10° < θ ≤ 30°
h ≤ 60' & alt design h<90'



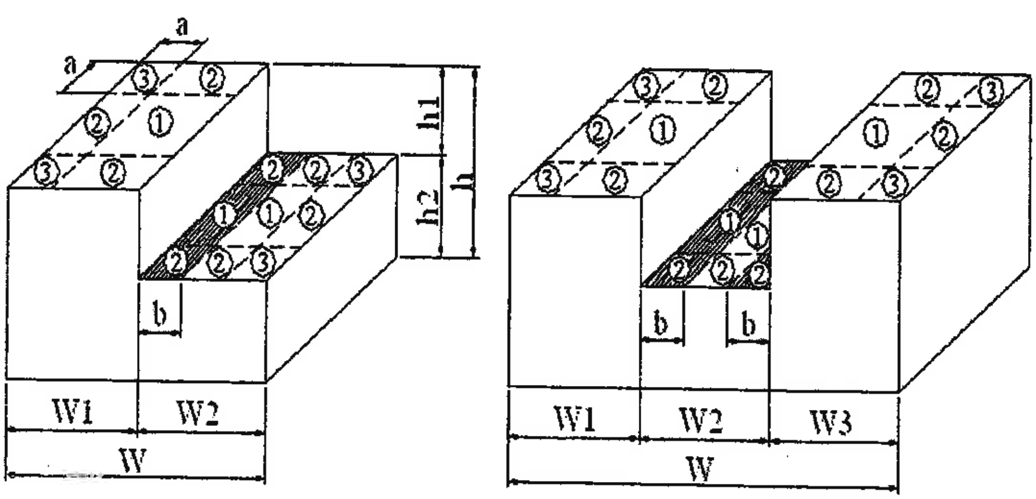
Multispan Gable &
#REF! < θ ≤ 45°



Hip 7° < θ ≤ 27°



Sawtooth 10° < θ ≤ 45°
h ≤ 60' & alt design h<90'



Stepped roofs θ ≤ 3°
h ≤ 60' & alt design h<90'

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Wind Loads - Rooftop Structures & Equipment

Ultimate Wind Pressures

Building (L) = 60.0 ft ✓
Building (B) = 50.0 ft ✓

Directionality (Kd) = 0.85 ✓

Rooftop Structures & Equipment #1

Equipment length parallel to L = 15.0 ft
Equipment length parallel to B = 10.0 ft
Height of equipment = 10.0 ft

Base pressure (qh) = **24.4** psf ✓

Vertical wind pressure		Wind normal to building B		Wind normal to building L	
Ar =	150.0 sf	Ar =	100.0 sf	Ar =	150.0 sf
GCr =	1.500	GCr =	1.90	GCr =	1.89
F = qhGCr Ar =	**36.6** Ar (psf)	F = qhGCr Ar =	**46.4** Ar (psf)	F = qhGCr Ar =	**46.1** Ar (psf)
Fv =	**5.5** kips	Fh =	**4.6** kips	Fh =	**6.9** kips

Rooftop Structures & Equipment #2

Equipment length parallel to L = 15.0 ft
Equipment length parallel to B = 10.0 ft
Height of equipment = 10.0 ft

Base pressure (qh) = **24.4** psf ✓

Vertical wind pressure		Wind normal to building B		Wind normal to building L	
Ar =	150.0 sf	Ar =	100.0 sf	Ar =	150.0 sf
GCr =	1.500	GCr =	1.90	GCr =	1.89
F = qhGCr Ar =	**36.6** Ar (psf)	F = qhGCr Ar =	**46.4** Ar (psf)	F = qhGCr Ar =	**46.1** Ar (psf)
Fv =	**5.5** kips	Fh =	**4.6** kips	Fh =	**6.9** kips

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Wind Loads - Other Structures:

Ultimate Wind Pressures

Importance Factor =	1.00		
Gust Effect Factor (G) =	0.85	Wind Speed =	110 mph
Kzt =	1.00	Exposure =	C

A. Solid Freestanding Walls & Solid Signs (& open signs with less than 30% open)

Dist to sign top (h)	8.0 ft	s/h =	1.00
Height (s)	8.0 ft	B/s =	25.00
Width (B)	200.0 ft	Lr/s =	0.00
Wall Return (Lr) =		Kz =	0.849
Directionality (Kd)	0.85	qz =	22.4 psf
Percent of open area to gross area	0.0%	Open reduction factor =	1.00

Case A & B

C_f =	1.30
F = qz G Cf As =	**24.7 As**
As =	10.0 sf
F =	247 lbs

Case C reduction factors

Factor if s/h>0.8 =	0.80
Wall return factor for Cf at 0 to s =	1.00

CaseC

Horiz dist from windward edge	Cf	F=qzGCfAs (psf)
0 to s	3.29	62.5 **As**
s to 2s	2.07	39.2 **As**
2s to 3s	1.59	30.1 **As**
3s to 4s	1.31	24.8 **As**
4s to 5s	1.23	23.4 **As**
5s to 10s	0.78	16.0 **As**
>10s	0.44	16.0 **As**

B. Open Signs & Lattice Frameworks (openings 30% or more of gross area)

Height to centroid of Af (z)	15.0 ft	Kz =	0.849
		Base pressure (qz) =	22.4 psf
Width (zero if round)	0.0 ft		
Diameter (zero if rect)	2.0 ft	D(qz)^.5 =	9.46
Percent of open area		I =	0.65
to gross area	35.0%	C_f =	1.1
Directionality (Kd)	0.85		

$F = q_z G C_f A_f$ =	**20.9 Af**
Solid Area: A_f =	10.0 sf
F =	209 lbs

C. Chimneys, Tanks, Rooftop Equipment (h>60') & Similar Structures

Height to centroid of Af (z)	15.0 ft	Kz =	0.849
Cross-Section	Square	Base pressure (qz) =	23.7 psf
Directionality (Kd)	0.90	h/D =	15.00
Height (h)	15.0 ft		
Width (D)	1.0 ft		
Type of Surface	N/A		

Square (wind along diagonal)		Square (wind normal to face)	
Cf =	1.28	C_f =	1.67
F = qz G Cf Af =	**25.7 Af**	$F = q_z G C_f A_f$ =	**33.5 Af**
Af =	sf	A_f =	10.0 sf
F =	0 lbs	F =	335 lbs

D. Trussed Towers

Height to centroid of Af (z)	15.0 ft	Kz =	0.849
ϵ =	0.27	Base pressure (qz) =	26.3 psf
Tower Cross Section	square		
Member Shape	flat	Diagonal wind factor =	1.2
Directionality (Kd)	1.00	Round member factor =	1.000

Square (wind along tower diagonal)		Square (wind normal to face)	
Cf =	3.24	C_f =	2.70
F = qz G Cf Af =	**72.4 Af**	$F = q_z G C_f A_f$ =	**60.3 Af**
Solid Area: Af =	10.0 sf	Solid Area: A_f =	10.0 sf
F =	724 lbs	F =	603 lbs

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Snow Loads :

Roof slope	=	4.8 deg ✓
Horiz. eave to ridge dist (W)	=	25.0 ft ✓
Roof length parallel to ridge (L)	=	60.0 ft ✓

Type of Roof			Hip and gable w/ trussed systems
Ground Snow Load	Pg	=	0.0 psf ✓
Risk Category		=	II ✓
Importance Factor	I	=	1.0 ✓
Thermal Factor	Ct	=	1.00
Exposure Factor	Ce	=	1.0
Pf = 0.7*Ce*Ct*I*Pg		=	0.0 psf
Unobstructed Slippery Surface (per Section 7.4)			yes
Sloped-roof Factor	Cs	=	1.00
Balanced Snow Load	**Ps**	**=**	**0.0 psf**
Rain on Snow Surcharge Angle			0.50 deg
Code Maximum Rain Surcharge			5.0 psf
Rain on Snow Surcharge		=	0.0 psf
Ps plus rain surcharge		=	0.0 psf
Minimum Snow Load	Pm	=	0.0 psf
Uniform Roof Design Snow Load		=	**0.0 psf** ✓

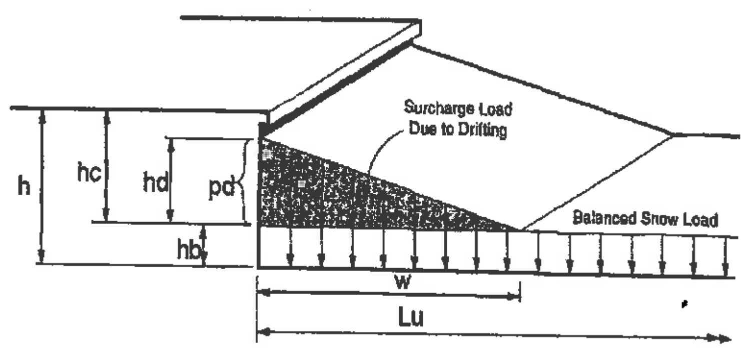
NOTE: Alternate spans of continuous beams and other areas shall be loaded with half the design roof snow load so as to produce the greatest possible effect - see code.

Unbalanced Snow Loads - for Hip & Gable roofs only

Required if slope is between 7 on 12 =	30.26 deg		
and 2.38 deg =	2.38 deg	**Unbalanced snow loads must be applied**	
Windward snow load =	0.0 psf	= 0.3Ps	
Leeward snow load from ridge to 6.8' =	3.0 psf	= hdγ / √S + Ps	
Leeward snow load from 6.8' to the eave =	0.0 psf	= Ps	

Windward Snow Drifts 1 - Against walls, parapets, etc more than 15' long

Upwind fetch	lu	=	220.0 ft
Projection height	h	=	5.2 ft
Snow density	g	=	14.0 pcf
Balanced snow height	hb	=	0.00 ft
	hc	=	5.20 ft
#DIV/0! #DIV/0!	**#DIV/0!**		
Drift height	hd	=	#DIV/0!
Drift width	w	=	#DIV/0!
Surcharge load:	pd = γ*hd	=	**#DIV/0!**
Balanced Snow load:		=	0.0 psf
			#DIV/0!



Windward Snow Drifts 2 - Against walls, parapets, etc > 15'

Upwind fetch	lu	=	220.0 ft
Projection height	h	=	5.2 ft
Snow density	g	=	14.0 pcf
Balanced snow height	hb	=	0.00 ft
	hc	=	5.20 ft
#DIV/0! #DIV/0!	**#DIV/0!**		
Drift height	hd	=	#DIV/0!
Drift width	w	=	#DIV/0!
Surcharge load:	pd = γ*hd	=	**#DIV/0!**
Balanced Snow load:		=	0.0 psf
			#DIV/0!

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Seismic Loads:

Risk Category : II ✓
Importance Factor (I) : 1.00 ✓
Site Class : D ✓

Ss (0.2 sec) = 23.00 %g ✓
S1 (1.0 sec) = 12.00 %g ✓

Fa =	1.600	Sms =	0.368	S_{DS} =	0.245 ✓	Design Category =	B
Fv =	2.320	Sm1 =	0.278	S_{D1} =	0.186 ✓	Design Category =	C ✓

Seismic Design Category = C ✓
Number of Stories: 1
Structure Type: Moment-resisting frame systems of steel ✓
Horizontal Struct Irregularities: No plan Irregularity
Vertical Structural Irregularities: No vertical Irregularity
Flexible Diaphragms: No
Building System: **Moment-resisting Frame Systems** ✓
Seismic resisting system: **Steel ordinary moment frames** ✓
System Structural Height Limit: **Height not limited**
Actual Structural Height (hn) = 22.8 ft ✓

(41 #/ft DL stairs × 19.083 ft grating/handrail × 4 stringers = 3.13K
1000# misc steel on stairs = 1K
10 psf interior walls × 10 ft tall × 50 ft long × 5 = 25K
(4 + 1 ~ for all E/W & misc N/S walls)
10 psf interior room ceiling × [(0.75 ft wide × 50 ft) + [7' × 21.5']] = 6,88K
TOTAL = 36,011

DESIGN COEFFICIENTS AND FACTORS

Response Modification Coefficient (R) = 3.5 ✓
Over-Strength Factor (Ωo) = 3
Deflection Amplification Factor (Cd) = 3
S_{DS} = 0.245
S_{D1} = 0.186

Seismic Load Effect (E) = $\rho Q_E \pm 0.2S_{DS} D$ = $\rho Q_E \pm$ 0.049D
Special Seismic Load Effect (Em) = $\Omega o Q_E \pm 0.2S_{DS} D$ = $3.0 Q_E \pm$ 0.049D

ρ = redundancy coefficient
Q_E = horizontal seismic force
D = dead load

PERMITTED ANALYTICAL PROCEDURES

TOTAL DL = 143.38K × (C_s = 0.07) = 10,000# BASE SHEAR

Simplified Analysis - Use Equivalent Lateral Force Analysis

Equivalent Lateral-Force Analysis - Permitted
Building period coef. (C_T) = 0.028
Approx fundamental period (Ta) = $C_T h_n$^ = 0.342 sec x= 0.80
User calculated fundamental period (T) = 0 sec
Long Period Transition Period (TL) = ASCE7 map = 12
Seismic response coef. (Cs) = $S_{DS}I/R$ = 0.070
need not exceed Cs = Sd1 I/RT = 0.155
but not less than Cs = 0.044SdsI = 0.011
USE Cs = 0.070
Design Base Shear V = 0.070W

Cu = 1.53
Tmax = CuTa = 0.522
Use T = 0.342

Model & Seismic Response Analysis - Permitted (see code for procedure)

ALLOWABLE STORY DRIFT

Structure Type: All other structures
Allowable story drift = 0.020hsx where hsx is the story height below level x

- 16.5 psf roof DL × 50' × 60' = 49,500#
- 6 psf × 21' eave × [(60' × 2) + (50' × 2)] = 27,720#
- 50#/ft columns × 21' × 8 columns = 8,400#
- 75#/ft × [(4 × 50' long) + (2' × 25' long)] 18,750#
- 3000# monorail connections & bridge DL

TOTAL DL = 107,370#

Seismic Loads - cont. :

Seismic Design Category (SDC)= C
I = 1.00
Sds = 0.245

CONNECTIONS

Force to connect smaller portions of structure to remainder of structure

$Fp = 0.133Sdsw_p =$ 0.033 w_p
or $Fp = 0.05w_p =$ 0.05 w_p Use Fp = 0.05 w_p w_p = weight of smaller portion

Beam, girder or truss connection for resisting horizontal force parallel to member

F_P = no less than 0.05 times dead plus live load vertical reaction

Anchorage of Structural Walls to elements providing lateral support

Fp = 0.20Ww = 0.20 Ww or
See ASCE7 Sect 12.11.2.1 for flexible diaphrams
Fp =0.4SdsIWw = 0.098 Ww (for rigid diaphragm) Fp = 0.2 Ww
but Fp shall not be less than 5 psf

MEMBER DESIGN

Bearing Walls and Shear Walls (out of plane force)

Fp = 0.4SdsIWw = 0.098 w_w
but not less than 0.10 w_w Use Fp = 0.10 w_w

Diaphragms

Fp = 0.2ISdsWp + Vpx = 0.049 Wp + Vpx

ARCHITECTURAL COMPONENTS SEISMIC COEFFICIENTS

Architectural Component : Interior Nonstructural Walls and Partitions:
Plain (unreinforced) masonry walls

Importance Factor (Ip) : 1.0

Component Amplification Factor (a_p) = 1 h= 22.8 feet
Comp Response Modification Factor (R_p) = 1.5 z= 50.0 feet z/h = 1.00

$Fp = 0.4a_pSdsIpWp(1+2z/h)/Rp =$ 0.196 Wp
not greater than Fp = 1.6SdsIpWp = 0.393 Wp
but not less than Fp = 0.3SdsIpWp = 0.074 Wp use Fp = 0.196 Wp

MECH AND ELEC COMPONENTS SEISMIC COEFFICIENTS

Mech or Electrical Component : Elevator and escalator components.

Importance Factor (Ip) : 1.5

Component Amplification Factor (a_p) = 1 h= 22.8 feet
Comp Response Modification Factor (R_p) = 2.5 z= 50.0 feet z/h = 1.00

$Fp = 0.4a_pSdsIpWp(1+2z/h)/Rp =$ 0.177 Wp
not greater than Fp = 1.6SdsIpWp = 0.589 Wp
but not less than Fp = 0.3SdsIpWp = 0.110 Wp use Fp = 0.177 Wp

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Wind Loads :

Ultimate Wind Speed	110 mph ✓
Directionality (Kd)	0.85 ✓
Exposure Category	C ✓
Enclosure Classif.	Enclosed Building ✓
Internal pressure	+/-0.18 ✓
Kh case 1	0.927 ✓
Kh case 2	0.927
Type of roof	Gable

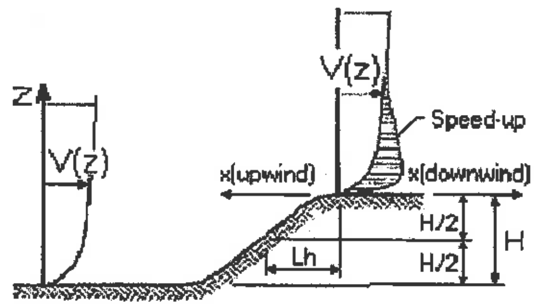
Topographic Factor (Kzt)

Topography		Flat
Hill Height (H)		80.0 ft
Half Hill Length (Lh)		100.0 ft
Actual H/Lh	=	0.80
Use H/Lh	=	0.50
Modified Lh	=	160.0 ft
From top of crest: x =		50.0 ft
Bldg up/down wind?		downwind

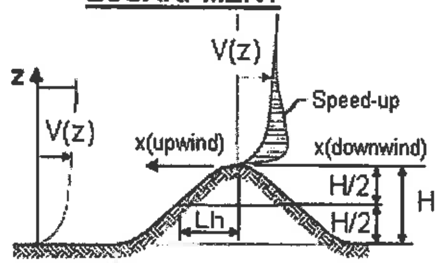
H/Lh= 0.50	K_1 =	0.000
x/Lh = 0.31	K_2 =	0.792
z/Lh = 0.14	K_3 =	1.000

At Mean Roof Ht:

$Kzt = (1+K_1K_2K_3)^2 =$ 1.00 ✓



ESCARPMENT



2D RIDGE or 3D AXISYMMETRICAL HILL

Gust Effect Factor

h =	22.8 ft
B =	50.0 ft
/z (0.6h) =	15.0 ft

Flexible structure if natural frequency < 1 Hz (T > 1 second).
However, if building h/B < 4 then probably rigid structure (rule of thumb).
h/B = 0.46 Rigid structure

G = 0.85 Using rigid structure default ✓

Rigid Structure

ē =	0.20
ℓ =	500 ft
z_{min} =	15 ft
c =	0.20
g_Q, g_v =	3.4
L_z =	427.1 ft
Q =	0.91
I_z =	0.23
G =	0.88 use G = 0.85

Flexible or Dynamically Sensitive Structure

Natural Frequency (η_1) =	0.0 Hz				
Damping ratio (β) =	0				
/b =	0.65				
/α =	0.15				
Vz =	92.9				
N_1 =	0.00				
R_n =	0.000				
R_h =	28.282	η =	0.000	h =	22.8 ft
R_B =	28.282	η =	0.000		
R_L =	28.282	η =	0.000		
g_R =	0.000				
R =	0.000				
G =	0.000				

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Enclosure Classification

Test for Enclosed Building: A building that does not qualify as open or partially enclosed.

Test for Open Building: All walls are at least 80% open.
$A_o \geq 0.8A_g$

Test for Partially Enclosed Building:

	Input			Test
Ao	11.1	sf	Ao ≥ 1.1Aoi	NO
Ag	1275.0	sf	Ao > 4' or 0.01Ag	YES
Aoi	11.1	sf	Aoi / Agi ≤ 0.20	YES
Agi	3400.0	sf		

Building is NOT Partially Enclosed ✓

Conditions to qualify as Partially Enclosed Building. Must satisfy all of the following:
- Ao ≥ 1.1Aoi
- Ao > smaller of 4' or 0.01 Ag
- Aoi / Agi ≤ 0.20

Where:
Ao = the total area of openings in a wall that receives positive external pressure.
Ag = the gross area of that wall in which Ao is identified.
Aoi = the sum of the areas of openings in the building envelope (walls and roof) not including Ao.
Agi = the sum of the gross surface areas of the building envelope (walls and roof) not including Ag.

Reduction Factor for large volume partially enclosed buildings (Ri) :

If the partially enclosed building contains a single room that is unpartitioned , the internal pressure coefficient may be multiplied by the reduction factor Ri.

Total area of all wall & roof openings (Aog):		0 sf
Unpartitioned internal volume (Vi) :		0 cf
	Ri =	1.00

Altitude adjustment to constant 0.00256 (caution - see code) :

Altitude = 0 feet   Average Air Density = 0.0765 lbm/ft^3
Constant = 0.00256

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Wind Loads - MWFRS all h (Enclosed/partially enclosed only)

Kh (case 2) =	0.93	h =	22.8 ft	GCpi =	+/-0.18
Base pressure (q_h) =	**24.4 psf**	ridge ht =	24.9 ft	G =	0.85
Roof Angle (θ) =	4.8 deg	L =	60.0 ft	qi = qh	
Roof tributary area - (h/2)*L:	684 sf	B =	50.0 ft		
(h/2)*B:	570 sf				

Ultimate Wind Surface Pressures (psf)

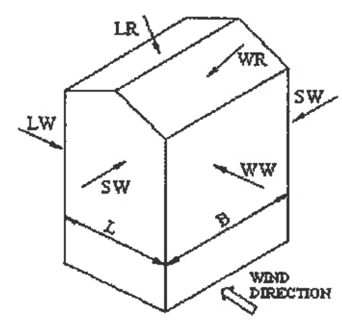
Surface	Wind Normal to Ridge				Wind Parallel to Ridge				
	B/L = 0.83		h/L = 0.46			L/B = 1.20		h/L = 0.38	
	Cp	q_hGC_p	w/+q_iGC_{pi}	w/-q_hGC_{pi}	Dist.*	Cp	q_hGC_p	w/ +q_iGC_{pi}	w/ -q_hGC_{pi}
Windward Wall (WW)	0.80	16.6	see table below			0.80	16.6	see table below	
Leeward Wall (LW)	-0.50	-10.4	-14.8	-6.0		-0.46	-9.5	-13.9	-5.2
Side Wall (SW)	-0.70	-14.5	-18.9	-10.1		-0.70	-14.5	-18.9	-10.1
Leeward Roof (LR)		**				Included in windward roof			
Windward Roof: 0 to h/2*	-0.90	-18.7	-23.1	-14.3	0 to h/2*	-0.90	-18.7	-23.1	-14.3
h/2 to h*	-0.90	-18.7	-23.1	-14.3	h/2 to h*	-0.90	-18.7	-23.1	-14.3
h to 2h*	-0.50	-10.37	-14.77	-5.98	h to 2h*	-0.50	-10.4	-14.8	-6.0
> 2h*	-0.30	-6.22	-10.62	-1.83	> 2h*	-0.30	-6.2	-10.6	-1.8

**Roof angle < 10 degrees. Therefore, leeward roof is included in windward roof pressure zones.

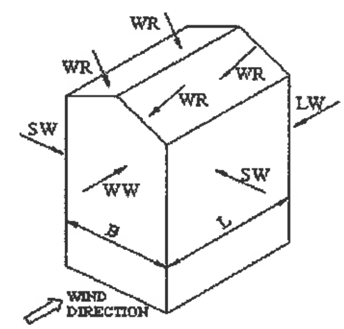
*Horizontal distance from windward edge

Windward Wall Pressures at "z" (psf)

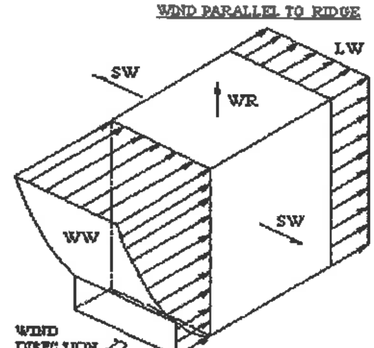
	z	Kz	Kzt	q_zGC_p	w/+q_iGC_{pi}	w/-q_hGC_{pi}	Combined WW + LW Normal to Ridge	Combined WW + LW Parallel to Ridge
	0 to 15'	0.85	1.00	15.2	10.8	19.6	25.6	24.7
	20.0 ft	0.90	1.00	16.1	11.8	20.5	26.5	25.7
h=	22.8 ft	0.93	1.00	16.6	12.2	21.0	27.0	26.1
ridge =	24.9 ft	0.94	1.00	16.9	12.5	21.3	27.3	26.5



WIND NORMAL TO RIDGE



WIND PARALLEL TO RIDGE



TYPICAL WIND LOADING

NOTE:
See figure in ASCE7 for the application of full and partial loading of the above wind pressures. There are 4 different loading cases.

Parapet

z	Kz	Kzt	qp (psf)
0.0 ft	0.85	1.00	0.0

Windward parapet: 0.0 psf (GCpn = +1.5)
Leeward parapet: 0.0 psf (GCpn = -1.0)

Windward roof overhangs (add to windward roof pressure) : 16.6 psf (upward)

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Wind Loads - MWFRS h≤60' (Low-rise Buildings) Enclosed/partially enclosed only

Kz = Kh (case 1) = 0.93 ✓
Base pressure (qh) = 24.4 psf ✓ → 20psf
GCpi = +/-0.18 ✓

Edge Strip (a) = 5.0 ft ✓
End Zone (2a) = 10.0 ft ✓
Zone 2 length = 25.0 ft ✓

Wind Pressure Coefficients

	CASE A	θ = 4.8 deg		CASE B		
Surface	GCpf	w/-GCpi	w/+GCpi	GCpf	w/-GCpi	w/+GCpi
1	0.40	0.58	0.22	-0.45	-0.27	-0.63
2	-0.69	-0.51	-0.87	-0.69	-0.51	-0.87
3	-0.37	-0.19	-0.55	-0.37	-0.19	-0.55
4	-0.29	-0.11	-0.47	-0.45	-0.27	-0.63
5	-0.45	-0.27	-0.63	0.40	0.58	0.22
6	-0.45	-0.27	-0.63	-0.29	-0.11	-0.47
1E	0.61	0.79	0.43	-0.48	-0.30	-0.66
2E	-1.07	-0.89	-1.25	-1.07	-0.89	-1.25
3E	-0.53	-0.35	-0.71	-0.53	-0.35	-0.71
4E	-0.43	-0.25	-0.61	-0.48	-0.30	-0.66
5E				0.61	0.79	0.43
6E				-0.43	-0.25	-0.61

Ultimate Wind Surface Pressures (psf)

Surface	Case A w/-GCpi	Case A w/+GCpi	Case B w/-GCpi	Case B w/+GCpi
1	14.2	5.4	-6.6	-15.4
2	-12.4	-21.2	-12.4	-21.2
3	-4.6	-13.4	-4.6	-13.4
4	-2.7	-11.5	-6.6	-15.4
5	-6.6	-15.4	14.2	5.4
6	-6.6	-15.4	-2.7	-11.5
1E	19.3	10.5	-7.3	-16.1
2E	-21.7	-30.5	-21.7	-30.5
3E	-8.5	-17.3	-8.5	-17.3
4E	-6.1	-14.9	-7.3	-16.1
5E			19.3	10.5
6E			-6.1	-14.9

Parapet

Windward parapet = 0.0 psf (GCpn = +1.5)
Leeward parapet = 0.0 psf (GCpn = -1.0)

Windward roof overhangs = 17.1 psf (upward) add to windward roof pressure

Horizontal MWFRS Simple Diaphragm Pressures (psf)

Transverse direction (normal to L)

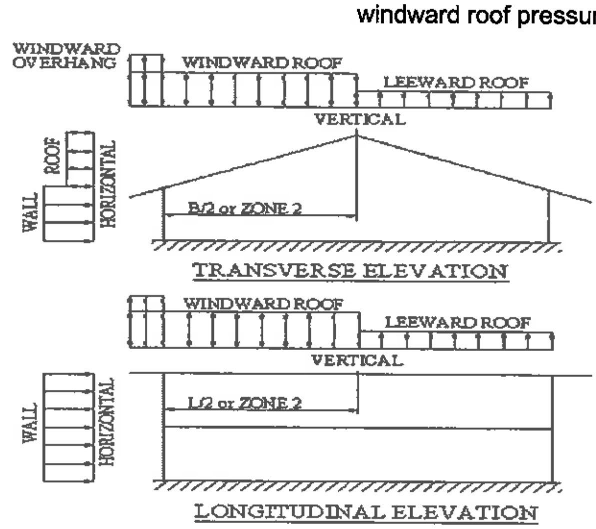
Interior Zone: Wall 16.8 psf ✓
Roof -7.8 psf ** ✓
End Zone: Wall 25.4 psf ✓
Roof -13.2 psf ** ✓

Longitudinal direction (parallel to L)

Interior Zone: Wall 16.8 psf ✓
End Zone: Wall 25.4 psf ✓

** NOTE: Total horiz force shall not be less than that determined by neglecting roof forces (except for MWFRS moment frames).

The code requires the MWFRS be designed for a min ultimate force of 16 psf multiplied by the wall area plus an 8 psf force applied to the vertical projection of the roof.



SAME AS PARTIALLY ENCLOSED BLDG

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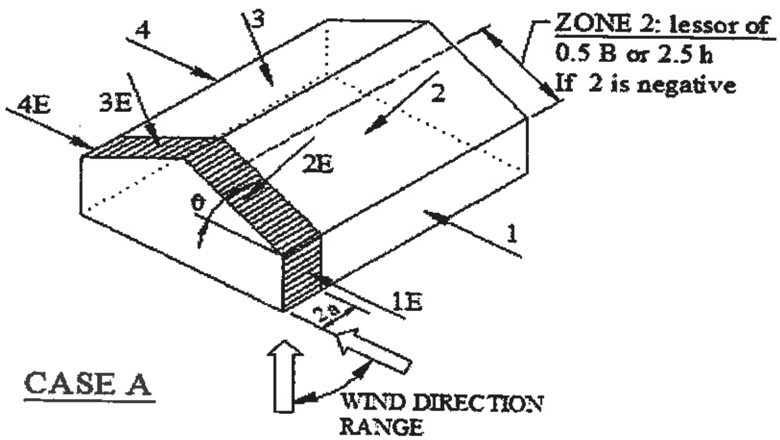
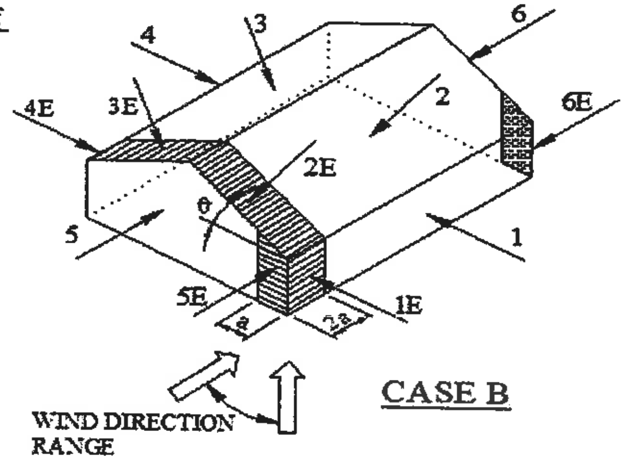
Location of MWFRS Wind Pressure Zones



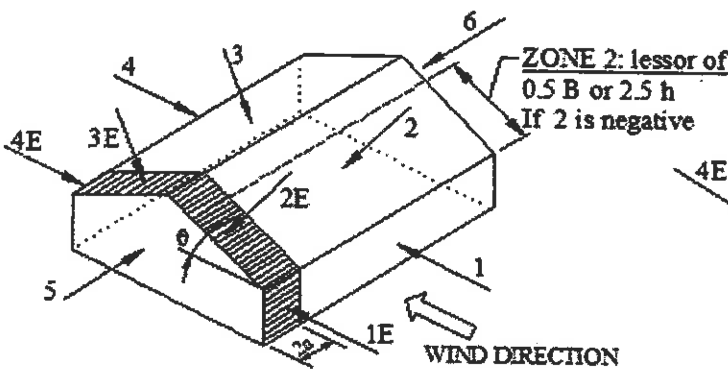
CASE A



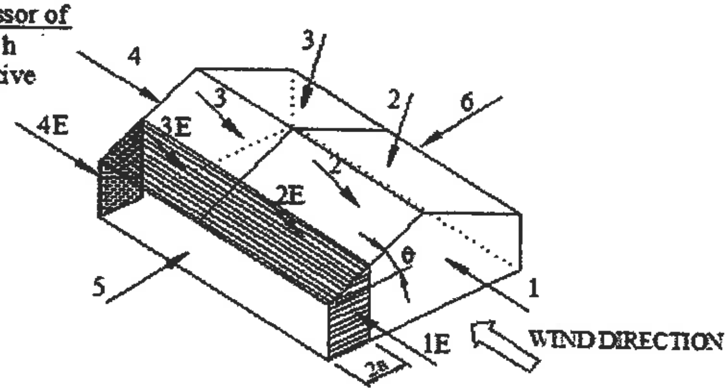
CASE B

NOTE: Torsional loads are 25% of zones 1 - 6. See code for loading diagram.

ASCE 7 -99 and ASCE 7-10 (& later)



Transverse Direction



Longitudinal Direction

NOTE: Torsional loads are 25% of zones 1 - 4. See code for loading diagram.

ASCE 7 -02 and ASCE 7-05

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DATE

Wind Loads - Components & Cladding : h <= 60'

Ultimate Wind Pressures

Kh (case 1) = 0.93 ✓
Base pressure (qh) = **24.4 psf** ✓
Minimum parapet ht = 0.0 ft
Roof Angle (θ) = 4.8 deg ✓
Type of roof = Gable ✓

h = 22.8 ft ✓
a = 5.0 ft ✓
GCpi = +/-0.18 ✓

ROOF WIND LOADS ARE 30% ↓ TO 35% ↓
C&C LOADS ARE SIGNIFICANTLY LESS THAN PARTIALLY

Roof

Area	GCp +/- GCpi			Surface Pressure (psf)			**User input**	
	10 sf	50 sf	100 sf	10 sf	50 sf	100 sf	25 sf	75 sf
Negative Zone 1	-1.18	-1.11	-1.08	-28.8	-27.1	-26.4	-27.8	-26.7
Negative Zone 2	-1.98	-1.49	-1.28	-48.3	-36.4	-31.2	-41.5	-33.4
Negative Zone 3	-2.98	-1.79	-1.28	-72.7	-43.7	-31.2	-56.2	-36.4
Positive All Zones	0.48	0.41	0.38	16.0	16.0	16.0	16.0	16.0
Overhang Zone 1&2	-1.70	-1.63	-1.60	-41.5	-39.8	-39.1	-40.5	-39.4
Overhang Zone 3	-2.80	-1.40	-0.80	-68.3	-34.2	-19.5	-48.9	-25.6

Overhang pressures in the table above assume an internal pressure coefficient (Gcpi) of 0.0
Overhang soffit pressure equals adjacent wall pressure minus internal pressure of -4.4 / 4.4 psf

Parapet

qp = 0.0 psf

CASE A = pressure towards building (pos)
CASE B = pressure away from bldg (neg)

Solid Parapet Pressure	Surface Pressure (psf)			**User input**
	10 sf	100 sf	500 sf	40 sf
CASE A : Interior zone:	0.0	0.0	0.0	0.0
Corner zone:	0.0	0.0	0.0	0.0
CASE B : Interior zone:	0.0	0.0	0.0	0.0
Corner zone:	0.0	0.0	0.0	0.0

Walls

Area	GCp +/- GCpi			Surface Pressure (psf)			**User input**	
	10 sf	100 sf	500 sf	10 sf	100 sf	500 sf	50 sf	200 sf
Negative Zone 4	-1.17	-1.01	-0.90	-28.6	-24.7	-22.0	-25.8	-23.5
Negative Zone 5	-1.44	-1.12	-0.90	-35.2	-27.4	-22.0	-29.7	-25.1
Positive Zone 4 & 5	1.08	0.92	0.81	26.4	22.5	19.8	23.7	21.3

Note: GCp reduced by 10% due to roof angle <= 10 deg.

36% TO 45% ↓

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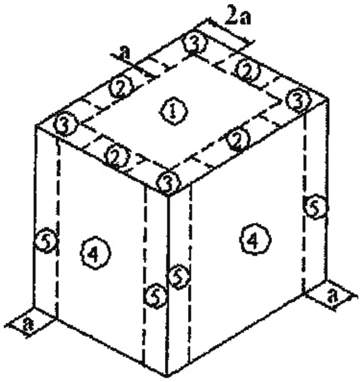
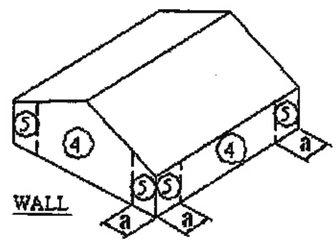
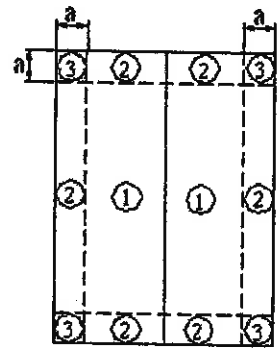
Location of C&C Wind Pressure Zones



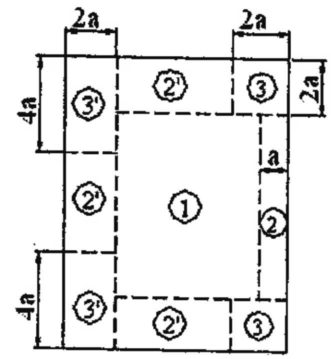
Roofs w/ θ ≤ 10°
and all walls
h > 60'



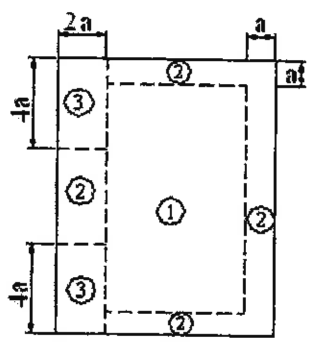
Walls h ≤ 60'
& alt design h<90'



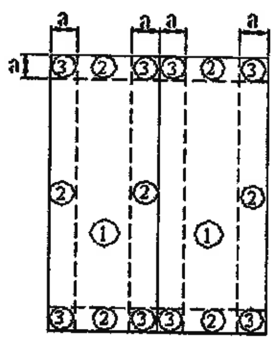
Gable, Sawtooth and
Multispan Gable θ ≤ 7 degrees &
Monoslope ≤ 3 degrees
h ≤ 60' & alt design h<90'



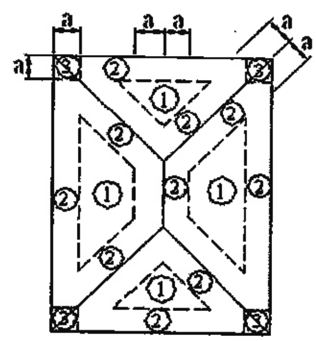
Monoslope roofs
3° < θ ≤ 10°
h ≤ 60' & alt design h<90'



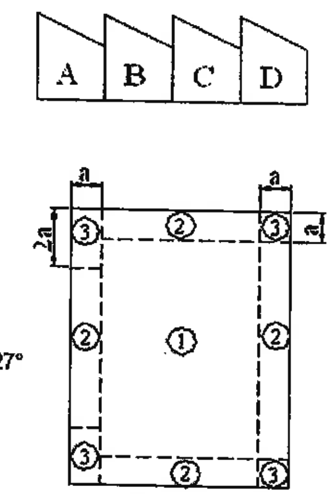
Monoslope roofs
10° < θ ≤ 30°
h ≤ 60' & alt design h<90'



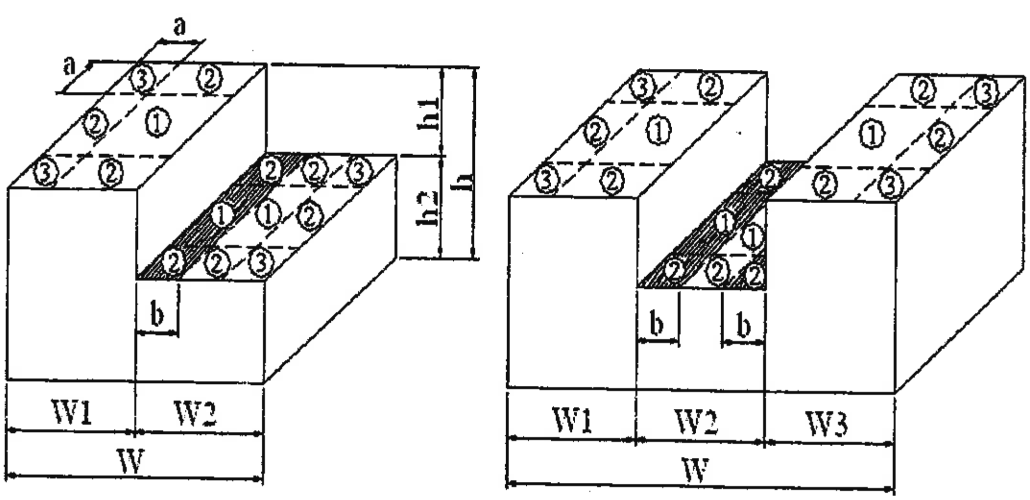
Multispan Gable &
#REF! < θ ≤ 45°



Hip 7° < θ ≤ 27°



Sawtooth 10° < θ ≤ 45°
h ≤ 60' & alt design h<90'



Stepped roofs θ ≤ 3°
h ≤ 60' & alt design h<90'

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	Worksop Building		
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Wind Loads - Other Structures:

Ultimate Wind Pressures

Importance Factor =	1.00		
Gust Effect Factor (G) =	0.85	Wind Speed =	110 mph
Kzt =	1.00	Exposure =	C

A. Solid Freestanding Walls & Solid Signs (& open signs with less than 30% open)

		s/h =	1.00
Dist to sign top (h)	8.0 ft	B/s =	25.00
Height (s)	8.0 ft	Lr/s =	0.00
Width (B)	200.0 ft	Kz =	0.849
Wall Return (Lr) =		qz =	22.4 psf
Directionality (Kd)	0.85		
Percent of open area to gross area	0.0%	Open reduction factor =	1.00

Case C reduction factors

Factor if s/h>0.8 =	0.80
Wall return factor for Cf at 0 to s =	1.00

Case A & B

C_f =	1.30
F = qz G Cf As =	**24.7 As** ✓
As =	10.0 sf
F =	247 lbs

CaseC

Horiz dist from windward edge	Cf	F=qzGCfAs (psf)
0 to s	3.29	62.5 **As**
s to 2s	2.07	39.2 **As**
2s to 3s	1.59	30.1 **As**
3s to 4s	1.31	24.8 **As**
4s to 5s	1.23	23.4 **As**
5s to 10s	0.78	16.0 **As**
>10s	0.44	16.0 **As**

B. Open Signs & Lattice Frameworks (openings 30% or more of gross area)

Height to centroid of Af (z)	15.0 ft		
Width (zero if round)	0.0 ft		
Diameter (zero if rect)	2.0 ft	D(qz)^.5 =	9.46
Percent of open area		I =	0.65
to gross area	35.0%	C_f =	1.1
Directionality (Kd)	0.85		

Kz =	0.849
Base pressure (qz) =	22.4 psf
$F = q_z G C_f A_f$ =	**20.9 Af** ✓
Solid Area: A_f =	10.0 sf
F =	209 lbs

C. Chimneys, Tanks, Rooftop Equipment (h>60') & Similar Structures

Height to centroid of Af (z)	15.0 ft
Cross-Section	Square
Directionality (Kd)	0.90
Height (h)	15.0 ft
Width (D)	1.0 ft
Type of Surface	N/A

Kz =	0.849
Base pressure (qz) =	23.7 psf
h/D =	15.00

Square (wind along diagonal)

Cf =	1.28
F = qz G Cf Af =	**25.7 Af**
Af =	sf
F =	0 lbs

Square (wind normal to face)

C_f =	1.67
$F = q_z G C_f A_f$ =	**33.5 Af** ✓
A_f =	10.0 sf
F =	335 lbs

D. Trussed Towers

Height to centroid of Af (z)	15.0 ft
ϵ =	0.27
Tower Cross Section	square
Member Shape	flat
Directionality (Kd)	1.00

Kz =	0.849
Base pressure (qz) =	26.3 psf
Diagonal wind factor =	1.2
Round member factor =	1.000

Square (wind along tower diagonal)

Cf =	3.24
F = qz G Cf Af =	**72.4 Af**
Solid Area: Af =	10.0 sf
F =	724 lbs

Square (wind normal to face)

C_f =	2.70
$F = q_z G C_f A_f$ =	**60.3 Af** ✓
Solid Area: A_f =	10.0 sf
F =	603 lbs

ARCADIS

SUBJECT: TOPOK – WORKSHOP BLDG

JOB NO:

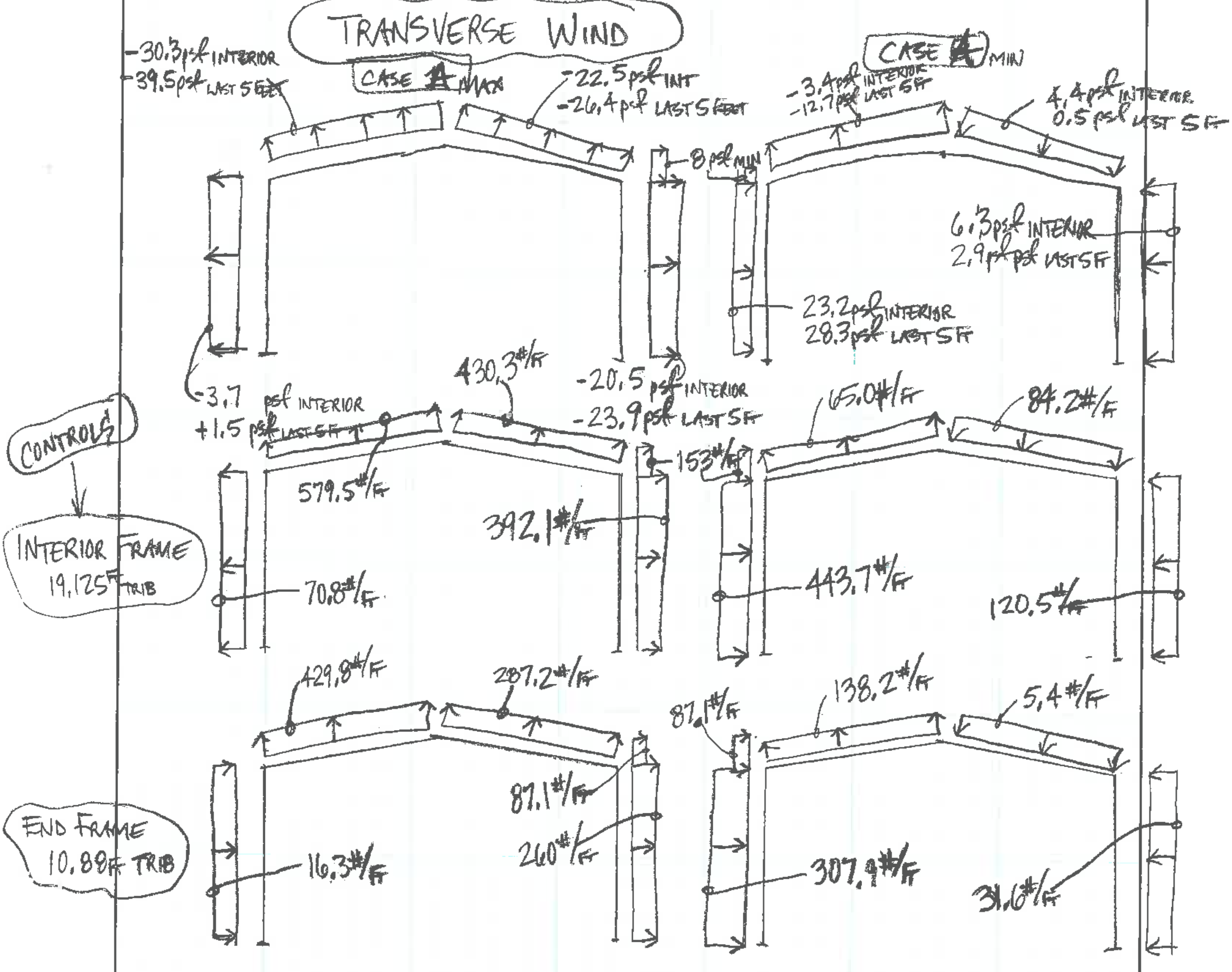
BY: MSL DATE: 1/5/15

CHKD: DATE:

PAGE I-5

SHEET 1

- ROOF LIVE LOAD = 20 psf
- FRAME LAYOUT:
  - ~ INTERIOR FRAME = $\left(\frac{20'6'' - 1'3''}{2}\right) + \frac{19'}{2} = 19.125$ FT TRIB AREA
  - ~ END FRAME = $1'3'' + \left(\frac{20'6'' - 1'3''}{2}\right) = 10.88$ FT TRIB AREA



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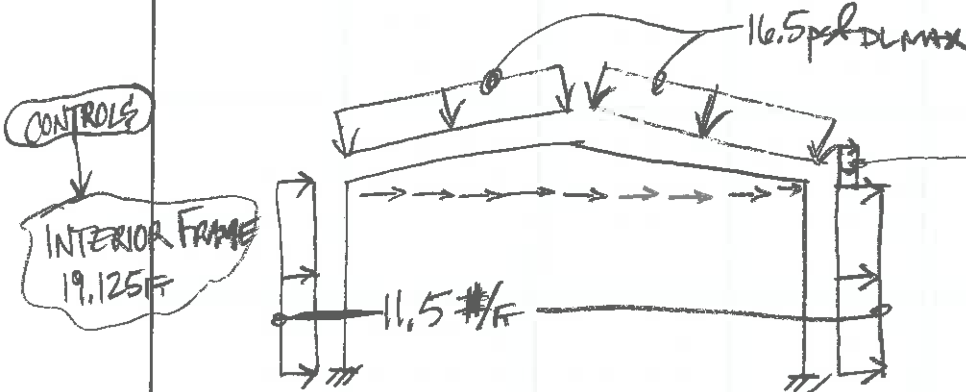
SUBJECT: TOPOK – WORKSHOP BLDG
JOB NO:

BY: MSL DATE: 1/5/15
CHKD: MSL DATE: 1/6/15

PAGE I-6
SHEET 1

SEISMIC LOADS ~ $C_s = 0.07W$ (SHT I-4) ← (N/A, WIND CONTROLS PER SHT I-7)

- ROOF MAX = 16.5 psf × C_s = 1.16 psf ; BEAM DL = 70#/FT × C_s = 4.9#/FT
- WALL MAX = 6 psf × " = 0.42 psf ; COLUMN DL = 50#/FT × C_s = 3.5#/FT



[(4.9#/FT × 50FT) + (1.16psf × 50FT × 19.125FT)] / 2'-1"

= 650#/FT → OVER 2'-1"

OR

27.09#/FT OVER 50FT →

~ REFERENCE SHT I-7 FOR RISA 2D FRAME

- MAX TENSION = 15.81K (LC#3) – HAIRPIN ← CONTROLS
- MAX GRAVITY = 33.06K (LC#4) ← CONTROLS
- MAX SLIDING OUT = 4.24K (LC#13) ← CONTROLS
- MAX UPLIFT = 5.2K (LC#18) ← CONTROLS

~ REF SHT I-8 FOR NUCOR LOADS

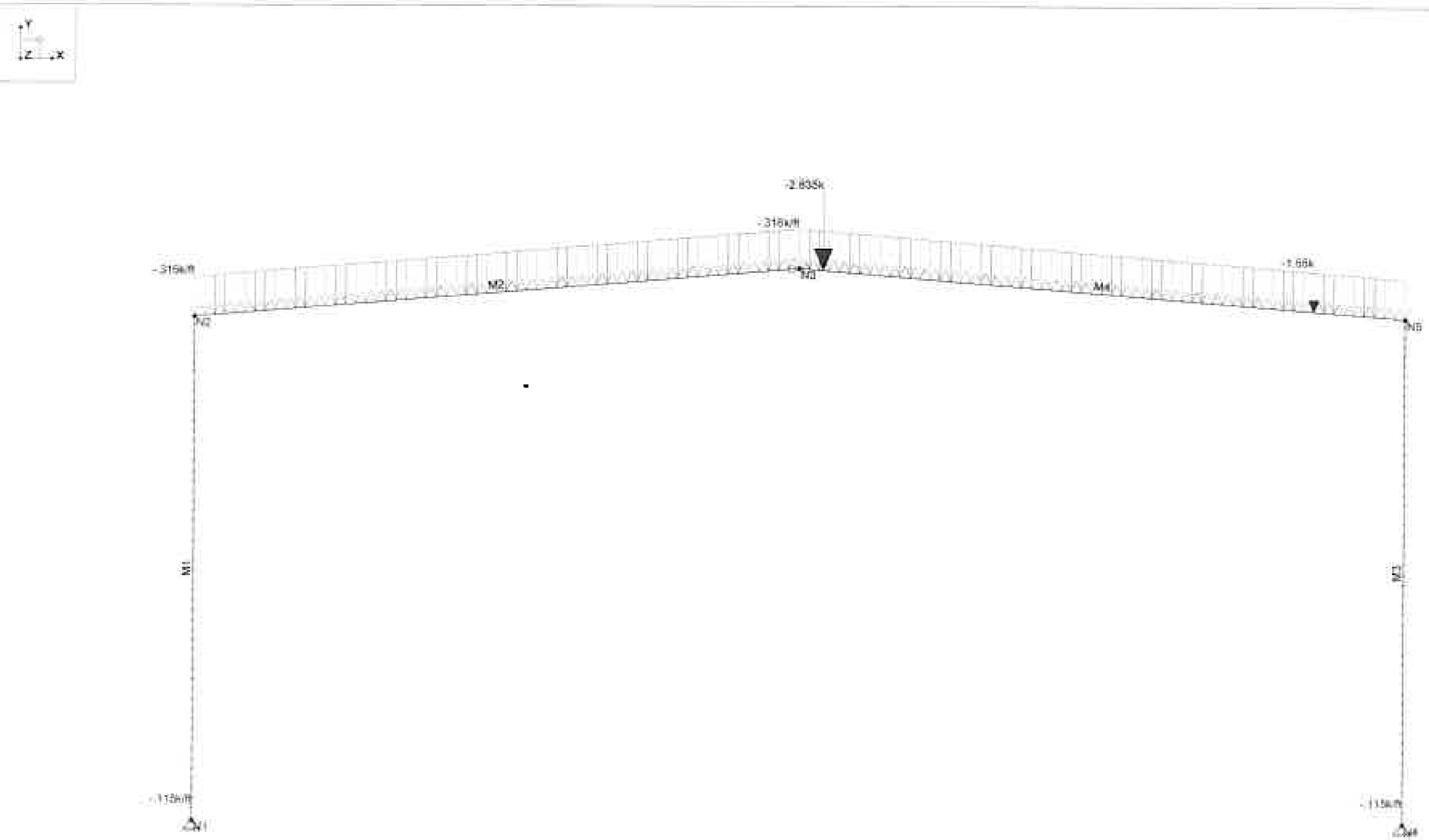
- 1 SPAN @ 50' SPAN WIDTH × 21FT EAVE @ 30FT BAY SPACING

USING 19.125FT c/c BAY SPACING FOR INTERIOR

$\frac{19.125'}{30'} = 0.638$

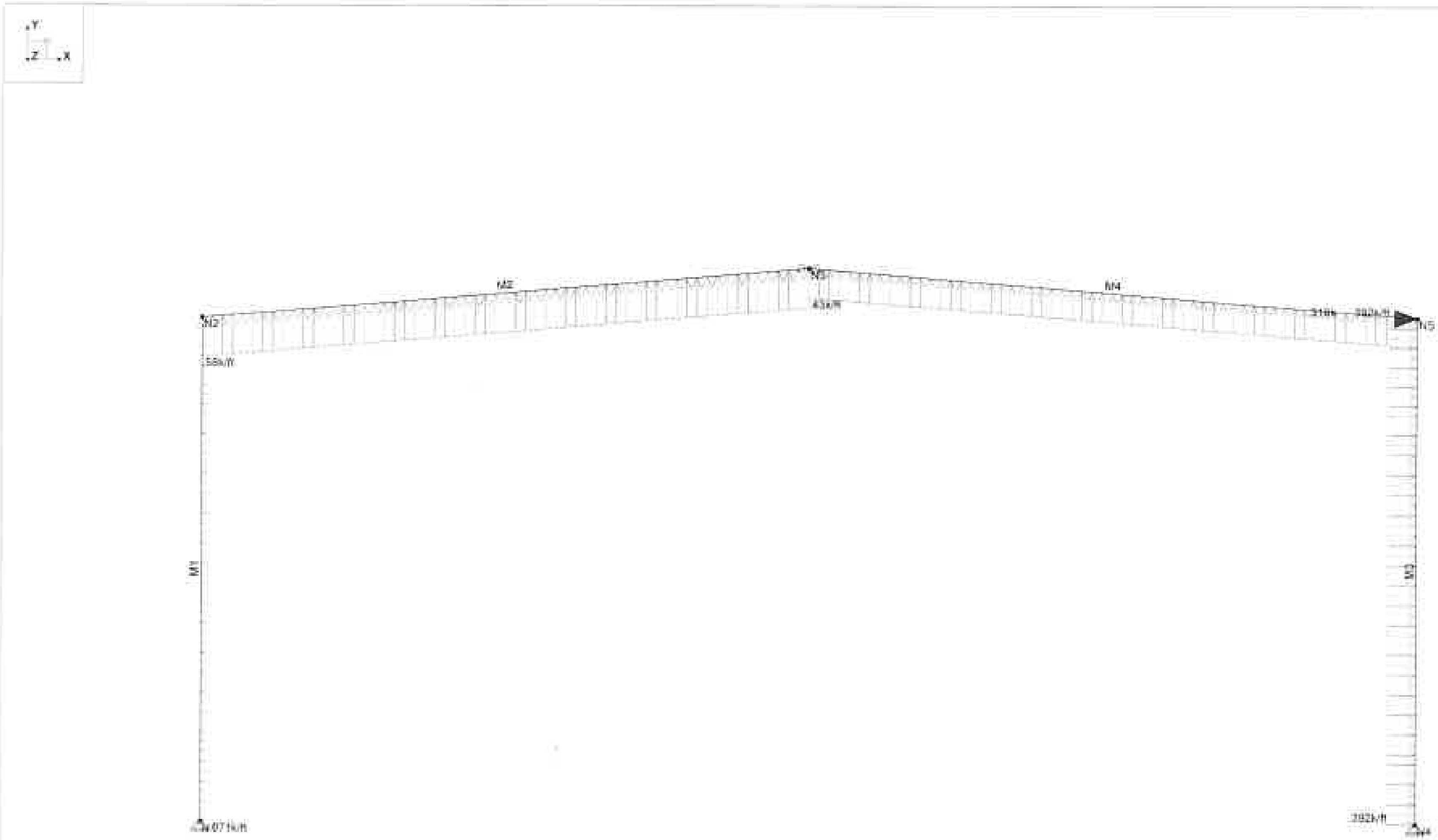
	RDL		RLL		WIL		WIR	
	X	Y	X	Y	X	Y	X	Y
COL 1	3.7K	11.5K	5K	15.4K	3.9K	-3.5K	11.2	-11.25K
COL 2	-3.7K	11.5K	-5K	15.4K	10.2K	-11.2K	-5.2K	-3.45K

I-7



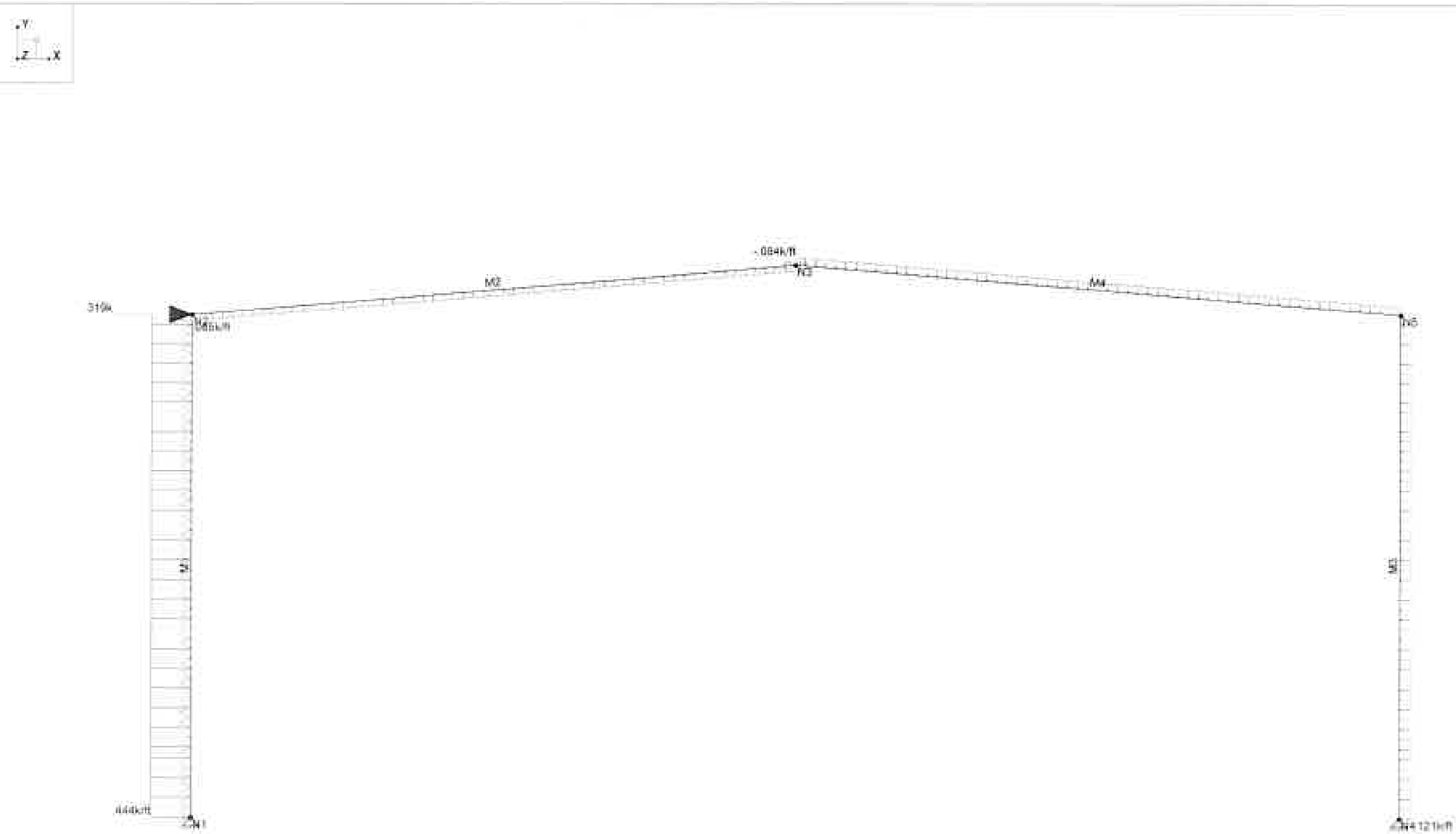
Loads: BLC 1, DL max (1)

ARCADIS	Topok Workshop Building	SK - 1
Matt Ltoycz		Jan 5, 2015 at 3:45 PM
		Typical Frame.r2d



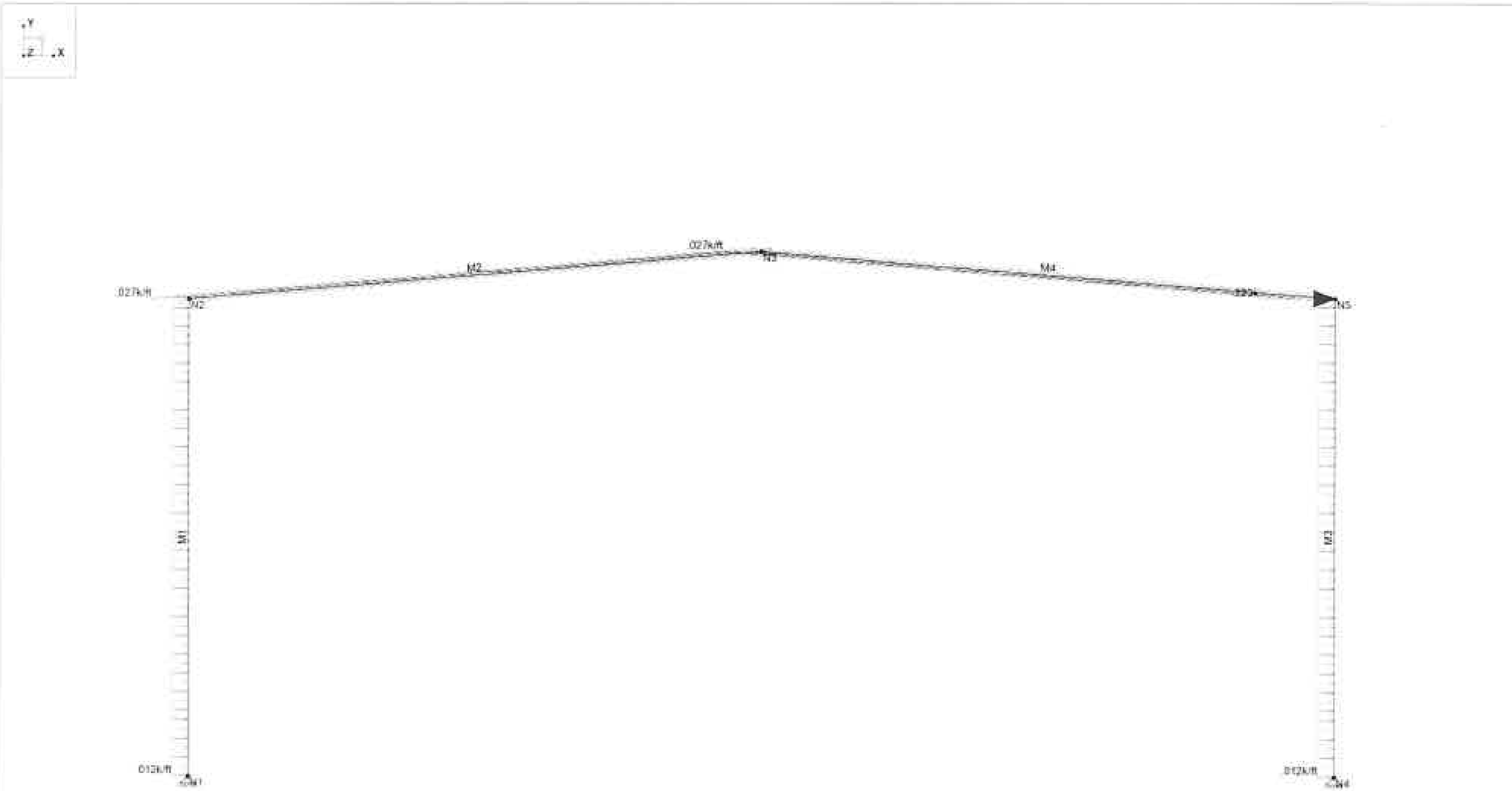
Loads: BLC 2: W1 wall and roof

ARCADIS	Topok Workshop Building	SK - 2
Matt Ltoycz		Jan 5, 2015 at 3:45 PM
		Typical Frame.r2d



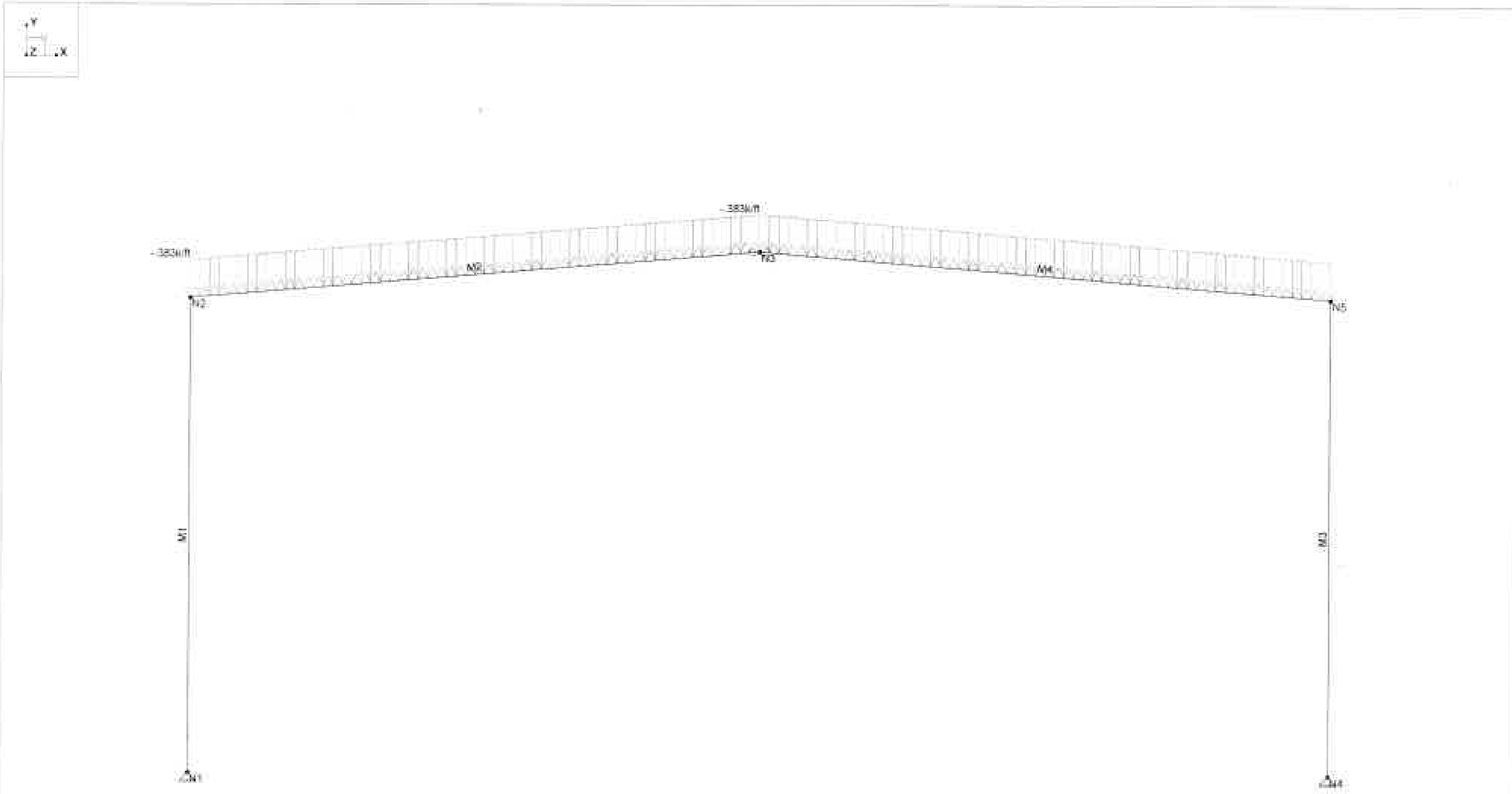
Loads: BLC 3, W2 wall and roof

ARCADIS	Topok Workshop Building	SK - 3
Matt Ltoycz		Jan 5, 2015 at 3:46 PM
		Typical Frame.r2d



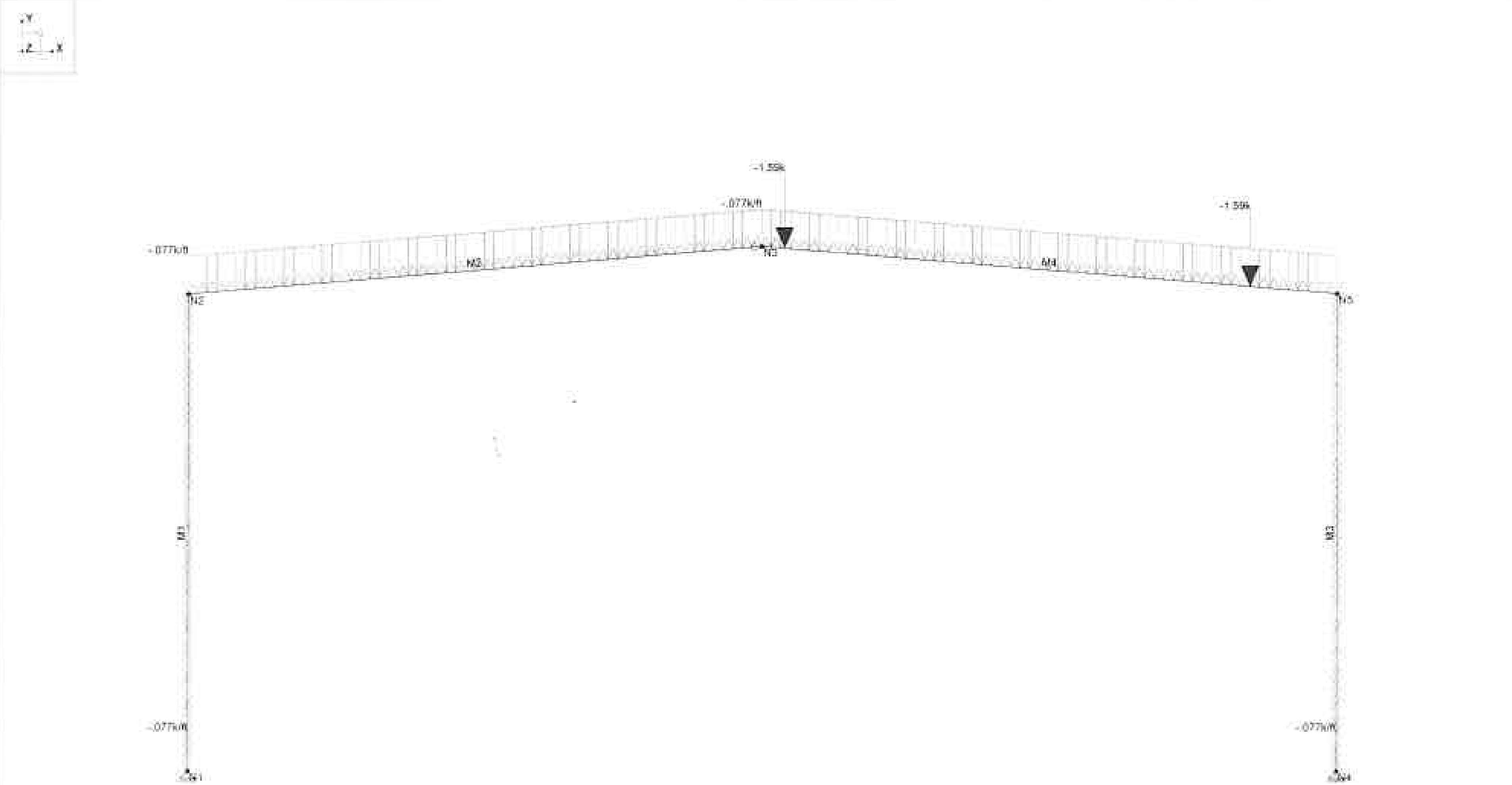
Loads: BLC 4, E

ARCADIS	Topok Workshop Building	SK - 4
Matt Ltoycz		Jan 5, 2015 at 3:46 PM
		Typical Frame.r2d



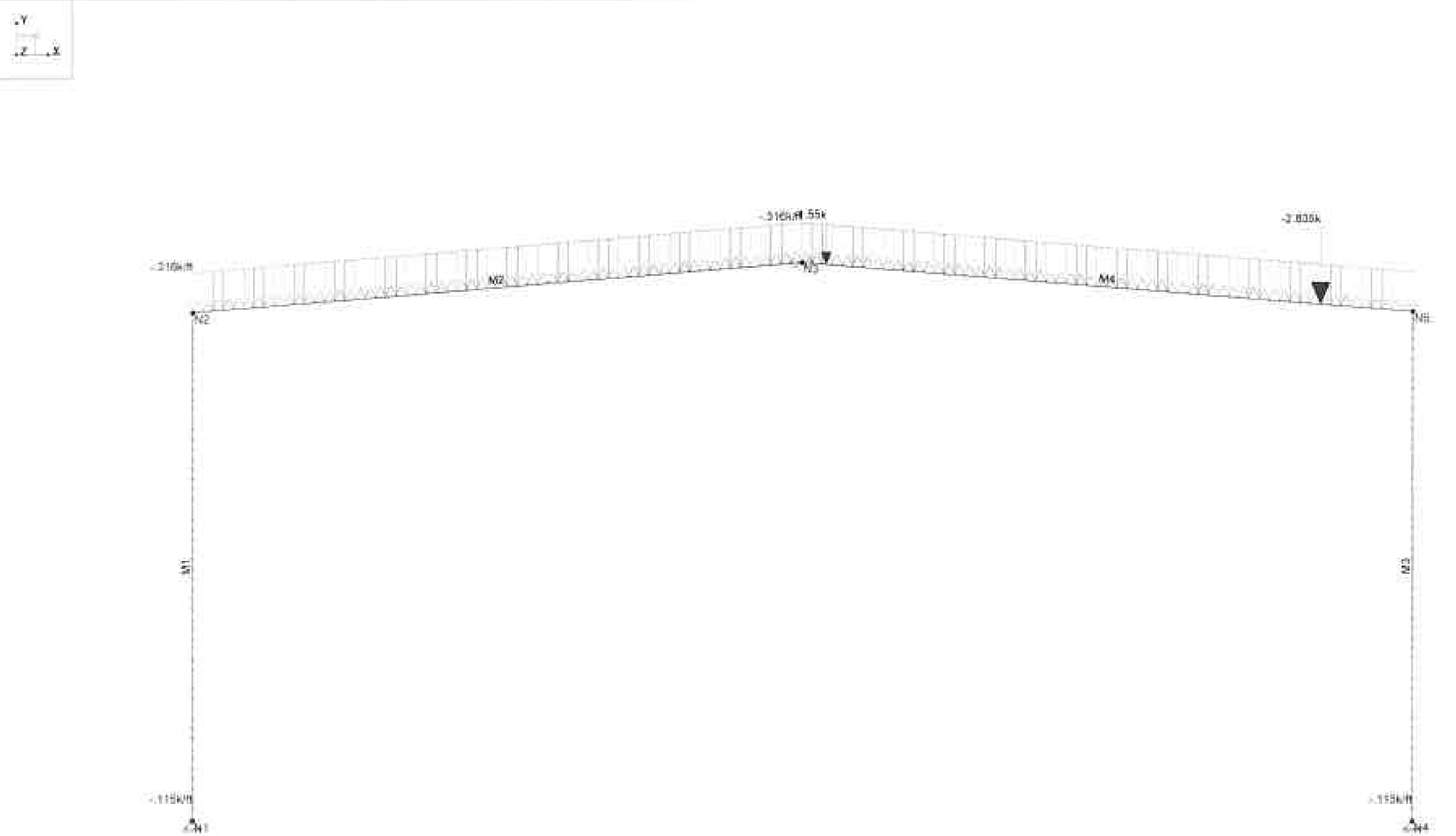
Loads: BLC 6, Lr roof

ARCADIS	Topok Workshop Building	SK - 5
Matt Ltoycz		Jan 5, 2015 at 3:47 PM
		Typical Frame.r2d



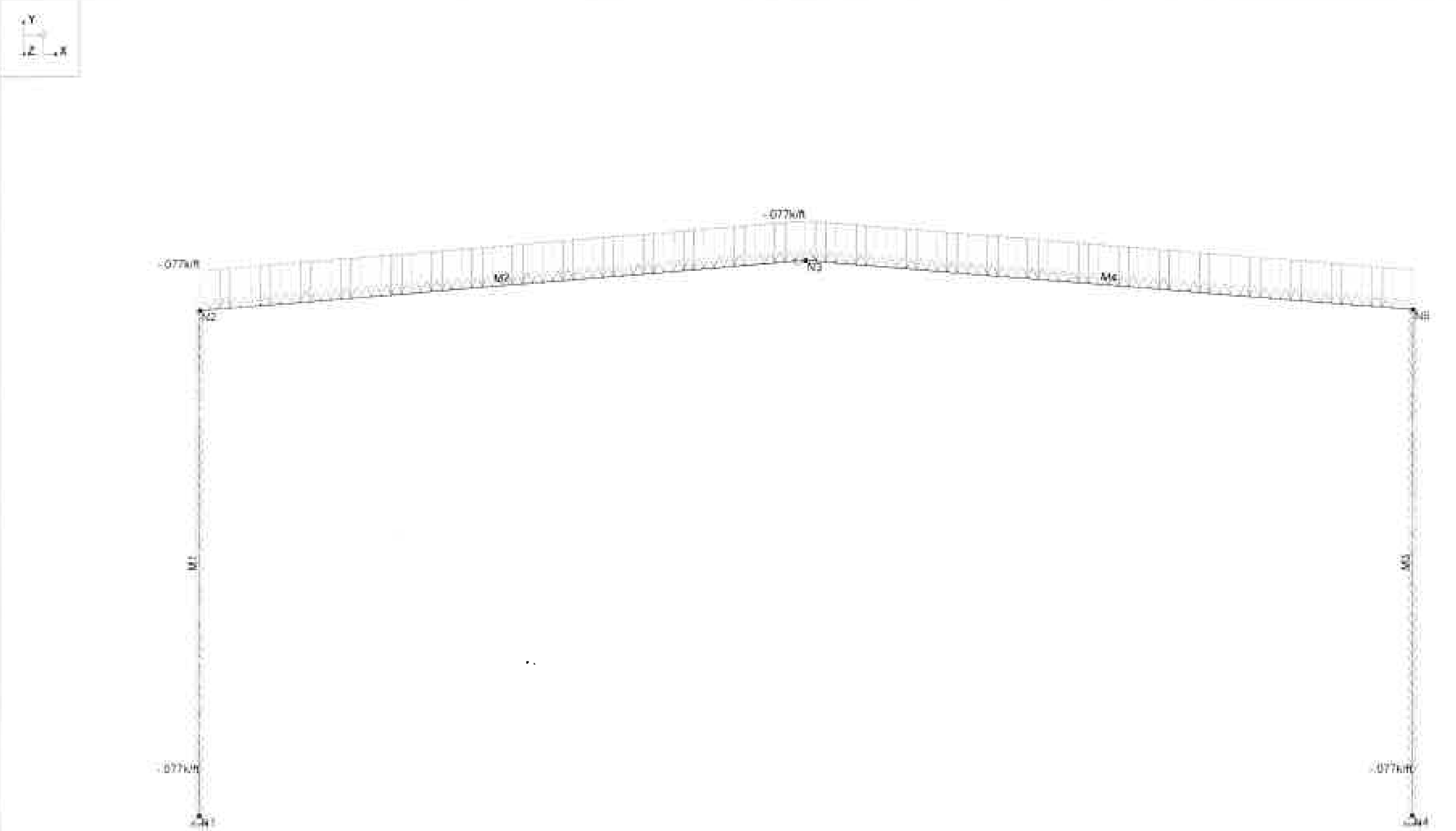
Loads: BLC 7, MIN DL (1)

ARCADIS	Topok Workshop Building	SK - 6
Matt Ltoycz		Jan 5, 2015 at 3:47 PM
		Typical Frame.r2d



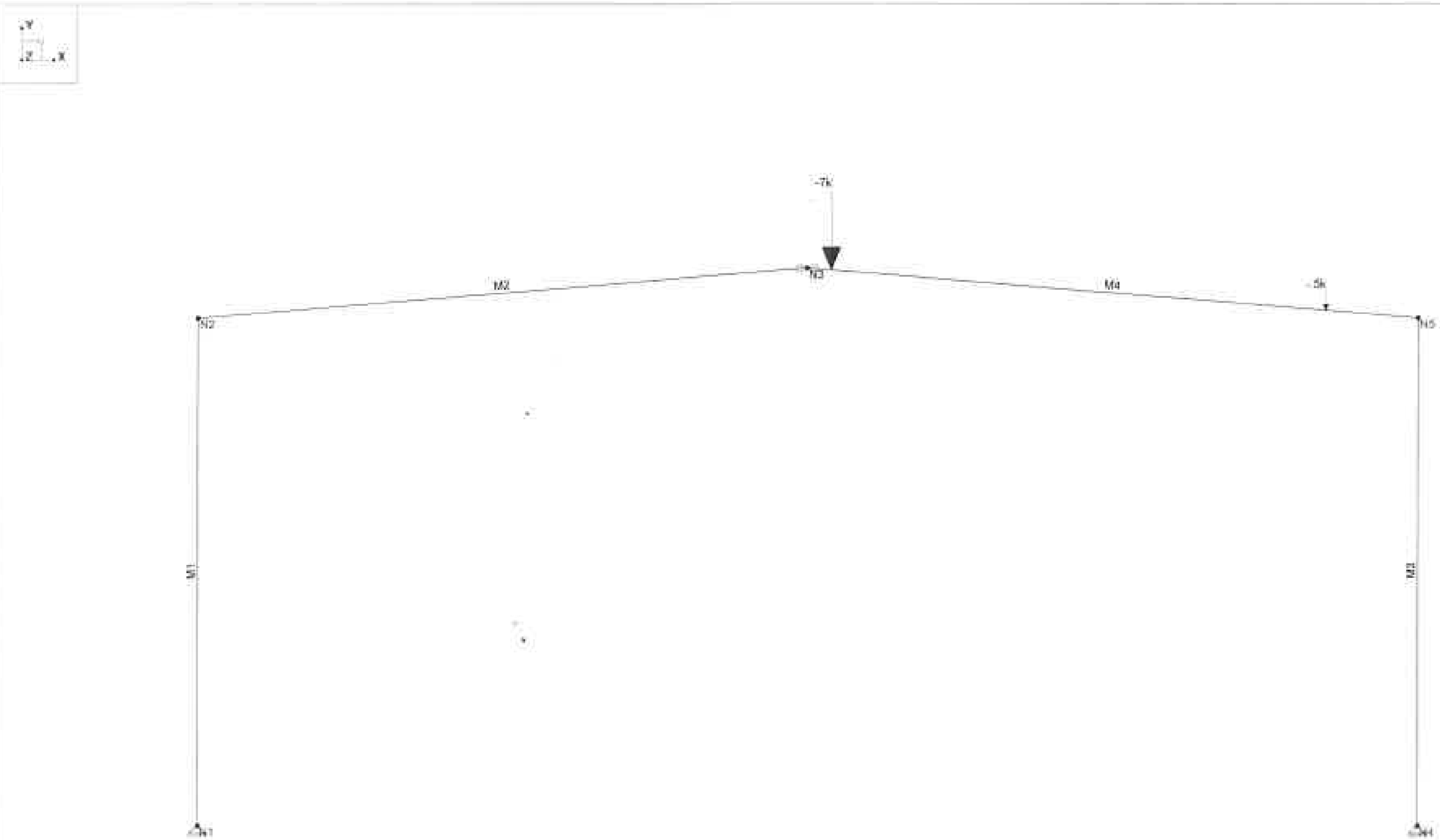
Loads: BLC 6, DL max (2)

ARCADIS	Topok Workshop Building	SK - 7
Matt Ltoycz		Jan 5, 2015 at 3:47 PM
		Typical Frame.r2d



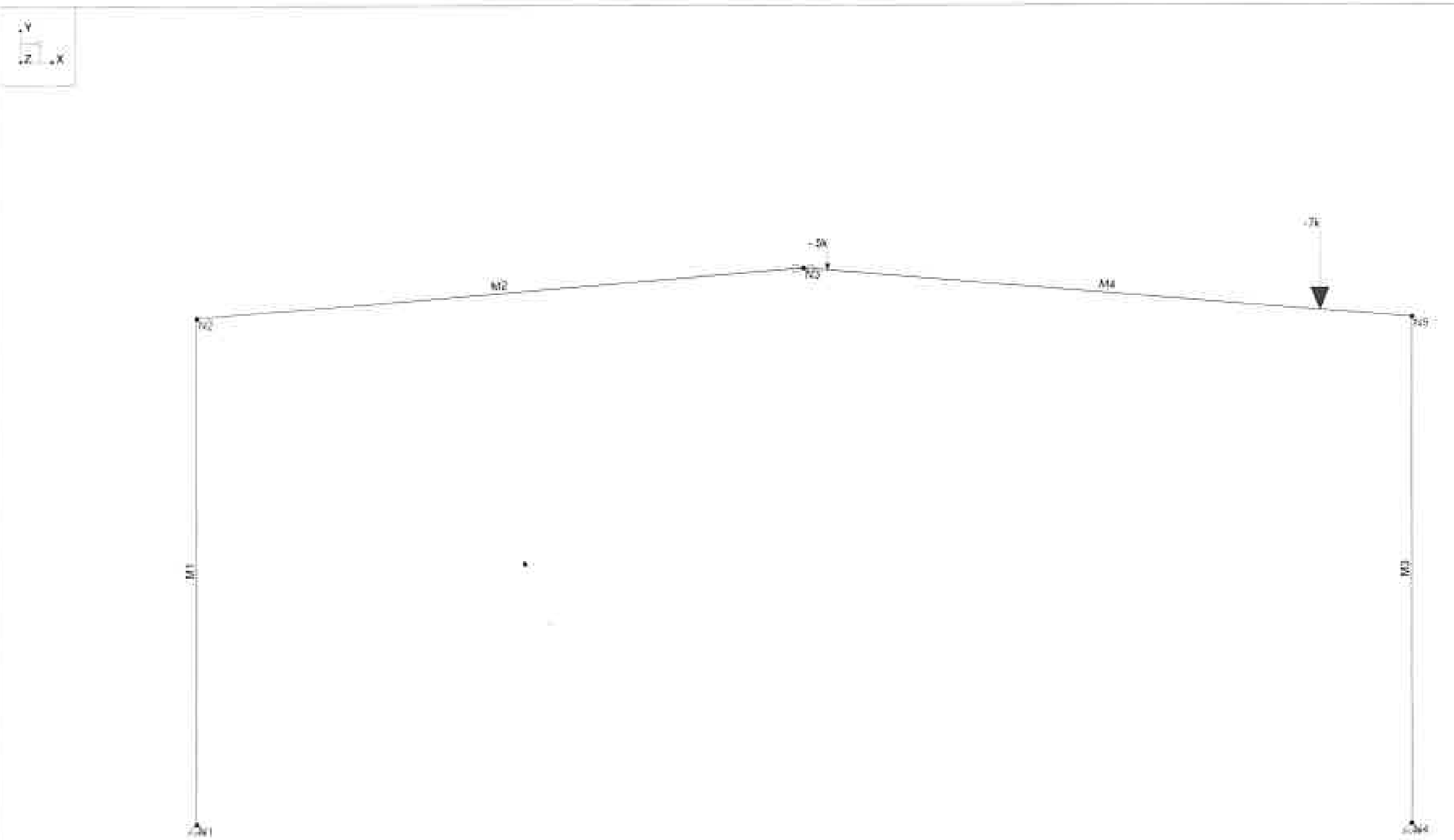
Loads: BLC II, MIN DL (2)

ARCADIS	Topok Workshop Building	SK - 14
Matt Ltoycz		Jan 5, 2015 at 4:05 PM
		Typical Frame.r2d



Loads: BLC 10, LLr max (1)

ARCADIS	Topok Workshop Building	SK - 9
Matt Ltoycz		Jan 5, 2015 at 3:48 PM
		Typical Frame.r2d



Loads: BLC 11, Lr max (2)

ARCADIS	Topok Workshop Building	SK - 10
Matt Ltoycz		Jan 5, 2015 at 3:48 PM
		Typical Frame.r2d

Joint Coordinates and Temperatures

	Label	X [ft]	Y [ft]	Temp [F]
1	N1	0	0	0
2	N2	0	21	0
3	N3	25	23.083	0
4	N4	50	0	0
5	N5	50	21	0

Joint Boundary Conditions

	Joint Label	X [k/in]	Y [k/in]	Rotation[k-ft/rad]	Footing
1	N1	Reaction	Reaction		
2	N4	Reaction	Reaction		

Member Primary Data

	Label	I Joint	J Joint	Rotate(deg)	Section/Shape	Type	Design List	Material	Design Rules
1	M1	N1	N2		W10x49	None	None	A36 Gr.36	Typical
2	M2	N2	N3		W24x76	None	None	A36 Gr.36	Typical
3	M3	N4	N5		W10x49	None	None	A36 Gr.36	Typical
4	M4	N3	N5		W24x76	None	None	A36 Gr.36	Typical

Joint Loads and Enforced Displacements (BLC 2 : W1 wall and roof)

	Joint Label	L,D,M	Direction	Magnitude[(k,k-ft), (in,rad), (k*s^2/ft...
1	N5	L	X	.319

Joint Loads and Enforced Displacements (BLC 3 : W2 wall and roof)

	Joint Label	L,D,M	Direction	Magnitude[(k,k-ft), (in,rad), (k*s^2/ft...
1	N2	L	X	.319

Joint Loads and Enforced Displacements (BLC 4 : E)

	Joint Label	L,D,M	Direction	Magnitude[(k,k-ft), (in,rad), (k*s^2/ft...
1	N5	L	X	.223

[(2080# + 490#)/2 + (75#/ft x 25') RUNWAY BEAM] x 0.07 Cs

Member Point Loads (BLC 1 : DL max (1))

	Member Label	Direction	Magnitude[k,k-ft]	Location[ft,%]
1	M4	Y	-2.835	1
2	M4	Y	-1.55	21.33

Member Point Loads (BLC 7 : MIN DL (1))

	Member Label	Direction	Magnitude[k,k-ft]	Location[ft,%]
1	M4	Y	-1.59	1
2	M4	Y	-1.59	21.33

Member Point Loads (BLC 8 : DL max (2))

	Member Label	Direction	Magnitude[k,k-ft]	Location[ft,%]
1	M4	Y	-2.835	21.33
2	M4	Y	-1.55	1

Member Point Loads (BLC 10 : LLr max (1))

	Member Label	Direction	Magnitude[k,k-ft]	Location[ft,%]
1	M4	Y	-7	1

Member Point Loads (BLC 10 : LLr max (1)) (Continued)

	Member Label	Direction	Magnitude[k,k-ft]	Location[ft,%]
2	M4	Y	-.5	21.33

Member Point Loads (BLC 11 : LLr max (2))

	Member Label	Direction	Magnitude[k,k-ft]	Location[ft,%]
1	M4	Y	-7	21.33
2	M4	Y	-.5	1

Member Distributed Loads (BLC 1 : DL max (1))

	Member Label	Direction	Start Magnitude[k/ft,F]	End Magnitude[k/ft,F]	Start Location[ft,%]	End Location[ft,%]
1	M2	Y	-.316	-.316	0	%100
2	M4	Y	-.316	-.316	0	%100
3	M1	Y	-.115	-.115	0	%100
4	M3	Y	-.115	-.115	0	%100

Member Distributed Loads (BLC 2 : W1 wall and roof)

	Member Label	Direction	Start Magnitude[k/ft,F]	End Magnitude[k/ft,F]	Start Location[ft,%]	End Location[ft,%]
1	M1	X	-.071	-.071	0	%100
2	M3	X	.392	.392	0	%100
3	M2	Y	.58	.58	0	%100
4	M4	Y	.43	.43	0	%100

Member Distributed Loads (BLC 3 : W2 wall and roof)

	Member Label	Direction	Start Magnitude[k/ft,F]	End Magnitude[k/ft,F]	Start Location[ft,%]	End Location[ft,%]
1	M1	X	.444	.444	0	%100
2	M3	X	-.121	-.121	0	%100
3	M2	Y	.065	.065	0	%100
4	M4	Y	-.084	-.084	0	%100

Member Distributed Loads (BLC 4 : E)

	Member Label	Direction	Start Magnitude[k/ft,F]	End Magnitude[k/ft,F]	Start Location[ft,%]	End Location[ft,%]
1	M2	X	.027	.027	0	%100
2	M4	X	.027	.027	0	%100
3	M1	X	.012	.012	0	%100
4	M3	X	.012	.012	0	%100

Member Distributed Loads (BLC 6 : Lr roof)

	Member Label	Direction	Start Magnitude[k/ft,F]	End Magnitude[k/ft,F]	Start Location[ft,%]	End Location[ft,%]
1	M2	Y	-.383	-.383	0	%100
2	M4	Y	-.383	-.383	0	%100

Member Distributed Loads (BLC 7 : MIN DL (1))

	Member Label	Direction	Start Magnitude[k/ft,F]	End Magnitude[k/ft,F]	Start Location[ft,%]	End Location[ft,%]
1	M2	Y	-.077	-.077	0	%100
2	M4	Y	-.077	-.077	0	%100
3	M1	Y	-.077	-.077	0	%100
4	M3	Y	-.077	-.077	0	%100

Member Distributed Loads (BLC 8 : DL max (2))

	Member Label	Direction	Start Magnitude[k/ft,F]	End Magnitude[k/ft,F]	Start Location[ft,%]	End Location[ft,%]
1	M2	Y	-.316	-.316	0	%100
2	M4	Y	-.316	-.316	0	%100
3	M1	Y	-.115	-.115	0	%100
4	M3	Y	-.115	-.115	0	%100

Member Distributed Loads (BLC 9 : MIN DL (2))

	Member Label	Direction	Start Magnitude[k/ft,F]	End Magnitude[k/ft,F]	Start Location[ft,%]	End Location[ft,%]
1	M2	Y	-.077	-.077	0	%100
2	M4	Y	-.077	-.077	0	%100
3	M1	Y	-.077	-.077	0	%100
4	M3	Y	-.077	-.077	0	%100

Basic Load Cases

	BLC Description	Category	X Gravity	Y Gravity	Joint	Point	Distributed
1	DL max (1)	None		-1		2	4
2	W1 wall and roof	None			1		4
3	W2 wall and roof	None			1		4
4	E	None		-1	1		4
6	Lr roof	None					2
7	MIN DL (1)	None		-1		2	4
8	DL max (2)	None		-1		2	4
9	MIN DL (2)	None		-1			4
10	LLr max (1)	None				2	
11	LLr max (2)	None				2	

Load Combinations

	Description	So...	P...	S...	BLC	Fac...	BLC	Fac...	BLC	Fac...	BLC	Fac...	BLC	Fac...	BLC	Fac...	BLC	Fac...	BLC	Fac...
1	DL max 1 + Lr	Yes			1	1	6	1												
2	DL max 2 + Lr	Yes			8	1	6	1												
3	DL max 1 + Lr + LLr max 1	Yes			1	1	6	1	10	1										
4	DL max 2 + Lr + LLr max 2	Yes			8	1	6	1	11	1										
5	DL max 1 + 0.75 Lr + (0.6*0.75) W1 wall...	Yes			1	1	6	.75	2	.45										
6	DL max 2 + 0.75 Lr + (0.6*0.75) W1 wall...	Yes			8	1	6	.75	2	.45										
7	DL max 1 + 0.75 Lr + (0.6*0.75) W2 wall...	Yes			1	1	6	.75	3	.45										
8	DL max 2 + 0.75 Lr - (0.6*0.75) W2 wall ...	Yes			8	1	6	.75	3	.45										
9	DL max 1 + 0.75 Lr + (0.6*0.75) W1 wall...	Yes			1	1	6	.75	2	.45	10	.75								
10	DL max 2 + 0.75 Lr + (0.6*0.75) W1 wall...	Yes			8	1	6	.75	2	.45	11	.75								
11	DL max 1 + 0.75 Lr + (0.6*0.75) W2 wall...	Yes			1	1	6	.75	3	.45	10	.75								
12	DL max 2 + 0.75 Lr + (0.6*0.75) W2 wall...	Yes			8	1	6	.75	3	.45	11	.75								
13	DL max 1 + 0.6W1 wall and roof	Yes			1	1	2	.6												
14	DL max 2 + 0.6W1 wall and roof	Yes			8	1	2	.6												
15	DL max 1 + 0.6W2 wall and roof	Yes			1	1	3	.6												
16	DL max 2 + 0.6W2 wall and roof	Yes			8	1	3	.6												
17	0.6DL min 1 + 0.6W1 wall & roof	Yes			7	.6	2	.6												
18	0.6DL min 2 + 0.6W1 wall & roof	Yes			9	.6	2	.6												
19	0.6DL min 1 + 0.6W2 wall and roof	Yes			7	.6	3	.6												
20	0.6DL min 2 + 0.6W2 wall and roof	Yes			9	.6	3	.6												
21	(1+0.105Sds) DL max 1 + 0.75 Lr + 0.75...	Yes			1	1.026	6	.75	10	.75	4	.525								
22	(1+0.105Sds) DL max 2 + 0.75 Lr + 0.75...	Yes			8	1.026	6	.75	11	.75	4	.525								
23	0.6DL min 1 + 0.7E	Yes			7	.56	4	.7												
24	0.6DL min 2 + 0.7E	Yes			9	.56	4	.7												

Load Combination Design

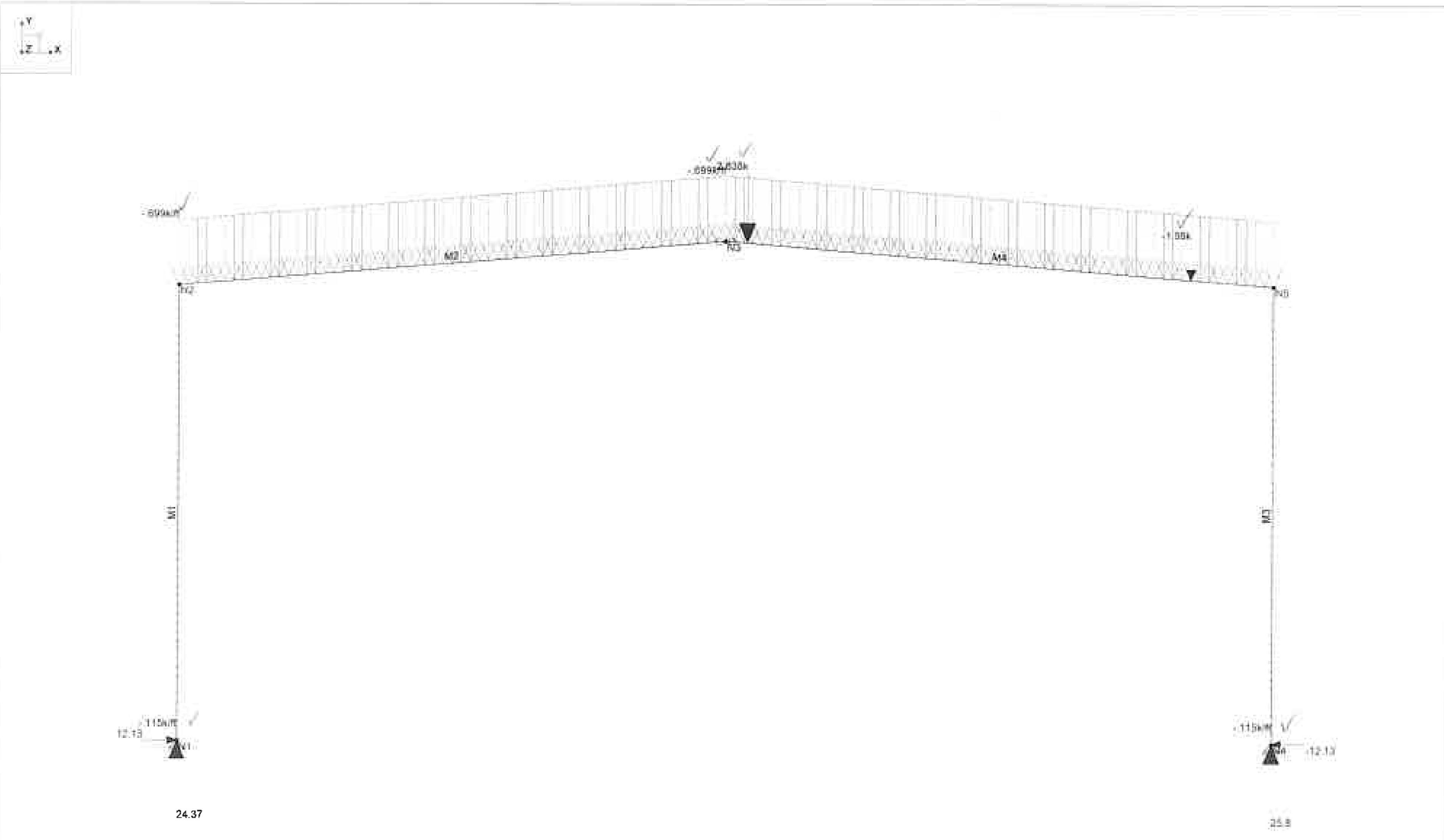
	Description	ASIF	CD	ABIF	Service	Hot Rolled	Cold Form...	Wood	Concrete	Masonry	Footings	Aluminum
1	DL max 1 + Lr					Yes	Yes	Yes	Yes	Yes	Yes	Yes
2	DL max 2 + Lr					Yes	Yes	Yes	Yes	Yes	Yes	Yes
3	DL max 1 + L...					Yes	Yes	Yes	Yes	Yes	Yes	Yes
4	DL max 2 + L...					Yes	Yes	Yes	Yes	Yes	Yes	Yes
5	DL max 1 + 0...					Yes	Yes	Yes	Yes	Yes	Yes	Yes
6	DL max 2 + 0...					Yes	Yes	Yes	Yes	Yes	Yes	Yes

Load Combination Design (Continued)

	Description	ASIF	CD	ABIF	Service	Hot Rolled	Cold Form...	Wood	Concrete	Masonry	Footings	Aluminum
7	DL max 1 + 0..					Yes	Yes	Yes	Yes	Yes	Yes	Yes
8	DL max 2 + 0..					Yes	Yes	Yes	Yes	Yes	Yes	Yes
9	DL max 1 + 0..					Yes	Yes	Yes	Yes	Yes	Yes	Yes
10	DL max 2 + 0..					Yes	Yes	Yes	Yes	Yes	Yes	Yes
11	DL max 1 + 0..					Yes	Yes	Yes	Yes	Yes	Yes	Yes
12	DL max 2 + 0..					Yes	Yes	Yes	Yes	Yes	Yes	Yes
13	DL max 1 + 0..					Yes	Yes	Yes	Yes	Yes	Yes	Yes
14	DL max 2 + 0..					Yes	Yes	Yes	Yes	Yes	Yes	Yes
15	DL max 1 + 0..					Yes	Yes	Yes	Yes	Yes	Yes	Yes
16	DL max 2 + 0..					Yes	Yes	Yes	Yes	Yes	Yes	Yes
17	0.6DL min 1 ...					Yes	Yes	Yes	Yes	Yes	Yes	Yes
18	0.6DL min 2 ...					Yes	Yes	Yes	Yes	Yes	Yes	Yes
19	0.6DL min 1 ...					Yes	Yes	Yes	Yes	Yes	Yes	Yes
20	0.6DL min 2 ...					Yes	Yes	Yes	Yes	Yes	Yes	Yes
21	(1+0.105Sds)..					Yes	Yes	Yes	Yes	Yes	Yes	Yes
22	(1+0.105Sds)..					Yes	Yes	Yes	Yes	Yes	Yes	Yes
23	0.6DL min 1 ...					Yes	Yes	Yes	Yes	Yes	Yes	Yes
24	0.6DL min 2 ...					Yes	Yes	Yes	Yes	Yes	Yes	Yes

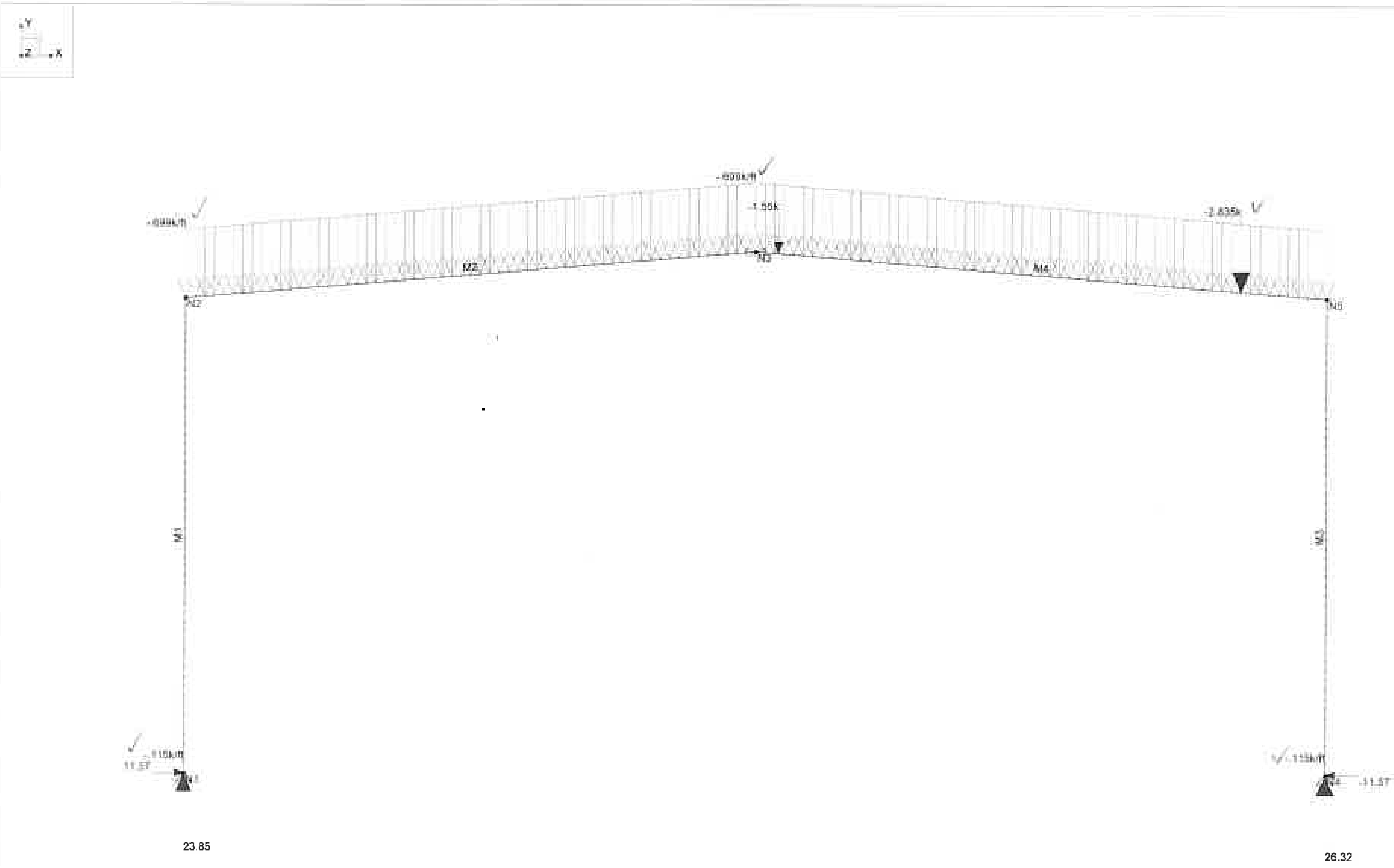
Joint Reactions

	LC	Joint Label	X [k]	Y [k]	MZ [k-ft]
1	1	N1	12.131	24.369	0
2	1	N4	-12.131	25.8	0
3	1	Totals:	0	50.168	
4	1	COG (ft):	X: 25.713	Y: 20.489	



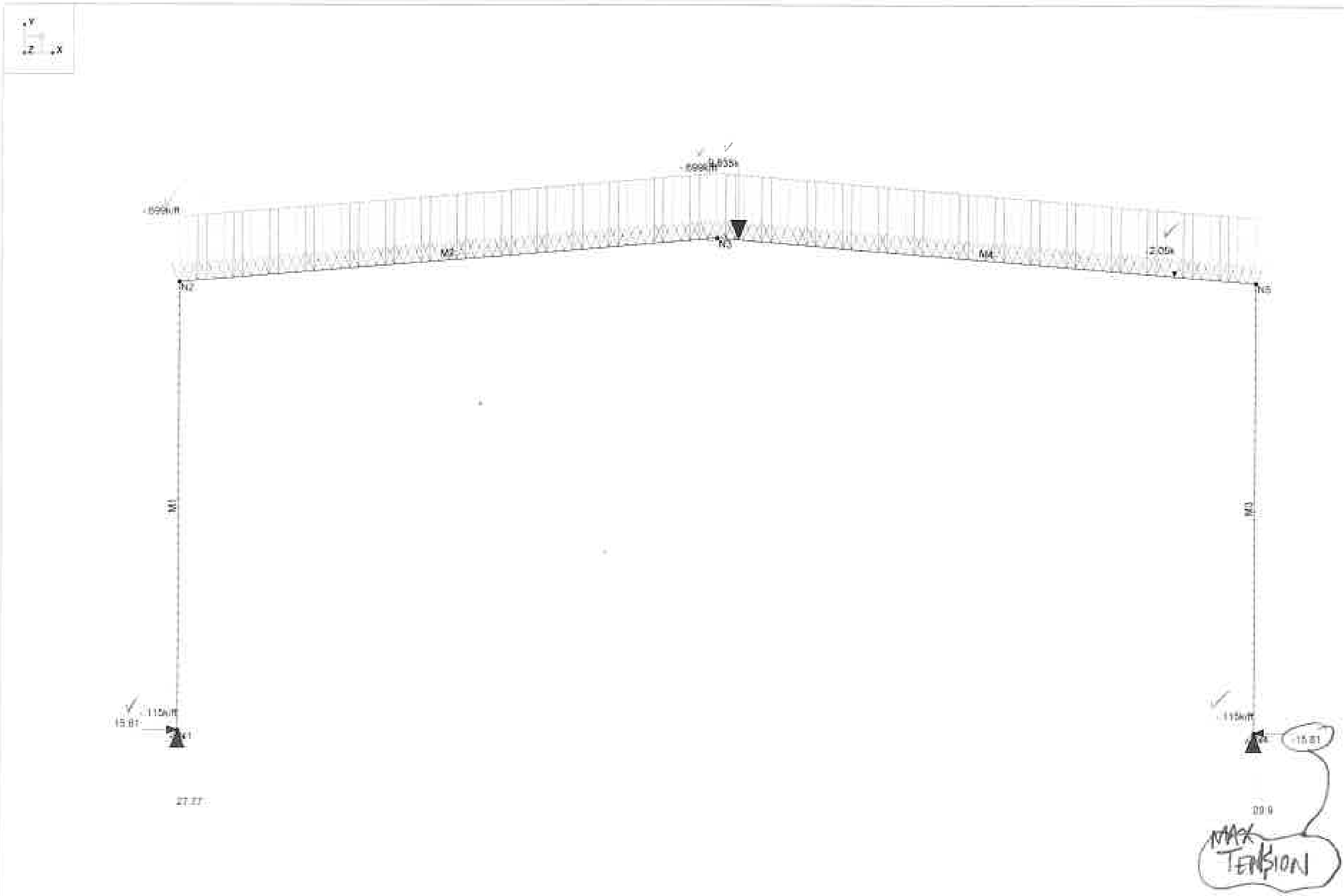
Loads: LC 1, DL max 1 + Lr
Results for LC 1, DL max 1 + Lr
Z-moment Reaction units are k and k-ft

ARCADIS	Topok Workshop Building	SK - 15
Matt Ltoycz		Jan 5, 2015 at 4:06 PM
		Typical Frame.r2d



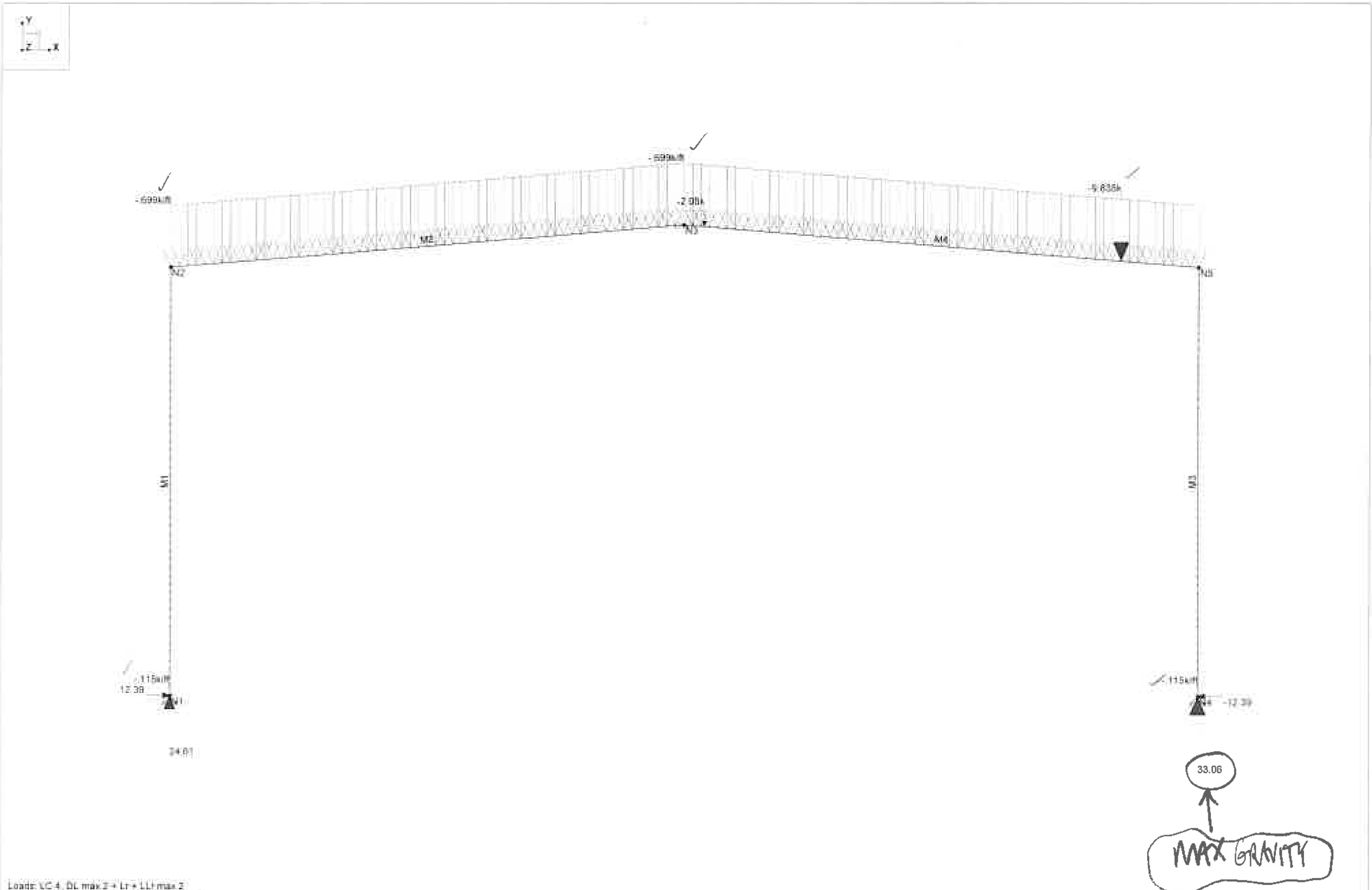
Loads: LC 2, DL max 2 + Lr
Results for LC 2, DL max 2 + Lr
Z-moment Reaction units are k and k-ft

ARCADIS	Topok Workshop Building	SK - 16
Matt Ltoycz		Jan 5, 2015 at 4:06 PM
		Typical Frame.r2d



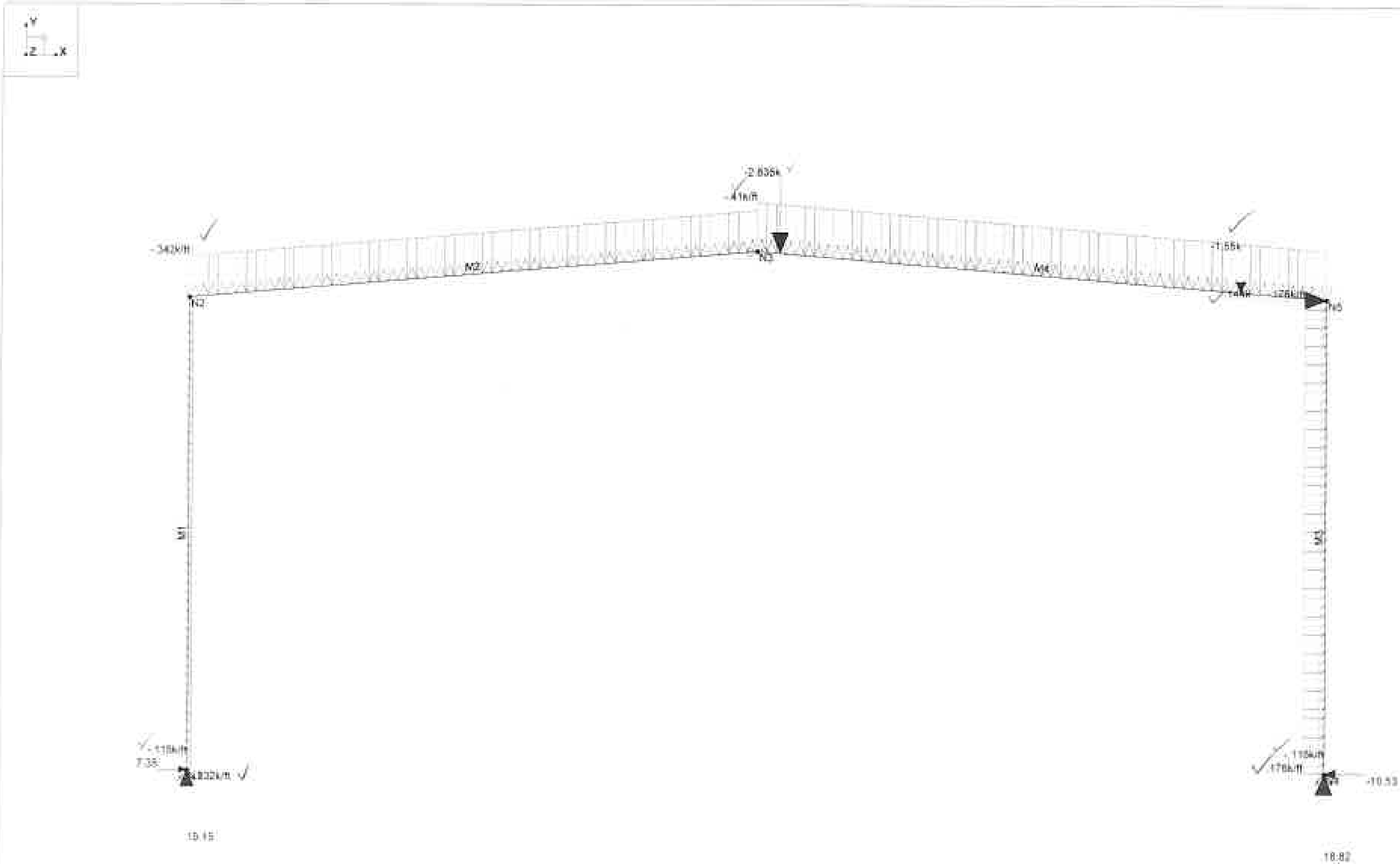
Loads: LC 3, DL max 1 + Lr + LLr max 1
Results for LC 3, DL max 1 + Lr + LLr max 1
Z-moment Reaction units are k and k-ft

ARCADIS	Topok Workshop Building	SK - 17
Matt Ltoycz		Jan 5, 2015 at 4:06 PM
		Typical Frame.r2d



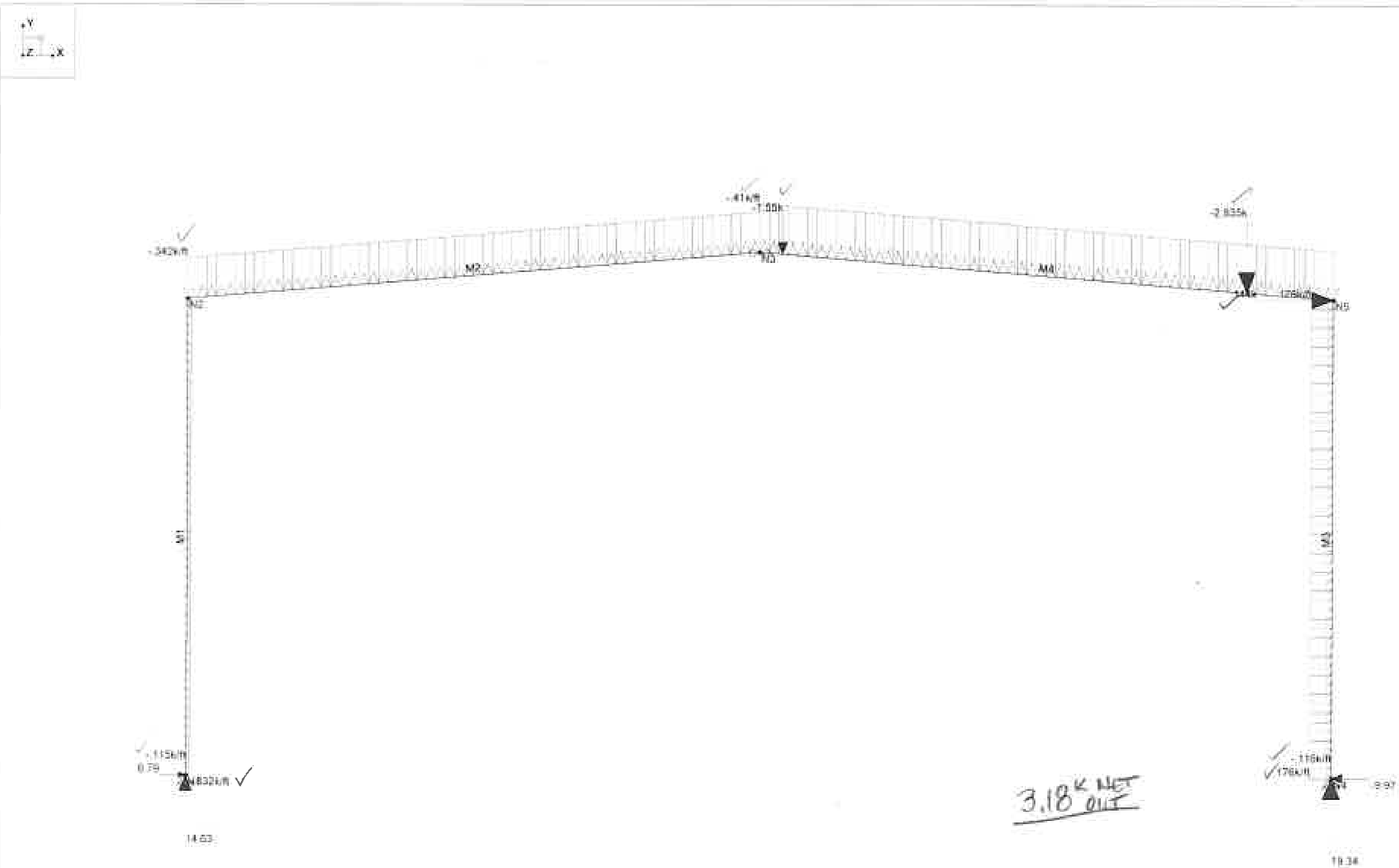
Loads: LC 4, DL max 2 + Lr + LLr max 2
Results for LC 4, DL max 2 + Lr + LLr max 2
Z-moment Reaction units are k and k-ft

ARCADIS	Topok Workshop Building	SK - 18
Matt Ltoycz		Jan 5, 2015 at 4:06 PM
		Typical Frame.r2d



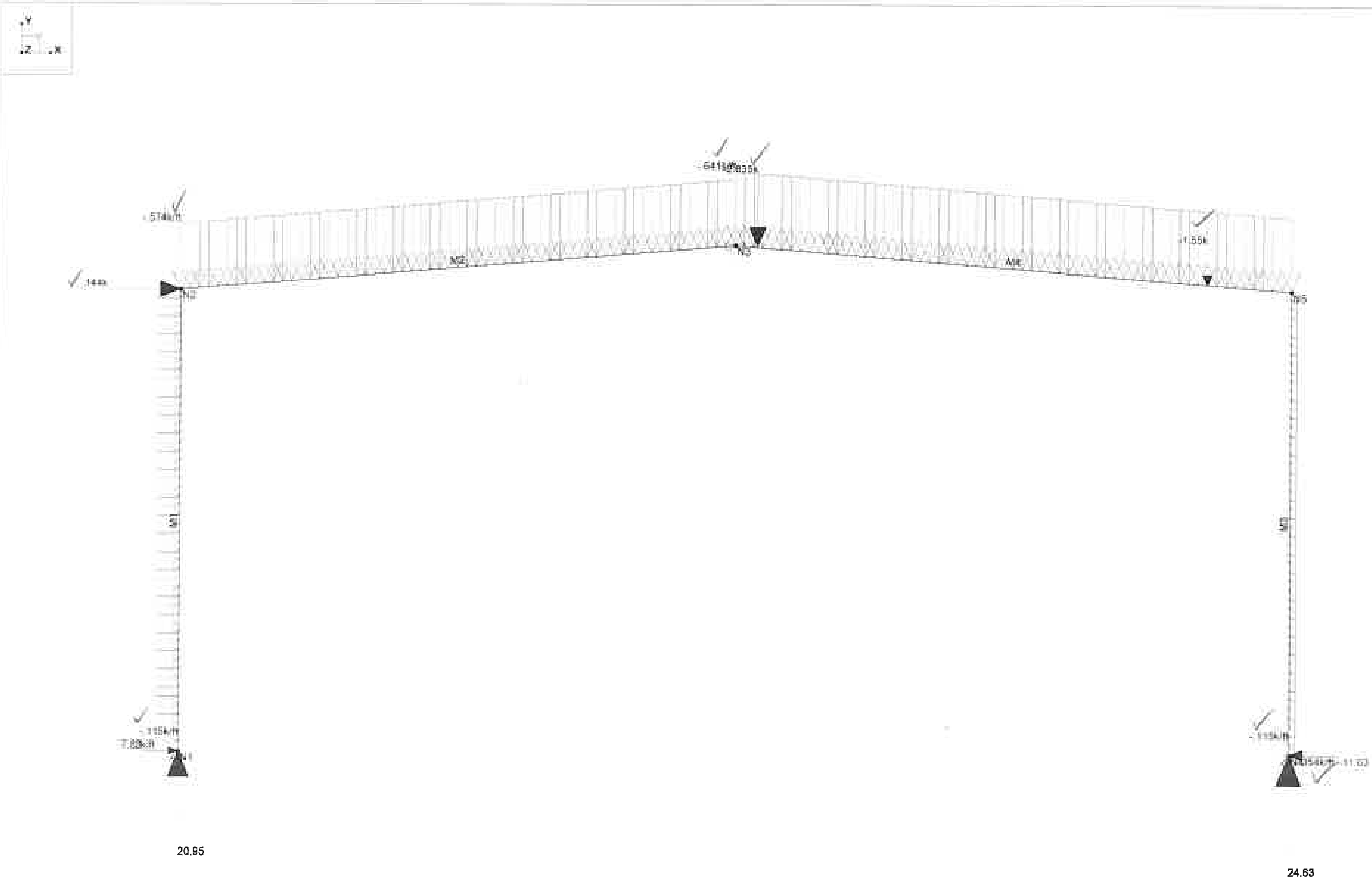
Loads: LC 5: DL max 1 + 0.75 Lr + (0.6*0.75) W1 wall & roof
Results for LC 5, DL max 1 + 0.75 Lr + (0.6*0.75) W1 wall & roof
Z-moment Reaction units are k and k-ft

ARCADIS	Topok Workshop Building	SK - 19
Matt Ltoycz		Jan 5, 2015 at 4:07 PM
		Typical Frame.r2d



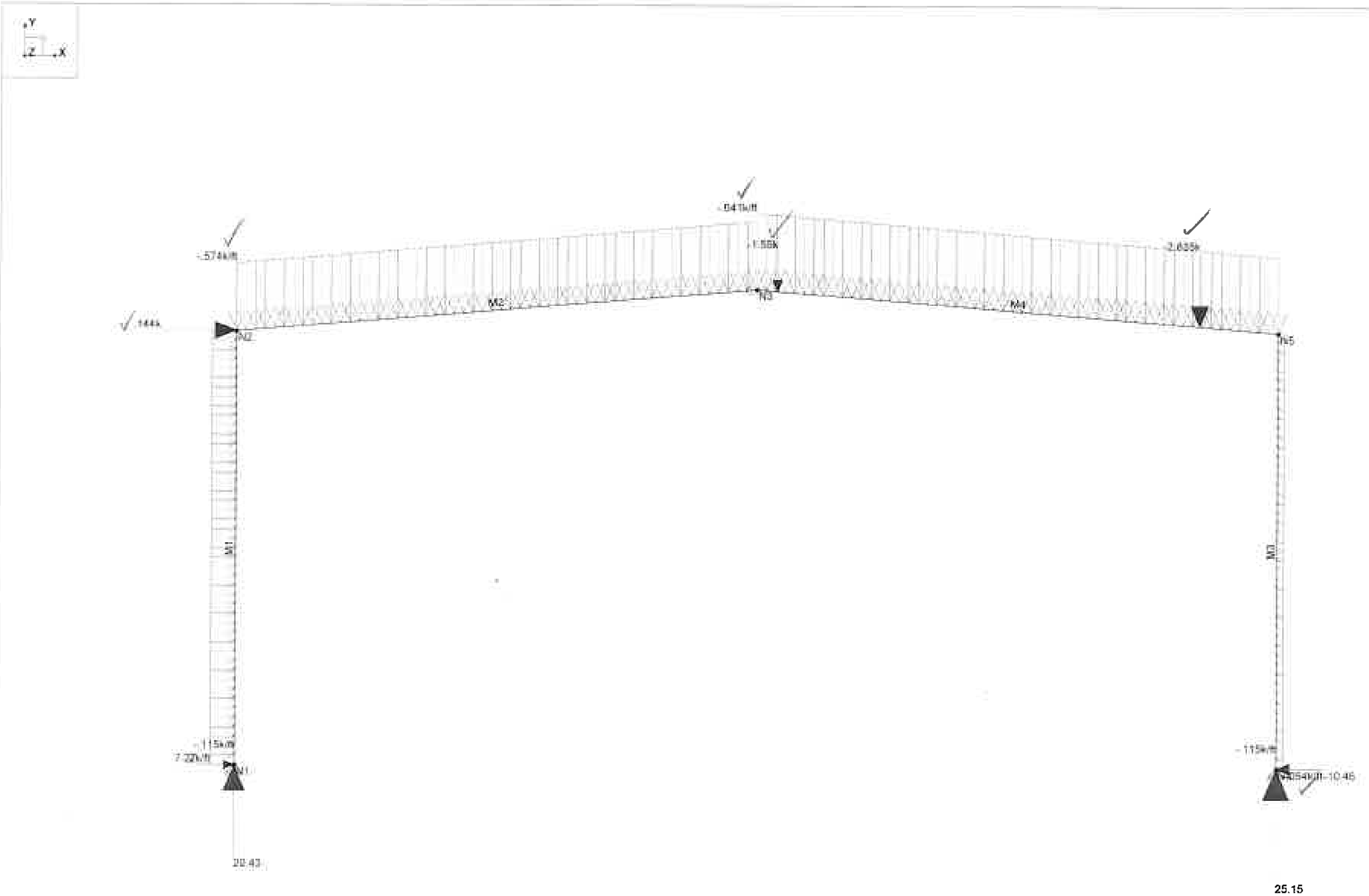
Loads: LC 6, DL max 2 + 0.75 Lr + (0.6*0.75) W1 wall & roof
Results for LC 6, DL max 2 + 0.75 Lr + (0.6*0.75) W1 wall & roof
Z-moment Reaction units are k and k-ft

ARCADIS	Topok Workshop Building	SK - 20
Matt Ltoycz		Jan 5, 2015 at 4:07 PM
		Typical Frame.r2d



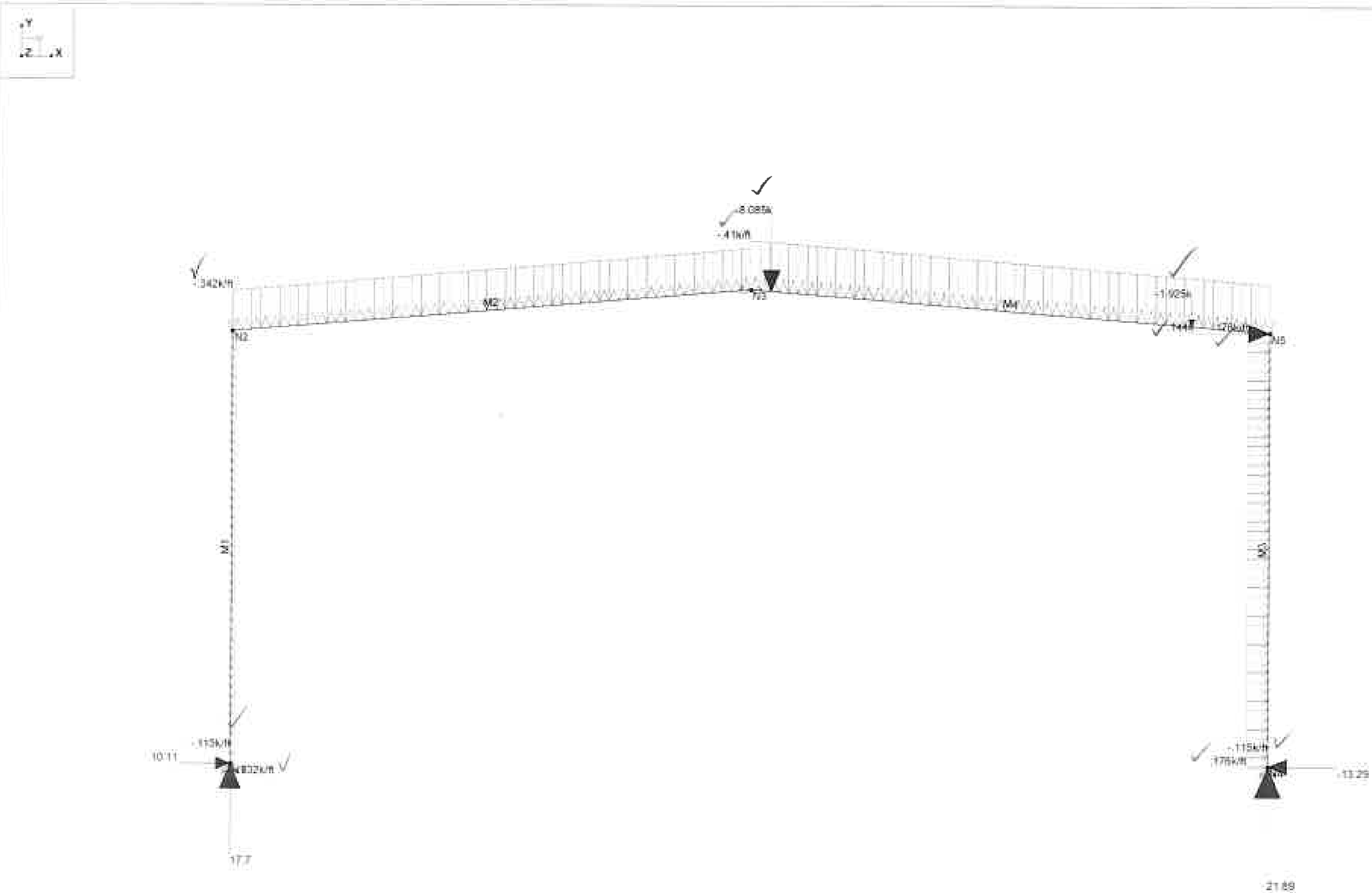
Loads: LC 7, DL max 1 + 0.75 Lr + (0.6*0.75) W2 wall and roof
Results for LC 7, DL max 1 + 0.75 Lr + (0.6*0.75) W2 wall and roof
Z-moment Reaction units are k and k-ft

ARCADIS	Topok Workshop Building	SK - 21
Matt Ltoycz		Jan 5, 2015 at 4:08 PM
		Typical Frame r2d



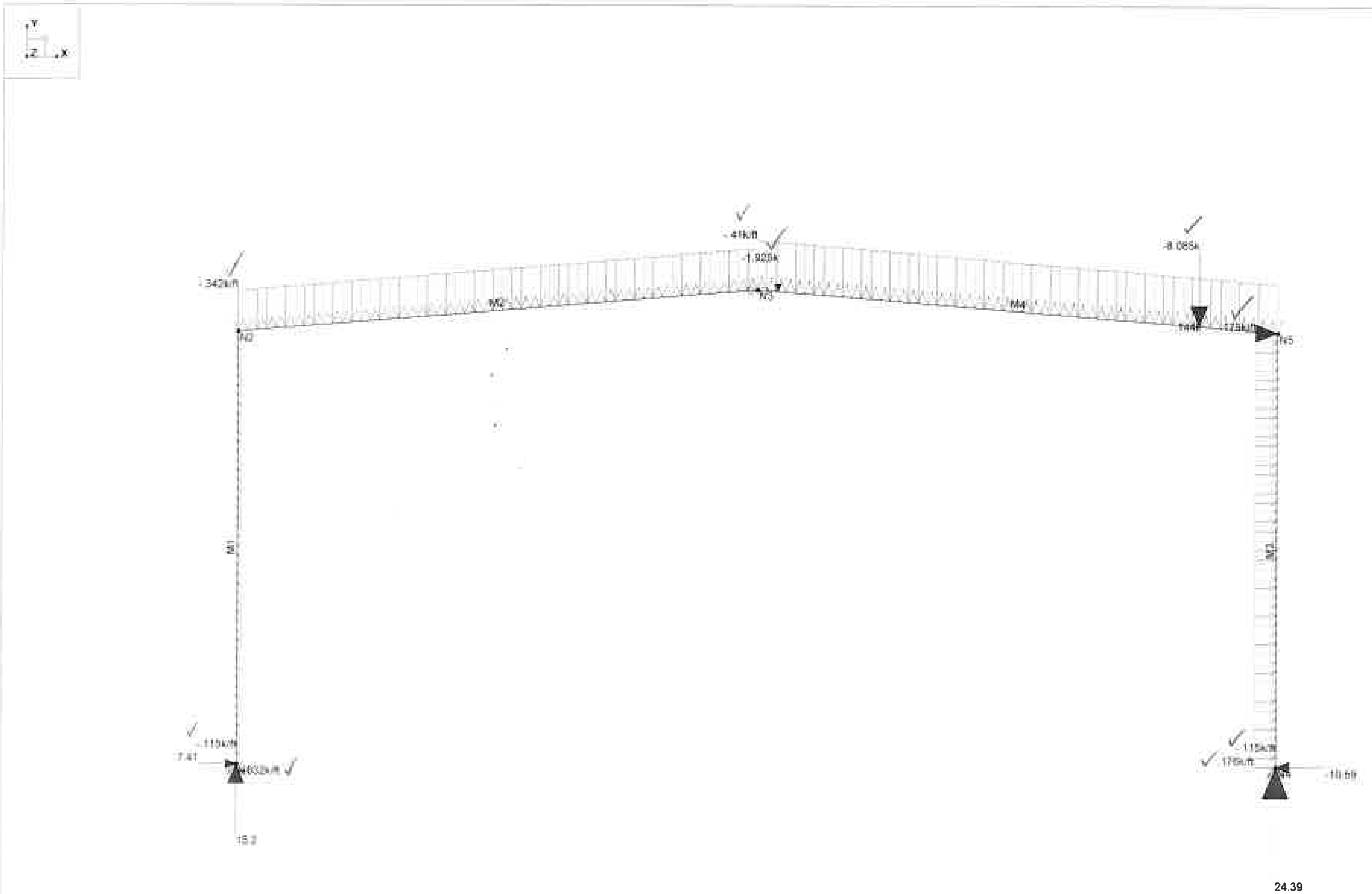
Loads: LC 8, DL max 2 + 0.75 Lr - (0.6*0.75) W2 wall and roof
Results for LC 8, DL max 2 + 0.75 Lr - (0.6*0.75) W2 wall and roof
Z-moment Reaction units are k and k-ft

ARCADIS	Topok Workshop Building	SK - 22
Matt Ltoycz		Jan 5, 2015 at 4:08 PM
		Typical Frame.r2d



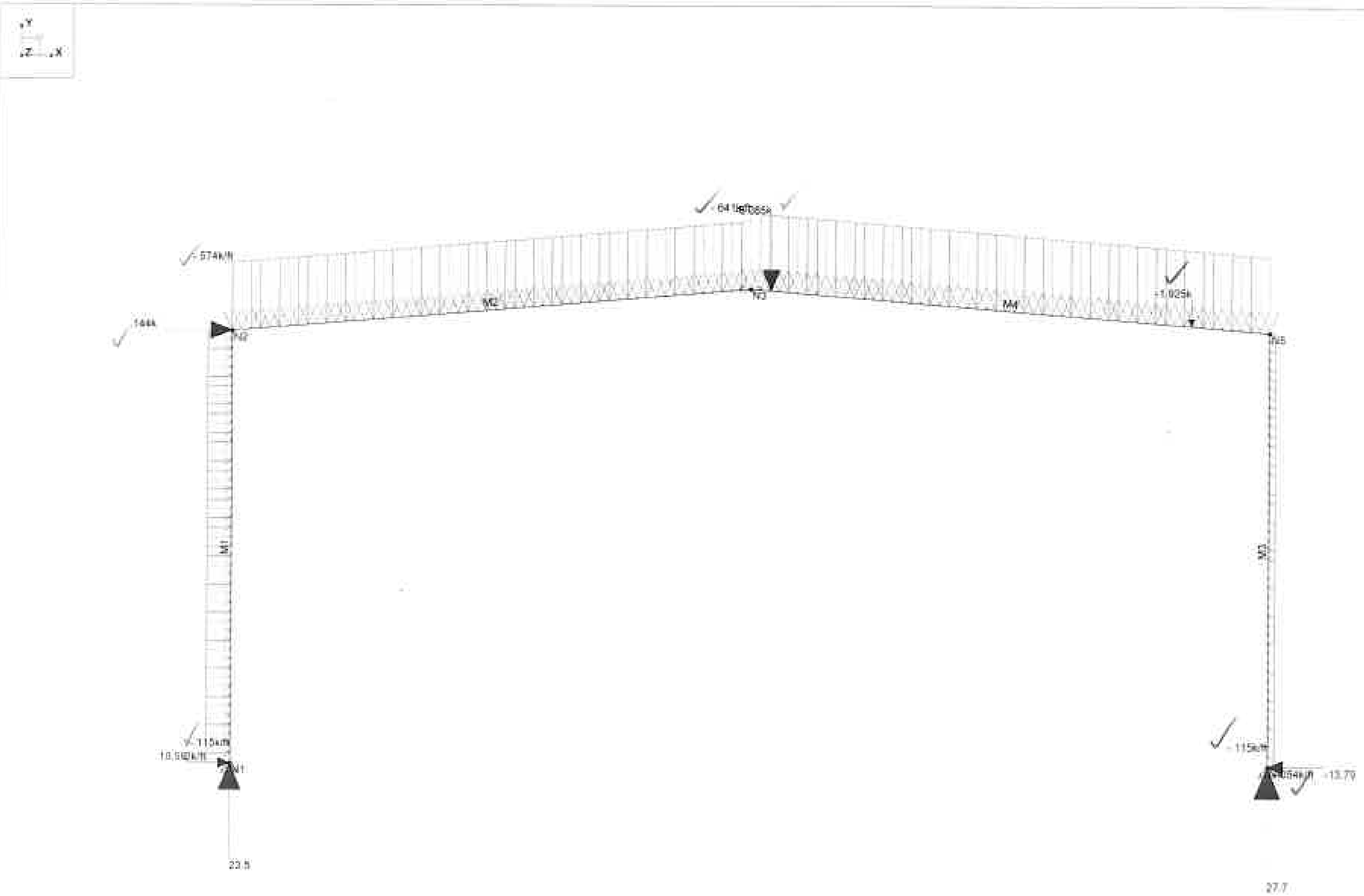
Loads: LC 9, DL max 1 + 0.75 Lr + (0.6*0.75) W1 wall & roof + 0.75 LLr max 1
Results for LC 9, DL max 1 + 0.75 Lr + (0.6*0.75) W1 wall & roof + 0.75 LLr max 1
Z-moment Reaction units are k and k-ft

ARCADIS	Topok Workshop Building	SK - 23
Matt Ltoycz		Jan 5, 2015 at 4:10 PM
		Typical Frame.r2d



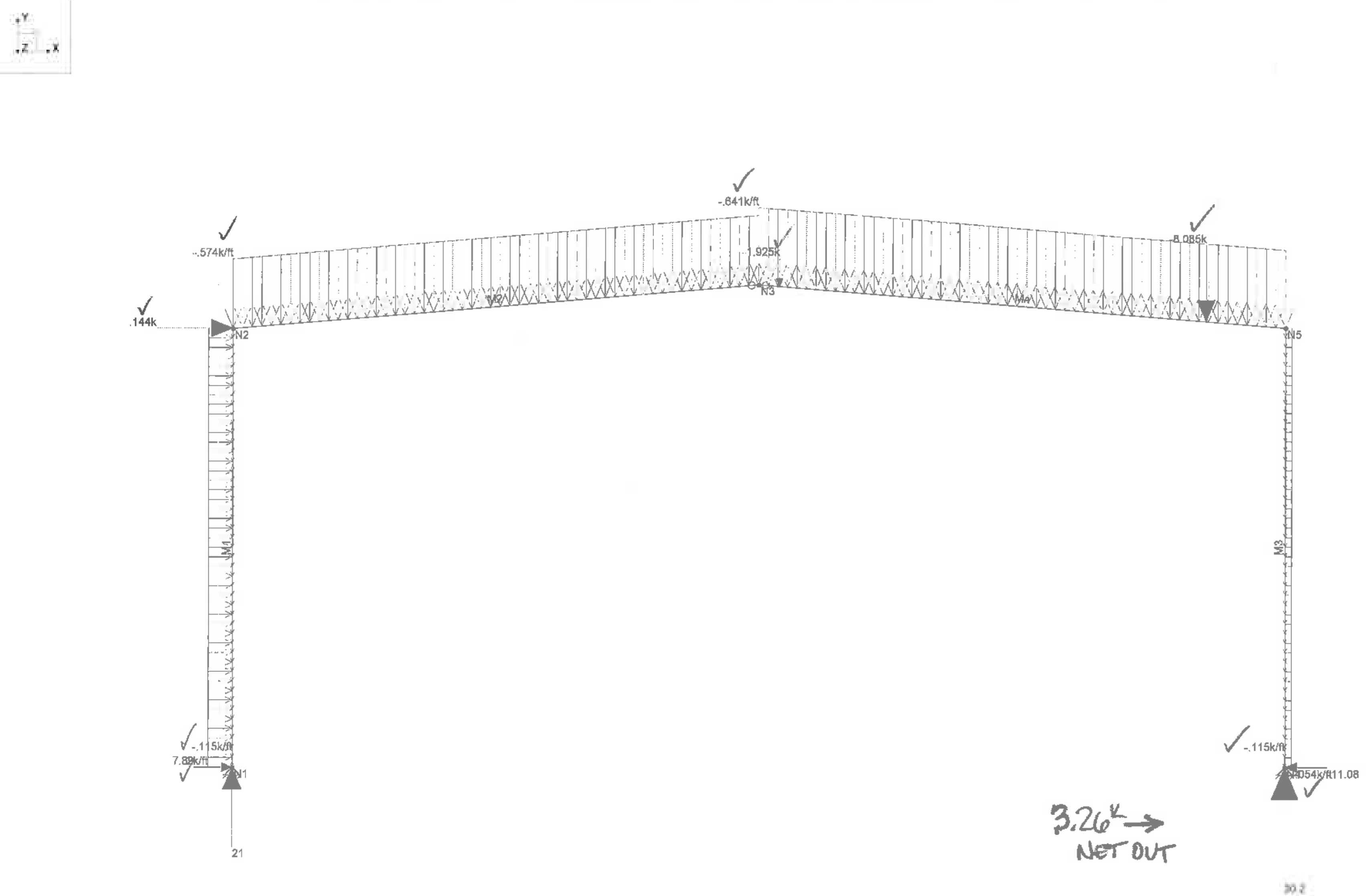
Loads: LC 10, DL max 2 + 0.75 Lr + (0.6*0.75) W1 wall & roof + 0.75 LLr max 2
Results for LC 10, DL max 2 + 0.75 Lr + (0.6*0.75) W1 wall & roof + 0.75 LLr max 2
Z-moment Reaction units are k and k-ft

ARCADIS	Topok Workshop Building	SK - 24
Matt Ltoycz		Jan 5, 2015 at 4:11 PM
		Typical Frame.r2d



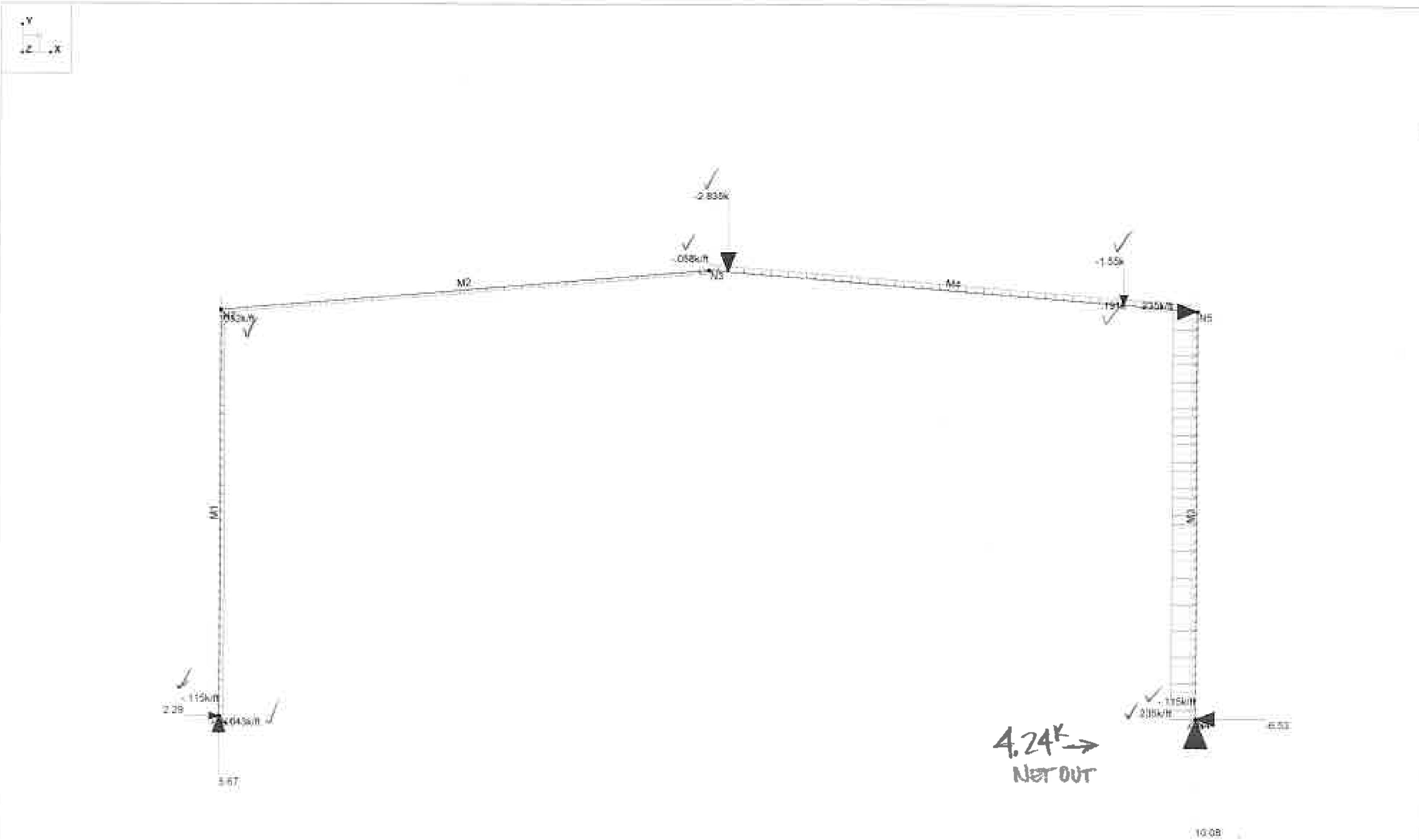
Loads: LC 11, DL max 1 + 0.75 Lr + (0.6*0.75) W2 wall & roof + 0.75 LLr max 1
Results for LC 11, DL max 1 + 0.75 Lr + (0.6*0.75) W2 wall & roof + 0.75 LLr max 1
Z-moment Reaction units are k and k-ft

ARCADIS	Topok Workshop Building	SK - 25
Matt Ltoycz		Jan 5, 2015 at 4:11 PM
		Typical Frame.r2d



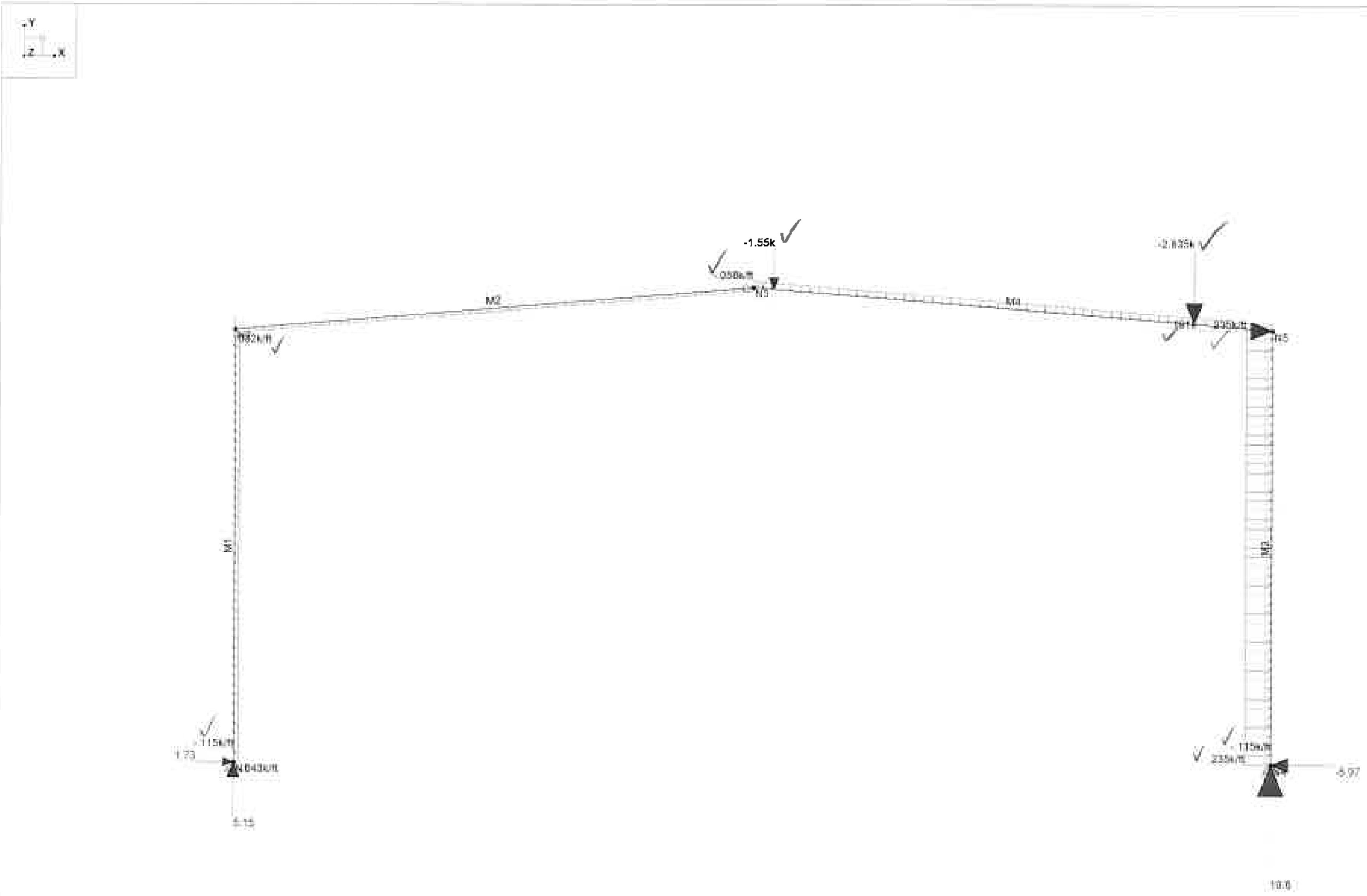
Loads: LC 12, DL max 2 + 0.75 Lr + (0.6*0.75) W2 wall & roof + 0.75 LLr max 2
Results for LC 12, DL max 2 + 0.75 Lr + (0.6*0.75) W2 wall & roof + 0.75 LLr max 2
Z-moment Reaction units are k and k-ft

ARCADIS	Topok Workshop Building	SK - 26
Matt Ltoycz		Jan 5, 2015 at 4:11 PM
		Typical Frame.r2d



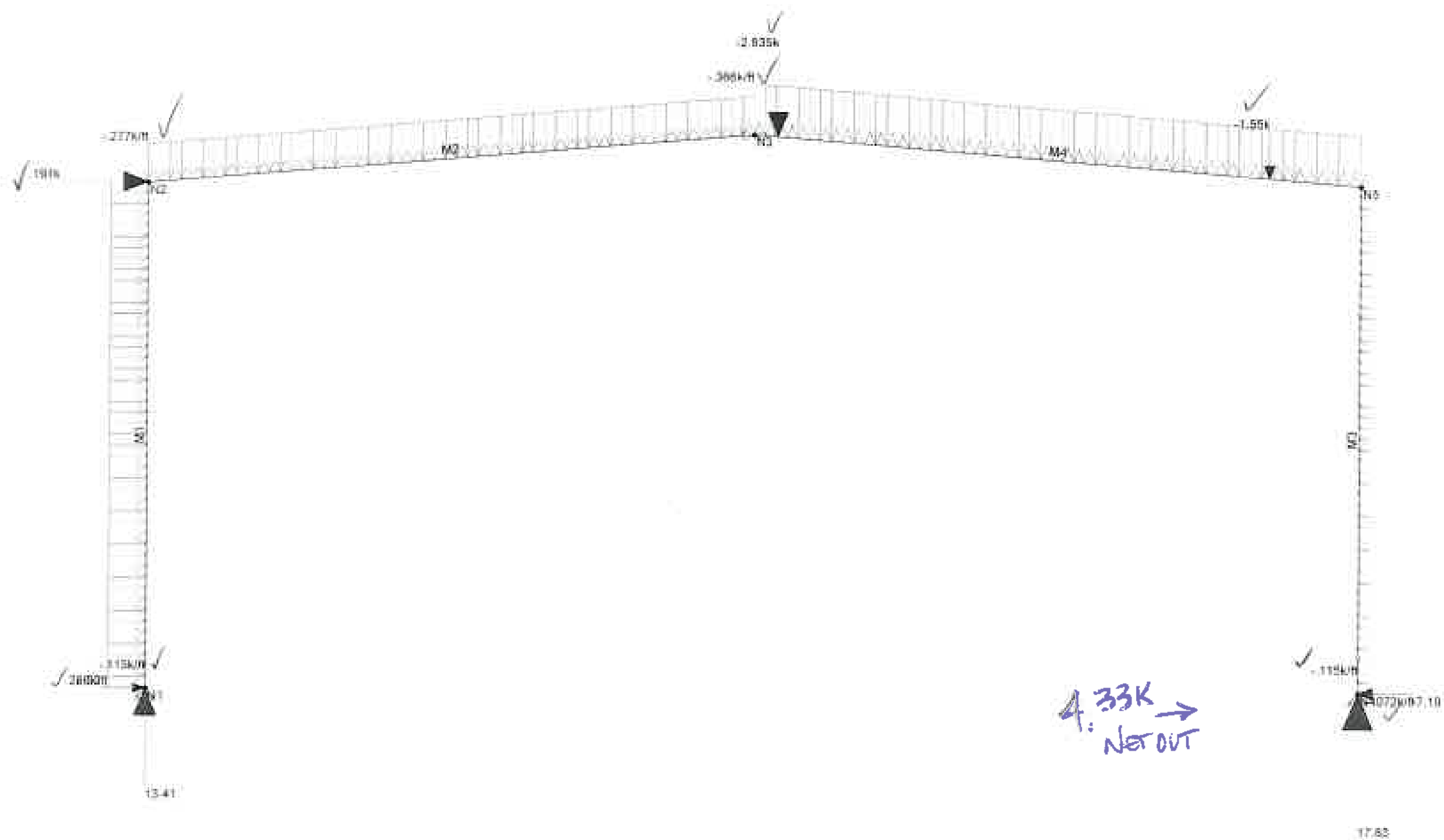
Loads: LC 13, DL max 1 + 0.6W1 wall and roof
Results for LC 13, DL max 1 + 0.6W1 wall and roof
Z-moment Reaction units are k and k-ft

ARCADIS	Topok Workshop Building	SK - 27
Matt Ltoycz		Jan 5, 2015 at 4:11 PM
		Typical Frame.r2d



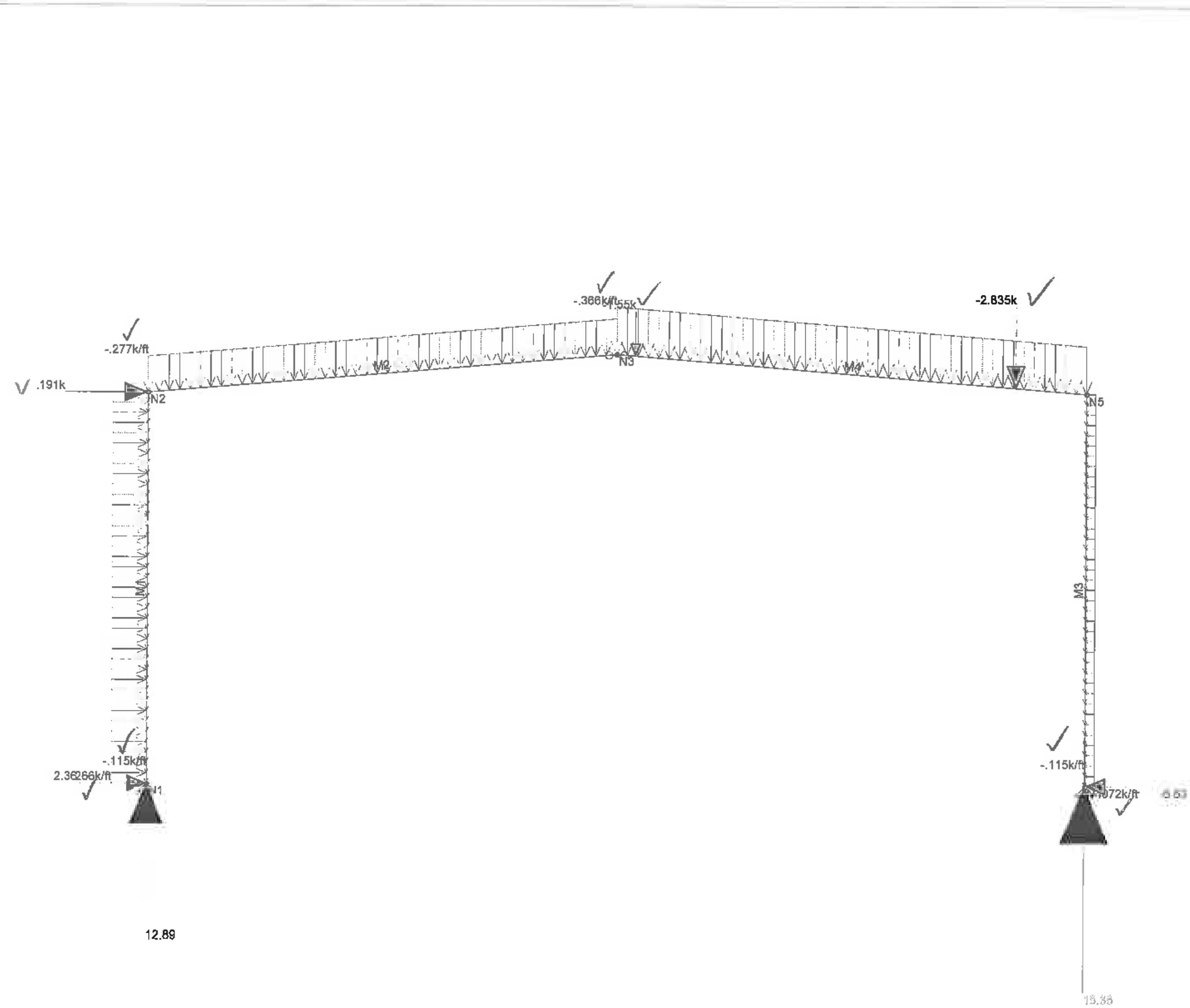
Loads: LC 14, DL max 2 + 0.6W1 wall and roof
Results for LC 14, DL max 2 + 0.6W1 wall and roof
Z-moment Reaction units are k and k-ft

ARCADIS	Topok Workshop Building	SK - 28
Matt Ltoycz		Jan 5, 2015 at 4:11 PM
		Typical Frame.r2d



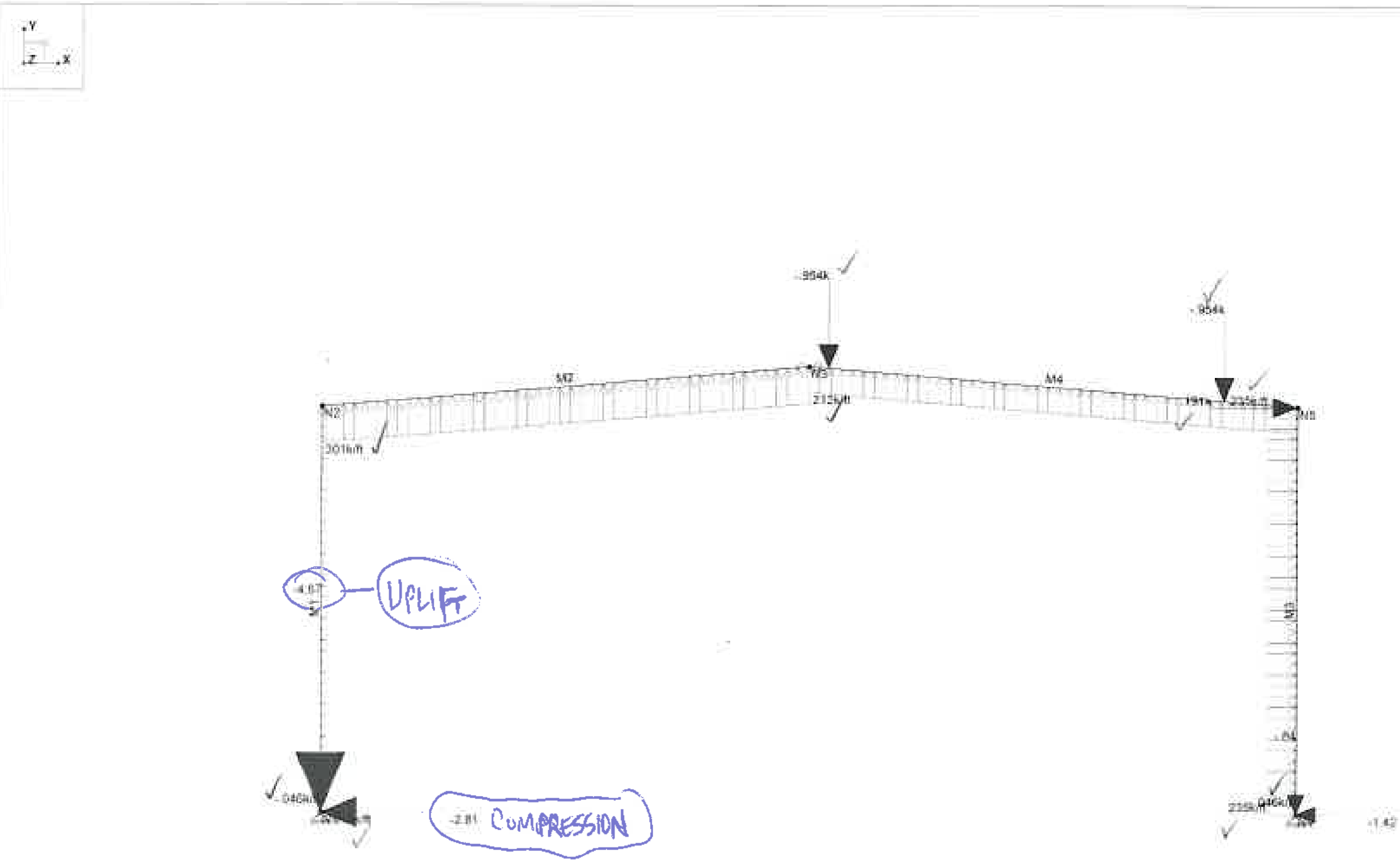
Loads: LC 15, DL max 1 + 0.6W2 wall and roof
Results for LC 15, DL max 1 + 0.6W2 wall and roof
Z-moment Reaction units are k and k-ft

ARCADIS	Topok Workshop Building	SK - 29
Matt Ltoycz		Jan 5, 2015 at 4:12 PM
		Typical Frame r2d



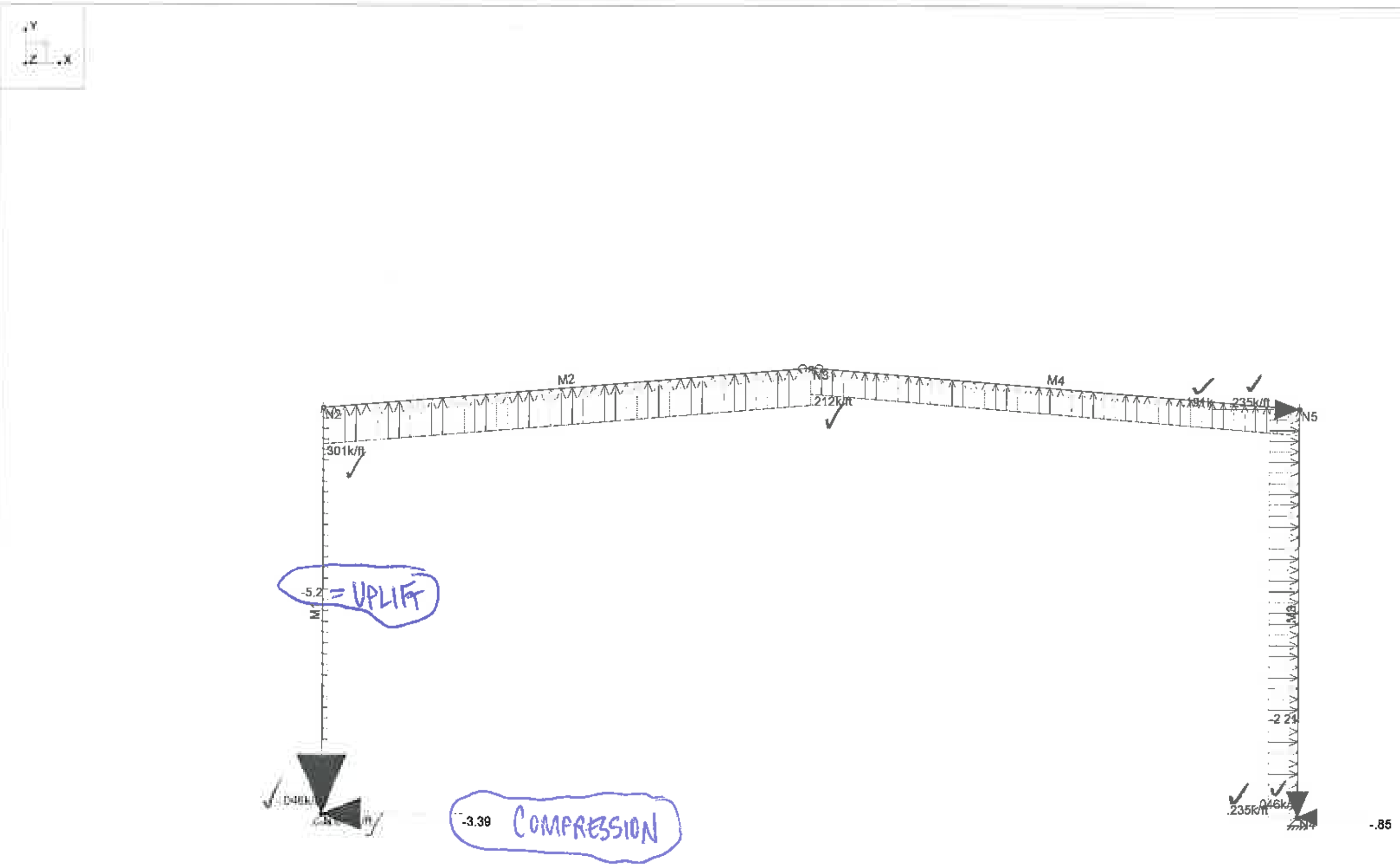
Loads: LC 16, DL max 2 + 0.6W2 wall and roof
Results for LC 16, DL max 2 + 0.6W2 wall and roof
Z-moment Reaction units are k and k-ft

ARCADIS	Topok Workshop Building	SK - 30
Matt Ltoycz		Jan 5, 2015 at 4:12 PM
		Typical Frame.r2d



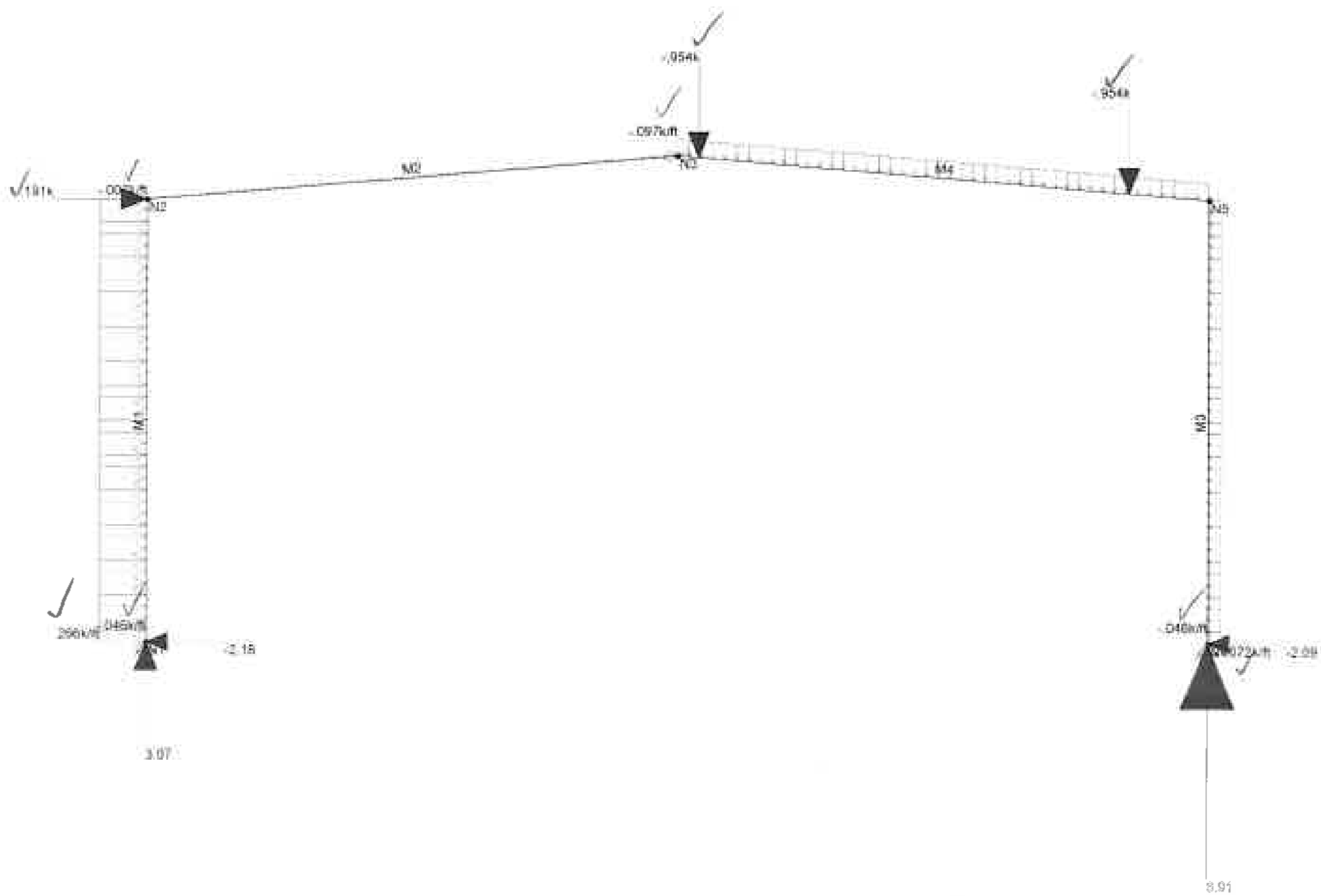
Loads: LC 17, 0.6DL min 1 + 0.6W1 wall & roof
Results for LC 17, 0.6DL min 1 + 0.6W1 wall & roof
Z-moment Reaction units are k and k-ft

ARCADIS	Topok Workshop Building	SK - 31
Matt Ltoycz		Jan 5, 2015 at 4:13 PM
		Typical Frame.r2d



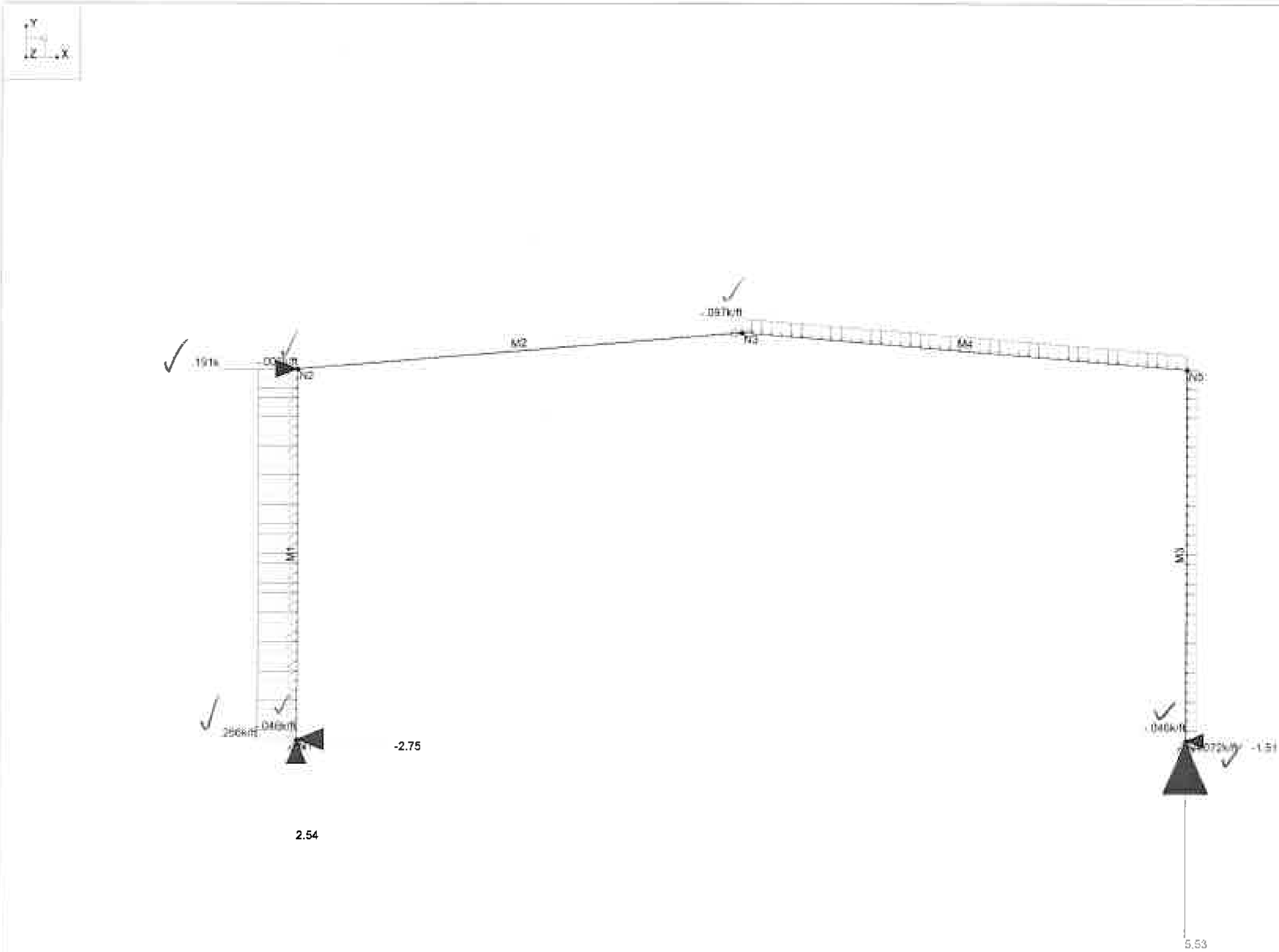
Loads: LC 18, 0.6DL min 2 + 0.6W1 wall & roof
Results for LC 18, 0.6DL min 2 + 0.6W1 wall & roof
Z-moment Reaction units are k and k-ft

ARCADIS	Topok Workshop Building	SK - 32
Matt Ltoycz		Jan 5, 2015 at 4:13 PM
		Typical Frame.r2d



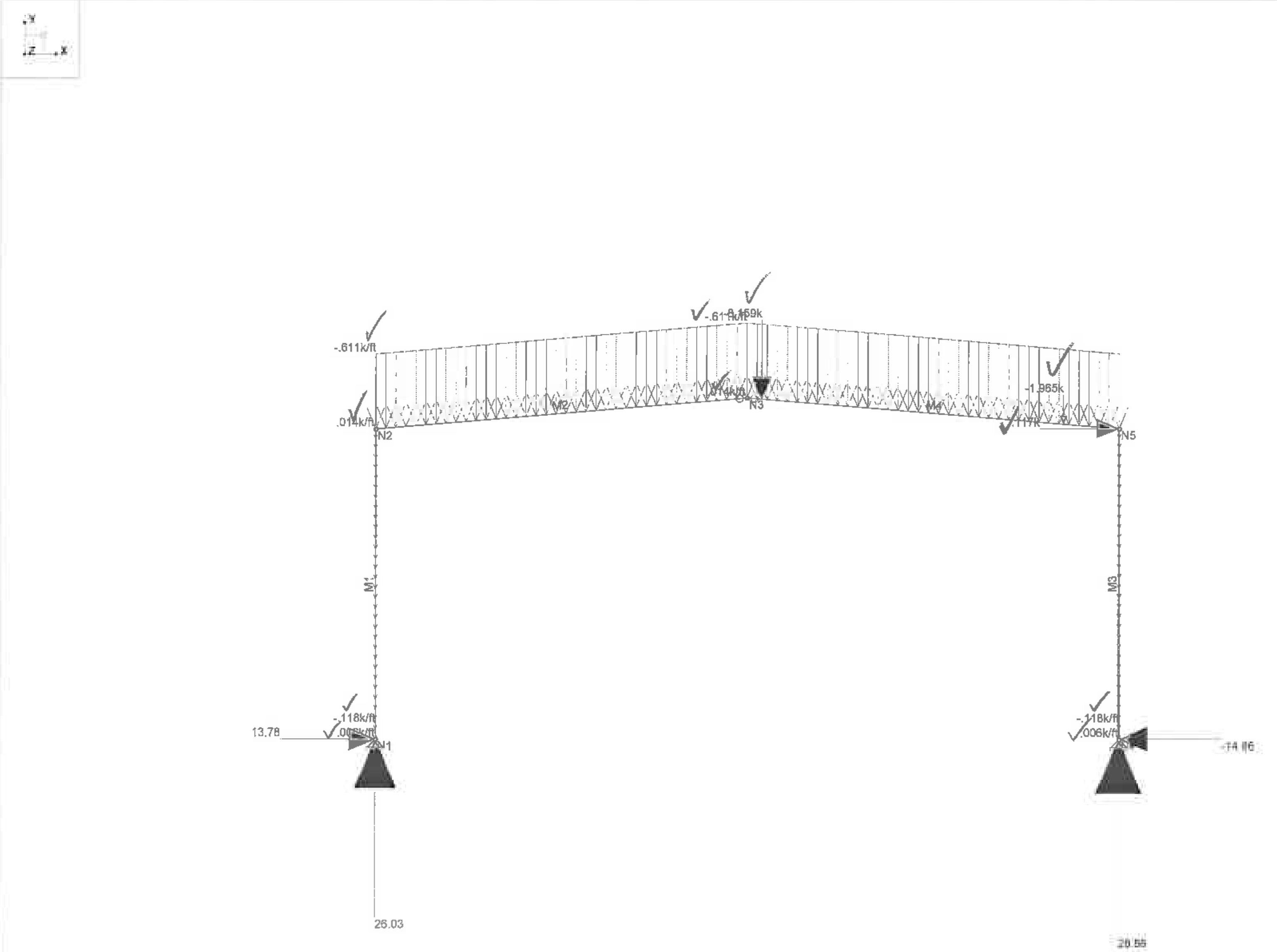
Loads: LC 19, 0.6DL min 1 + 0.6W2 wall and roof
Results for LC 19, 0.6DL min 1 + 0.6W2 wall and roof
Z-moment Reaction units are k and k-ft

ARCADIS	Topok Workshop Building	SK - 33
Matt Ltoycz		Jan 5, 2015 at 4:13 PM
		Typical Frame.r2d



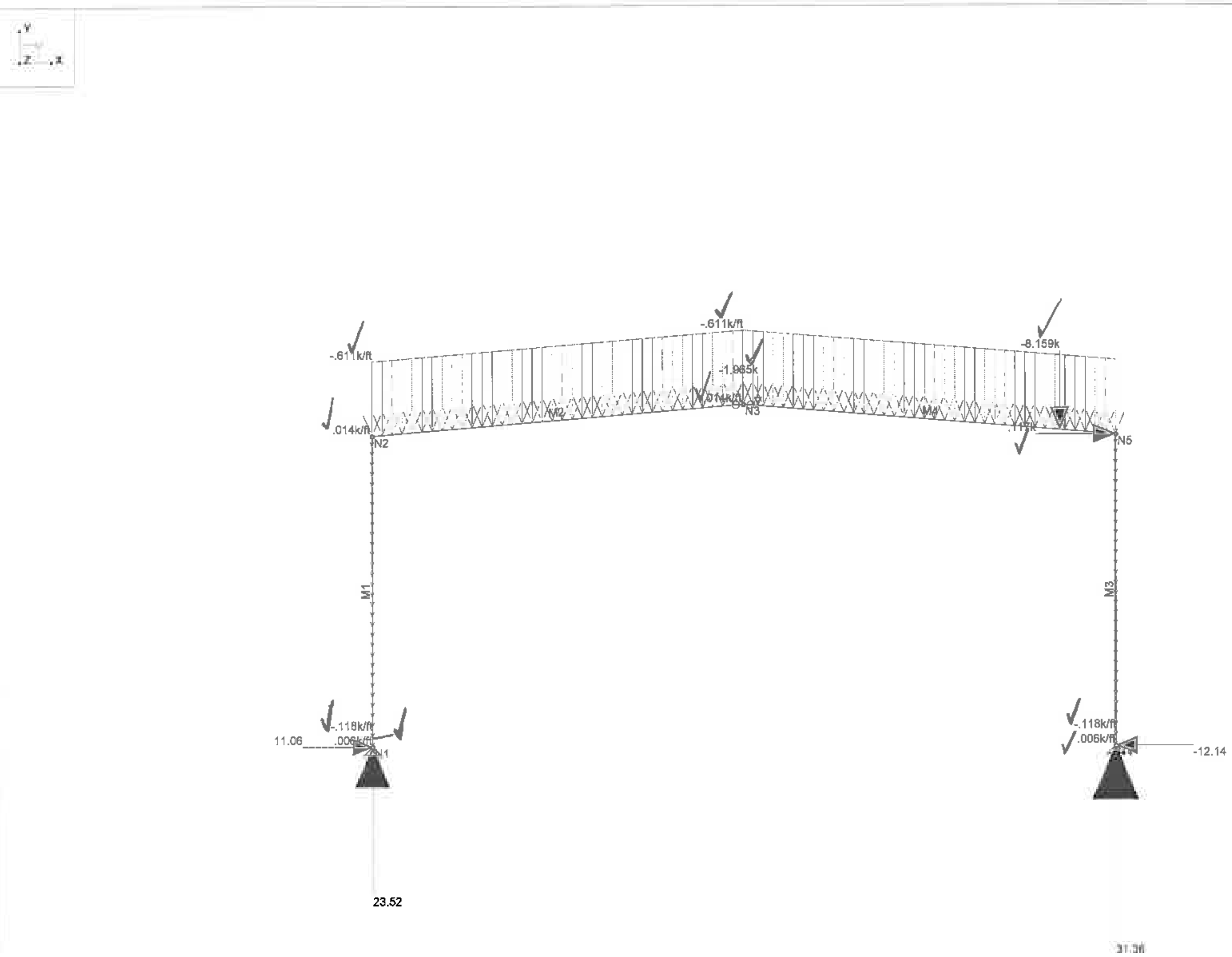
Loads: LC 20, 0.6DL min 2 + 0.6W2 wall and roof
Results for LC 20, 0.6DL min 2 + 0.6W2 wall and roof
Z-moment Reaction units are k and k-ft

ARCADIS	Topok Workshop Building	SK - 34
Matt Ltoycz		Jan 5, 2015 at 4:14 PM
		Typical Frame.r2d



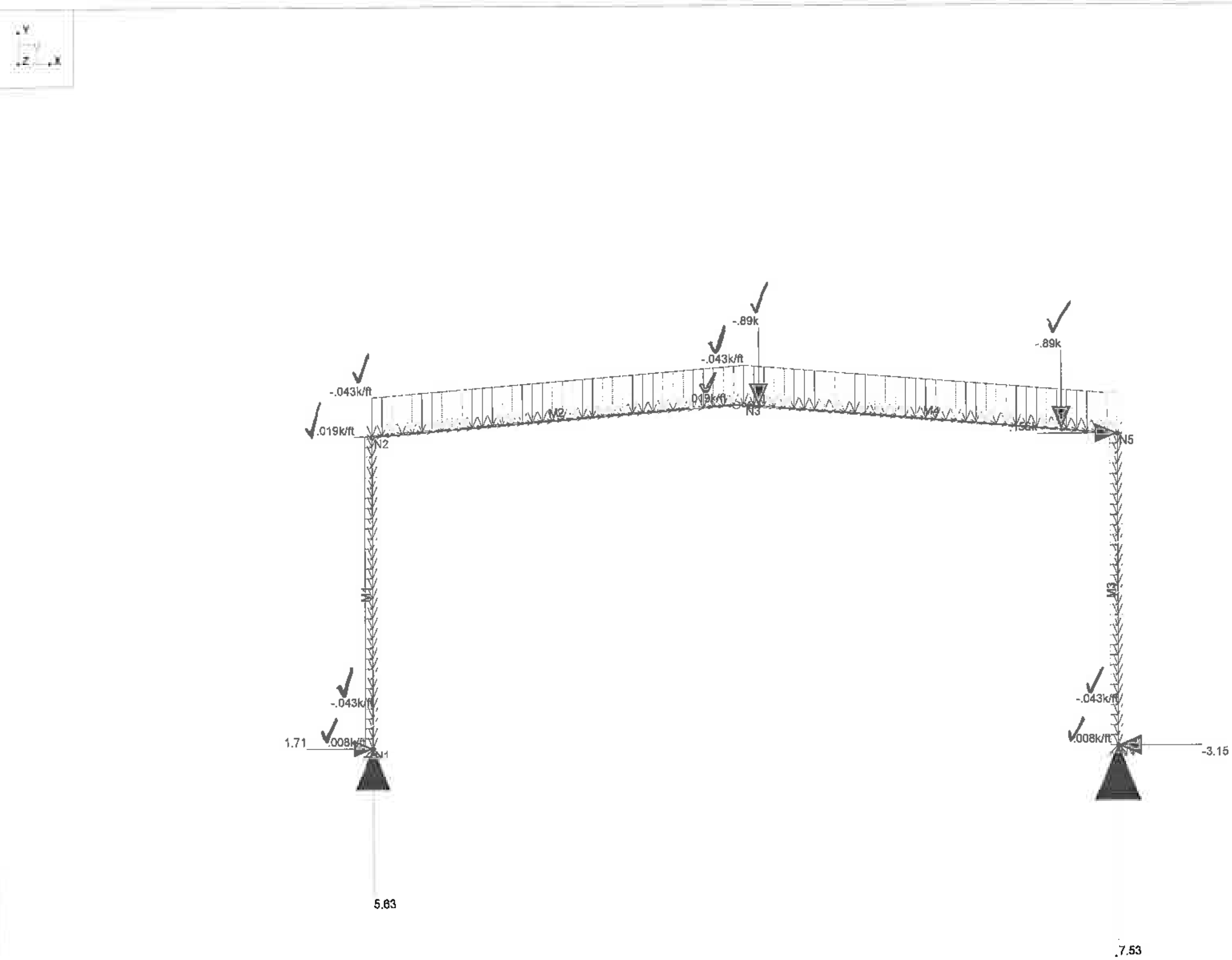
Loads: LC 21, (1+0.105Sds) DL max 1 + 0.75 Lr + 0.75 LLr max 1 + 0.525E
Results for LC 21, (1+0.105Sds) DL max 1 + 0.75 Lr + 0.75 LLr max 1 + 0.525E
Z-moment Reaction units are k and k-ft

ARCADIS	Topok Workshop Building	SK - 35
Matt Ltoycz		Jan 5, 2015 at 4:14 PM
		Typical Frame.r2d



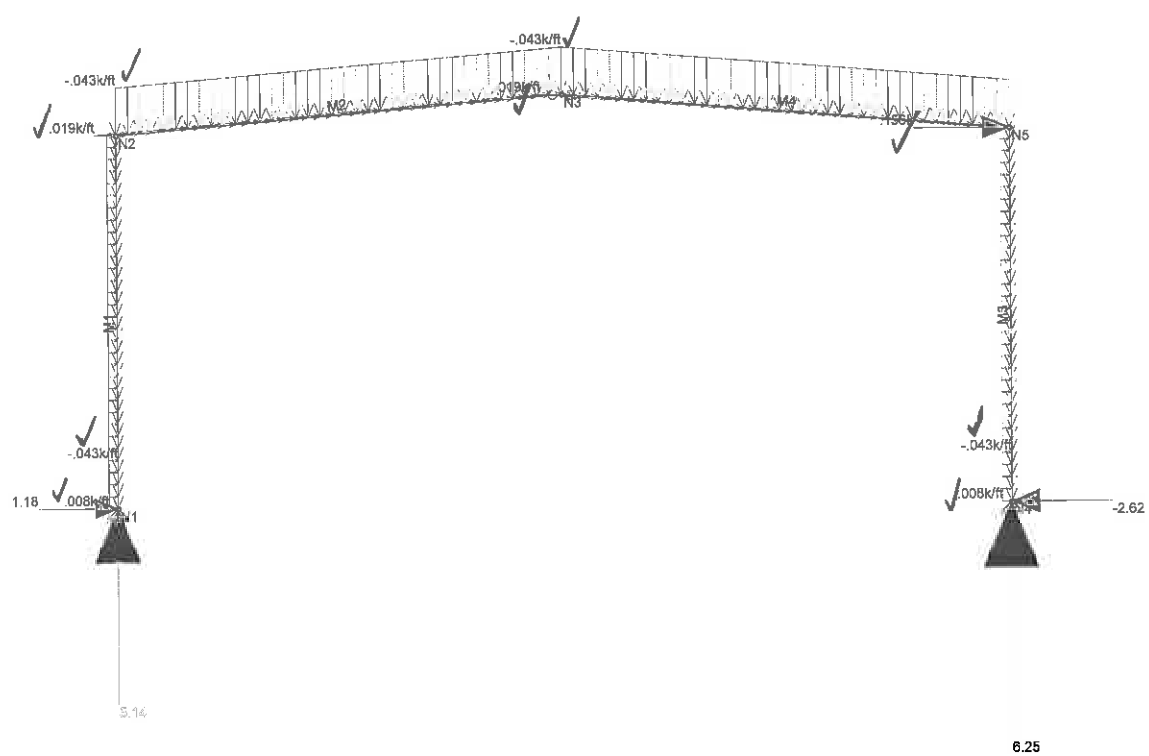
Loads: LC 22, (1+0.105Sds) DL max 2 + 0.75 Lr + 0.75 LLr max 2 + 0.525E
Results for LC 22, (1+0.105Sds) DL max 2 + 0.75 Lr + 0.75 LLr max 2 + 0.525E
Z-moment Reaction units are k and k-ft

ARCADIS	Topok Workshop Building	SK - 36
Matt Ltoycz		Jan 5, 2015 at 4:14 PM
		Typical Frame.r2d



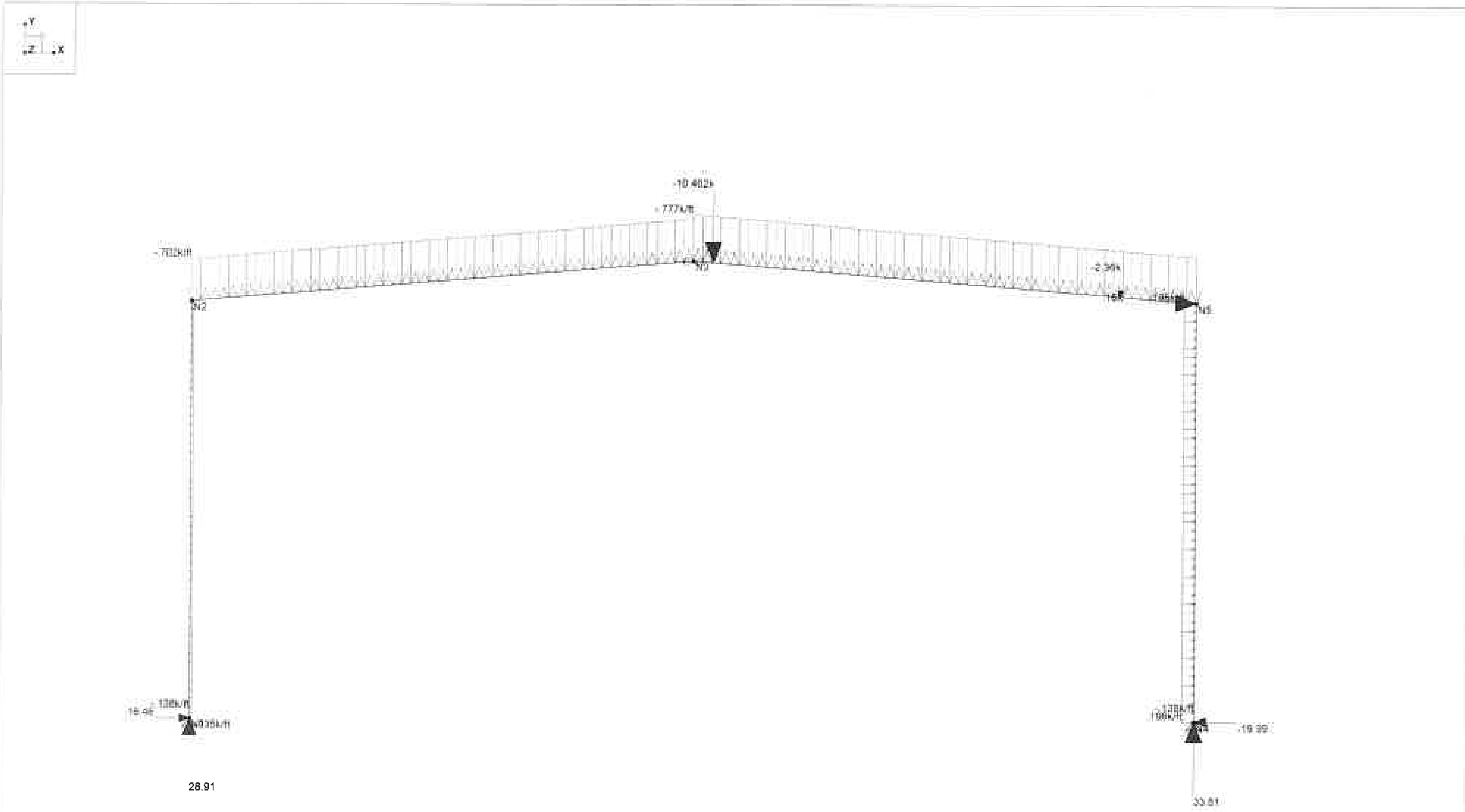
Loads: LC 23, 0.6DL min 1 + 0.7E
Results for LC 23, 0.6DL min 1 + 0.7E
Z-moment Reaction units are k and k-ft

ARCADIS	Topok Workshop Building	SK - 37
Matt Ltoycz		Jan 5, 2015 at 4:14 PM
		Typical Frame.r2d



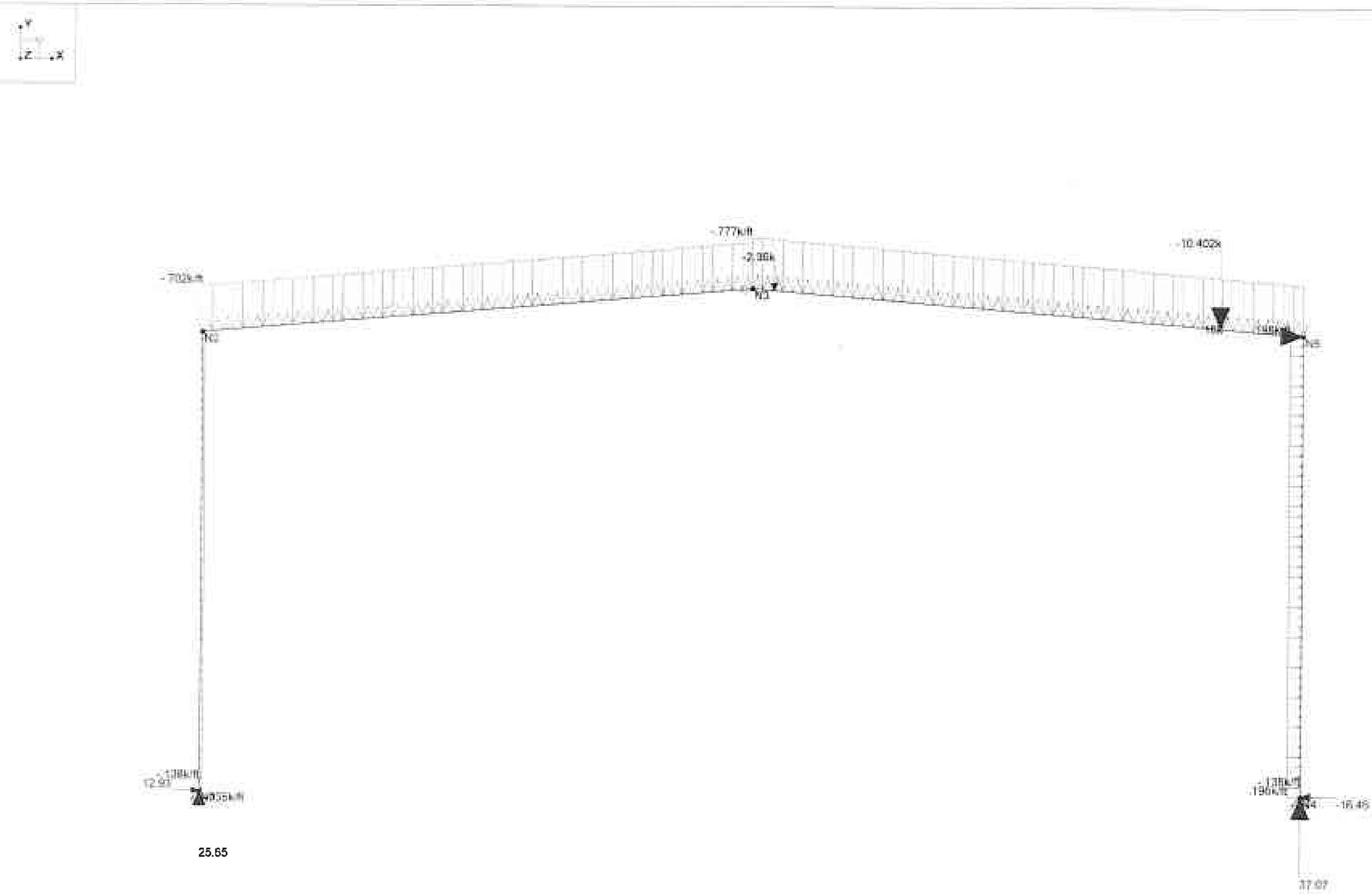
Loads: LC 24, 0.6DL min 2 + 0.7E
Results for LC 24, 0.6DL min 2 + 0.7E
Z-moment Reaction units are k and k-ft

ARCADIS	Topok Workshop Building	SK - 38
Matt Ltoycz		Jan 5, 2015 at 4:14 PM
		Typical Frame.r2d



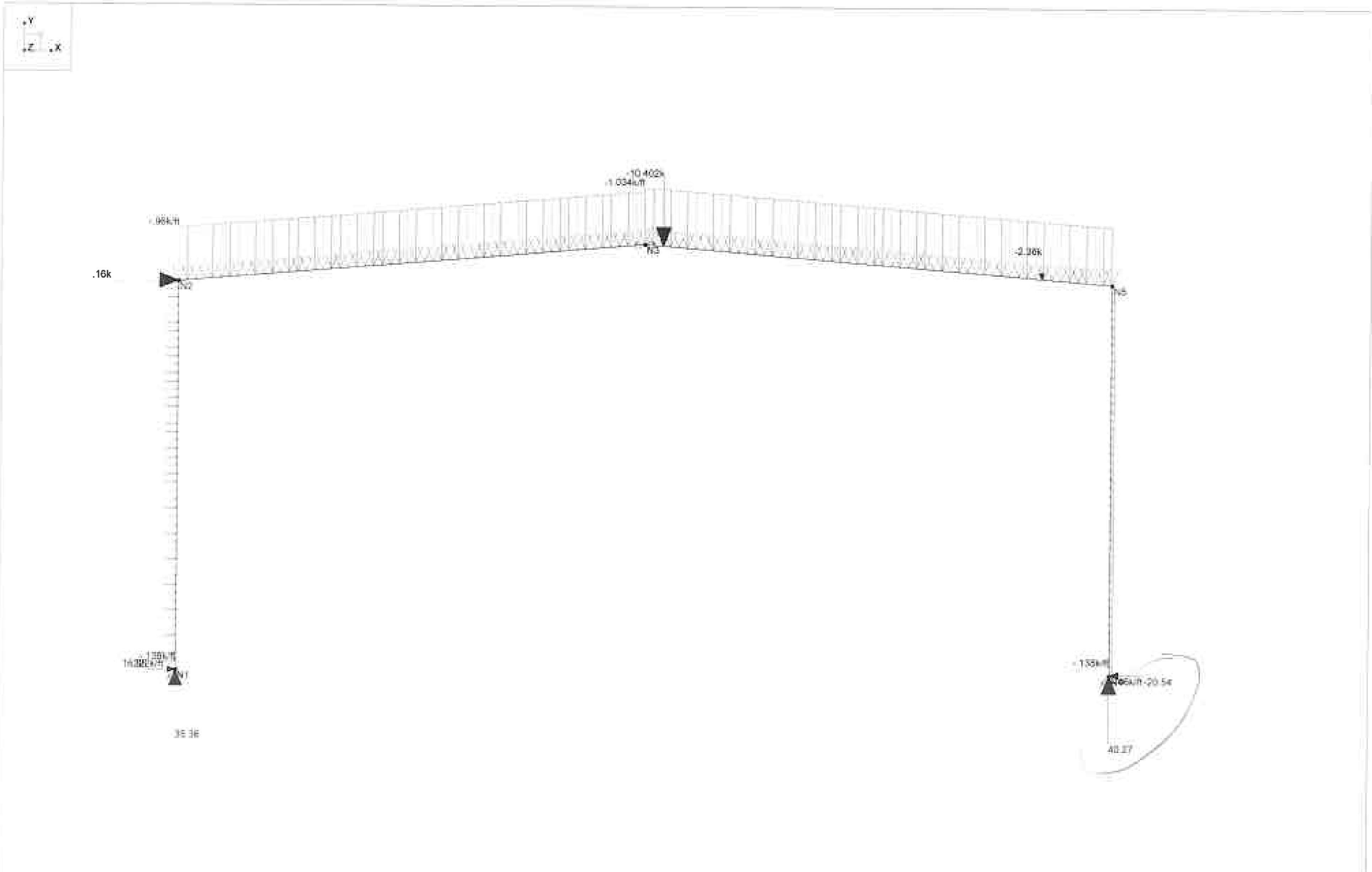
Loads: LC 25, 1.2DL max 1 + 1.6 Lr + 1.0 Lrr max 1 + 0.5 W1 wall and roof
Results for LC 25, 1.2DL max 1 + 1.6 Lr + 1.0 Lrr max 1 + 0.5 W1 wall and roof
Z-moment Reaction units are k and k-ft

ARCADIS	Topok Workshop Building	SK - 1
Matt Ltoycz		Jan 7, 2015 at 2:47 PM
		Typical Frame.r2d



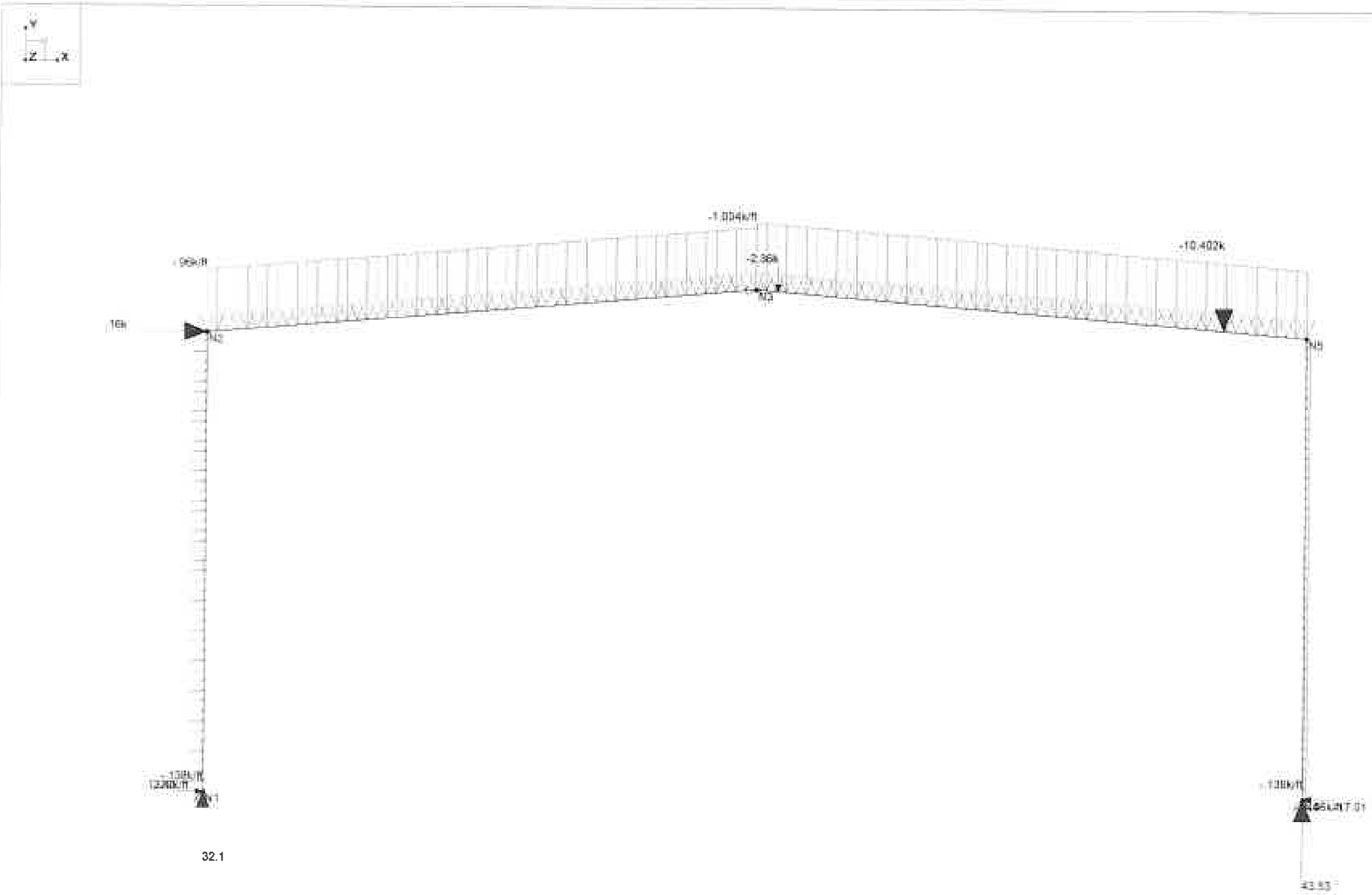
Loads: LC 26, 1.2DL max 2 + 1.6 Lr + 1.0 Lr max 2 + 0.5 W1 wall and roof
Results for LC 26, 1.2DL max 2 + 1.6 Lr + 1.0 Lr max 2 + 0.5 W1 wall and roof
Z-moment Reaction units are k and k-ft

ARCADIS	Topok Workshop Building	SK - 2
Matt Ltoycz		Jan 7, 2015 at 2:47 PM
		Typical Frame.r2d



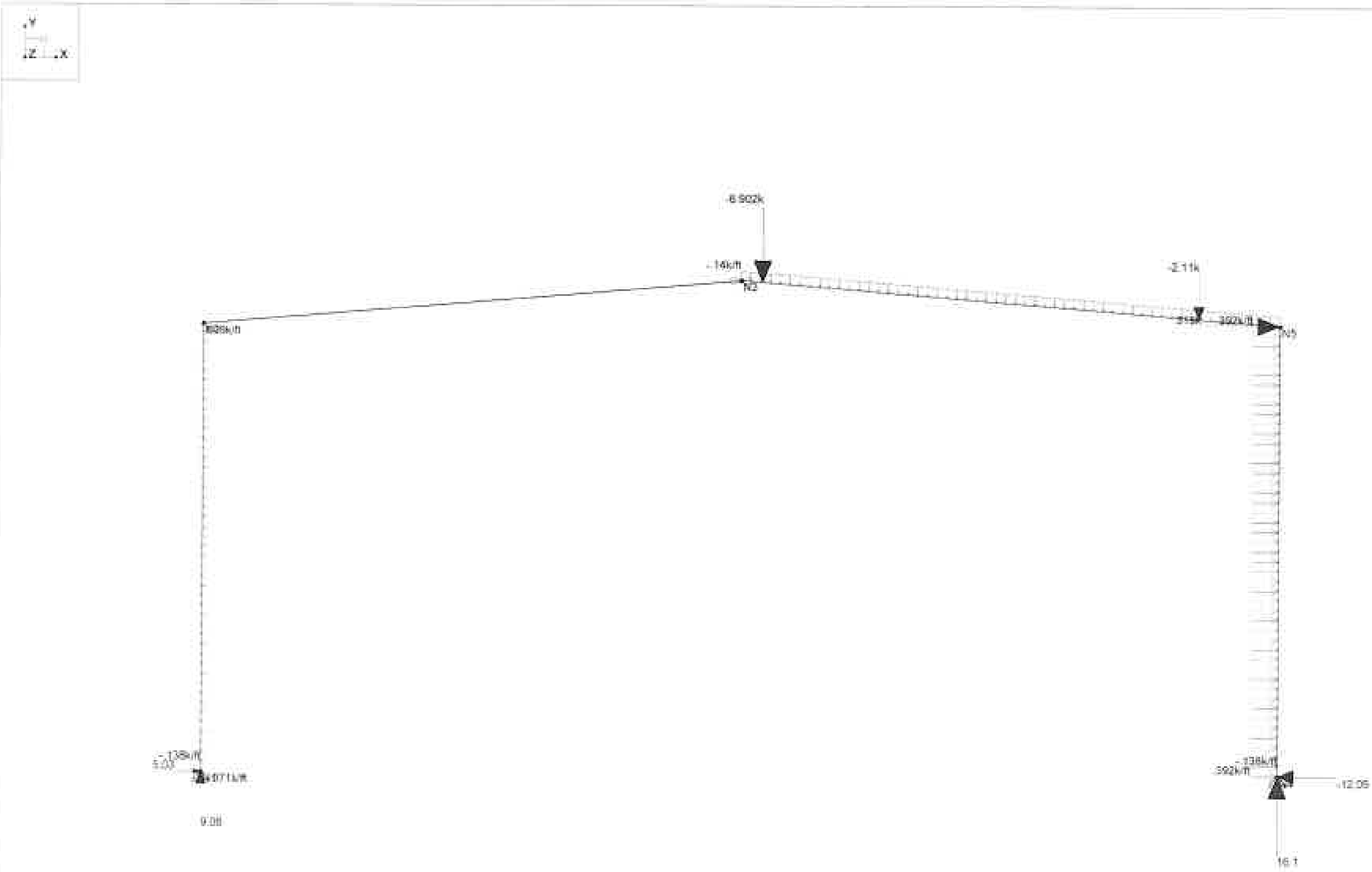
Loads: LC 27, 1.2DL max 1 + 1.6 Lr + 1.0 Lrr max 1 + 0.5 W2 wall and roof
Results for LC 27, 1.2DL max 1 + 1.6 Lr + 1.0 Lrr max 1 + 0.5 W2 wall and roof
Z-moment Reaction units are k and k-ft

ARCADIS	Topok Workshop Building	SK - 3
Matt Ltoycz		Jan 7, 2015 at 2:47 PM
		Typical Frame.r2d



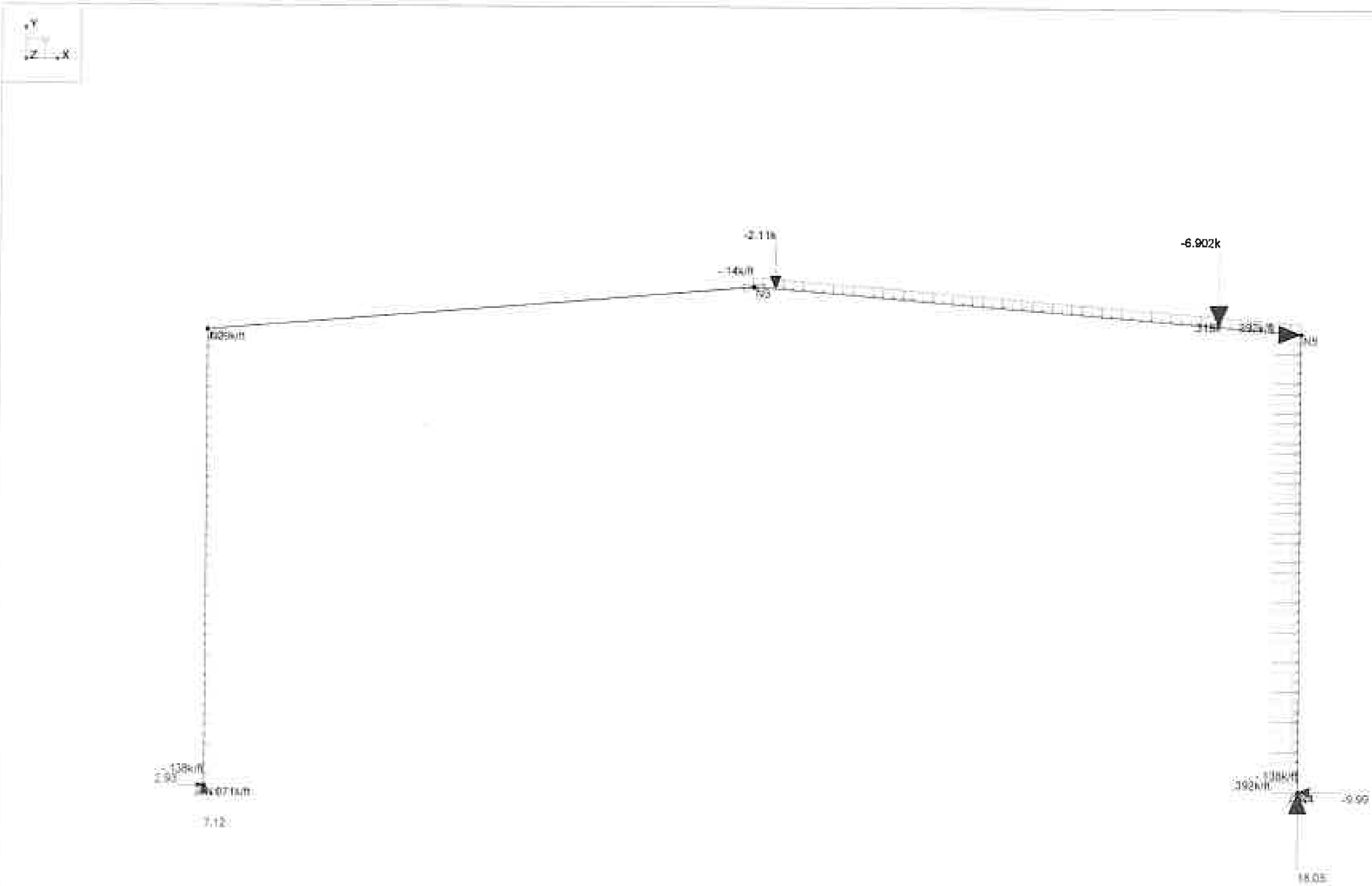
Loads: LC 28, 1.2DL max 2 + 1.6 Lr + 1.0 Lrr max 2 + 0.5 W2 wall and roof
Results for LC 28, 1.2DL max 2 + 1.6 Lr + 1.0 Lrr max 2 + 0.5 W2 wall and roof
Z-moment Reaction units are k and k-ft

ARCADIS	Topok Workshop Building	SK - 4
Matt Ltoycz		Jan 7, 2015 at 2:48 PM
		Typical Frame r2d



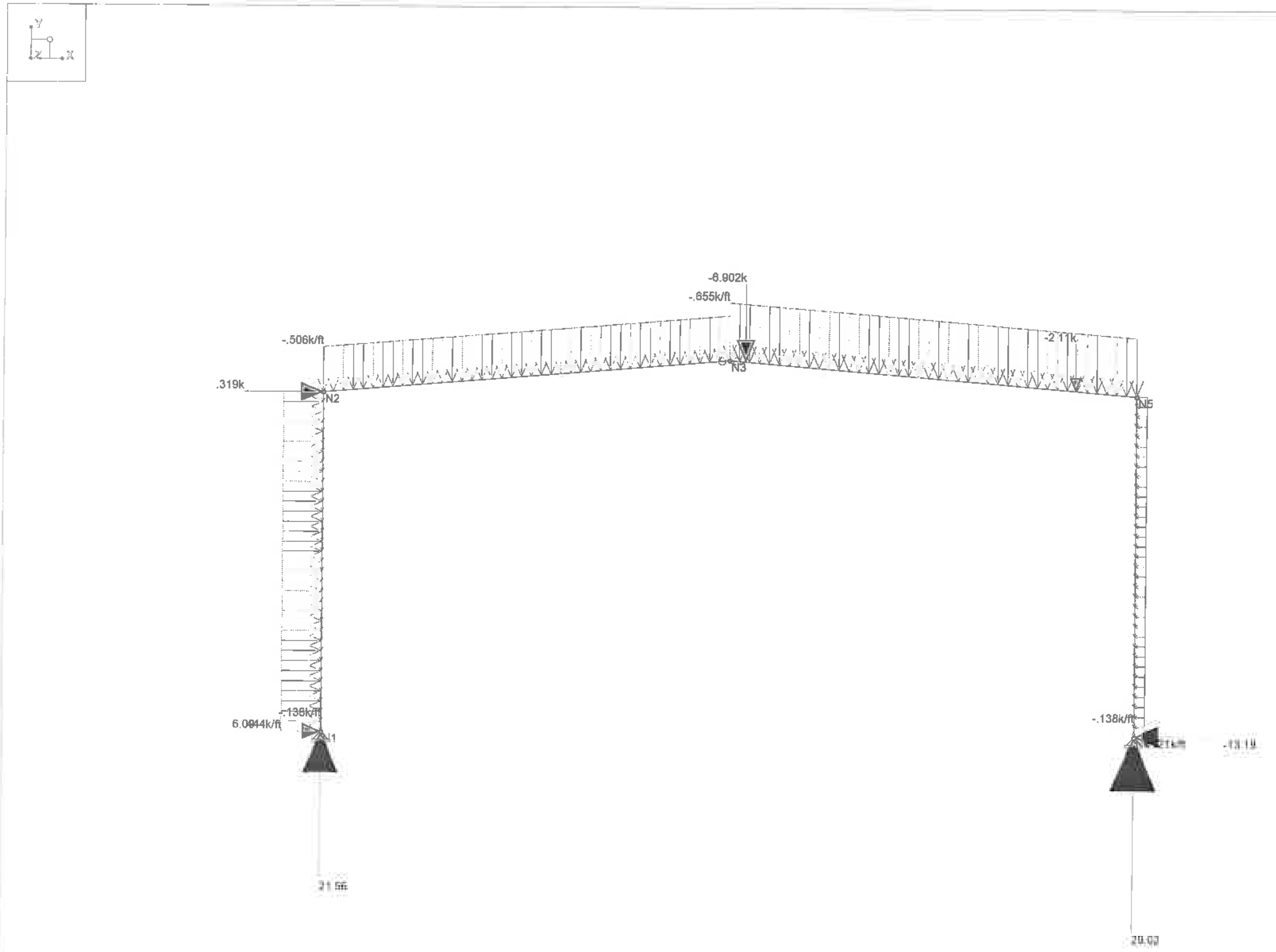
Loads: LC 29, 1.2DL max 1 + 0.5 Lr + 0.5 Lr max 1 + 1.0 W1 wall and roof
Results for LC 29, 1.2DL max 1 + 0.5 Lr + 0.5 Lr max 1 + 1.0 W1 wall and roof
Z-moment Reaction units are k and k-ft

ARCADIS	Topok Workshop Building	SK - 5
Matt Ltoycz		Jan 7, 2015 at 2:48 PM
		Typical Frame.r2d



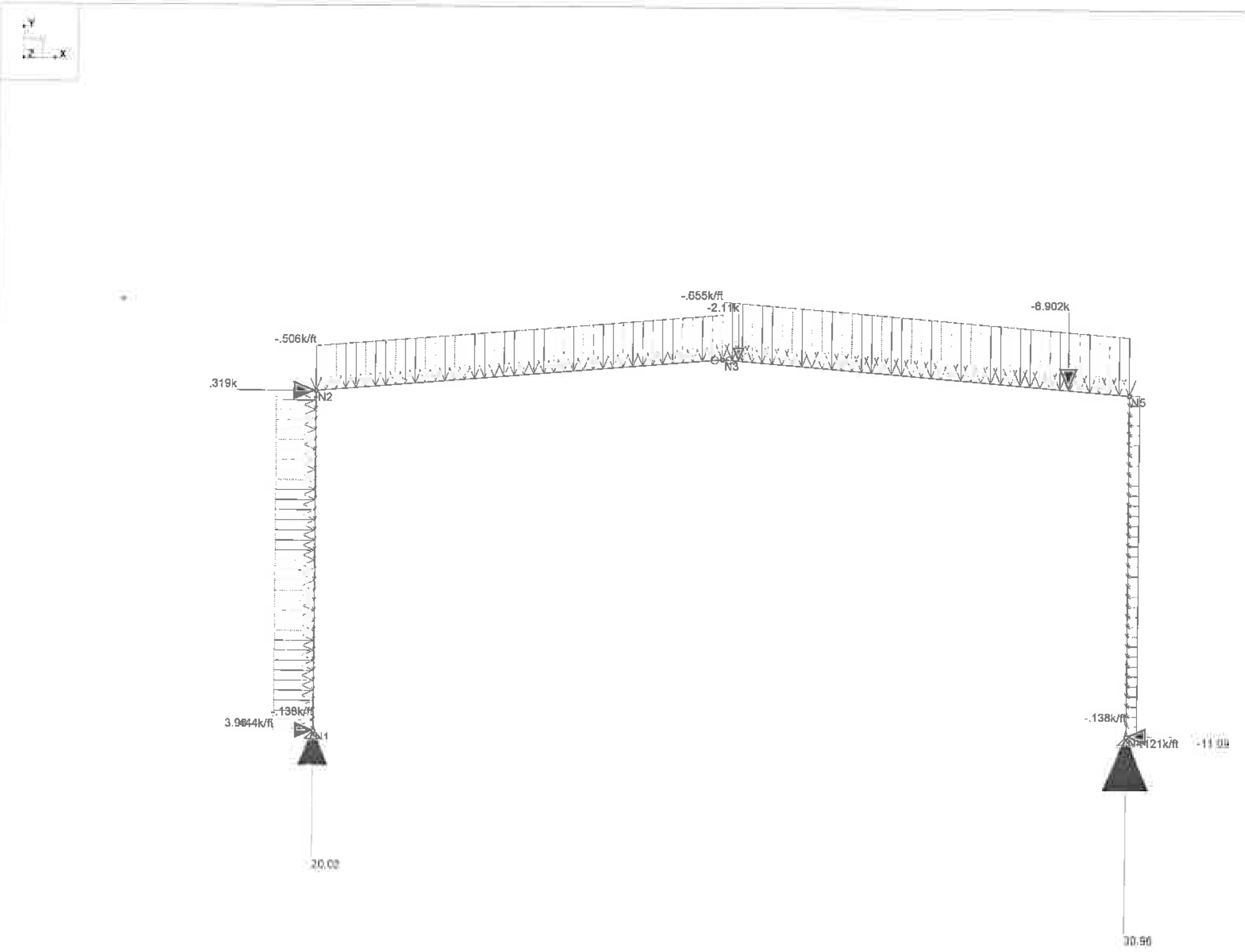
Loads: LC 30, 1.2DL max 2 + 0.5 Lr + 0.5 Lr max 2 + 1.0 W1 wall and roof
Results for LC 30, 1.2DL max 2 + 0.5 Lr + 0.5 Lr max 2 + 1.0 W1 wall and roof
Z-moment Reaction units are k and k-ft

ARCADIS	Topok Workshop Building	SK - 6
Matt Ltoycz		Jan 7, 2015 at 2:48 PM
		Typical Frame.r2d



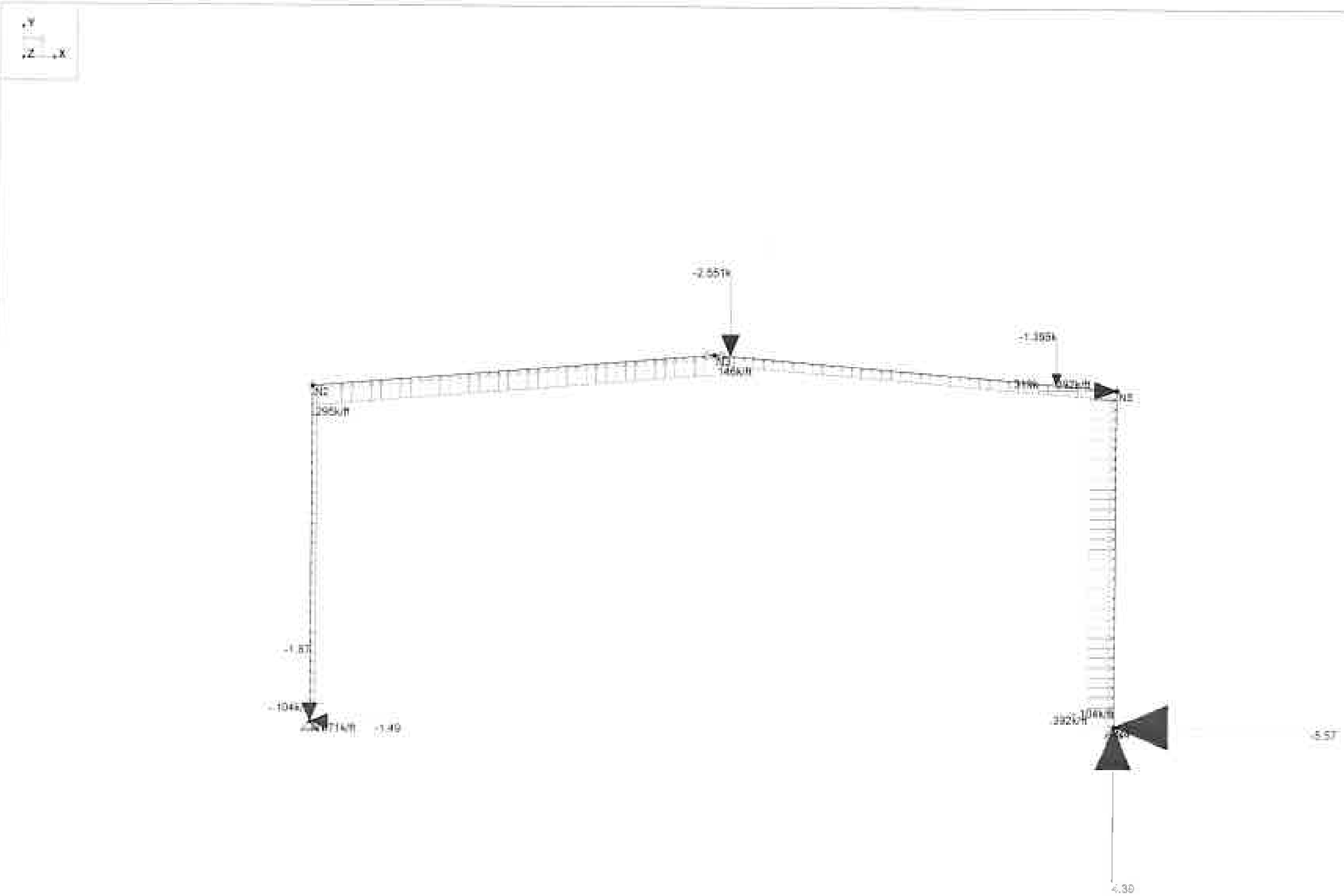
Loads: LC 31, 1.2DL max 1 + 0.5 Lr + 0.5 Lr max 1 + 1.0 W2 wall and roof
Results for LC 31, 1.2DL max 1 + 0.5 Lr + 0.5 Lr max 1 + 1.0 W2 wall and roof
Z-moment Reaction units are k and k-ft

ARCADIS	Topok Workshop Building	SK - 7
Matt Ltoycz		Jan 7, 2015 at 2:49 PM
		Typical Frame.r2d



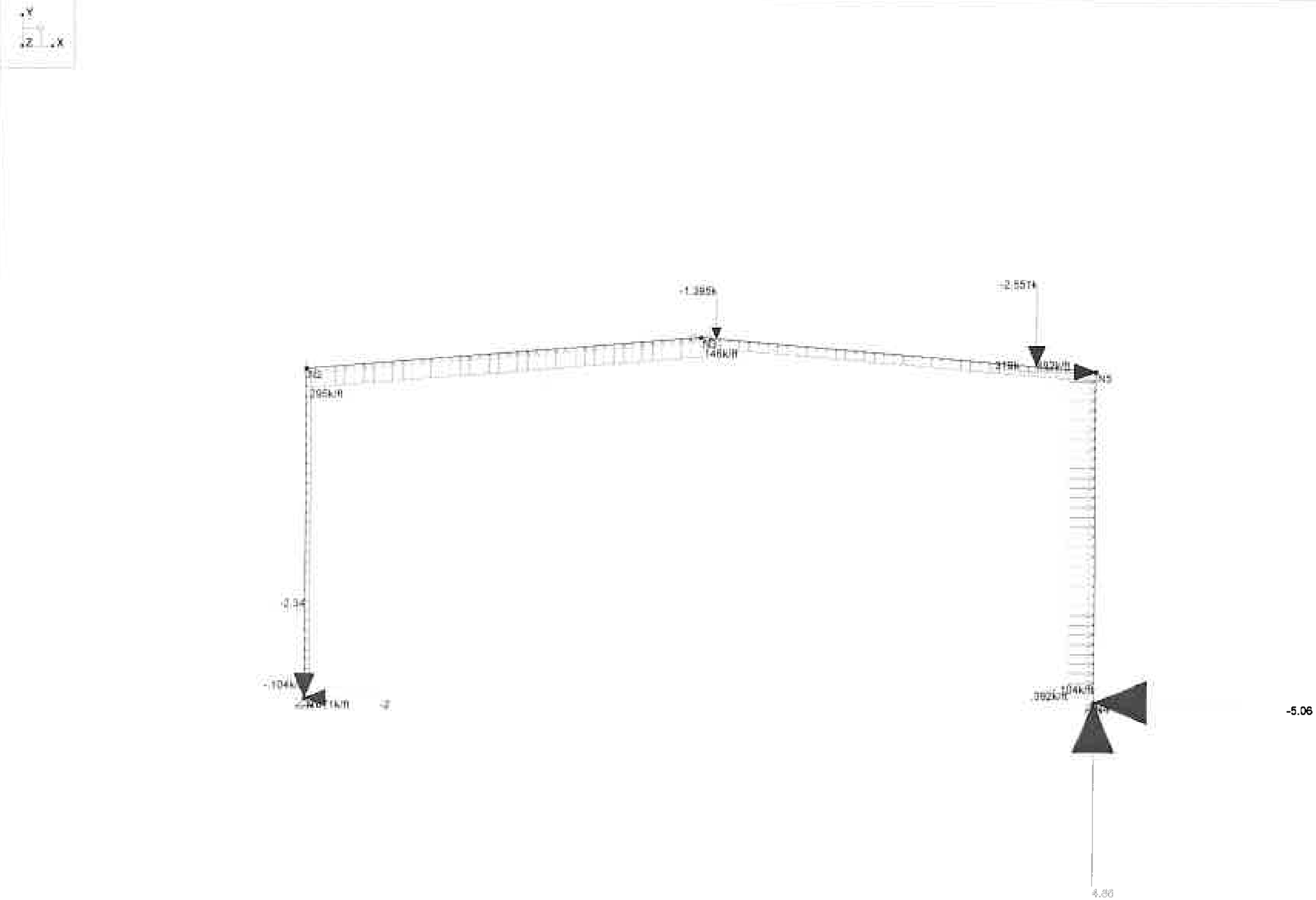
Loads: LC 32, 1.2DL max 2 + 0.5 Lr + 0.5 Lr max 2 + 1.0 W2 wall and roof
Results for LC 32, 1.2DL max 2 + 0.5 Lr + 0.5 Lr max 2 + 1.0 W2 wall and roof
Z-moment Reaction units are k and k-ft

ARCADIS	Topok Workshop Building	SK - 8
Matt Ltoycz		Jan 7, 2015 at 2:50 PM
		Typical Frame.r2d



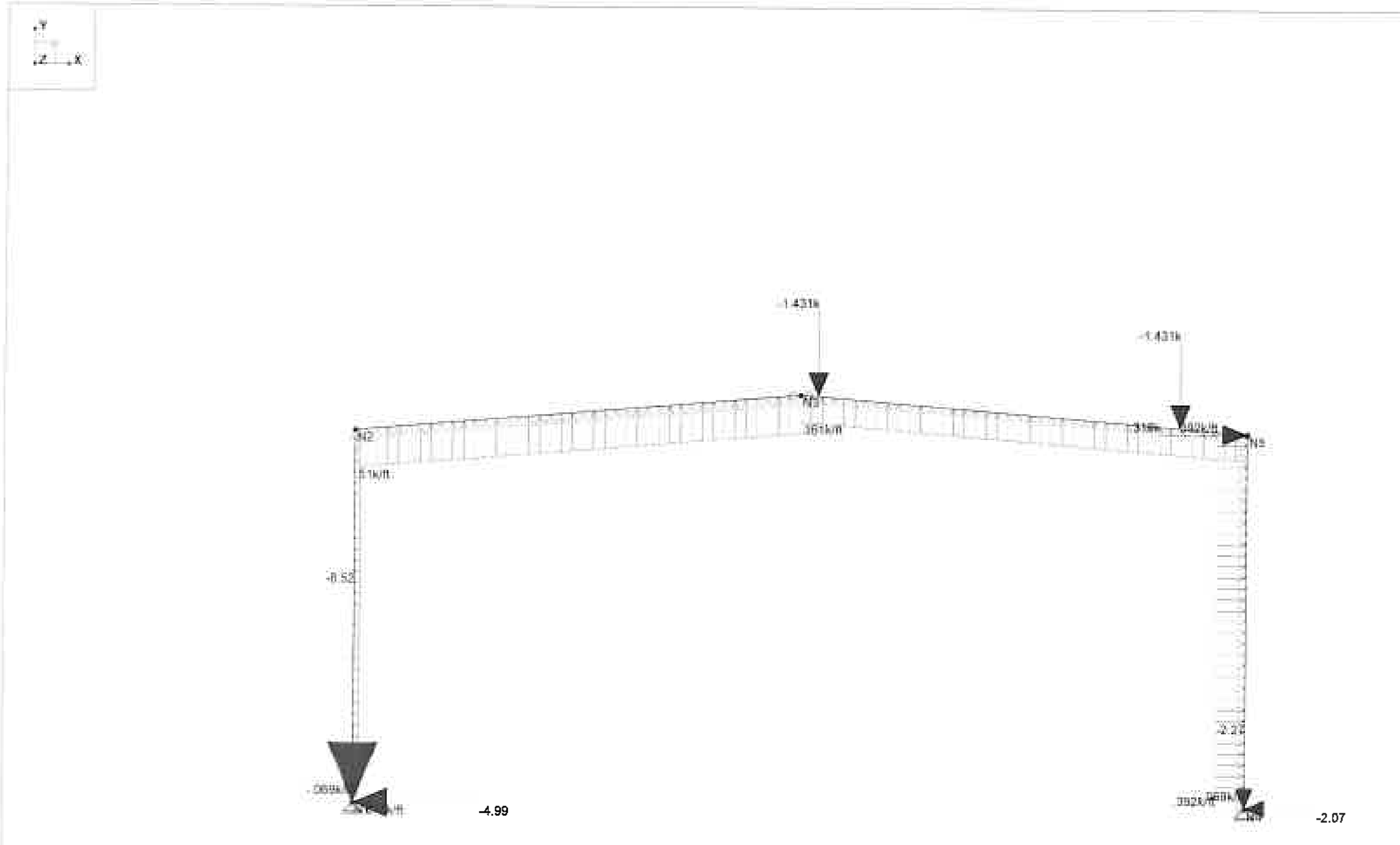
Loads: LC 33, 0.9DL max 1 + 1.0W1 roof and wall
Results for LC 33, 0.9DL max 1 + 1.0W1 roof and wall
Z-moment Reaction units are k and k-ft

ARCADIS	Topok Workshop Building	SK - 9
Matt Ltoycz		Jan 7, 2015 at 2:50 PM
		Typical Frame.r2d



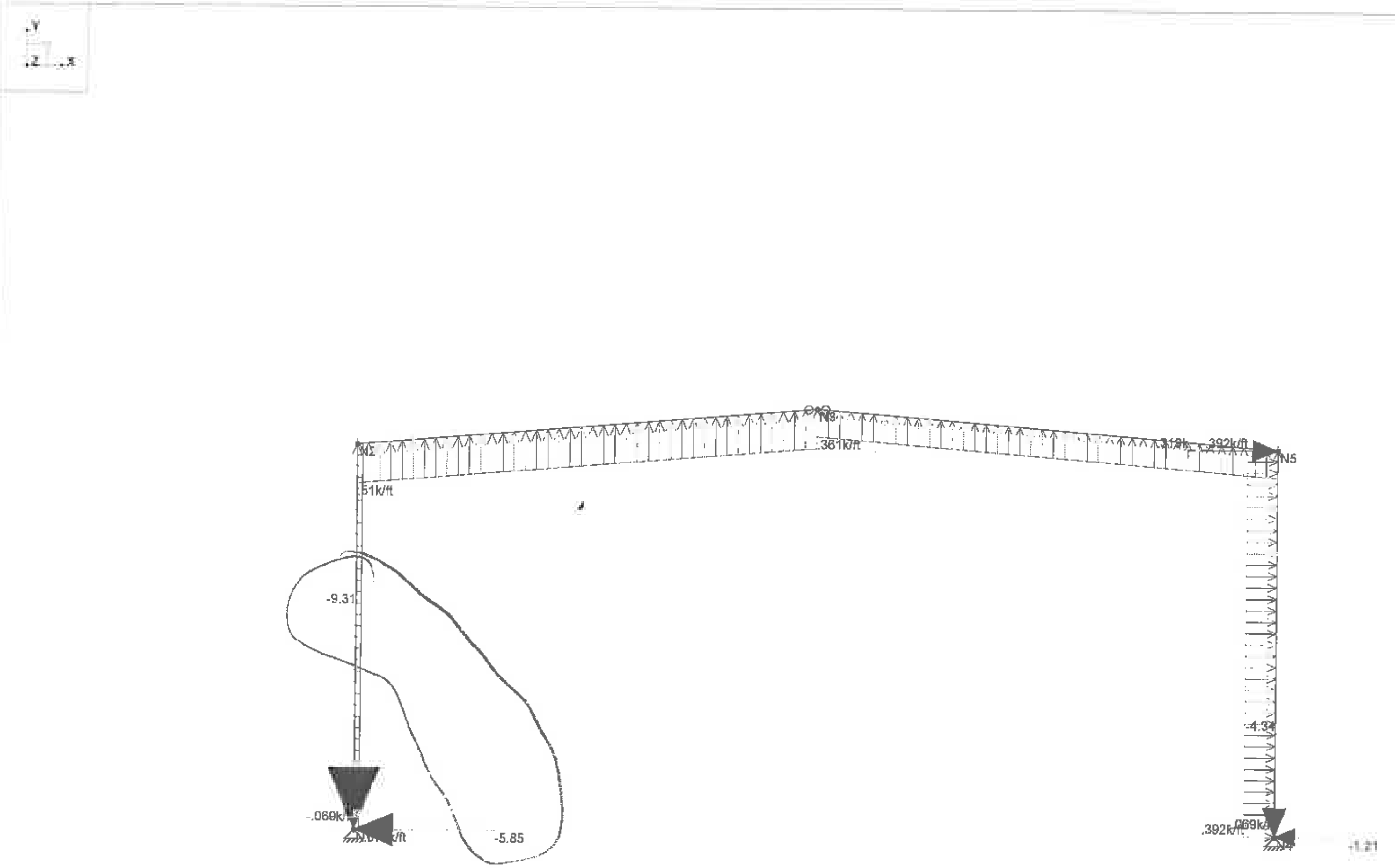
Loads: LC 34, 0.9DL max 2 + 1.0W1 roof and wall
Results for LC 34, 0.9DL max 2 + 1.0W1 roof and wall
Z-moment Reaction units are k and k-ft

ARCADIS	Topok Workshop Building	SK - 10
Matt Ltoycz		Jan 7, 2015 at 2:50 PM
		Typical Frame.r2d



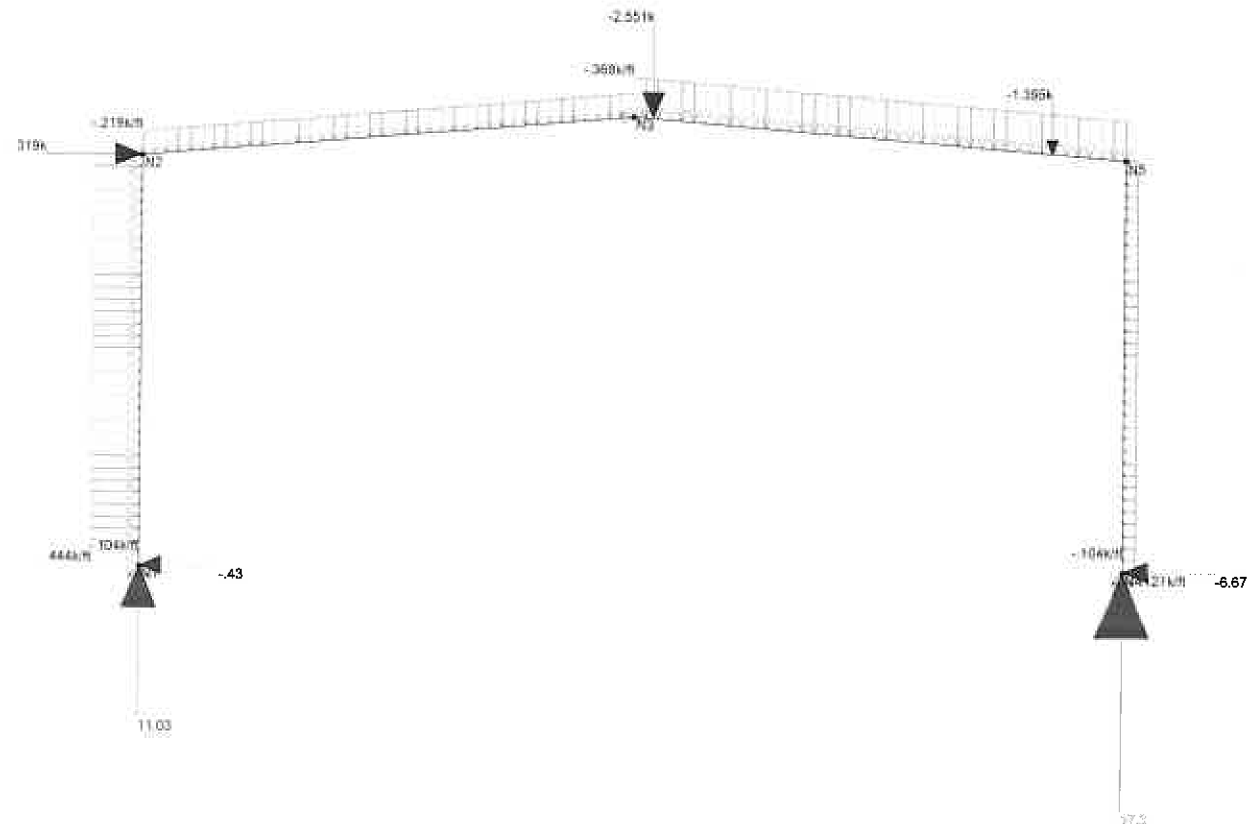
Loads: LC 35, 0.9DL min 1 + 1.0W1 roof and wall
Results for LC 35, 0.9DL min 1 + 1.0W1 roof and wall
Z-moment Reaction units are k and k-ft

ARCADIS	Topok Workshop Building	SK - 11
Matt Ltoycz		Jan 7, 2015 at 2:50 PM
		Typical Frame.r2d



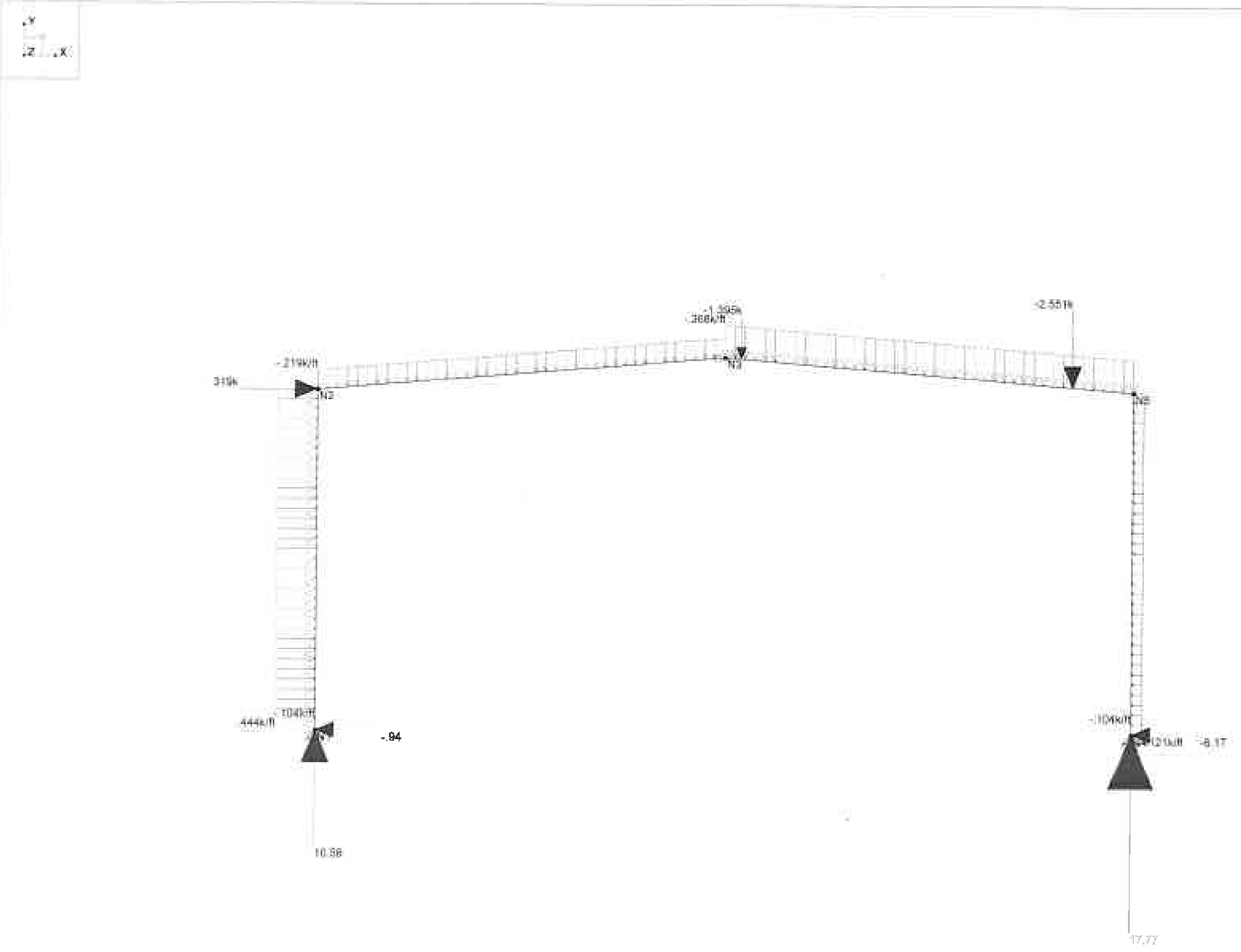
Loads: LC 36, 0.9DL min 2 + 1.0W1 roof and wall
Results for LC 36, 0.9DL min 2 + 1.0W1 roof and wall
Z-moment Reaction units are k and k-ft

ARCADIS	Topok Workshop Building	SK - 12
Matt Ltoycz		Jan 7, 2015 at 2:51 PM
		Typical Frame.r2d



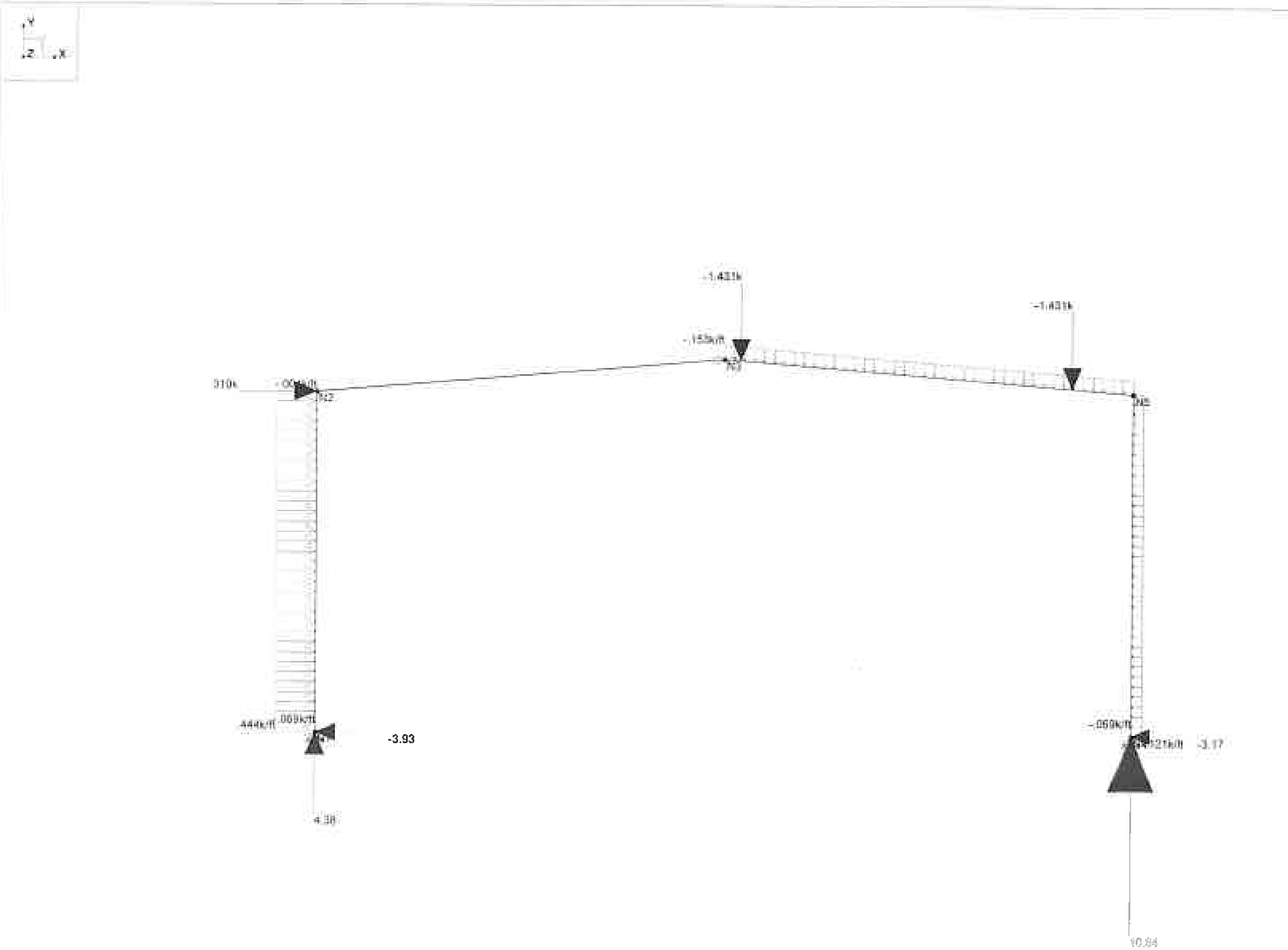
Loads: LC 37, 0.9DL max 1 + 1.0W2 roof and wall
Results for LC 37, 0.9DL max 1 + 1.0W2 roof and wall
Z-moment Reaction units are k and k-ft

ARCADIS	Topok Workshop Building	SK - 13
Matt Ltoycz		Jan 7, 2015 at 2:51 PM
		Typical Frame.r2d



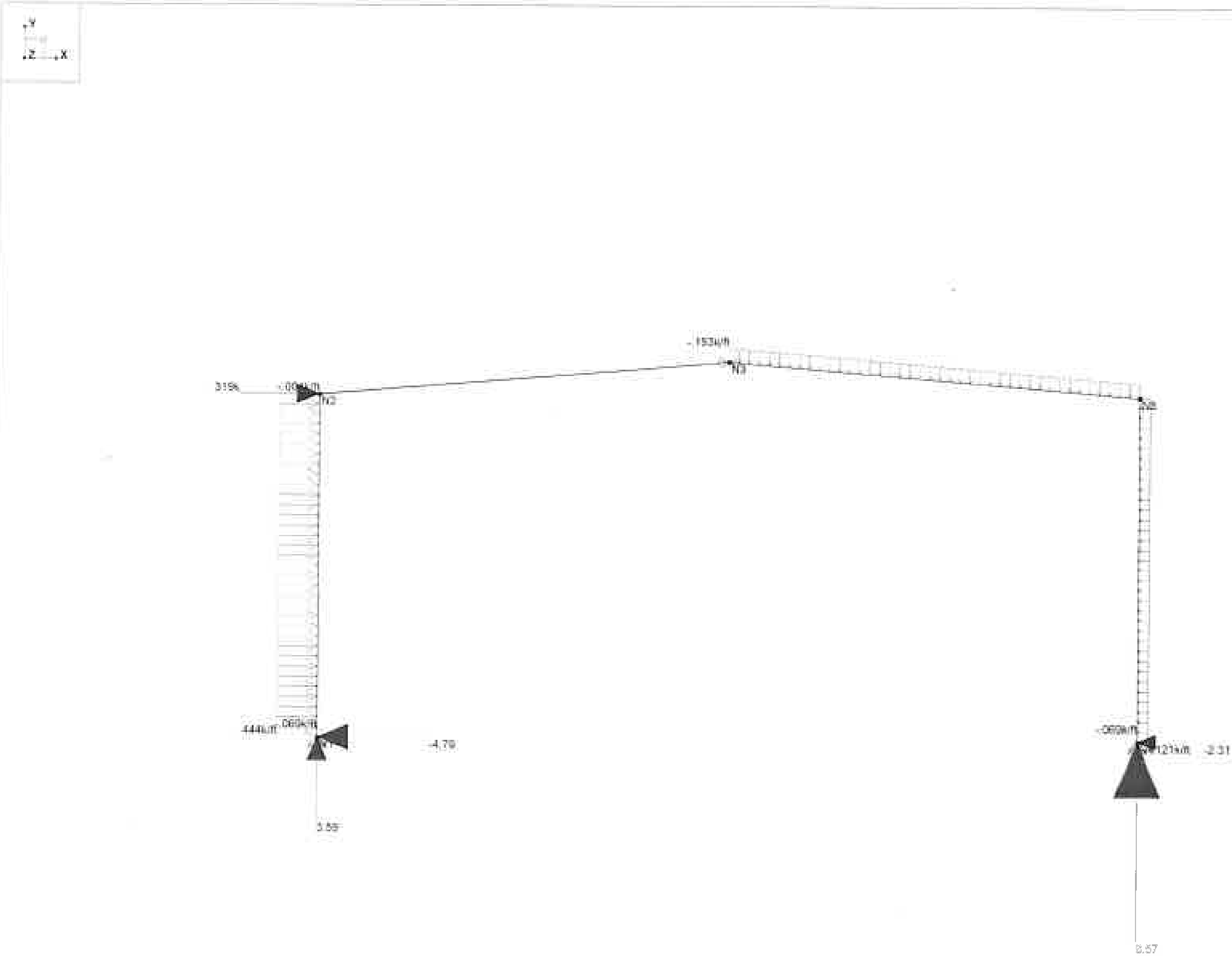
Loads: LC 38, 0.9DL max 2 + 1.0W2 roof and wall
Results for LC 38, 0.9DL max 2 + 1.0W2 roof and wall
Z-moment Reaction units are k and k-ft

ARCADIS	Topok Workshop Building	SK - 14
Matt Ltoycz		Jan 7, 2015 at 2:51 PM
		Typical Frame.r2d



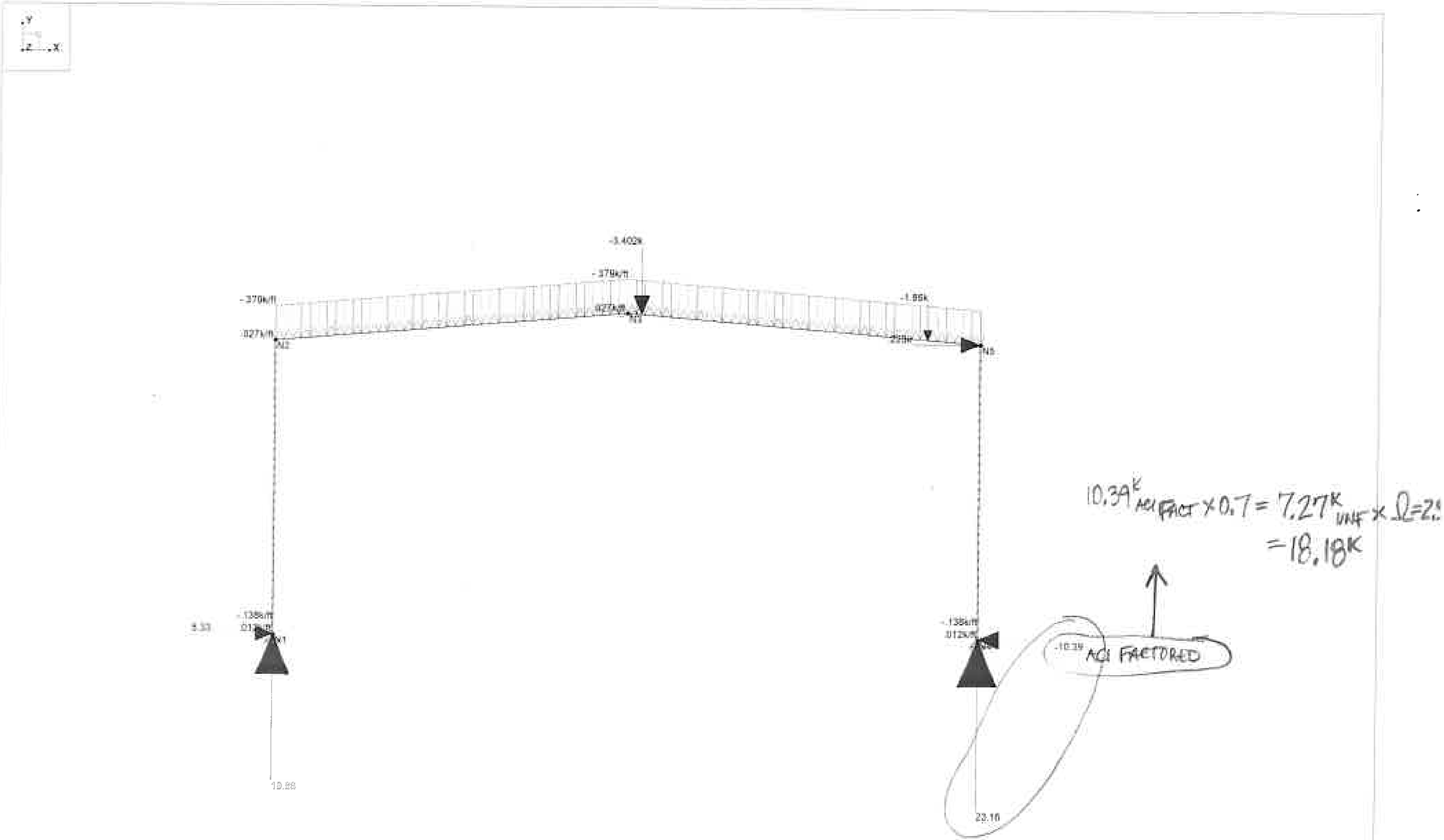
Loads: LC 39, 0.9DL min 1 + 1.0W2 roof and wall
Results for LC 39, 0.9DL min 1 + 1.0W2 roof and wall
Z-moment Reaction units are k and k-ft

ARCADIS	Topok Workshop Building	SK - 15
Matt Ltoycz		Jan 7, 2015 at 2:51 PM
		Typical Frame.r2d



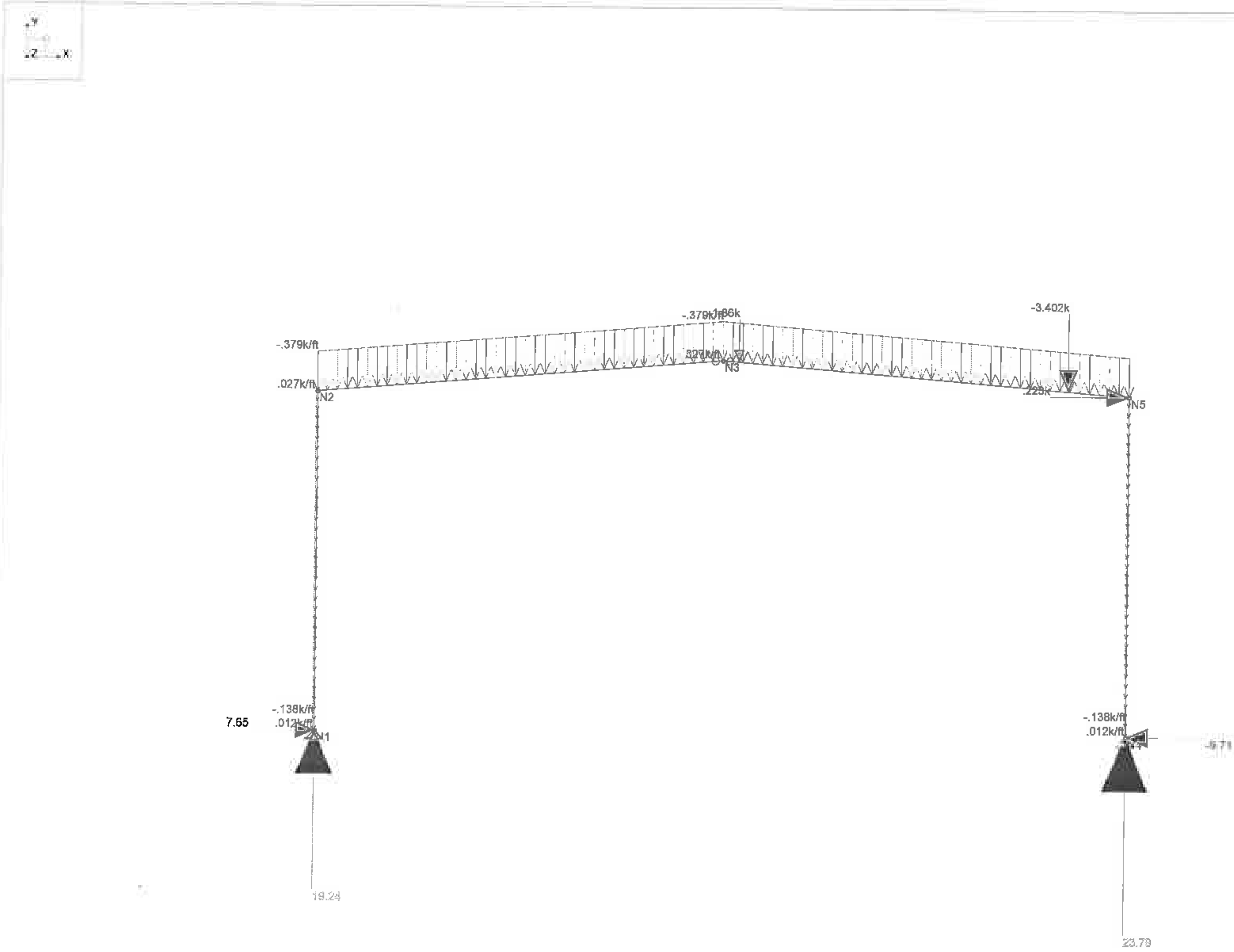
Loads: LC 40, 0.9DL min 2 + 1.0W2 roof and wall
Results for LC 40, 0.9DL min 2 + 1.0W2 roof and wall
Z-moment Reaction units are k and k-ft

ARCADIS	Topok Workshop Building	SK - 16
Matt Ltoycz		Jan 7, 2015 at 2:52 PM
		Typical Frame.r2d



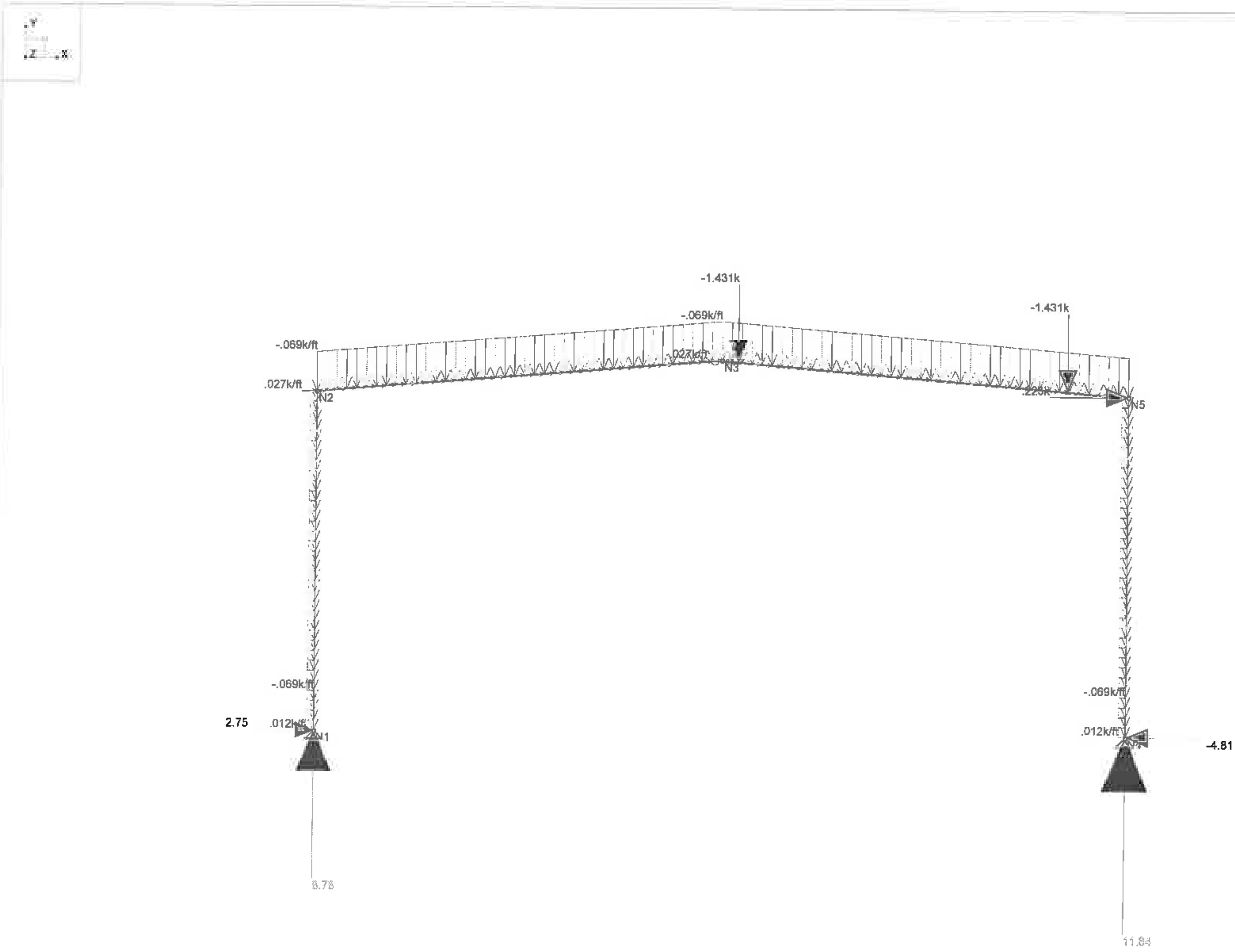
Loads: LC 41, 1.2DL max 1 + 1.0E
Results for LC 41, 1.2DL max 1 + 1.0E
Z-moment Reaction units are k and k-ft

ARCADIS	Topok Workshop Building	SK - 17
Matt Ltoycz		Jan 7, 2015 at 3:13 PM
		Typical Frame.r2d



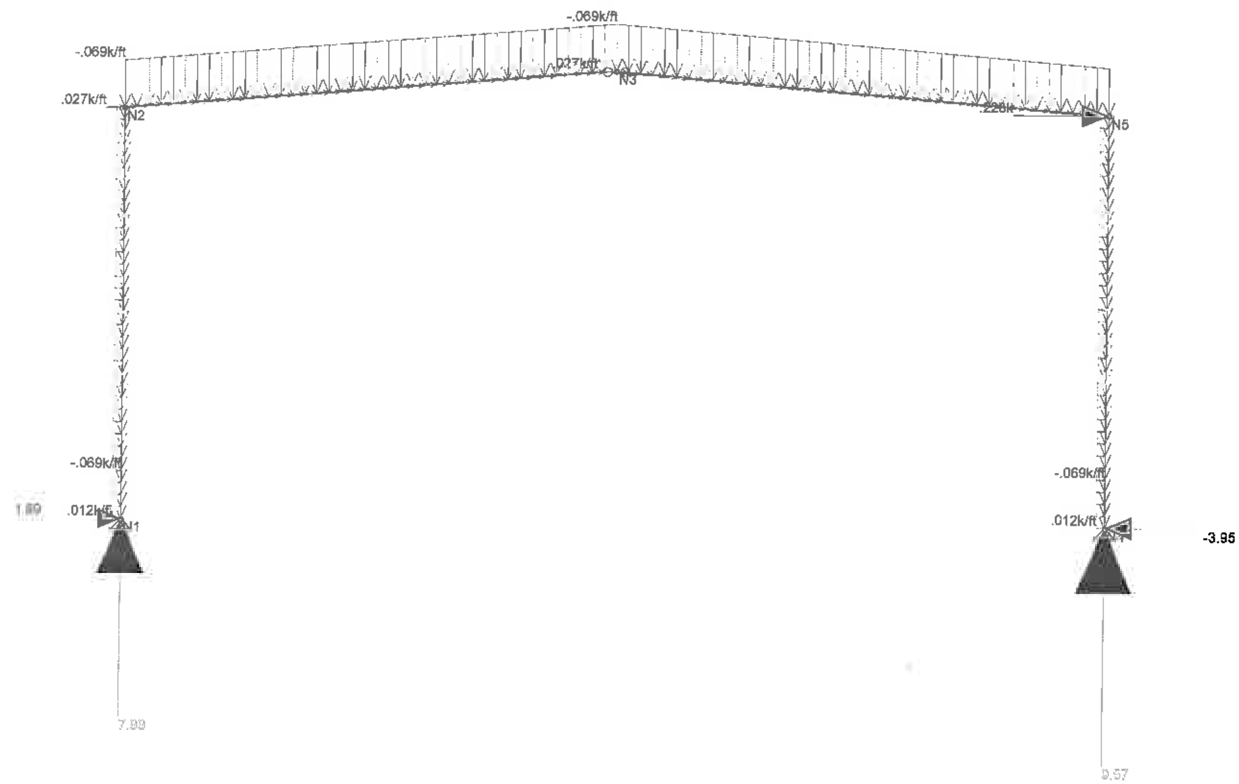
Loads: LC 42, 1.2DL max 2 + 1.0E
Results for LC 42, 1.2DL max 2 + 1.0E
Z-moment Reaction units are k and k-ft

ARCADIS	Topok Workshop Building	SK - 18
Matt Ltoycz		Jan 7, 2015 at 3:13 PM
		Typical Frame.r2d



Loads: LC 43, 0.9DL min 1 + 1.0E
Results for LC 43, 0.9DL min 1 + 1.0E
Z-moment Reaction units are k and k-ft

ARCADIS	Topok Workshop Building	SK - 19
Matt Ltoycz		Jan 7, 2015 at 3:14 PM
		Typical Frame.r2d



Loads: LC 44, 0.9DL min 2 + 1.0E
Results for LC 44, 0.9DL min 2 + 1.0E
Z-moment Reaction units are k and k-ft

ARCADIS	Topok Workshop Building	SK - 20
Matt Ltoycz		Jan 7, 2015 at 3:14 PM
		Typical Frame.r2d

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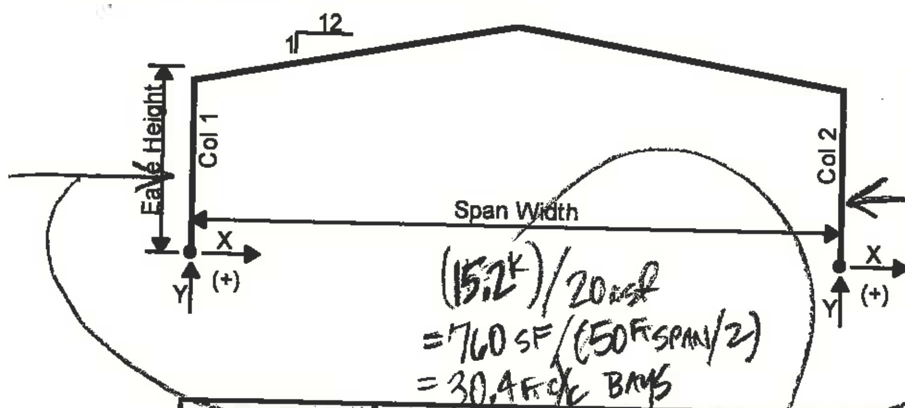
GABLE, CLEAR SPAN @ 50'-0"

** ASSUME 30 ft BAY SPACING USED IN TABLE BELOW



Reactions are presented below by case to be used in any required combination. Abbreviations are defined as follows:

RDL => Roof Dead Load
RLL => Roof Live Load
W1L => Wind Load to Left
W1R => Wind Load to Right

* [# of Spans] @ [Span Width] x [Eave Height]
** [Width] x [Length] † [# of Bolts] @ [Bolt Dia.]

Frame Description*	Column	Column Base Reactions (kips)								Base-plate Size**	Anchor Bolts†	
		RDL		RLL		W1L		W1R				
		X	Y	X	Y	X	Y	X	Y			
1@50' x 12' RLL = 20 psf	COL 1	6.6	11.3	8.8	15.2	-0.7	-5.7	-8.6	-9.0	8"x10"	2 @ 3/4"	
	COL 2	-6.6	11.3	-8.8	15.2	8.6	-9.0	0.7	-5.7	8"x10"	2 @ 3/4"	
1@50' x 12' RLL = 30 psf	COL 1	6.8	11.5	13.1	21.8	-0.7	-5.5	-8.7	-8.9	8"x10"	2 @ 1"	
	COL 2	-6.8	11.4	13.1	21.7	8.7	-8.9	0.7	-5.5	8"x10"	2 @ 1"	
1@50' x 12' RLL = 40 psf	COL 1	7.2	11.6	17.8	28.3	-2.2	-9.7	14.5	-15.0	8"x10"	2 @ 1-1/4"	
	COL 2	-7.2	11.6	17.8	28.3	14.5	-15.0	2.2	-9.7	8"x10"	2 @ 1-1/4"	
1@50' x 18' RLL = 20 psf	COL 1	3.9	11.4	5.3	15.3	2.8	-4.3	-8.9	-10.1	8"x10"	2 @ 1"	****
	COL 2	-3.9	11.4	-5.3	15.3	9.0	-10.1	-2.8	-4.3	8"x10"	2 @ 1"	****
1@50' x 18' RLL = 30 psf	COL 1	3.9	11.6	7.5	21.9	3.0	-4.1	-9.0	-10.0	8"x10"	2 @ 1"	****
	COL 2	-3.9	11.6	-7.5	21.9	9.0	-10.0	-3.0	-4.1	8"x10"	2 @ 1"	****
1@50' x 18' RLL = 40 psf	COL 1	4.1	11.7	10.2	28.5	3.9	-7.7	14.4	-16.8	8"x10"	2 @ 1"	****
	COL 2	-4.1	11.8	-10.2	28.5	14.6	-16.7	-4.1	-7.6	8"x10"	2 @ 1"	****
1@50' x 24' RLL = 20 psf	COL 1	3.5	11.6	4.7	15.5	5.0	-2.7	11.2	-12.4	8"x10"	2 @ 1"	
	COL 2	-3.5	11.6	-4.7	15.5	11.4	-12.3	-5.2	-2.6	8"x10"	2 @ 1"	
1@50' x 24' RLL = 30 psf	COL 1	3.2	11.6	6.0	21.9	5.4	-2.6	11.0	-12.3	8"x10"	2 @ 1"	
	COL 2	-3.2	11.6	-6.0	21.9	11.0	-12.3	-5.4	-2.6	8"x10"	2 @ 1"	
1@50' x 24' RLL = 40 psf	COL 1	4.0	11.9	9.8	28.7	7.0	-5.5	18.4	-20.4	8"x10"	2 @ 1-1/4"	
	COL 2	-4.0	11.9	-9.8	28.7	18.4	-20.4	-7.0	-5.5	8"x10"	2 @ 1-1/4"	
1@50' x 30' RLL = 20 psf	COL 1	3.2	12.0	4.3	15.9	7.3	0.2	13.4	-14.3	8"x10"	2 @ 1"	
	COL 2	-3.2	12.0	-4.3	15.9	13.4	-14.3	-7.3	0.2	8"x10"	2 @ 1"	
1@50' x 30' RLL = 30 psf	COL 1	3.0	12.0	5.8	22.3	7.4	0.1	13.2	-14.2	8"x10"	2 @ 1"	
	COL 2	-3.0	12.0	-5.8	22.3	13.2	-14.2	-7.4	0.1	8"x10"	2 @ 1"	
1@50' x 30' RLL = 40 psf	COL 1	3.2	12.4	8.0	29.1	11.1	-1.1	21.4	-24.0	8"x10"	2 @ 1-1/4"	
	COL 2	-3.2	12.4	-8.0	29.1	21.4	-24.0	11.1	-1.1	8"x10"	2 @ 1-1/4"	

**** *For 18' eave height, tapered beam frames, baseplate length = 12".*
**** *For 20' eave height, tapered beam frames, baseplate length = 14".*

28.3k/40 psf = 707.5 SF/(50 ft SPAN/2)
28.3 ft o/c BAY SPACING

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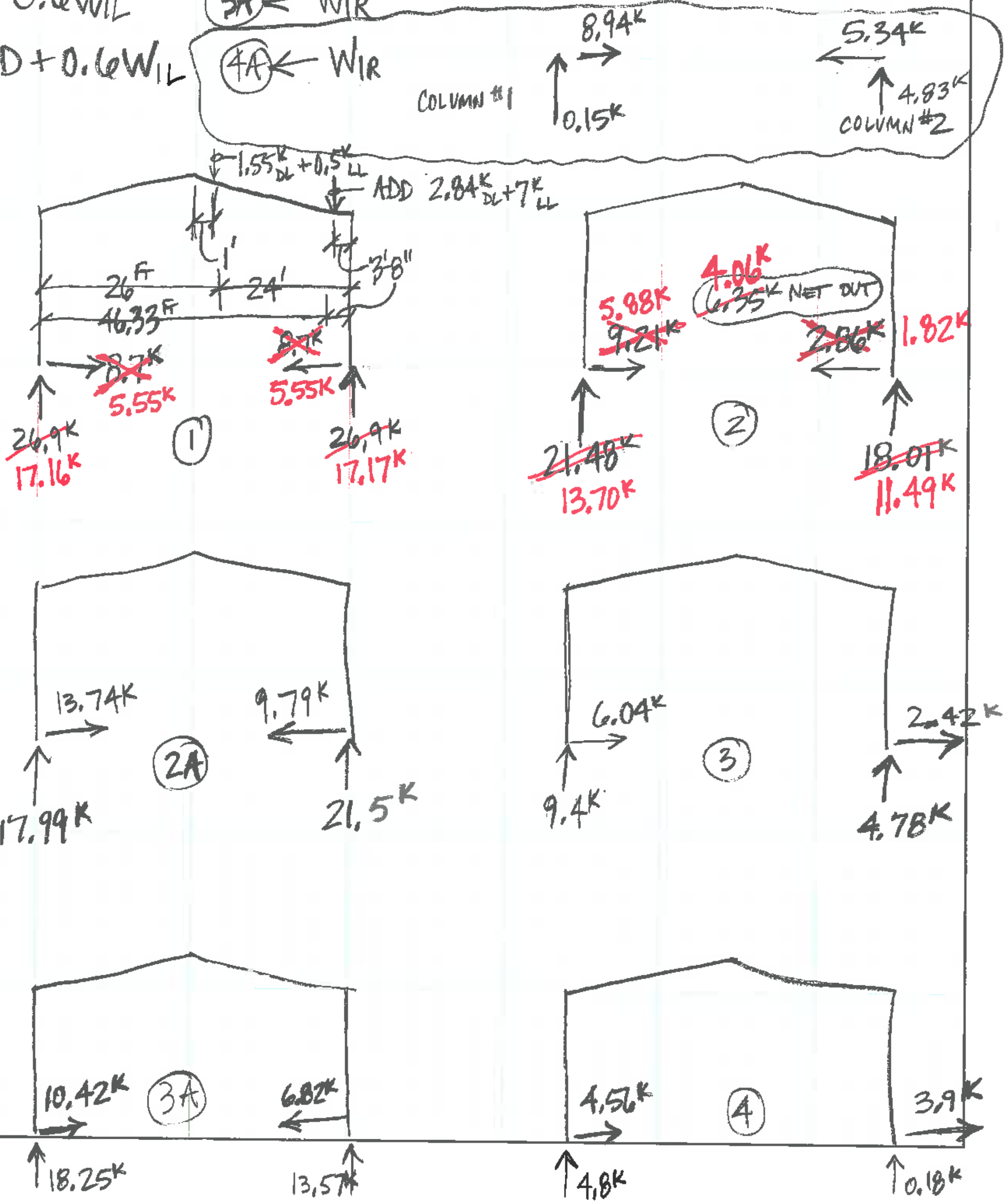
(NUCOR LOADS CONT)

(1) • $D + L_r$

(2) • $D + 0.75L_r + (0.6 \times 0.75)W_{IL}$ (0.45) (2A) ← W_{IR}

(3) • $D + 0.6W_{IL}$ (3A) ← W_{IR}

(4) • $0.6D + 0.6W_{IL}$ (4A) ← W_{IR}



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SHEET 1

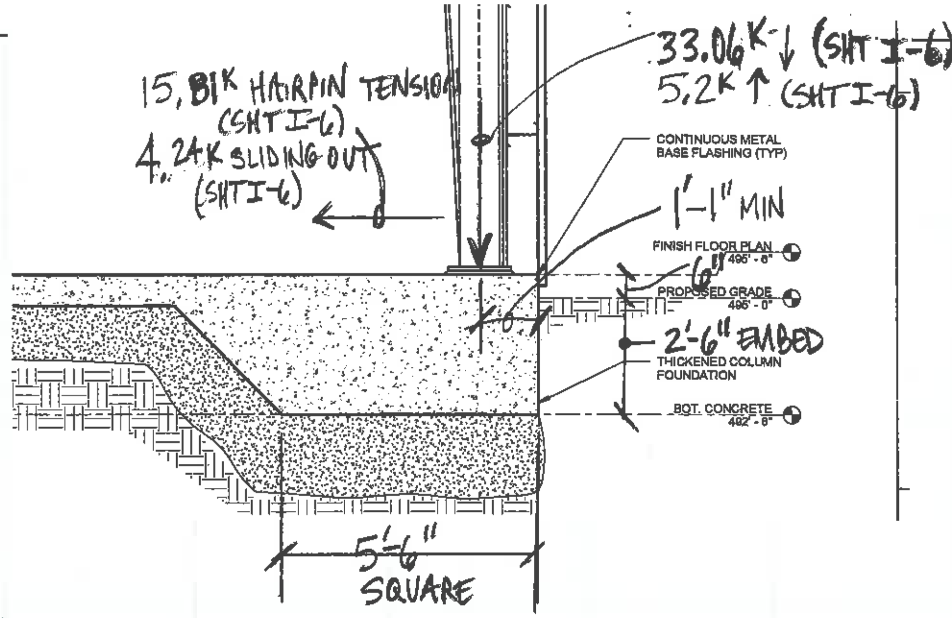
(NUCOR LOADS CON'T)

~ UPDATED LC#1 COLUMN #2 REACTION W/ CRANE LOAD

$$\Sigma\ \sout{26.9^K}\ 17.16^K \uparrow + \frac{Pa}{\ell} + \frac{Pa}{\ell} = \sout{26.9^K}\ 17.16^K + 1.066^K + 9.12^K$$

(first term: P = 2.05^K, a = 24', ℓ ~ 50'; second term: P = 9.84^K, a = 46.33', ℓ ~ 50')

$$= \sout{37.09^K}\ 27.35 \downarrow$$



- NET ALLOWABLE BEARING PRESSURE = 2,000 psf.
- CHECK 5'-6" SQ FTG:
  - $\Sigma P = 33.06^K\downarrow + (5.5^{ft} \times 5.5^{ft} \times 3' \text{THICK} \times 150\text{pcf})$ [13.61K]
    $= 46.67^K$
  - $A = 30.25^{ft^2}$, $y = 2.75^{ft}$, $I = \frac{bh^3}{12} = 76.26^{ft^4}$ [b = 5.5ft]
  - $\Sigma M_{\mathbb{C}} = (33.06^K) \times (2.75^{ft} - 1.083') = 55.11^{K\cdot F}$
  - $q = P/A \pm My/I = 1.543\text{ KSF} \pm 1.987\text{ KSF}$ ← NO GOOD
  - $e = M/P = 1.181^{ft} \rightarrow f_p \times 0.5 \times 5.5^{ft} \times [3 \times (2.75' - 1.181')] = 46.67$ [4.707' < 5.5]
    $f_p = 3.61\text{ KSF} > 2\text{ KSF}$ ~ NO GOOD
- USE 5'-6" WIDE × 4'-6"
  - $\Sigma P = 46.61^K$, $A = 24.75^{ft}$, $y = 2.25'$, $I = 41.77^{ft^4}$, $\Sigma M_{\mathbb{C}} = 41.39^{K\cdot F}$
  - $q = P/A + My/I = 1.883\text{ KSF} \pm 2.29\text{ KSF}$ ~ NO GOOD
  - $e = M/P = 0.889^{ft} \rightarrow f_p \times 0.5 \times 5.5^{ft} \times [3 \times (2.25 - 1.083')] = 46.61^K$ [3.501K < 4.5ft]
    $f_p = 4.84\text{ KSF} > 2\text{ KSF}$ ~ NO GOOD

(FDN DESIGN CON'T)

- LC#3 & 4 DL + Lr + Lrr IS TOO CONSERVATIVE FOR MAX GRAVITY LOADS
  2 USE WORST CASE 1, 2, & 9 THRU 12
  - 30.2K↓ (LC#12)
  - 13.79K (LC#11) → HAIRPIN TENSION

→ USE 5'-6" SQ FTG (EVEN IF FOOTING CENTERED UNDER COLUMN) = 43.81/2 KSF = $\sqrt{21.91 SF}$ = 4.68 FT ✓ OK

- ΣP = 43.81K, A, y, & I ON SHT I-11
- 2ΣM℄ = 50.34 KIFT
- q = P/A +/− My/I = 1.448 KSF +/− 1.815 KSF ~ NO GOOD
- e = M/P = 1.149 FT → fp × 0.5 × 5.5' × [3 × (2.75' − 1.149')] = 43.81K (4.803' < 5.5')

  fp = 3.317 KSF > 2 KSF NO GOOD

→ TRY 6'-0" SQ FTG

- ΣP = 46.4K, A = 36 SF, y = 3', I = 108 FT⁴, 2ΣM℄ = 57.89 KIFT
- q = P/A +/− My/I = 1.289 KSF +/− 1.608 KSF
- e = M/P = 1.248 FT → fp × 6' × 0.5 × [3 × (3' − 1.248')] = 46.4K (5.256 FT < 6 FT)

  fp = 2.943 KSF > 2 KSF NO GOOD

→ TRY 6'-6" SQ FTG

- ΣP = 49.21K, A = 42.25 FT, y = 3.25 FT, I = 148.76 FT⁴, 2ΣM℄ = 65.05 KIFT
- q = P/A +/− My/I = 1.165 KSF +/− 1.421 KSF ~ NO GOOD (5.78' < 6.5')
- e = M/P = 1.322 → fp × 6.5' × 0.5 × [3 × (3.25' − 1.322')] = 49.21K

  fp = 2.62 KSF > 2 KSF ← NO GOOD

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SHEET 1

(FDN DESIGN CON'T)

→ USE 6'-0" ∥ TO SPAN × 8'-0" FTG ← INTERIOR FRAME COLUMNS

- $\Sigma P = 51.8^K$, $A = 48 FT^2$, $y = 3'$, $I = 144 FT^4$, $\Sigma M_{CL} = 57.55^{K\cdot FT}$
- $q = P/A \pm My/I = 1.079$ KSF $\pm$ 1.199 KSF
- $e = M/P = 1.111$ FT → $f_p \times 8' \times 0.5 \times [3 \times (3' - 1.111')] = 51.8^K$ (5.667')

$f_p = 2.29$ KSF ≈ 2 KSF NET ALLOWABLE
+ (2.5' OVERBURDEN × 110 pcf)
2.28 KSF ✓OK

END FRAME

→ TRIB AREA = $\frac{\text{END FRAME}}{\text{INT FRAME}} = \frac{10.875'}{19.125'} = 0.569$

$\times \frac{(51.2\% \uparrow \text{ IN LAST 5 FEET END FRAME}) + [(10.875' - 5') \times 1.0]}{10.875'} = 1.23$

× 25.8^K (LC#1) ← i.e. minimal bridge CRANE DL included

= 18.17^K ↓ ← CONSERVATIVE B/C MID-SPAN COLUMN SHOULD TAKE SOME DEAD LOAD

→ USE 4'-6" ∥ TO SPAN × 4'-6" FTG

- $\Sigma P = 27.28^K$, $A = 20.25 FT^2$, $y = 2'-3"$, $I = 34.17 FT^4$, $\Sigma M_{CL} = 21.20^{K\cdot FT}$
- $q = P/A - My/I = 1.347$ KSF $\pm$ 1.396 KSF ← NO GOOD
- $e = M/P = 0.777'$ → $f_p \times 4.5' \times 0.5' \times [3 \times (2.25' - 0.777')] = 27.28^K$ (4.42' < 4.5')

$f_p = 2.74$ KSF > 2.28 KSF ~ NO GOOD

→ TRY 5'-0" SQ ← USE 5'-3" SQ

- $\Sigma P = 29.42^K$, $A = 25 FT^2$, $y = 2.5'$, $I = 52.08 FT^4$, $\Sigma M_{CL} = 25.75^{K\cdot FT}$
- $q = 1.177$ KSF $\pm$ 1.236 KSF ~ NO GOOD
- $e = M/P = 0.875'$ → $f_p \times 5' \times 0.5 \times [3 \times (2.5' - 0.875')] = 29.42^K$ (4.875' < 5')

$f_p = 2.41$ KSF ≈ 2.28 KSF

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CHKD: DATE:

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SHEET 1

(FDN DESIGN CON'T)

SLIDING RESISTANCE

- SLIDING OUT = 4.24^K_{UNF} (SHT I-6)
- SLIDING RESISTANCE =  → 688psf × 0.5 × 2.5' × 8' WIDE FTG = 6.88^K PASSIVE SOIL RESISTANCE

  (110pcf) × (3-0.5) × 2.5' EMBED = 688psf

  = DL FRICTION → $(21.6^K_{FDN DL} - 5.2^K_{UPLIFT}) \times 0.3\mu \times 0.6DL = 2.95^K$

  → $9.83^K > 4.24^K_{SLIDING}$ ~ FS = 2.31 > 1.5 √OK

UPLIFT RESISTANCE

- MAX UPLIFT = 5.2^K_{UNF} (SHT I-6)
- 6'×8' INT FRAME FDN DL = 6'×8'×3' THICK × 150pcf × 0.6DL = 12.96^K

  FS = 2.49 > 1.5 √OK

- MAX END FRAME UPLIFT = 5.2^K × 0.569 (TRIB AREA) × 1.238↑ (END FRAME INCREASE) = 3.67^K↑
- 5'3" SQ FDN END FRAME DL = 5'3" SQ × 3' THICK × 150pcf × 0.6DL = 7.44 K

  FS = 2.028 > 1.5 √OK

TENSION RESISTANCE

- MAX TENSION = 15.81^K_{UNF} (SHT I-6)
- HAIRPIN SIZE REQ'D = $A_S = \frac{T}{\phi F_y} = \frac{15.81^K \times 1.6_{ACI}}{0.9 \times 60ksi} = 0.47\ in^2/ft$

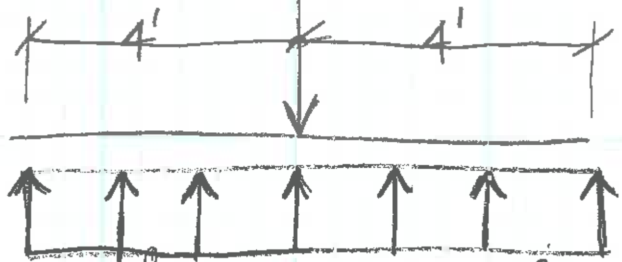
  (20.54^K – LC#27 1.2DL+1.6Lr+1.0Lr+0.5W2 CONSERVATIVE LOAD CASE)

  → #6 HAIRPIN USED ($A_S = 0.44\ in^2/ft$) √OK ≈

AGM Form 30 12-01

FDN RESTEEL DESIGN

- SINCE 6'x8' INTERIOR FRAME IS HEAVIEST LOADED & LARGEST FTG SIZE, WILL BASE RESTEEL DESIGN BASED ON THAT



$2.29\,ksf_{GROSS} - (3' \times 150\,pcf)_{UNF}$ (450 psf) $= 1.84\,ksf_{UNF}$

~ BOT STL

- $M_{ACI} = \frac{wl^2}{2} = \frac{(1.84\,ksf_{UNF} \times 1.6_{ACI}) \times 4\,ft^2}{2} = 23.55^{K \cdot FT}$
- $V_{ACI} = wl = 11.78^K$
- $\phi V_c = 2\phi\sqrt{f'_c}\,bd = 2(0.75)(\sqrt{4500})(12)(31.5^{IN}) = 35.86^K > V_{ACI}$ ✓OK
  - ~ $d = 36'' - 3''\text{COVER} - 8/8'' - 8/16'' = 31.5''$
- $R = M_u/\phi b d^2 = 26.37 \rightarrow \rho = 0.00045 \rightarrow A_s = 4/3\,\rho bd = 0.23\ IN^2/FT$

→ USE #6 @ 11" o/c ($A_s = 0.47\,IN^2/FT$) > ✓OK

~ TOP STL

- $M_{ACI} = \frac{wl^2}{2} = \frac{(3' \times 150\,pcf)_{UNF} \times 1.6_{ACI} \times 4\,ft^2}{2} = 5.76^{K \cdot FT}$
- $V_{ACI} = wl = 2.88^K << \phi V_c$ ✓OK
  - ~ $d = 36'' - 2''\text{COVER} - 8/8'' - 8/16'' = 32.5''$
- $R = 6.06 \rightarrow \rho = 0.0001 \rightarrow A_s = 4/3\,\rho bd = 0.053\ IN^2/FT$ <<

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Specifier:	Matt Lotycz	Project:	Topok Workshop Bldg
Address:		Sub-Project I Pos. No.:	Interior Frame Column
Phone I Fax:	|	Date:	1/7/2015
E-Mail:			

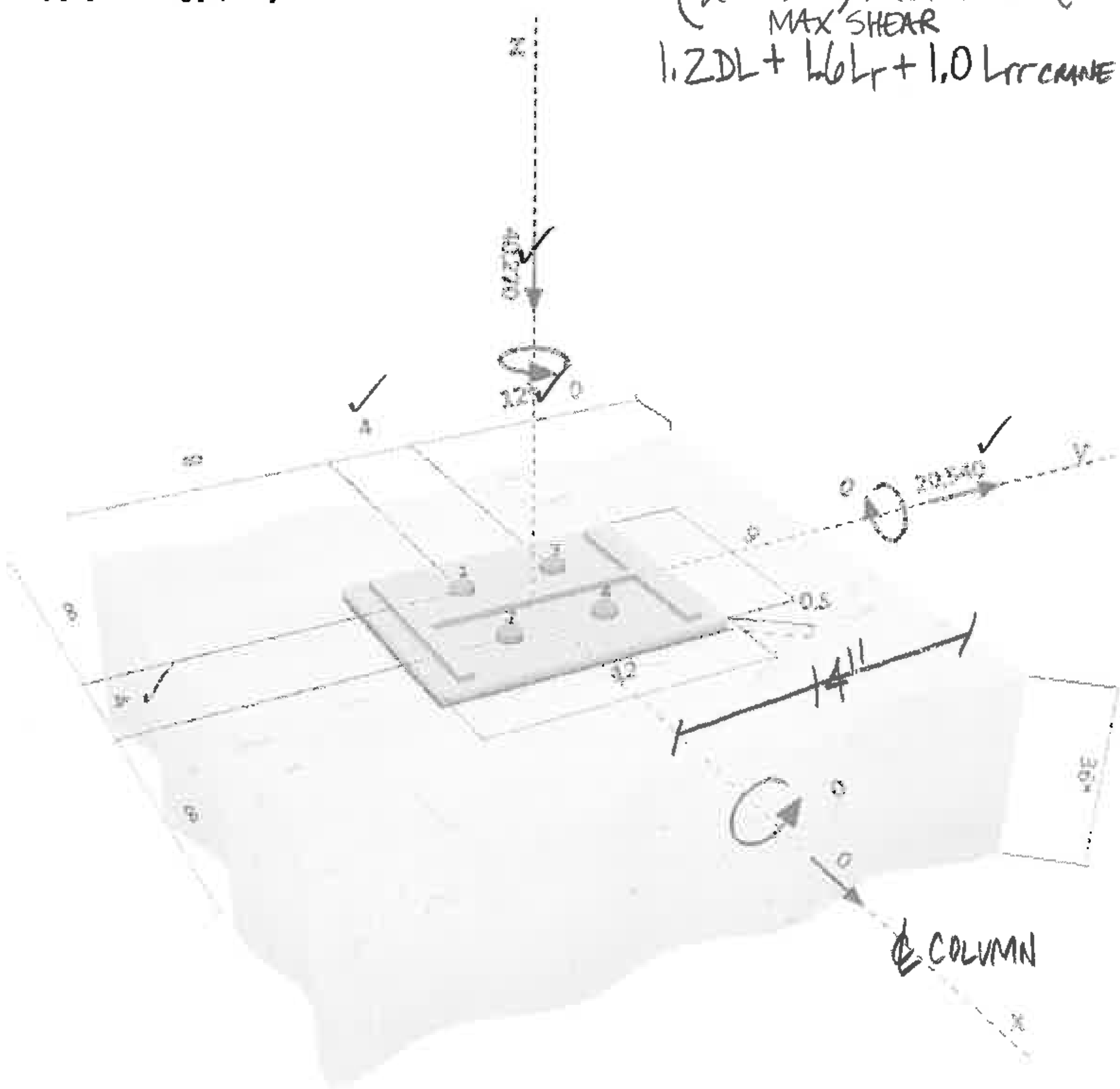
Specifier's comments: Base Plate Anchorage - Worst Case ACI Factored Shear

1 Input data

Anchor type and diameter:	**Heavy Hex Head ASTM F 1554 GR. 36 1**
Effective embedment depth:	h_{ef} = 24.000 in.
Material:	ASTM F 1554
Proof:	design method ACI 318-11 / CIP
Stand-off installation:	e_b = 0.000 in. (no stand-off); t = 0.500 in.
Anchor plate:	l_x x l_y x t = 9.000 in. x 12.000 in. x 0.500 in.; (Recommended plate thickness: not calculated)
Profile:	W shape (AISC); (L x W x T x FT) = 10.100 in. x 8.020 in. x 0.350 in. x 0.620 in.
Base material:	cracked concrete, 4000, f_c' = 4000 psi; h = 36.000 in.
Reinforcement:	tension: condition B, shear: condition B;
	edge reinforcement: > No. 4 bar

Geometry [in.] & Loading [lb, in.lb]

(LC#27) FACTORED (SHT I-7)
MAX SHEAR
1.2DL + 1.6Lr + 1.0 Lrr CRANE + 0.5W



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E-Mail:			

2 Load case/Resulting anchor forces

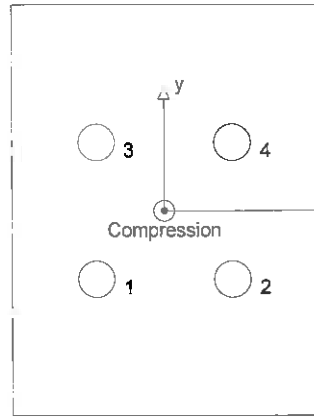
Load case: Design loads

Anchor reactions [lb]

Tension force: (+Tension, -Compression)

Anchor	Tension force	Shear force	Shear force x	Shear force y
1	0	5135	0	5135
2	0	5135	0	5135
3	0	5135	0	5135
4	0	5135	0	5135

max. concrete compressive strain: 0.09 [‰]
max. concrete compressive stress: 373 [psi]
resulting tension force in (x/y)=(0.000/0.000): 0 [lb]
resulting compression force in (x/y)=(0.000/0.000): 40270 [lb]



3 Tension load

	Load N_{ua} [lb]	Capacity ϕN_n [lb]	Utilization $\beta_N = N_{ua}/\phi N_n$	Status
Steel Strength*	N/A	N/A	N/A	N/A
Pullout Strength*	N/A	N/A	N/A	N/A
Concrete Breakout Strength**	N/A	N/A	N/A	N/A
Concrete Side-Face Blowout, direction **	N/A	N/A	N/A	N/A

* anchor having the highest loading **anchor group (anchors in tension)

Input data and results must be checked for agreement with the existing conditions and for plausibility!
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E-Mail:			

4 Shear load

	Load V_{ua} [lb]	Capacity ϕV_n [lb]	Utilization $\beta_V = V_{ua}/\phi V_n$	Status
Steel Strength*	5135	13708	38	OK
Steel failure (with lever arm)*	N/A	N/A	N/A	N/A
Pryout Strength**	20540	172533	12	OK
Concrete edge failure in direction y+**	20540	22084	94	OK

* anchor having the highest loading **anchor group (relevant anchors)

4.1 Steel Strength

$V_{sa} = n\ 0.6\ A_{se,V}\ f_{uta}$ ACI 318-11 Eq. (D-29)

$\phi\ V_{steel} \geq V_{ua}$ ACI 318-11 Table D.4.1.1

Variables

n	$A_{se,V}$ [in.^{2}]	f_{uta} [psi]
1	0.61	58000

Calculations

V_{sa} [lb]
21089

Results

V_{sa} [lb]	ϕ_{steel}	$\phi\ V_{sa}$ [lb]	V_{ua} [lb]
21089	0.650	13708	5135

4.2 Pryout Strength

$V_{cpg} = k_{cp} \left[\left(\frac{A_{Nc}}{A_{Nc0}} \right) \psi_{ec,N}\ \psi_{ed,N}\ \psi_{c,N}\ \psi_{cp,N}\ N_b \right]$ ACI 318-11 Eq. (D-41)

$\phi\ V_{cpg} \geq V_{ua}$ ACI 318-11 Table D.4.1.1

A_{Nc} see ACI 318-11, Part D.5.2.1, Fig. RD.5.2.1(b)

$A_{Nc0} = 9\ h_{ef}^2$ ACI 318-11 Eq. (D-5)

$\psi_{ec,N} = \left(\frac{1}{1 + \frac{2\ e_N}{3\ h_{ef}}} \right) \leq 1.0$ ACI 318-11 Eq. (D-8)

$\psi_{ed,N} = 0.7 + 0.3 \left(\frac{c_{a,min}}{1.5 h_{ef}} \right) \leq 1.0$ ACI 318-11 Eq. (D-10)

$\psi_{cp,N} = \mathrm{MAX}\left(\frac{c_{a,min}}{c_{ac}}, \frac{1.5 h_{ef}}{c_{ac}} \right) \leq 1.0$ ACI 318-11 Eq. (D-12)

$N_b = 16\ \lambda_a \sqrt{f'_c}\ h_{ef}^{5/3}$ ACI 318-11 Eq. (D-7)

Variables

k_{cp}	h_{ef} [in.]	$e_{c1,N}$ [in.]	$e_{c2,N}$ [in.]	$c_{a,min}$ [in.]
2	24.000	0.000	0.000	12.000

$\psi_{c,N}$	c_{ac} [in.]	k_c	λ_a	f'_c [psi]
1.000	[illegible]	16	1.000	4000

Calculations

A_{Nc} [in.^{2}]	A_{Nc0} [in.^{2}]	$\psi_{ec1,N}$	$\psi_{ec2,N}$	$\psi_{ed,N}$	$\psi_{cp,N}$	N_b [lb]
3952.00	5184.00	1.000	1.000	0.800	1.000	202070

Results

V_{cpg} [lb]	$\phi_{concrete}$	$\phi\ V_{cpg}$ [lb]	V_{ua} [lb]
246476	0.700	172533	20540

Input data and results must be checked for agreement with the existing conditions and for plausibility!
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Specifier: Matt Lotycz
Address:
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E-Mail:

4.3 Concrete edge failure in direction y+

$V_{cbg} = \left(\frac{A_{Vc}}{A_{Vc0}}\right) \psi_{ec,V}\ \psi_{ed,V}\ \psi_{c,V}\ \psi_{h,V}\ \psi_{parallel,V}\ V_b$ ACI 318-11 Eq. (D-31)

$\phi\ V_{cbg} \geq V_{ua}$ ACI 318-11 Table D.4.1.1

A_{Vc} see ACI 318-11, Part D.6.2.1, Fig. RD.6.2.1(b)

$A_{Vc0} = 4.5\ c_{a1}^2$ ACI 318-11 Eq. (D-32)

$\psi_{ec,V} = \left(\frac{1}{1 + \frac{2e_V}{3c_{a1}}}\right) \leq 1.0$ ACI 318-11 Eq. (D-36)

$\psi_{ed,V} = 0.7 + 0.3\left(\frac{c_{a2}}{1.5c_{a1}}\right) \leq 1.0$ ACI 318-11 Eq. (D-38)

$\psi_{h,V} = \sqrt{\frac{1.5c_{a1}}{h_a}} \geq 1.0$ ACI 318-11 Eq. (D-39)

$V_b = 9\ \lambda_a \sqrt{f'_c}\ c_{a1}^{1.5}$ ACI 318-11 Eq. (D-34)

Variables

c_{a1} [in.]	c_{a2} [in.]	e_{cV} [in.]	$\psi_{c,V}$	h_a [in.]
12.000	-	0.000	1.200	36.000

l_e [in.]	λ_a	d_a [in.]	f'_c [psi]	$\psi_{parallel,V}$
8.000	1.000	1.000	4000	1.000

Calculations

A_{Vc} [in.^{2}]	A_{Vc0} [in.^{2}]	$\psi_{ec,V}$	$\psi_{ed,V}$	$\psi_{h,V}$	V_b [lb]
720.00	648.00	1.000	1.000	1.000	23662

Results

V_{cbg} [lb]	$\phi_{concrete}$	$\phi\ V_{cbg}$ [lb]	V_{ua} [lb]
31549	0.700	22084	20540

5 Warnings

- Load re-distributions on the anchors due to elastic deformations of the anchor plate are not considered. The anchor plate is assumed to be sufficiently stiff, in order not to be deformed when subjected to the loading!
- Condition A applies when supplementary reinforcement is used. The Φ factor is increased for non-steel Design Strengths except Pullout Strength and Pryout strength. Condition B applies when supplementary reinforcement is not used and for Pullout Strength and Pryout Strength. Refer to your local standard.
- Checking the transfer of loads into the base material and the shear resistance are required in accordance with ACI 318 or the relevant standard!

Fastening meets the design criteria! ✓

Input data and results must be checked for agreement with the existing conditions and for plausibility!
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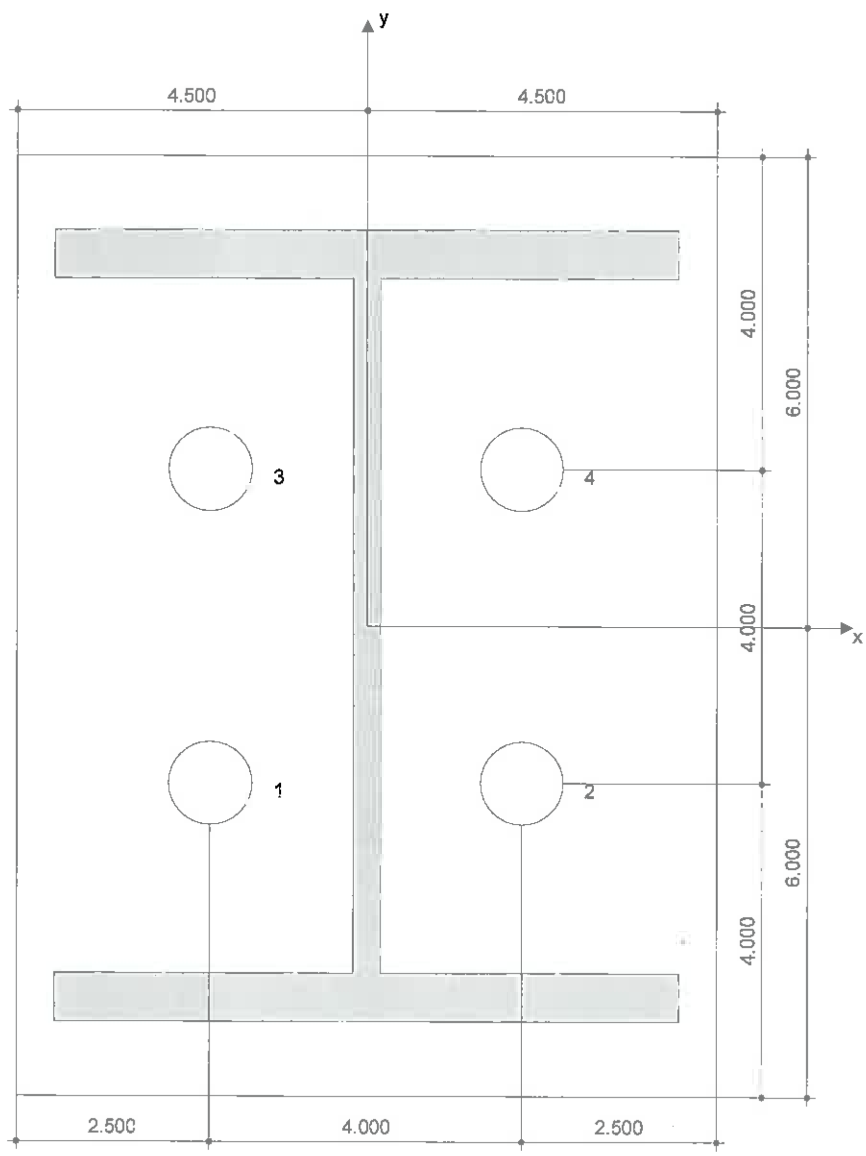
Address:		Sub-Project I Pos. No.:	Interior Frame Column
Phone I Fax:	|	Date:	1/7/2015
E-Mail:			

6 Installation data

Anchor plate, steel: -
Profile: W shape (AISC); 10.100 x 8.020 x 0.350 x 0.620 in.
Hole diameter in the fixture: d_f = 1.063 in.
Plate thickness (input): 0.500 in.
Recommended plate thickness: not calculated
Cleaning: No cleaning of the drilled hole is required

Anchor type and diameter: Heavy Hex Head ASTM F 1554 GR. 36 1
Installation torque: -0.009 in.lb
Hole diameter in the base material: - in.
Hole depth in the base material: 24.000 in.
Minimum thickness of the base material: 26.172 in.



Coordinates Anchor in.

Anchor	x	y	c_{-x}	c_{+x}	c_{-y}	c_{+y}
1	-2.000	-2.000	-	-	-	16.000
2	2.000	-2.000	-	-	-	16.000
3	-2.000	2.000	-	-	-	12.000
4	2.000	2.000	-	-	-	12.000

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Phone I Fax:	|	Date:	1/7/2015
E-Mail:			

7 Remarks; Your Cooperation Duties

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Profis Anchor 2.4.8

Company:	ARCADIS	Page:	1
Specifier:	Matt Lotycz	Project:	Topok Workshop Bldg
Address:		Sub-Project I Pos. No.:	Interior Frame Column
Phone I Fax:	|	Date:	1/7/2015
E-Mail:			

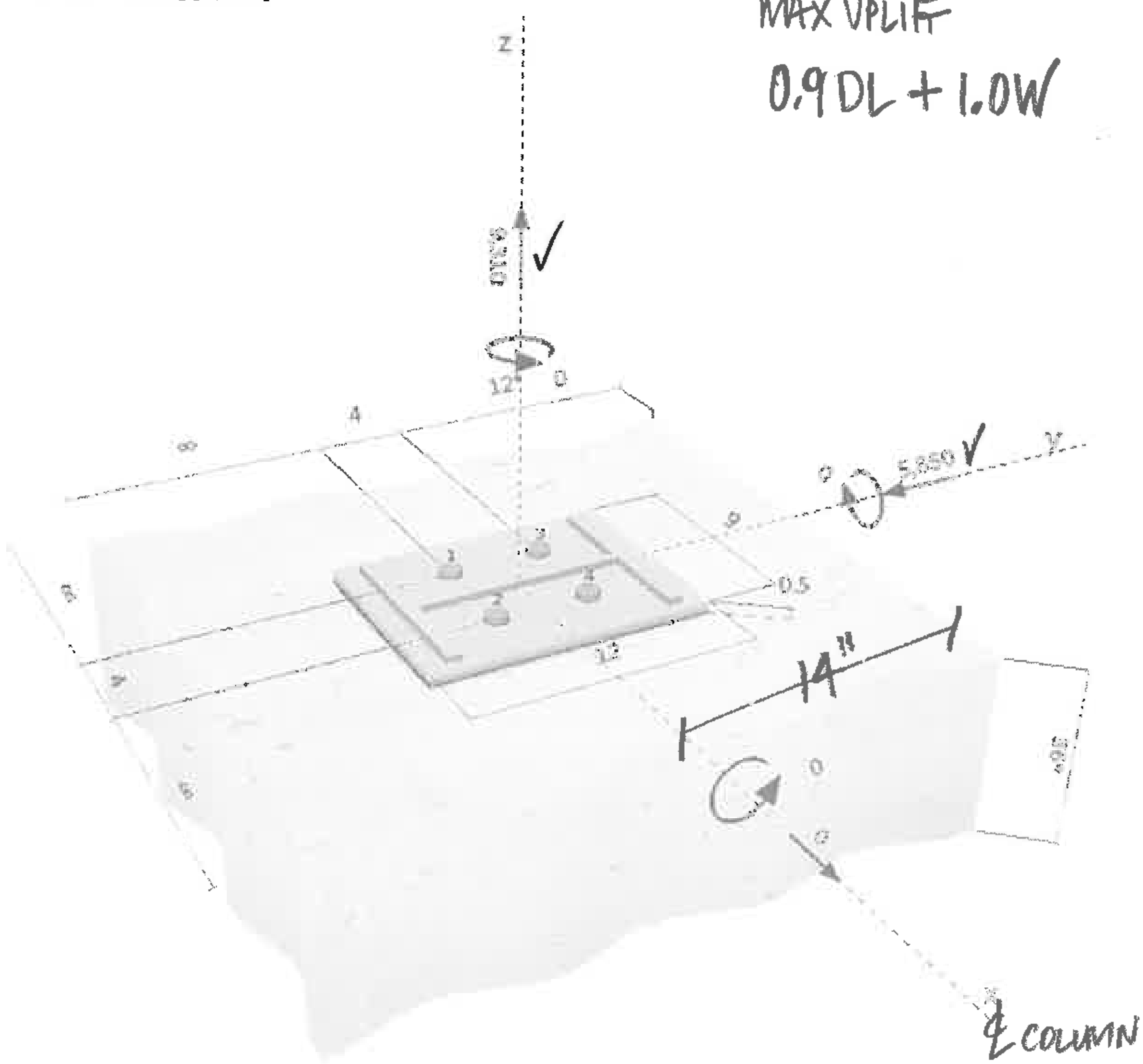
Specifier's comments: Base Plate Anchorage - Worst Case ACI Uplift with associated Shear

1 Input data

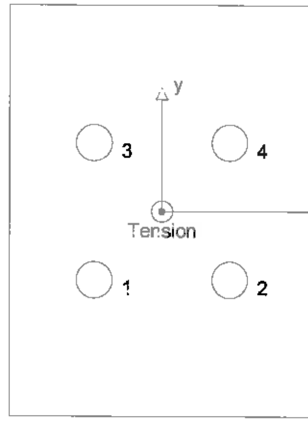
Anchor type and diameter:	**Heavy Hex Head ASTM F 1554 GR. 36 1**
Effective embedment depth:	h_{ef} = 24.000 in.
Material:	ASTM F 1554
Proof:	design method ACI 318-11 / CIP
Stand-off installation:	e_b = 0.000 in. (no stand-off); t = 0.500 in.
Anchor plate:	l_x x l_y x t = 9.000 in. x 12.000 in. x 0.500 in.; (Recommended plate thickness: not calculated)
Profile:	W shape (AISC); (L x W x T x FT) = 10.100 in. x 8.020 in. x 0.350 in. x 0.620 in.
Base material:	cracked concrete, 4000, f_c' = 4000 psi; h = 36.000 in.
Reinforcement:	tension: condition B, shear: condition B; edge reinforcement: > No. 4 bar

LC# 36 FACTORED (SHT I-7)
MAX UPLIFT
0.9DL + 1.0W

Geometry [in.] & Loading [lb, in.lb]



2 Load case/Resulting anchor forces



Load case: Design loads

Anchor reactions [lb]
Tension force: (+Tension, -Compression)

Anchor	Tension force	Shear force	Shear force x	Shear force y
1	2328	1463	0	-1463
2	2328	1463	0	-1463
3	2328	1463	0	-1463
4	2328	1463	0	-1463

max. concrete compressive strain: - [‰]
max. concrete compressive stress: - [psi]
resulting tension force in (x/y)=(0.000/0.000): 9310 [lb]
resulting compression force in (x/y)=(0.000/0.000): 0 [lb]

3 Tension load

	Load N_{ua} [lb]	Capacity ϕN_n [lb]	Utilization $\beta_N = N_{ua}/\phi N_n$	Status
Steel Strength*	2328	26361	9	OK
Pullout Strength*	2328	33622	7	OK
Concrete Breakout Strength**	9310	86266	11	OK
Concrete Side-Face Blowout, direction **	N/A	N/A	N/A	N/A

* anchor having the highest loading **anchor group (anchors in tension)

3.1 Steel Strength

$N_{sa} = n\, A_{se,N}\, f_{uta}$ ACI 318-11 Eq. (D-2)
$\phi\, N_{steel} \geq N_{ua}$ ACI 318-11 Table D.4.1.1

Variables

n	$A_{se,N}$ [in.^{2}]	f_{uta} [psi]
1	0.61	58000

Calculations

N_{sa} [lb]
35148

Results

N_{sa} [lb]	ϕ_{steel}	$\phi\, N_{sa}$ [lb]	N_{ua} [lb]
35148	0.750	26361	2328

3.2 Pullout Strength

$N_{pN} = \psi_{c,p}\, N_p$ ACI 318-11 Eq. (D-13)
$N_p = 8\, A_{brg}\, f'_c$ ACI 318-11 Eq. (D-14)
$\phi\, N_{pN} \geq N_{ua}$ ACI 318-11 Table D.4.1.1

Variables

$\psi_{c,p}$	A_{brg} [in.^{2}]	λ_a	f'_c [psi]
1.000	1.50	1.000	4000

Calculations

N_p [lb]
48032

Results

N_{pn} [lb]	$\phi_{concrete}$	$\phi\, N_{pn}$ [lb]	N_{ua} [lb]
48032	0.700	33622	2328

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3.3 Concrete Breakout Strength

$N_{cbg} = \left(\frac{A_{Nc}}{A_{Nc0}}\right) \psi_{ec,N}\, \psi_{ed,N}\, \psi_{c,N}\, \psi_{cp,N}\, N_b$ ACI 318-11 Eq. (D-4)

$\phi\, N_{cbg} \geq N_{ua}$ ACI 318-11 Table D.4.1.1

A_{Nc} see ACI 318-11, Part D.5.2.1, Fig. RD.5.2.1(b)

$A_{Nc0} = 9\, h_{ef}^2$ ACI 318-11 Eq. (D-5)

$\psi_{ec,N} = \left(\frac{1}{1 + \frac{2\, e_N}{3\, h_{ef}}}\right) \leq 1.0$ ACI 318-11 Eq. (D-8)

$\psi_{ed,N} = 0.7 + 0.3 \left(\frac{c_{a,min}}{1.5 h_{ef}}\right) \leq 1.0$ ACI 318-11 Eq. (D-10)

$\psi_{cp,N} = \text{MAX}\left(\frac{c_{a,min}}{c_{ac}}, \frac{1.5 h_{ef}}{c_{ac}}\right) \leq 1.0$ ACI 318-11 Eq. (D-12)

$N_b = 16\, \lambda_a \sqrt{f'_c}\, h_{ef}^{5/3}$ ACI 318-11 Eq. (D-7)

Variables

h_{ef} [in.]	$e_{c1,N}$ [in.]	$e_{c2,N}$ [in.]	$c_{a,min}$ [in.]	$\psi_{c,N}$
24.000	0.000	0.000	12.000	1.000

c_{ac} [in.]	k_c	λ_a	f'_c [psi]
-	16	1.000	4000

Calculations

A_{Nc} [in.^{2}]	A_{Nc0} [in.^{2}]	$\psi_{ec1,N}$	$\psi_{ec2,N}$	$\psi_{ed,N}$	$\psi_{cp,N}$	N_b [lb]
3952.00	5184.00	1.000	1.000	0.800	1.000	202070

Results

N_{cbg} [lb]	$\phi_{concrete}$	$\phi\, N_{cbg}$ [lb]	N_{ua} [lb]
123238	0.700	86266	9310

Input data and results must be checked for agreement with the existing conditions and for plausibility!
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Company: ARCADIS
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Address:
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4 Shear load

	Load V_{ua} [lb]	Capacity ϕV_n [lb]	Utilization $\beta_V = V_{ua}/\phi V_n$	Status
Steel Strength*	1463	13708	11	OK
Steel failure (with lever arm)*	N/A	N/A	N/A	N/A
Pryout Strength**	5850	172533	4	OK
Concrete edge failure in direction **	N/A	N/A	N/A	N/A

* anchor having the highest loading **anchor group (relevant anchors)

4.1 Steel Strength

$V_{sa} = n\ 0.6\ A_{se,V}\ f_{uta}$ ACI 318-11 Eq. (D-29)
$\phi V_{steel} \geq V_{ua}$ ACI 318-11 Table D.4.1.1

Variables

n	$A_{se,V}$ [in.^{2}]	f_{uta} [psi]
1	0.61	58000

Calculations

V_{sa} [lb]
21089

Results

V_{sa} [lb]	ϕ_{steel}	ϕV_{sa} [lb]	V_{ua} [lb]
21089	0.650	13708	1463

4.2 Pryout Strength

$V_{cpg} = k_{cp} \left[\left(\frac{A_{Nc}}{A_{Nc0}}\right) \psi_{ec,N}\ \psi_{ed,N}\ \psi_{c,N}\ \psi_{cp,N}\ N_b\right]$ ACI 318-11 Eq. (D-41)
$\phi V_{cpg} \geq V_{ua}$ ACI 318-11 Table D.4.1.1
A_{Nc} see ACI 318-11, Part D.5.2.1, Fig. RD.5.2.1(b)
$A_{Nc0} = 9\ h_{ef}^2$ ACI 318-11 Eq. (D-5)
$\psi_{ec,N} = \left(\frac{1}{1 + \frac{2\ e_N}{3\ h_{ef}}}\right) \leq 1.0$ ACI 318-11 Eq. (D-8)
$\psi_{ed,N} = 0.7 + 0.3 \left(\frac{c_{a,min}}{1.5 h_{ef}}\right) \leq 1.0$ ACI 318-11 Eq. (D-10)
$\psi_{cp,N} = \mathrm{MAX}\left(\frac{c_{a,min}}{c_{ac}}, \frac{1.5 h_{ef}}{c_{ac}}\right) \leq 1.0$ ACI 318-11 Eq. (D-12)
$N_b = 16\ \lambda_a \sqrt{f'_c}\ h_{ef}^{5/3}$ ACI 318-11 Eq. (D-7)

Variables

k_{cp}	h_{ef} [in.]	$e_{c1,N}$ [in.]	$e_{c2,N}$ [in.]	$c_{a,min}$ [in.]
2	24.000	0.000	0.000	12.000

$\psi_{c,N}$	c_{ac} [in.]	k_c	λ_a	f'_c [psi]
1.000	-	16	1.000	4000

Calculations

A_{Nc} [in.^{2}]	A_{Nc0} [in.^{2}]	$\psi_{ec1,N}$	$\psi_{ec2,N}$	$\psi_{ed,N}$	$\psi_{cp,N}$	N_b [lb]
3952.00	5184.00	1.000	1.000	0.800	1.000	202070

Results

V_{cpg} [lb]	$\phi_{concrete}$	ϕV_{cpg} [lb]	V_{ua} [lb]
246476	0.700	172533	5850

5 Combined tension and shear loads

β_N	β_V	ζ	Utilization $\beta_{N,V}$ [%]	Status
0.108	0.107	5/3	5	OK

$\beta_{NV} = \beta_N^{\zeta} + \beta_V^{\zeta} <= 1$

Input data and results must be checked for agreement with the existing conditions and for plausibility!
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Company:	ARCADIS	Page:	5
Specifier:	Matt Lotycz	Project:	Topok Workshop Bldg
Address:		Sub-Project I Pos. No.:	Interior Frame Column
Phone I Fax:	|	Date:	1/7/2015
E-Mail:			

6 Warnings

- Load re-distributions on the anchors due to elastic deformations of the anchor plate are not considered. The anchor plate is assumed to be sufficiently stiff, in order not to be deformed when subjected to the loading!
- Condition A applies when supplementary reinforcement is used. The Φ factor is increased for non-steel Design Strengths except Pullout Strength and Pryout strength. Condition B applies when supplementary reinforcement is not used and for Pullout Strength and Pryout Strength. Refer to your local standard.
- Checking the transfer of loads into the base material and the shear resistance are required in accordance with ACI 318 or the relevant standard!

Fastening meets the design criteria!

Input data and results must be checked for agreement with the existing conditions and for plausibility!
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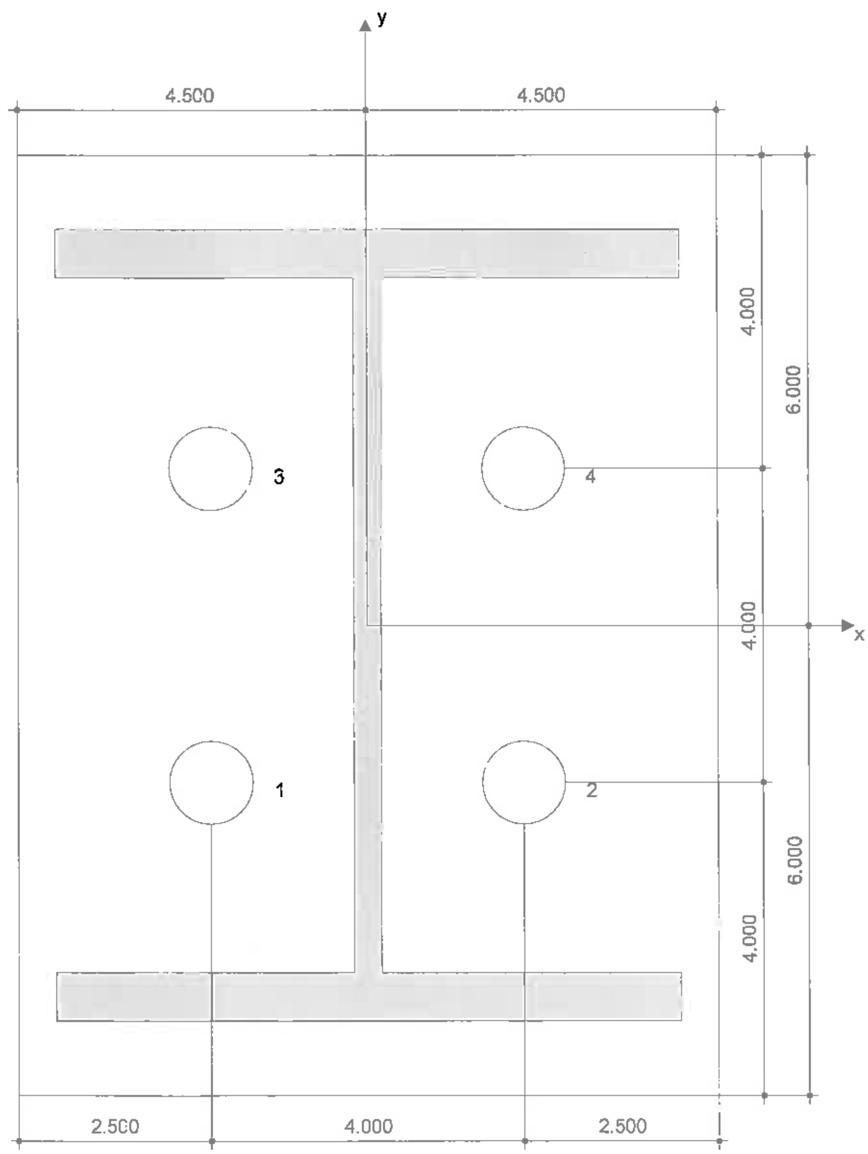
Address:		Sub-Project I Pos. No.:	Interior Frame Column
Phone I Fax:	|	Date:	1/7/2015
E-Mail:			

7 Installation data

Anchor plate, steel: -
Profile: W shape (AISC); 10.100 x 8.020 x 0.350 x 0.620 in.
Hole diameter in the fixture: d_f = 1.063 in.
Plate thickness (input): 0.500 in.
Recommended plate thickness: not calculated
Cleaning: No cleaning of the drilled hole is required

Anchor type and diameter: Heavy Hex Head ASTM F 1554 GR. 36 1
Installation torque: -0.009 in.lb
Hole diameter in the base material: - in.
Hole depth in the base material: 24.000 in.
Minimum thickness of the base material: 26.172 in.



Coordinates Anchor in.

Anchor	x	y	c_{-x}	c_{+x}	c_{-y}	c_{+y}
1	-2.000	-2.000	-	-	-	16.000
2	2.000	-2.000	-	-	-	16.000
3	-2.000	2.000	-	-	-	12.000
4	2.000	2.000	-	-	-	12.000

Input data and results must be checked for agreement with the existing conditions and for plausibility!
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- You must take all necessary and reasonable steps to prevent or limit damage caused by the Software. In particular, you must arrange for the regular backup of programs and data and, if applicable, carry out the updates of the Software offered by Hilti on a regular basis. If you do not use the AutoUpdate function of the Software, you must ensure that you are using the current and thus up-to-date version of the Software in each case by carrying out manual updates via the Hilti Website. Hilti will not be liable for consequences, such as the recovery of lost or damaged data or programs, arising from a culpable breach of duty by you.

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Specifier:	Matt Lotycz	Project:	Topok Workshop Bldg
Address:		Sub-Project I Pos. No.:	Interior Frame Column
Phone I Fax:	|	Date:	1/7/2015
E-Mail:			

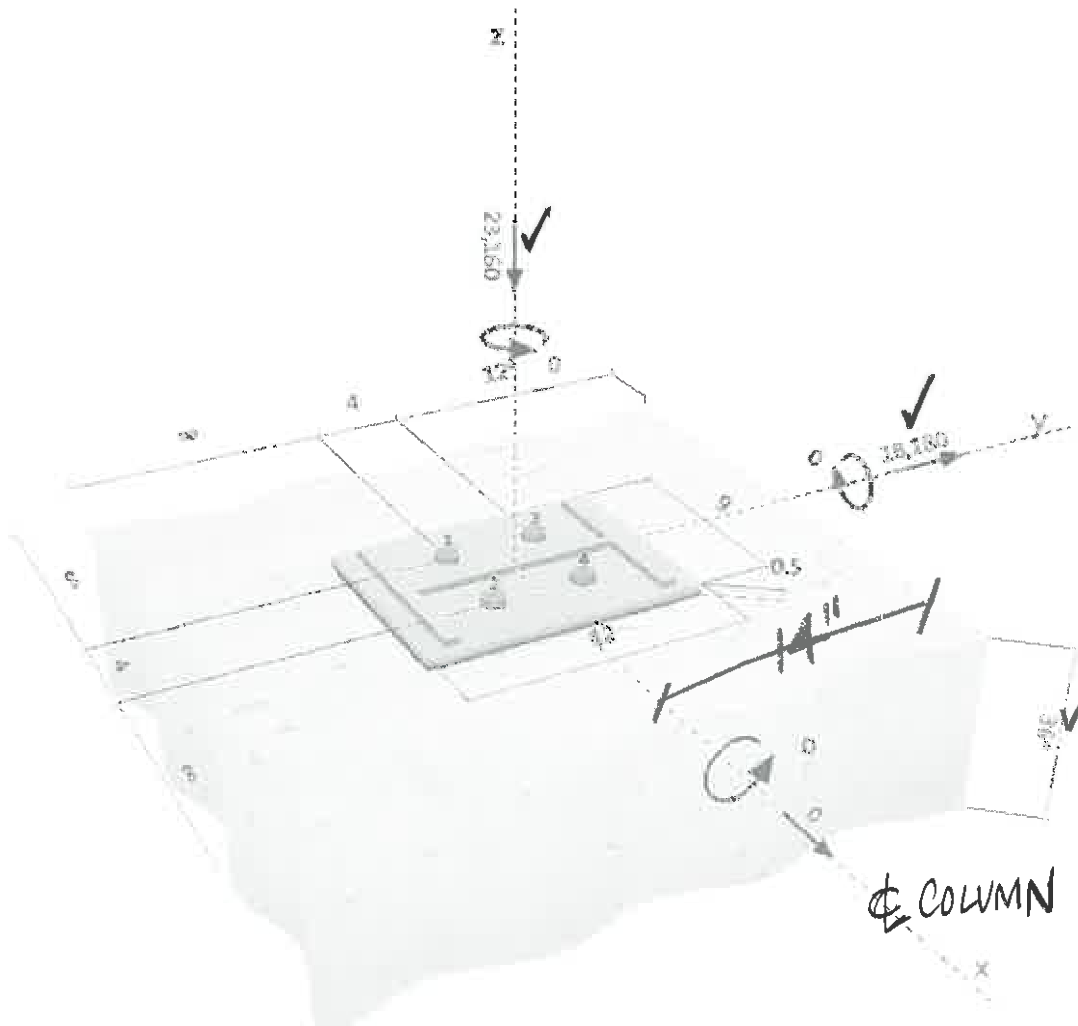
Specifier's comments: Base Plate Anchorage - Worst Case Seismic Shear with 2.5 Overstrength

1 Input data

Anchor type and diameter:	**Heavy Hex Head ASTM F 1554 GR. 36 1**
Effective embedment depth:	h_{ef} = 24.000 in.
Material:	ASTM F 1554
Proof:	design method ACI 318-11 / CIP
Stand-off installation:	e_b = 0.000 in. (no stand-off); t = 0.500 in.
Anchor plate:	l_x x l_y x t = 9.000 in. x 12.000 in. x 0.500 in.; (Recommended plate thickness: not calculated)
Profile:	W shape (AISC); (L x W x T x FT) = 10.100 in. x 8.020 in. x 0.350 in. x 0.620 in.
Base material:	cracked concrete, 4000, f_c' = 4000 psi; h = 36.000 in.
Reinforcement:	tension: condition B, shear: condition B; edge reinforcement: > No. 4 bar
Seismic loads (cat. C, D, E, or F)	Tension load: yes (D.3.3.4.3 (a)) Shear load: yes (D.3.3.5.3 (c))

LC#41

Geometry [in.] & Loading [lb, in.lb]



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Company: ARCADIS
Specifier: Matt Lotycz
Address:
Phone I Fax: |
E-Mail:

2 Load case/Resulting anchor forces

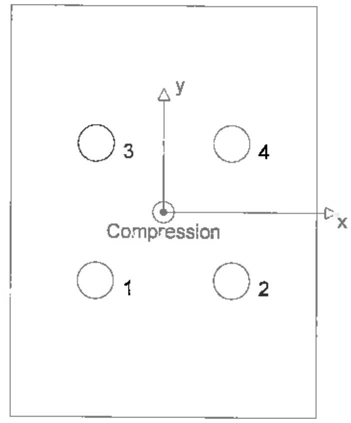
Load case: Design loads

Anchor reactions [lb]

Tension force: (+Tension, -Compression)

Anchor	Tension force	Shear force	Shear force x	Shear force y
1	0	4545	0	4545
2	0	4545	0	4545
3	0	4545	0	4545
4	0	4545	0	4545

max. concrete compressive strain: 0.05 [‰]
max. concrete compressive stress: 214 [psi]
resulting tension force in (x/y)=(0.000/0.000): 0 [lb]
resulting compression force in (x/y)=(0.000/0.000): 23160 [lb]



3 Tension load

	Load N_{ua} [lb]	Capacity ϕN_n [lb]	Utilization $\beta_N = N_{ua}/\phi N_n$	Status
Steel Strength*	N/A	N/A	N/A	N/A
Pullout Strength*	N/A	N/A	N/A	N/A
Concrete Breakout Strength**	N/A	N/A	N/A	N/A
Concrete Side-Face Blowout, direction **	N/A	N/A	N/A	N/A

* anchor having the highest loading **anchor group (anchors in tension)

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4 Shear load

	Load V_{ua} [lb]	Capacity ϕV_n [lb]	Utilization $\beta_V = V_{ua}/\phi V_n$	Status
Steel Strength*	4545	13708	34	OK
Steel failure (with lever arm)*	N/A	N/A	N/A	N/A
Pryout Strength**	18180	172533	11	OK
Concrete edge failure in direction y+**	18180	22084	83	OK

* anchor having the highest loading   **anchor group (relevant anchors)

4.1 Steel Strength

$V_{sa} = n\ 0.6\ A_{se,V}\ f_{uta}$ ACI 318-11 Eq. (D-29)

$\phi\ V_{steel} \geq V_{ua}$ ACI 318-11 Table D.4.1.1

Variables

n	$A_{se,V}$ [in.^{2}]	f_{uta} [psi]
1	0.61	58000

Calculations

V_{sa} [lb]
21089

Results

V_{sa} [lb]	ϕ_{steel}	$\phi\ V_{sa}$ [lb]	V_{ua} [lb]
21089	0.650	13708	4545

4.2 Pryout Strength

$V_{cpg} = k_{cp}\left[\left(\frac{A_{Nc}}{A_{Nc0}}\right)\psi_{ec,N}\ \psi_{ed,N}\ \psi_{c,N}\ \psi_{cp,N}\ N_b\right]$ ACI 318-11 Eq. (D-41)

$\phi\ V_{cpg} \geq V_{ua}$ ACI 318-11 Table D.4.1.1

A_{Nc} see ACI 318-11, Part D.5.2.1, Fig. RD.5.2.1(b)

$A_{Nc0} = 9\ h_{ef}^2$ ACI 318-11 Eq. (D-5)

$\psi_{ec,N} = \left(\frac{1}{1+\frac{2\ e_N}{3\ h_{ef}}}\right) \leq 1.0$ ACI 318-11 Eq. (D-8)

$\psi_{ed,N} = 0.7 + 0.3\left(\frac{c_{a,min}}{1.5h_{ef}}\right) \leq 1.0$ ACI 318-11 Eq. (D-10)

$\psi_{cp,N} = \text{MAX}\left(\frac{c_{a,min}}{c_{ac}}, \frac{1.5h_{ef}}{c_{ac}}\right) \leq 1.0$ ACI 318-11 Eq. (D-12)

$N_b = 16\ \lambda_a \sqrt{f'_c}\ h_{ef}^{5/3}$ ACI 318-11 Eq. (D-7)

Variables

k_{cp}	h_{ef} [in.]	$e_{c1,N}$ [in.]	$e_{c2,N}$ [in.]	$c_{a,min}$ [in.]
2	24.000	0.000	0.000	12.000

$\psi_{c,N}$	c_{ac} [in.]	k_c	λ_a	f'_c [psi]
1.000	-	16	1.000	4000

Calculations

A_{Nc} [in.^{2}]	A_{Nc0} [in.^{2}]	$\psi_{ec1,N}$	$\psi_{ec2,N}$	$\psi_{ed,N}$	$\psi_{cp,N}$	N_b [lb]
3952.00	5184.00	1.000	1.000	0.800	1.000	202070

Results

V_{cpg} [lb]	$\phi_{concrete}$	$\phi_{seismic}$	$\phi_{nonductile}$	$\phi\ V_{cpg}$ [lb]	V_{ua} [lb]
246476	0.700	1.000	1.000	172533	18180

Input data and results must be checked for agreement with the existing conditions and for plausibility!
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4.3 Concrete edge failure in direction y+

$V_{cbg} = \left(\frac{A_{Vc}}{A_{Vc0}}\right) \psi_{ec,V}\, \psi_{ed,V}\, \psi_{c,V}\, \psi_{h,V}\, \psi_{parallel,V}\, V_b$ — ACI 318-11 Eq. (D-31)

$\phi\, V_{cbg} \geq V_{ua}$ — ACI 318-11 Table D.4.1.1

A_{Vc} see ACI 318-11, Part D.6.2.1, Fig. RD.6.2.1(b)

$A_{Vc0} = 4.5\, c_{a1}^2$ — ACI 318-11 Eq. (D-32)

$\psi_{ec,V} = \left(\frac{1}{1 + \frac{2e_V}{3c_{a1}}}\right) \leq 1.0$ — ACI 318-11 Eq. (D-36)

$\psi_{ed,V} = 0.7 + 0.3\left(\frac{c_{a2}}{1.5c_{a1}}\right) \leq 1.0$ — ACI 318-11 Eq. (D-38)

$\psi_{h,V} = \sqrt{\frac{1.5c_{a1}}{h_a}} \geq 1.0$ — ACI 318-11 Eq. (D-39)

$V_b = 9\, \lambda_a \sqrt{f'_c}\, c_{a1}^{1.5}$ — ACI 318-11 Eq. (D-34)

Variables

c_{a1} [in.]	c_{a2} [in.]	e_{cV} [in.]	$\psi_{c,V}$	h_a [in.]
12.000	-	0.000	1.200	36.000

l_e [in.]	λ_a	d_a [in.]	f'_c [psi]	$\psi_{parallel,V}$
8.000	1.000	1.000	4000	1.000

Calculations

A_{Vc} [in.^{2}]	A_{Vc0} [in.^{2}]	$\psi_{ec,V}$	$\psi_{ed,V}$	$\psi_{h,V}$	V_b [lb]
720.00	648.00	1.000	1.000	1.000	23662

Results

V_{cbg} [lb]	$\phi_{concrete}$	$\phi_{seismic}$	$\phi_{nonductile}$	$\phi\, V_{cbg}$ [lb]	V_{ua} [lb]
31549	0.700	1.000	1.000	22084	18180

5 Warnings

- Load re-distributions on the anchors due to elastic deformations of the anchor plate are not considered. The anchor plate is assumed to be sufficiently stiff, in order not to be deformed when subjected to the loading!
- Condition A applies when supplementary reinforcement is used. The Φ factor is increased for non-steel Design Strengths except Pullout Strength and Pryout strength. Condition B applies when supplementary reinforcement is not used and for Pullout Strength and Pryout Strength. Refer to your local standard.
- Checking the transfer of loads into the base material and the shear resistance are required in accordance with ACI 318 or the relevant standard!
- An anchor design approach for structures assigned to Seismic Design Category C, D, E or F is given in ACI 318-11 Appendix D, Part D.3.3.4.3 (a) that requires the governing design strength of an anchor or group of anchors be limited by ductile steel failure. If this is NOT the case, the connection design (tension) shall satisfy the provisions of Part D.3.3.4.3 (b), Part D.3.3.4.3 (c), or Part D.3.3.4.3 (d). The connection design (shear) shall satisfy the provisions of Part D.3.3.5.3 (a), Part D.3.3.5.3 (b), or Part D.3.3.5.3 (c).
- Part D.3.3.4.3 (b) / part D.3.3.5.3 (a) requires that the attachment the anchors are connecting to the structure be designed to undergo ductile yielding at a load level corresponding to anchor forces no greater than the controlling design strength. Part D.3.3.4.3 (c) / part D.3.3.5.3 (b) waives the ductility requirements and requires that the anchors shall be designed for the maximum tension / shear that can be transmitted to the anchors by a non-yielding attachment. Part D.3.3.4.3 (d) / part D.3.3.5.3 (c) waives the ductility requirements and requires the design strength of the anchors to equal or exceed the maximum tension / shear obtained from design load combinations that include E, with E increased by Ω_0.

Fastening meets the design criteria!

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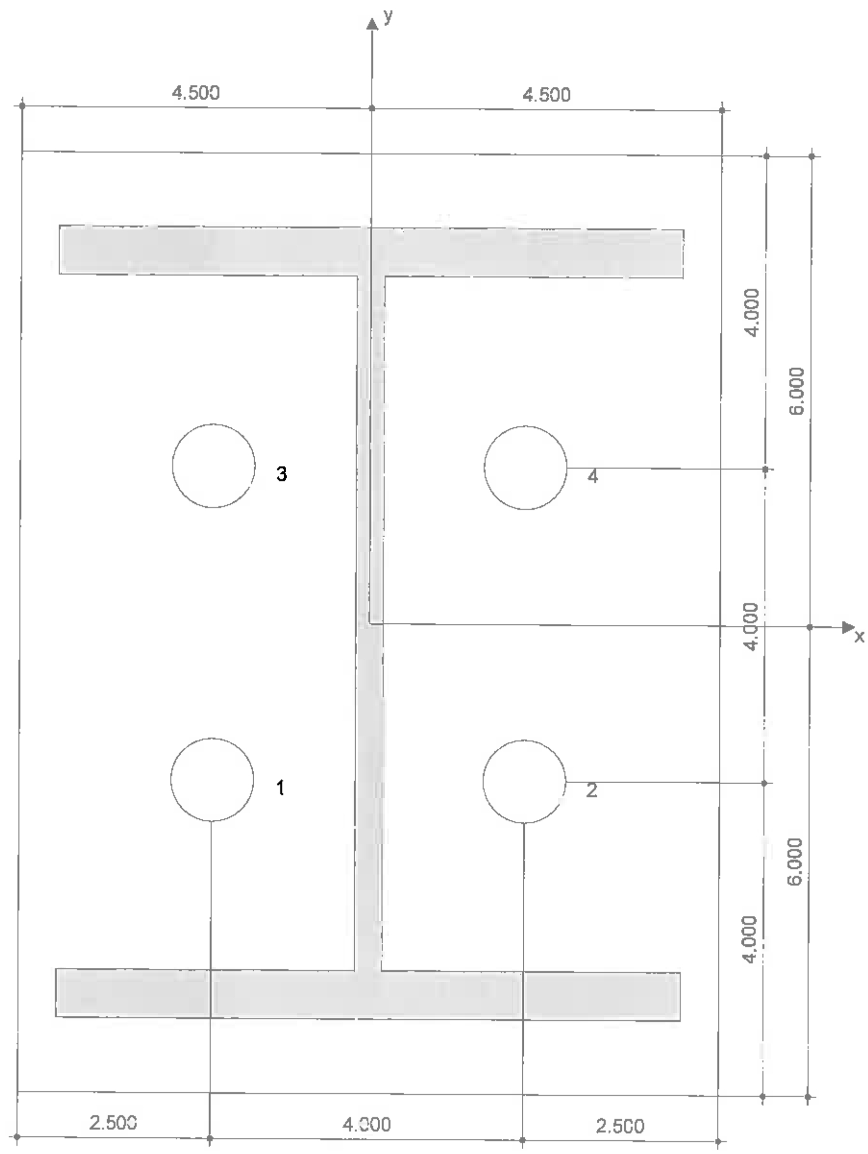
Phone I Fax:	|	Date:	1/7/2015
E-Mail:			

6 Installation data

Anchor plate, steel: -
Profile: W shape (AISC); 10.100 x 8.020 x 0.350 x 0.620 in.
Hole diameter in the fixture: d_f = 1.063 in.
Plate thickness (input): 0.500 in.
Recommended plate thickness: not calculated
Cleaning: No cleaning of the drilled hole is required

Anchor type and diameter: Heavy Hex Head ASTM F 1554 GR. 36 1
Installation torque: -0.009 in.lb
Hole diameter in the base material: - in.
Hole depth in the base material: 24.000 in.
Minimum thickness of the base material: 26.172 in.



Coordinates Anchor in.

Anchor	x	y	c_{-x}	c_{+x}	c_{-y}	c_{+y}
1	-2.000	-2.000	-	-	-	16.000
2	2.000	-2.000	-	-	-	16.000
3	-2.000	2.000	-	-	-	12.000
4	2.000	2.000	-	-	-	12.000

Input data and results must be checked for agreement with the existing conditions and for plausibility!
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- You must take all necessary and reasonable steps to prevent or limit damage caused by the Software. In particular, you must arrange for the regular backup of programs and data and, if applicable, carry out the updates of the Software offered by Hilti on a regular basis. If you do not use the AutoUpdate function of the Software, you must ensure that you are using the current and thus up-to-date version of the Software in each case by carrying out manual updates via the Hilti Website. Hilti will not be liable for consequences, such as the recovery of lost or damaged data or programs, arising from a culpable breach of duty by you.

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SLAB-ON-GRADE DESIGN

	kcf
LOOSE SAND	30-100
MEDIUM SAND	60-50[0]
SAND W/ SILT	150-3[00]

- MODULUS OF SUBGRADE REACTION = 100 kcf ← CONSERVATIVE SINCE
- NET ALLOWABLE SOIL BEARING PRESSURE = 2,000 psf (GEOTECH REPORT)
- Refer to Sht I-20 thru I-25 FOR SLAB-ON-GRADE DESIGN

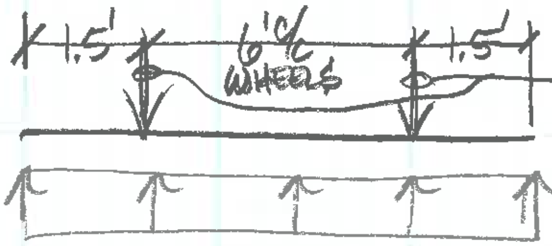
~I-20 ~ 3 TON FORKLIFT

~I-21 ~ HS-20 WHEEL LOAD – 32,000# AXLE → 16,000# WHEEL LOAD @ 100 kcf

~I-22 ~ " " " – 32,000# × 1.25 IMPACT = 40,000# AXLE
130 kcf @ 20,000# WHEEL LOAD

~I-23 ~ & I-24 WALL LOAD = $\left[\left(\frac{10.75^{FT}\ \text{o/o OF WALLS}}{2}\right) \times (50\,psf_{LL} + 10\,psf_{DL})\right]$
$+ [10^{FT}\ \text{HIGH} \times 10\,psf]$
$= 423\#/FT \rightarrow$ USE 450#/FT

~I-25 ~ HS 20 WHEEL LOAD
↳ 32,000# AXLE × 1.25 IMPACT = 40,000# / 3.5 FT DISTRIBUTION ← CONSERVATIVE
= 11,429# IN 1 FT SLAB SECTION



→ $M_{UNF} = 3.75^{K\cdot FT} \times 1.6_{ACI} = 6^{K\cdot FT}_{ACI}$

$V_{UNF} = 3.6^{K} \times 1.6_{ACI} = 5.76^{K}_{ACI}$ ← TOO CONSERVATIVE $= 4.60^{K}$ $(3.6^{K}/1.25_{IMPACT}) \times 1.6_{ACI}$

– 8" SOG w/ #6 @ 11" o/c CENTERED ~ $d = 8"/2 - 6/16" = 3.62^{IN}$

4500 psi

- $\phi V_c = 2\phi\sqrt{f'_c}\,bd = 4.37^{K} \approx 4.6^{K}$ ✓ OK B/C 3.5 FT SLAB DISTRIBUTION IS CONSERVATIVE
- $R = M_u/\phi bd^2 = 508.7 \rightarrow \rho = 0.0086 \rightarrow A_s = \rho bd = 0.37^{IN^2}/FT$

#6 @ 11" o/c CENTERED / $A_s = 0.48^{IN^2}/FT$ > ✓ OK

CONCRETE SLAB ON GRADE ANALYSIS

For Slab Subjected to Interior Concentrated Post or Wheel Loading

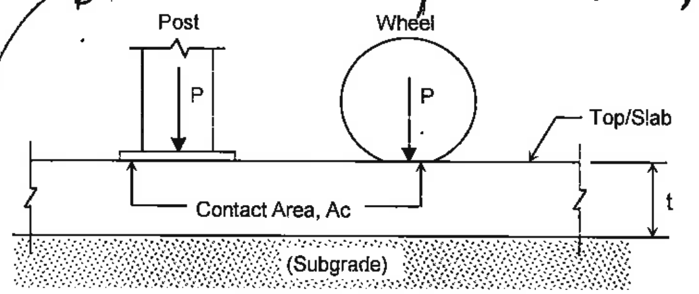
Assuming ACI-360 "Type B" Design - Reinforced for Shrinkage and Temperature Only

Job Name:	Topok - Workshop Building	Subject:	Slab-on-Grade
Job Number:	RC000753.0008	Originator:	MSL
		Checker:	

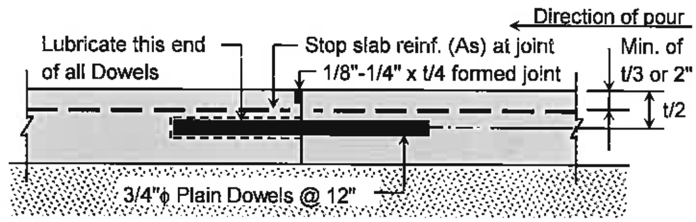
Input Data:

3TON FORKLIFT ≈ 6,000# × 1.25 = 7,500#

Slab Thickness, t =	8.000	in.
Concrete Strength, f 'c =	4000	psi
Conc. Unit Weight, wc =	150	pcf
Reinforcing Yield, fy =	60000	psi
Subgrade Modulus, k =	100	pci
Concentrated Load, P =	7750.00	lbs.
Contact Area, Ac =	72.00	in.^2
Factor of Safety, FS =	2.00	
Dowel Bar Dia., db =	0.750	in.
Dowel Bar Spacing, s =	11.000	in.
Const. Joint Width, z =	0.1250	in.
Joint Spacing, L =	15.000	ft.
Temperature Range, ΔT =	50.00	deg.
Increase for 2nd Wheel, i =	15	%



Concrete Slab on Grade



Typical Construction Joint for Load Transfer

Results:

Check Slab Flexural Stress: (assuming unreinforced slab with interior load condition)

Effective Load Radius, a =	4.787	in.	a = SQRT(Ac/π)	
Modulus of Elasticity, Ec =	3834254	psi	Ec = 33*wc^1.5*SQRT(f 'c)	
Modulus of Rupture, MR =	569.21	psi	MR = 9*SQRT(f 'c)	
Cracking Moment, Mr =	6.07	ft-k/ft.	Mr = MR*(12*t^2/6)/12000 (per 1' = 12" width)	
Poisson's Ratio, μ =	0.15		μ = 0.15 (assumed for concrete)	
Radius of Stiffness, Lr =	35.968	in.	Lr = (Ec*t^3/(12*(1-μ^2)*k))^0.25	
Equivalent Radius, b =	4.633	in.	b = SQRT(1.6*a^2+t^2)-0.675*t , for a < 1.724*t	
1 Load: fb1(actual) =	177.21	psi	fb1(actual) = 3*P*(1+μ)/(2*π*t^2)*(LN(Lr/b)+0.6159)	(Ref. 1)
2 Loads: fb2(actual) =	203.79	psi	fb2(actual) = fb1(actual)*(1+i/100)	
Fb(allow) =	284.60	psi >	Fb(allow) = MR/FS	**Fb(allow) >= fb(actual), O.K.** ✓

Check Slab Bearing Stress: (assuming working stress) (Ref. 4)

fp(actual) =	107.64	psi	fp(actual) = P/Ac	
Fp(allow) =	2390.68	psi	Fp(allow) = 4.2*MR	**Fp(allow) >= fp(actual), O.K.** ✓

Check Slab Punching Shear Stress: (assuming working stress) (Ref. 4)

bo =	33.941	in.	bo = 4*SQRT(Ac) (assumed shear perimeter)	
fv(actual) =	14.69	psi	fv(actual) = P/(t*(bo+4*t))	
Fv(allow) =	153.69	psi	Fv(allow) = 0.27*MR	**Fv(allow) >= fv(actual), O.K.** ✓

Shrinkage and Temperature Reinf.: (assuming subgrade drag method) (Ref. 3)

Friction Factor, F =	1.50		F = 1.5 (assumed friction factor between subgrade and slab)
Slab Weight, W =	100.00	psf	W = wc*(t/12)
Reinf. Allow. Stress, fs =	45000	psi	fs = 0.75*fy
As =	0.025	in.^2/ft.	As = F*L*W/(2*fs)

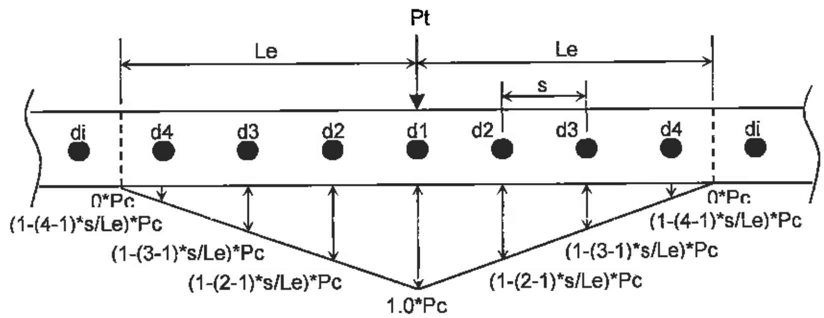
(continued)

< #6@11" o/c (A_s = 0.48 in²/ft)

Determine Estimated Crack Width: (assuming no use of stabilized or granular subbase)

Slab-base Frict. Adjust., C =	1.00		C = 1.0 (assumed value for no subbase)
Thermal Expansion, α =	0.0000055	in./in./deg	α = 5.5x10^(-6) (assumed thermal expansion coefficient)
Shrinkage Coefficient, ε =	0.00035	in./in.	ε = 3.5x10^(-4) (assumed coefficient of shrinkage)
Est. Crack Width, ΔL =	0.1125	in.	ΔL = C*L*12*(α*ΔT+ε) (Ref. 5)

Check Bearing Stress on Dowels at Construction Joints with Load Transfer: (Ref. 2)



Assumed Load Transfer Distribution for Dowels at Construction Joint

Le =	35.968	in.	Le = 1.0*Lr = applicable dist. each side of critical dowel
Effective Dowels, Ne =	3.33	bars	Ne = 1.0+2*Σ(1-d(n-1)*s/Le) (where: n = dowel #)
Joint Load, Pt =	3875.00	lbs.	Pt = 0.50*P (assumed load transferred across joint)
Critical Dowel Load, Pc =	1163.65	lbs.	Pc = Pt/Ne
Mod. of Dowel Suppt., kc =	1500000	psi	kc = 1.5x10^6 (assumed for concrete)
Mod. of Elasticity, Eb =	29000000	psi	Eb = 29x10^6 (assumed for steel dowels)
Inertia/Dowel Bar, Ib =	0.0155	in.^4	Ib = π*db^4/64
Relative Bar Stiffness, β =	0.889		β = (kc*db/(4*Eb*Ib))^(1/4)
fd(actual) =	2911.67	psi	fd(actual) = kc*(Pc*(2+β*z)/(4*β^3*Eb*Ib))
Fd(allow) =	4333.33	psi	Fd(allow) = (4-db)/3*f 'c **Fd(allow) >= fd(actual), O.K.**

References:

1. "Load Testing of Instumented Pavement Sections - Improved Techniques for Appling the Finite Element Method to Strain Predition in PCC Pavement Structures" - by University of Minnesota, Department of Civil Engineering (submitted to MN/DOT, March 24, 2002)
2. "Dowel Bar Opimization: Phases I and II - Final Report" - by Max L. Porter (Iowa State University, 2001)
3. "Design of Slabs-on-Ground" - ACI 360R-06 - by American Concrete Institute (2006)
4. "Slab Thickness Design for Industrial Concrete Floors on Grade" (IS195.01D) - by Robert G. Packard (Portland Cement Association, 1976)
5. "Streses and Stains in Rigid Pavements" (Lecture Notes 3) - by Charles Nunoo, Ph.D., P.E. (Florida International University, Miami FL - Fall 2002)

Comments:

I-21

CONCRETE SLAB ON GRADE THICKNESS ANALYSIS

For Slab Subjected to Single Wheel Loading from Vehicles with Pneumatic Tires

Per PCA "Slab Thickness Design for Industrial Concrete Floors on Grade" - Figure 3, page 5

Job Name:	Topok - Workshop Building	Subject:	Slab-on-Grade
Job Number:	RC000753.0008	Originator:	MSL
		Checker:	

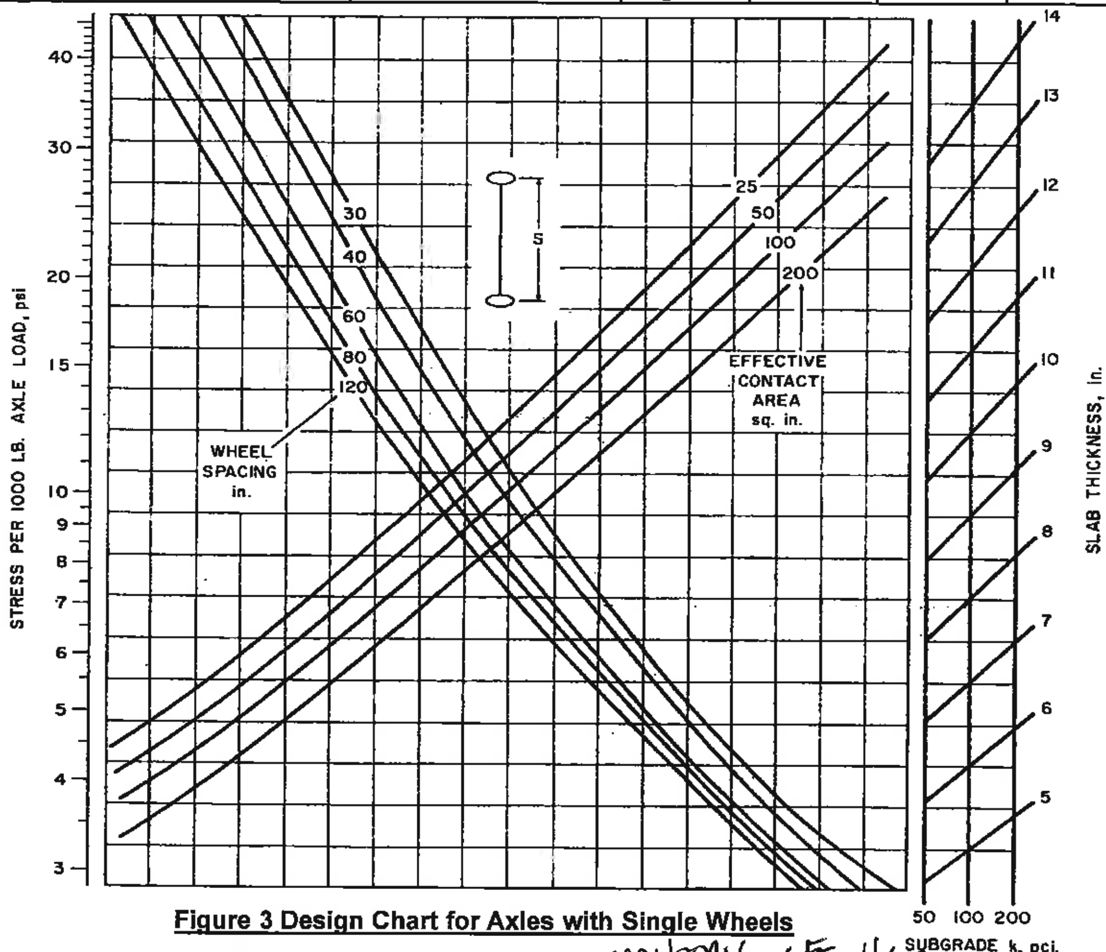


Figure 3 Design Chart for Axles with Single Wheels

Input Data:

Concrete Strength, f 'c =	4000	psi
Subgrade Modulus, k =	100.00	pci
Axle Load, Pa =	32000.00	lbs.
Wheel Spacing, S =	37.00	in.
Tire Inflation Pressure, Ip =	110.00	psi
Factor of Safety, FS =	2.00	

CONSERV ~ 6FT - HS20

Instructions for Use of Figure 3:

1. *Enter chart with slab stress = 8.89*
2. *Move to right to eff. contact area = 145.45*
3. *Move up/down to wheel spacing = 37*
4. *Move to right to subgrade modulus = 100*
5. *Read required slab thickness, t*

Results:

Wheel Load, Pw =	16000.00	lbs.	Pw = Pa/2 (1/2 of axle load for 2 wheels/axle)
Tire Contact Area, Ac =	145.45	in.^2	Ac = Pw/Ip
Effective Contact Area, Ac(eff) =	145.45	in.^2	Ac(eff) = determined from Figure 5, page 6
Concrete Flexual Strength, MR =	569.21	psi	MR = 9*SQRT(f 'c) (Modulus of Rupture)
Concrete Working Stress, WS =	284.60	psi	WS = MR/FS
Slab Stress/1000 lb. Axle Load =	8.89	psi	Ss = WS/(Pa/1000)
Slab Thickness, t =	7.900	in.	t = determined from Figure 3 above

< 8 IN

√ OK

CONCRETE SLAB ON GRADE THICKNESS ANALYSIS

For Slab Subjected to Single Wheel Loading from Vehicles with Pneumatic Tires
Per PCA "Slab Thickness Design for Industrial Concrete Floors on Grade" - Figure 3, page 5

Job Name:	Topok - Workshop Building		Subject:	Slab-on-Grade	
Job Number:	RC000753.0008		Originator:	MSL	Checker:

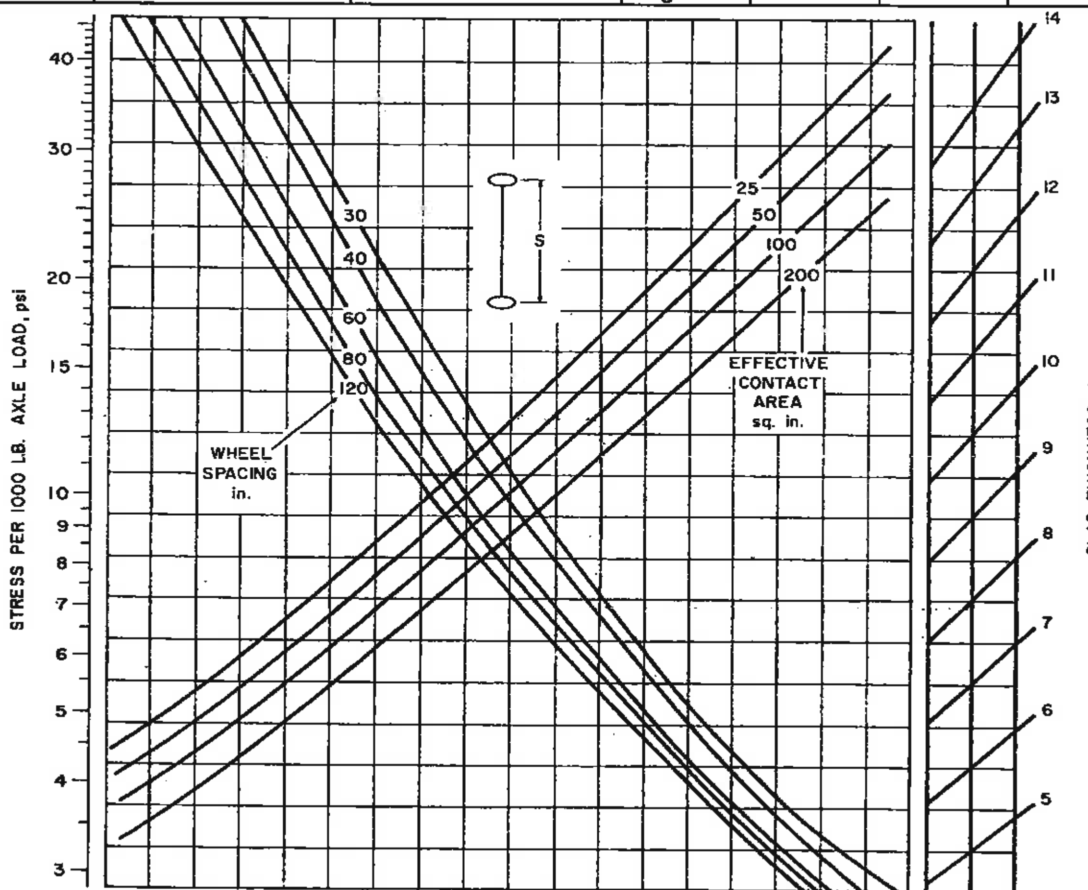


Figure 3 Design Chart for Axles with Single Wheels

CONSERV ~ 6" C/C HS 20

Input Data:

Concrete Strength, f 'c =	4000	psi
Subgrade Modulus, k =	130.00	pci
Axle Load, Pa =	40000.00	lbs.
Wheel Spacing, S =	37.00	in.
Tire Inflation Pressure, Ip =	110.00	psi
Factor of Safety, FS =	2.00	

Instructions for Use of Figure 3:

1. *Enter chart with slab stress = 7.12*
2. *Move to right to eff. contact area = 181.82*
3. *Move up/down to wheel spacing = 37*
4. *Move to right to subgrade modulus = 130*
5. *Read required slab thickness, t*

Results:

Wheel Load, Pw =	20000.00	lbs.	Pw = Pa/2 (1/2 of axle load for 2 wheels/axle)
Tire Contact Area, Ac =	181.82	in.^2	Ac = Pw/Ip
Effective Contact Area, Ac(eff) =	181.82	in.^2	Ac(eff) = determined from Figure 5, page 6
Concrete Flexual Strength, MR =	569.21	psi	MR = 9*SQRT(f 'c) (Modulus of Rupture)
Concrete Working Stress, WS =	284.60	psi	WS = MR/FS
Slab Stress/1000 lb. Axle Load =	7.12	psi	Ss = WS/(Pa/1000)
Slab Thickness, t =	7.900	in. < 8 IN	t = determined from Figure 3 above

√ OK

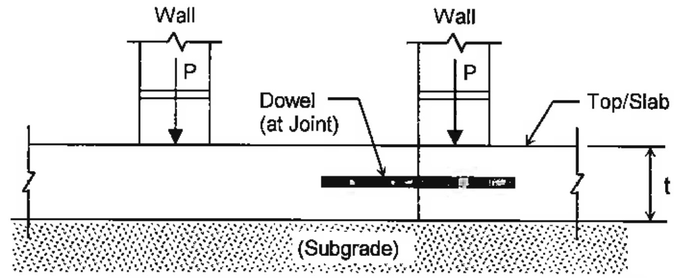
"GRDSLAB.xls" Program
Version 1.6

CONCRETE SLAB ON GRADE ANALYSIS
For Slab Subjected to Continuous Line Loading from Wall

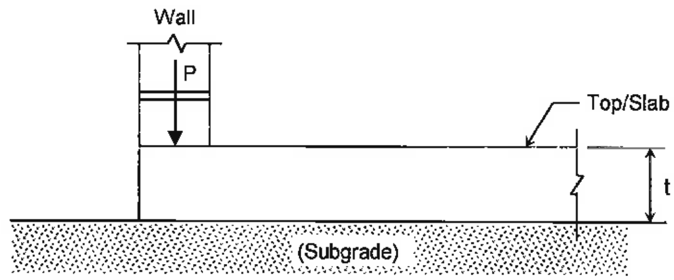
Job Name:	Topok - Workshop Building	Subject:	Slab-on-Grade		
Job Number:	RC000753.0008	Originator:	MSL	Checker:	

Input Data:

Slab Thickness, t =	8.000	in.
Concrete Strength, f 'c =	4000	psi
Subgrade Modulus, k =	100	pci
Wall Load, P =	450.00	lb./ft.



Concrete Slab Loaded Near Center or at Joint



Concrete Slab Loaded Near Free Edge

Results:

Design Parameters:

Modulus of Rupture, MR =	569.21	psi	MR = 9*SQRT(f 'c)
Allow. Bending Stress, Fb =	101.19	psi	Fb = 1.6*SQRT(f 'c) (as recommended in reference below)
Factor of Safety, FS =	5.625		FS = MR/Fb
Section Modulus, S =	128.00	in.^3/ft.	S = b*t^2/6
Modulus of Elasticity, Ec =	3604997	psi	Ec = 57000*SQRT(f 'c)
Width, b =	12.00	in.	b = 12" (assumed)
Moment of Inertia, I =	512.00	in.^4	I = b*t^3/12
Stiffness Factor, λ =	0.0201		λ = (k*b/(4*Ec*I))^(0.25)
Coefficient, Bλx =	0.3224		Bλx = coefficient from "*Beams on Elastic Foundations*" by M. Hetenyi

Wall Load Near Center of Slab or Keyed/Doweled Joints:

Allowable Wall Load, Pc = 1040.30 lb./ft. Pc = 4*Fb*S*λ
= 12.8*SQRT(f 'c)*t^2*(k/(19000*SQRT(f 'c)*t^3))^(0.25)

Pc(allow) >= P, O.K. ✓

Wall Load Near Free Edge of Slab:

Allowable Wall Load, Pe = 806.68 lb./ft. Pe = Fb*S*λ/Bλx
= 9.9256*SQRT(f 'c)*t^2*(k/(19000*SQRT(f 'c)*t^3))^(0.25)

Pe(allow) >= P, O.K. ✓

Reference:

"Concrete Floor Slabs on Grade Subjected to Heavy Loads"
Army Technical Manual TM 5-809-12, Air Force Manual AFM 88-3, Chapter 15 (1987)

Comments:

1/8/2015 9:04 AM

I-24

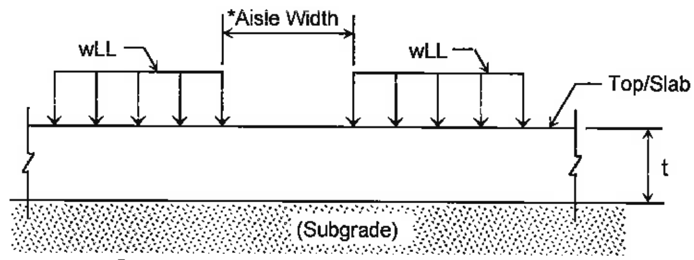
"GRDSLAB.xls" Program
Version 1.6

CONCRETE SLAB ON GRADE ANALYSIS
For Slab Subjected to Stationary Uniformly Distributed Live Loads

Job Name:	Topok - Workshop Building	Subject:	Slab-on-Grade		
Job Number:	RC000753.0008	Originator:	MSL	Checker:	

Input Data:

Slab Thickness, t =	8.000	in.
Concrete Strength, f 'c =	4000	psi
Subgrade Modulus, k =	100	pci
Factor of Safety, FS =	2.000	
Uniform Live Load, wLL =	450.00	psf



Concrete Slab on Grade with Uniform Loads

*Note: In an unjointed aisleway between uniformly distributed load areas, negative bending moment in slab may be up to twice as great as positive moment in slab beneath loaded area. Allowable uniform load determined below is based on critical aisle width and as a result, there are no restrictions on load layout configuration or uniformity of loading.

Results:

Design Parameters:

Modulus of Rupture, MR =	569.21	psi	MR = 9*SQRT(f 'c)
Allow. Bending Stress, Fb =	284.60	psi	Fb = MR/FS
Modulus of Elasticity, Ec =	3604997		Ec = 57000*SQRT(f 'c)
Poisson's Ratio, μ =	0.15		μ = 0.15 (assumed for concrete)
Radius of Stiffness, Lr =	35.42	in.	Lr = (Ec*t^3/(12*(1-μ^2)*k))^0.25
Critical Aisle Width, Wcr =	6.52	ft.	Wcr = (2.209*Lr)/12 (Ref. 3, Appendix 2 page 64) (presented for information only)

Stationary Uniformly Distributed Live Loads:

Per Ref. #1: wLL(allow) = 1093.32 psf — wLL(allow) = 257.876*Fb*SQRT(k*t/Ec)

wLL(allow) >= wLL, O.K. ✓

Per Ref. #2: wLL(allow) = 990.13 psf — wLL(allow) = 0.123*Fb*SQRT(k*t)

wLL(allow) >= wLL, O.K. ✓

Reference:

1. "Concrete Floor Slabs on Grade Subjected to Heavy Loads" Army Technical Manual TM 5-809-12, Air Force Manual AFM 88-3, Chapter 15 (1987)
2. "Slab Thickness Design for Industrial Concrete Floors on Grade" (IS195.01D) by Robert G. Packard (Portland Cement Association, 1976)
3. "Design of Slabs-on-Ground" - ACI 360R-06 - by American Concrete Institute

Comments:

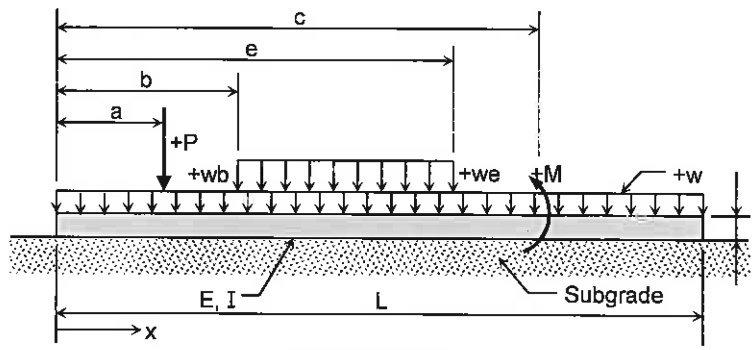
BEAM ON ELASTIC FOUNDATION ANALYSIS
For Soil Supported Beam, Combined Footing, Slab Strip or Mat Strip of Assumed Finite Length with Both Ends Free

Job Name:	Topok - Workshop Building	Subject:	Slab-on-Grade		
Job Number:	RC000753.0008	Originator:	MSL	Checker:	

Input Data:

Beam Data:

Length, L =	9.0000 ✓	ft.
Width, B =	1.0000 ✓	ft.
Thickness, T =	0.6667 ✓	ft.
Modulus, E =	3600 ✓	ksi
Subgrade, K =	100 ✓	pci



Nomenclature

Beam Loadings:

Full Uniform:

w = 0.1000 ✓ kips/ft.

Distributed:

	Start		End	
Distributed:	b (ft.)	Wb (kips/ft.)	e (ft.)	We (kips/ft.)
#1:				
#2:				
#3:				
#4:				
#5:				
#6:				

Point Loads:

Point Loads:	a (ft.)	P (kips)
#1:	1.5000 ✓	5.71 ✓
#2:	7.5000 ✓	5.71 ✓
#3:		
#4:		
#5:		
#6:		
#7:		
#8:		
#9:		
#10:		
#11:		
#12:		

Moments:

Moments:	c (ft.)	M (ft-kips)
#1:		
#2:		
#3:		
#4:		

Results:

Beam Flexiblity Criteria:

for β*L <= π/4	beam is rigid
for π/4 < β*L < π	beam is semi-rigid
for β*L >= π	beam is flexible
for β*L >= 6	beam is semi-infinite long

Inertia, I =	0.0247	ft.^4 I = B*T^3/12
β =	0.241	β = ((K*B)/(4*E*I))^(1/4)
β*L =	2.169	β*L = Flexibility Factor

Beam is semi-rigid

Max. Shears and Locations:

+V(max) =	3.64	k	@ x =	7.50	ft.
-V(max) =	-3.64	k	@ x =	1.50	ft.

Max. Moments and Locations:

+M(max) =	1.57	ft-k	@ x =	1.50	ft.
-M(max) =	-3.75	ft-k	@ x =	4.50	ft.

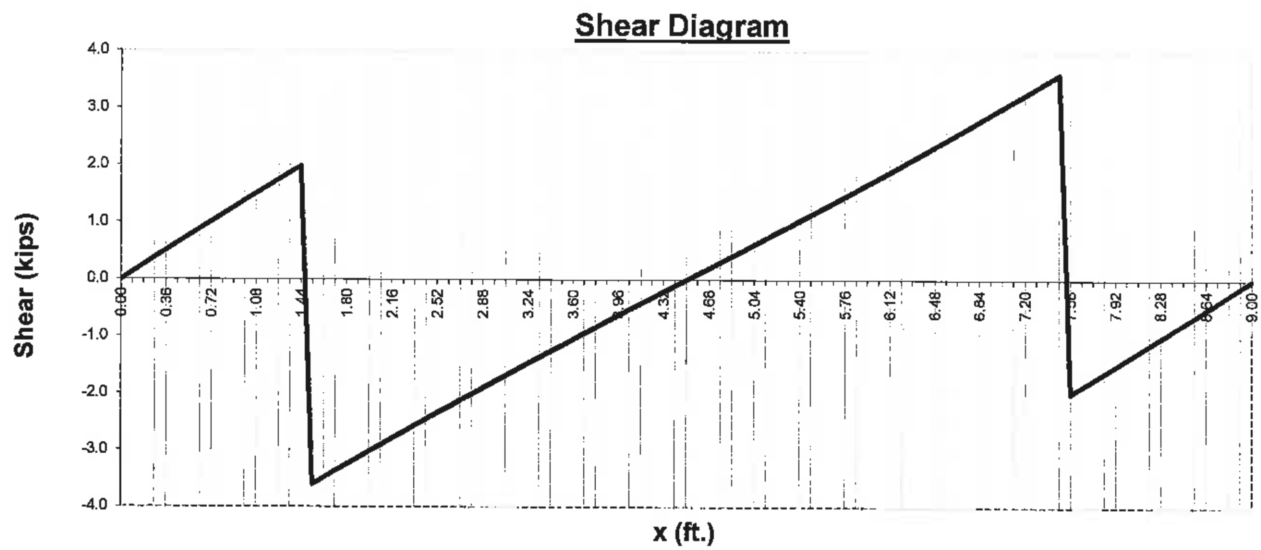
Max. Deflection and Location:

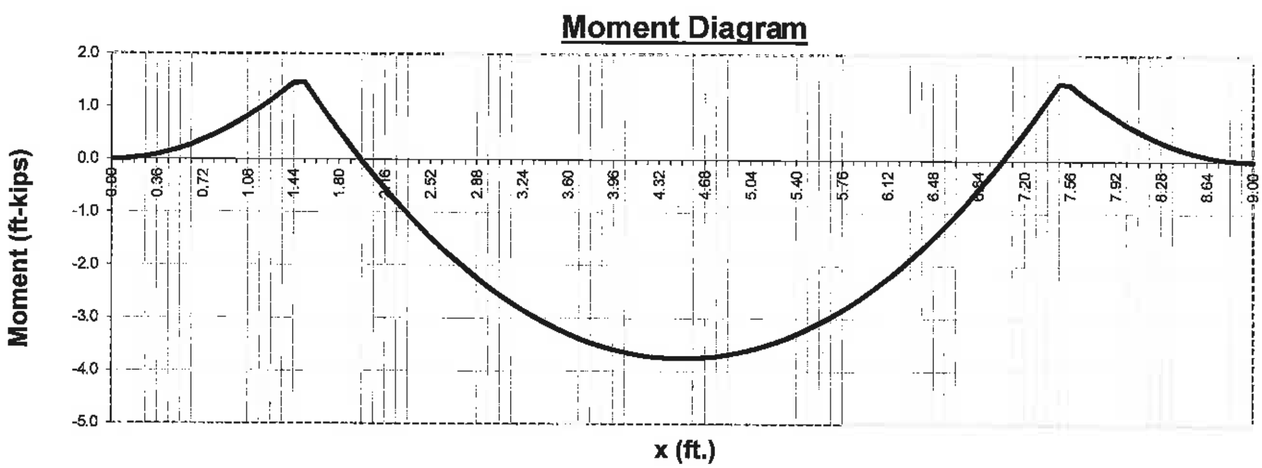
Δ(max) = -0.107 in. @ x = 0.00 ft.

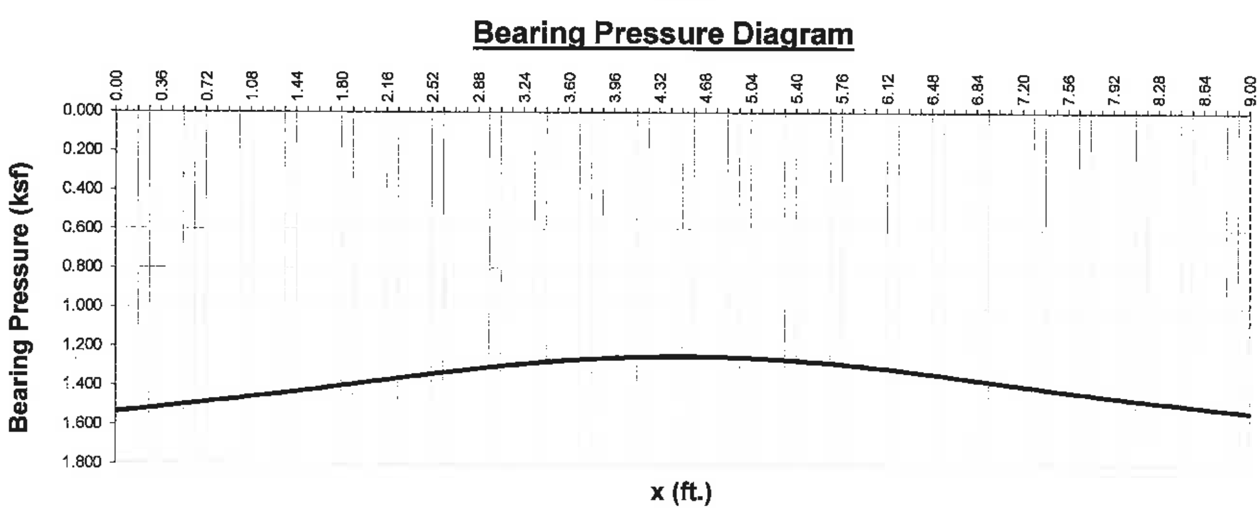
Max. Soil Pressure and Location:

Q(max) = 1.534 ksf @ x = 0.00 ft.

Comments:


Shear Diagram
Shear (kips)
4.0
3.0
2.0
1.0
0.0
-1.0
-2.0
-3.0
-4.0
0.00 0.36 0.72 1.08 1.44 1.80 2.16 2.52 2.88 3.24 3.60 3.96 4.32 4.68 5.04 5.40 5.76 6.12 6.48 6.84 7.20 7.56 7.92 8.28 8.64 9.00
x (ft.)


Moment Diagram
Moment (ft-kips)
2.0
1.0
0.0
-1.0
-2.0
-3.0
-4.0
-5.0
0.00 0.36 0.72 1.08 1.44 1.80 2.16 2.52 2.88 3.24 3.60 3.96 4.32 4.68 5.04 5.40 5.76 6.12 6.48 6.84 7.20 7.56 7.92 8.28 8.64 9.00
x (ft.)


Bearing Pressure Diagram
Bearing Pressure (ksf)
0.00 0.36 0.72 1.08 1.44 1.80 2.16 2.52 2.88 3.24 3.60 3.96 4.32 4.68 5.04 5.40 5.76 6.12 6.48 6.84 7.20 7.56 7.92 8.28 8.64 9.00
0.000
0.200
0.400
0.600
0.800
1.000
1.200
1.400
1.600
1.800
x (ft.)

ARCADIS

SUBJECT: TOPOK-WORKSHOP BLDG
STAIR DESIGN

JOB NO:

BY: MSL DATE: 1/8/15

CHKD: DATE:

STAIR DESIGN

- LIVE LOAD = 100 psf (BASIS OF DESIGN)
- REF SHT I-27 FOR STAIR PLAN LAYOUT
- GRATING DESIGN
  - STAIR ~ 3'-0" IN/IN STRINGERS
  - OHIO GRATING (SHT I-28) ~ 19-W-4 ~ LIGHT-DUTY WELDED STEEL BAR GRATING

3/4" x 3/16" →
- 306 psf > 300 psf UNIFORM ✓OK
- 402# ≈ 450# CONC ✓OK

~ USE 1" x 3/16" LIGHT DUTY WELDED STEEL BAR GRATING (19-W-4) W/ SERRATED TOP SURFACE

- STAIR STRINGER DESIGN
  - LOAD = (7.04 psf GRATING DL + 100 psf LL) × (3 FT IN/IN / 2)
    = 160.6 #/FT + 20 #/FT STRINGER DEAD LOAD + 10 #/FT RAILING DL
    = 191 #/FT
  - SPAN = 15'-7" + 3'-6" = 19.08 FT
  - (STRONG AXIS) $M_{UNF} = \frac{wl^2}{8} = 8.69$ KIFT

    $V_{UNF} = \frac{wl}{2} = 1.82$ K

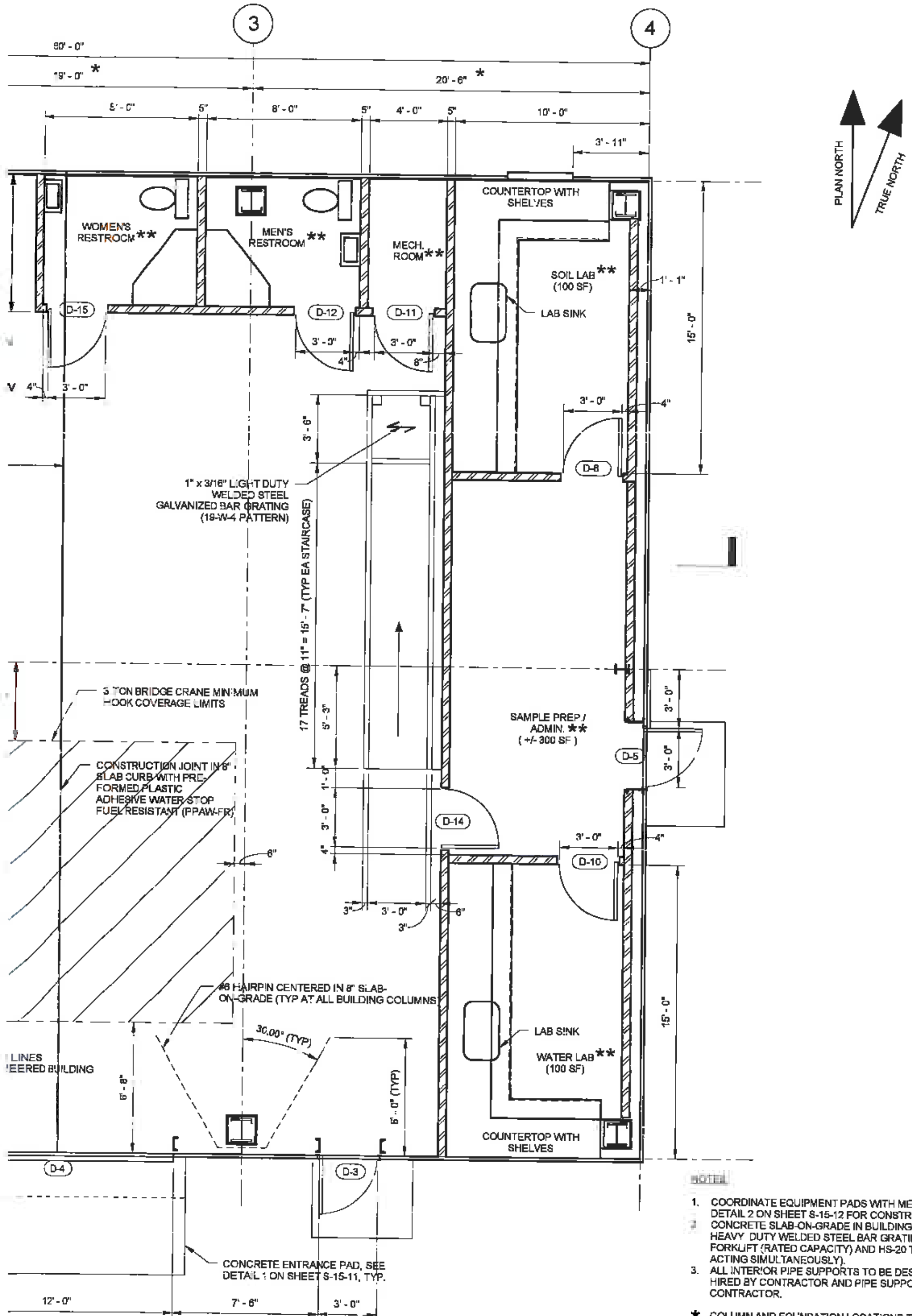
WEAK AXIS

(41 #/FT DL) × (1 + 0.14 S_{DS}) × C_S = 0.07
= 2.97 #/FT
= MIN 16 psf INTERIOR ULTIMATE WIND × 0.6
11 #/FT ← = 10 psf × (10" + 3")

- $M_{UNF} = \frac{wl^2}{8} = 0.50$ KIFT
- $V_{UNF} = \frac{wl}{2} = 105$ #

6 7 8 9 10

I-27



SH FLOOR PLAN
= 1'-0"

NOTES

1. COORDINATE EQUIPMENT PADS WITH MECHANICAL DRAWINGS. SEE DETAIL 2 ON SHEET S-15-12 FOR CONSTRUCTION REQUIREMENTS.
2. CONCRETE SLAB-ON-GRADE IN BUILDING, CONCRETE RAMPS, AND HEAVY DUTY WELDED STEEL BAR GRATING IS DESIGNED FOR 3 TON FORKLIFT (RATED CAPACITY) AND HS-20 TRAFFIC LOADS (LOADS NOT ACTING SIMULTANEOUSLY).
3. ALL INTERIOR PIPE SUPPORTS TO BE DESIGNED BY CALIFORNIA P.E. HIRED BY CONTRACTOR AND PIPE SUPPORTS TO BE PORVIDED BY CONTRACTOR.

* COLUMN AND FOUNDATION LOCATIONS TO BE VERIFIED PER APPROVED PRE-ENGINEERED BUILDING COLUMN LOCATIONS.

** 1/2" PLYWOOD SHEATHING FASTENED TO TOP OF METAL ROOF DECK (1.5B DECK 22 GA) w/ 6" METAL STUD JOISTS AT 16" C/C (TYP ALL INTERIOR ROOMS) (MAX LIVE LOAD RATING = 50 PSF)

- DRAFT -
NOT FOR CONSTRUCTION

No.	Date	DESCRIPTION	GM/SPEC	DWN	CHKD	SUPV	APVD BY
0	12/30/14	SUPPLEMENTAL PRE-FINAL (90%) DESIGN SUBMITTAL		CMW	MEL	JB	RAK

REVISIONS

SUPV JB; DSGN MEL; DWN CMW; CHKD MEL; OK RAK; DATE 12/30/14; SCALES NONE or AS SHOWN

TOPOCK GROUNDWATER REMEDIATION PROJECT

WORKSHOP BUILDING FINISH FLOOR PLAN

GAS TRANSMISSION & DISTRIBUTION
PACIFIC GAS AND ELECTRIC COMPANY
SAN FRANCISCO, CALIFORNIA

MICROFILM / BILL OF MAT'L / DWG LIST / SUPSDS / SUPSD BY / SHEET NO. / SHEETS / REV

S-15-06

I-28

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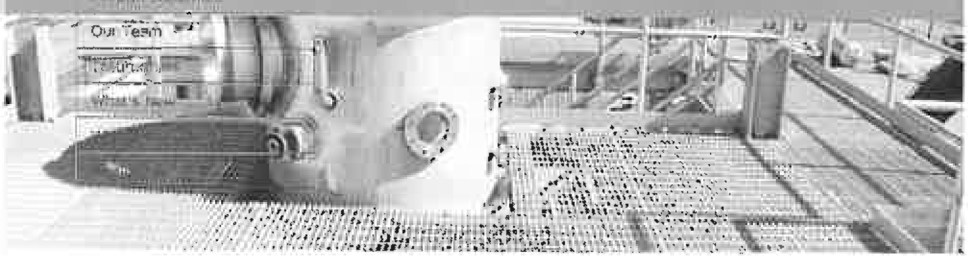
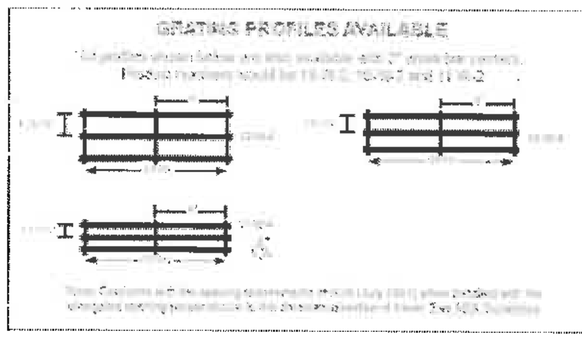
Product Catalog

LIGHT DUTY STEEL GRATING



W Series

ADA compliant light duty steel grating is the workhorse of the industrial flooring market and is used for many different types of pedestrian (walking) applications. The open grid construction provides maximum passage for light, air circulation and drainage. Electro-forging, a machine process combining hydraulic pressure and heat fusion, is readily available and an economical method for manufacturing steel grating panels. The bearing bar surface can be ordered smooth or with a serrated surface for maximum skid resistance. Also available in Stainless Steel, type 304 or 316, upon request. ***Serrated surfaces also available.***



3-Part Specifications

- 19-W-4
- 15-W-4
- 11-W-4

Load Tables

- 19 Space
- 15 Space
- 11 Space

YouTube Video

- Light Duty Welded Steel

Applications for this product include:

- Bridge Walkway Areas
- Vault Covers
- Machinery Safety Guards
- Access to Public/Government Buildings
- Sidewalk Grates
- Stair Treads
- Stage Flooring
- Tree & Pole Guards
- Machine & Motor Bases
- Entranceways to Buildings
- Commercial Entranceways
- Trench Grating

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Programmed & Maintained by OGI Business Applications Development

2'-8" CLEAR — L2x2 STAIR TREAD SUPPORTS!

Bar Size, Inches	Ped Span, Inches	Wt. Lbs Sq. Ft.	Sec. Prop. S_x in³ / I_x in⁴		2'-0"	2'-6"	3'-0"	3'-6"	4'-0"	4'-6"	5'-0"	5'-6"	6'-0"	6'-6"	7'-0"	8'-0"
3/4 x 3/16 (SERRATED)	46	5.43	0.178	U	933	311	222	174	139							
				D	0.099	0.155	0.224	0.304	0.397							
			0.067	C	531	429	354	305	266							
				D	0.079	0.124	0.178	0.242	0.317							
1 x 1/8	51	4.60	0.211	U	632	404	281	206	158	125						
				D	0.079	0.119	0.169	0.228	0.298	0.378						
			0.105	C	632	505	421	361	316	281						
				D	0.066	0.093	0.134	0.183	0.239	0.302						
1 x 3/16 (USE)	57	7.04	0.316	U	947	606	421	309	237	187	152					
				D	0.074	0.116	0.166	0.226	0.296	0.377	0.46					
			0.158	C	947	758	632	541	474	421	379					
				D	0.066	0.093	0.134	0.182	0.238	0.302	0.372					
1-1/4 x 1/8	61	5.86	0.329	U	987	631	438	322	247	195	158	130				
				D	0.060	0.093	0.134	0.182	0.238	0.302	0.373	0.449				
			0.206	C	987	789	658	564	493	438	395	359				
				D	0.048	0.074	0.107	0.146	0.191	0.242	0.298	0.361				
1-1/4 x 3/16	67	8.54	0.493	U	1480	947	658	483	370	292	237	196	164			
				D	0.060	0.093	0.134	0.182	0.238	0.301	0.373	0.451	0.536			
			0.308	C	1480	1184	987	846	740	658	592	538	493			
				D	0.048	0.074	0.107	0.146	0.191	0.241	0.298	0.360	0.429			
1-1/2 x 1/8	76	7.04	0.474	U	1421	909	632	464	355	281	227	188	158			
				D	0.050	0.078	0.112	0.152	0.198	0.252	0.310	0.376	0.447			
			0.355	C	1421	1137	947	812	711	632	568	517	474			
				D	0.040	0.062	0.089	0.122	0.159	0.201	0.248	0.301	0.358			
1-1/2 x 3/16	77	10.25	0.711	U	2132	1364	947	696	533	421	341	282	237	202		
				D	0.050	0.078	0.112	0.152	0.199	0.251	0.310	0.376	0.447	0.525		
			0.533	C	2132	1705	1421	1218	1066	947	853	775	711	656		
				D	0.040	0.062	0.089	0.122	0.159	0.201	0.248	0.300	0.358	0.420		
1-3/4 x 3/16	87	11.97	0.967	U	2901	1857	1289	947	725	573	464	384	322	275	237	181
				D	0.043	0.067	0.096	0.130	0.170	0.215	0.266	0.322	0.383	0.450	0.522	0.680
			0.846	C	2901	2321	1934	1658	1451	1289	1160	1055	967	893	829	725
				D	0.034	0.053	0.077	0.104	0.136	0.172	0.213	0.257	0.306	0.359	0.417	0.545
2 x 3/16	95	13.49	1.263	U	3789	2425	1684	1237	947	749	606	501	421	359	309	237
				D	0.037	0.058	0.084	0.114	0.149	0.189	0.233	0.282	0.335	0.394	0.456	0.596
			1.263	C	3789	3031	2526	2165	1895	1684	1516	1378	1263	1166	1083	947
				D	0.030	0.047	0.067	0.091	0.119	0.151	0.186	0.225	0.268	0.315	0.365	0.477
2-1/4 x 3/16	105	15.65	1.598	U	4795	3069	2131	1566	1199	947	767	634	533	454	391	300
				D	0.033	0.052	0.074	0.101	0.132	0.168	0.207	0.250	0.298	0.350	0.406	0.530
			1.798	C	4795	3837	3197	2740	2398	2131	1918	1744	1598	1476	1370	1199
				D	0.026	0.041	0.060	0.081	0.106	0.134	0.165	0.200	0.238	0.280	0.324	0.424
2-1/2 x 3/16	113	16.70	1.974	U	5921	3789	2632	1933	1480	1170	947	783	658	561	483	370
				D	0.030	0.047	0.067	0.091	0.119	0.151	0.186	0.225	0.268	0.315	0.365	0.477
			2.467	C	5921	4737	3947	3383	2960	2632	2368	2153	1974	1822	1692	1480
				D	0.024	0.037	0.054	0.073	0.095	0.121	0.149	0.180	0.214	0.252	0.292	0.381

U = Safe uniform load in lbs/sq. ft.
C = Safe concentrated load in lbs/ft of grating width.
D = Deflection in inches.

*Based on 19-3/16 bars/ft. of grating width. Bearing bars 1-3/16" o.c. Add .6 lbs./sq. ft. for 19-SGCS-2. Note: Grating for spans to the left of the heavy line have a deflection less than 1/4" for uniform loads of 100 lbs./sq. ft. This is the maximum deflection to afford pedestrian comfort and can be exceeded for other types of load at the discretion of the engineer. The actual Ped (pedestrian) Span under this condition is shown above for each size of grating. When serrated grating is specified, the depth of grating required for a specific load will be 1/4" greater than that shown in these tables. 3/4" x 3/16" serrated grating is not available.

Panel Width Chart (in.) - 19-W-4, 19-W-2, 19-DT-4, 19-DT-2, 19-SGCS-4 & 19-SGCS-2

Dimensions Are Out-to-Out of Bearing Bars**

No. of Bars	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
3/16" Bars	1-3/8	2-9/16	3-3/4	4-15/16	6-1/8	7-5/16	8-1/2	9-11/16	10-7/8	12-1/16	13-1/4	14-7/16	15-5/8	16-13/16	18
No. of Bars	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
3/16" Bars	19-3/16	20-3/8	21-9/16	22-3/4	23-15/16	25-1/8	26-5/16	27-1/2	28-11/16	29-7/8	31-1/16	32-1/4	33-7/16	34-5/8	35-13/16

(STAIR CON'T) ~ TRY C10×15.3 ($I_y = 2.27\,in^4$, $S_y = 1.15\,in^3$; $I_x = 67.3\,in^4$, $S_x = 13.5\,in^3$)

STRONG AXIS

- $L_b = 1^{FT}$ o/c
- $M_{CAP} = 0.66 F_y S_x = 0.66(36ksi)(13.5in^3) = 26.73^{K\cdot FT} > M_{UNF} = 8.69^{K\cdot FT}$ ✓OK
- $V_{CAP} = 0.4 F_y A_w (0.9) = 69.98^K > V_{UNF} = 1.82^K$
- $\Delta_{DES} = \frac{5wl^4}{384EI} = 0.29^{IN} \approx l/784 \ll l/240$ & 1^{IN} ✓OK

WEAK AXIS

- $M_{CAP} = 0.9 F_y S_y = 3.11^{K\cdot FT} > M_{UN} = 0.5^{K\cdot FT}$ ✓OK
- $V_{CAP} = 0.4 F_y (A_f \times 2) 0.9 = 29.38K > V_{UNF}$ ✓OK
- $\Delta_{DES} = 0.50^{IN} \approx l/457 \ll l/240$ OR $1''$
  ↑ CONSERVATIVE, BOTH STRINGERS RESISTING LATERAL LOAD

- COMBINED STRESSES $= \left(\frac{8.69}{26.73}\right)^{K\cdot FT} + \left(\frac{0.5}{3.11}\right)^{K\cdot FT} = 0.49 < 1.0$ ✓OK

COLUMN DESIGN

- $R_{UNF} = 1.82^K + 0.2^K_{HARDWARE} + (12.18^{\#}/FT \times 10^{FT}) = 2.14^K$
- $Kl = 1.0(10^{FT}) = 10$
- AISC 13TH ED – TABLE 4-4 → R_{UNF} CAPACITY $= 61.1^K > R_{UNF}$ ✓OK
  HSS4x4x1/4

~ COLUMN @ BASE OF STAIR IS CLIP ANGLE ATTACHED TO SLAB-ON-GRADE & C10×15.3 FRAMING INTO TOP OF INTERIOR ROOM WALLS

~ BASE PL DESIGN ~ NO MOMENT, JUST VERTICAL LOAD

- $M = N = \frac{10'' - (0.95 \times 4'')}{2} = 3.1^{IN}$, $n' = 1''$ → M CONTROLS ($X = 0.036 \rightarrow l = 0.19$) $= 363^{\#}$
- $t_{MIN} = l\sqrt{\frac{3.33 P_u}{F_y BN}} = 0.138''$ → USE 3/8" THICK $\quad T_{UNF} = \left(\frac{300^{\#}MAN \times 18^{IN}}{7/8 \times 8.5^{IN}}\right)/2$ ANC

~ NO UPLIFT OR SHEAR IN ANCHOR BOLTS, BY INSPECTION (4) 1/2" Ø EXPANSION ANCHOR BOLTS @ 7" o/c SPACING w/ 4" EMBED IS SUFFICIENT FOR 363# TENSION

COLUMN / STRINGER CONNECTION

- $R_{UNF} = 2.02^K$
- AISC 13TH ED - TABLE 7-1

  (2)-3/4"ϕ BOLTS = $10.6^K \times 2_{BOLTS} = 21.2^K > R_{UNF}$ ✓OK

ARCADIS

SUBJECT: TOPOK – WORKSHOP BLDG
INTERIOR ROOM CEILING

JOB NO:

BY: MSL DATE: 1/8/15

CHKD: DATE:

SHEET /

INTERIOR ROOM CEILING

- LIVE LOAD = 50psf (SIGNAGE POSTED & LISTED ON DRAWINGS)
- DEAD LOAD = 3psf 3/4" PLYWOOD + 5psf MECH/ELE

  58psf SUPERIMPOSED LOAD

- REF VULCRAFT 1.5B METAL DECK – 22GA ~ MAX SPAN FOR LOAD = 7'-0" o/c (SHT I-32)

  MAX SPAN FM GLOBAL = 6'-0" o/c ← MAX

  MAX SPAN FOR CONSTRUCTION LOADS = 6'-6" o/c

→ USE 36/5 PATTERN SINCE NOT A TRUE DIAGRAPHM FOR BUILDING LATERAL RESTRAINT w/ 4 SIDELAP FASTENERS ~ #12 TEK SUPPORT FASTENERS

#10 TEK SIDELAP FASTENERS

(279 #/FT DIAPHRAGM SHEAR STRENGTH

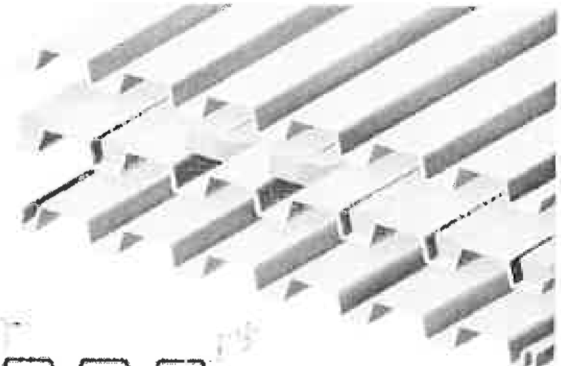
> 196 #/F MIN SEISMIC ATTACHMENTS (280#/F × 0.7E)

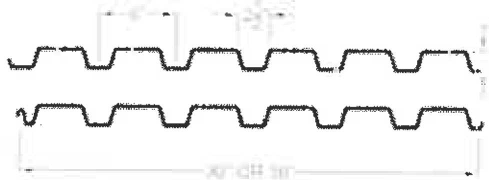
↖ 280#/F × 0.7

- REF SHT I-33 & 34 FOR METAL DECK SECTION CALLOUTS & NOTES

1.5 B, BI, BA, BIA, BSV

Maximum Sheet Length 42'-0
Extra charge for lengths under 6'-0
ICC ER-3415
FM Global Approved[2]





Interlocking side lap is not drawn to show actual detail.

ROOF

SECTION PROPERTIES

Deck type	Design thickness in.	W psf	I_p in⁴/ft	S_p in³/ft	I_n in⁴/ft	S_n in³/ft	V_a lbs/ft	F_y ksi
B24	0.0239	1.46	0.107	0.120	0.135	0.131	2634	60
B22	0.0295	1.78	0.155	0.186	0.183	0.192	1818	33
B20	0.0358	2.14	0.201	0.234	0.222	0.247	2193	33
B19	0.0418	2.49	0.246	0.277	0.260	0.289	2546	33
B18	0.0474	2.82	0.289	0.318	0.295	0.327	2870	33
B16	0.0598	3.54	0.373	0.408	0.373	0.411	3578	33

ACOUSTICAL INFORMATION

Deck Type	Absorption Coefficient						Noise Reduction Coefficient[1]
	125	250	500	1000	2000	4000	
1.5BA, 1.5BIA	.11	.18	.66	1.02	0.61	0.33	0.60

[1] Source: Riverbank Acoustical Laboratories.
Test was conducted with 1.50 pcf fiberglass batts and 2 inch polyisocyanurate foam insulation for the SDI.

Type B (wide rib) deck provides excellent structural load carrying capacity per pound of steel utilized, and its nestable design eliminates the need for die-set ends.

1" or more rigid insulation is required for Type B deck.

Acoustical deck (Type BA, BIA) is particularly suitable in structures such as auditoriums, schools, and theatres where sound control is desirable. Acoustic perforations are located in the vertical webs where the load carrying properties are negligibly affected (less than 5%).

Inert, non-organic glass fiber sound absorbing batts are placed in the rib openings to absorb up to 60% of the sound striking the deck.

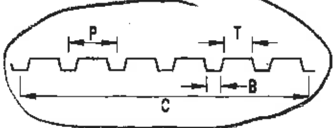
Batts are field installed and may require separation.

VERTICAL LOADS FOR TYPE 1.5B

No. of Spans	Deck Type	Max. SDI Const. Span	Allowable Total (PSF) / Load Causing Deflection of L/240 or 1 inch (PSF) — Span (ft.-in.) ctr to ctr of supports										
			5-0	5-6	6-0	6-6	7-0	7-6	8-0	8-6	9-0	9-6	10-0
1	B24	4'-8	115 / 56	95 / 42	80 / 32	68 / 26	59 / 20	51 / 17	45 / 14	40 / 11	35 / 10	32 / 8	29 / 7
	B22	5'-7	98 / 81	81 / 61	68 / 47	58 / 37	50 / 30	44 / 24	38 / 20	34 / 17	30 / 14	27 / 12	25 / 10
	B20	6'-5	123 / 105	102 / 79	86 / 61	73 / 48	63 / 38	55 / 31	48 / 26	43 / 21	38 / 18	34 / 15	31 / 13
	B19	7'-1	146 / 129	121 / 97	101 / 75	86 / 59	74 / 47	65 / 38	57 / 31	51 / 26	45 / 22	40 / 19	36 / 16
	B18	7'-8	168 / 152	138 / 114	116 / 88	99 / 69	85 / 55	74 / 45	65 / 37	58 / 31	52 / 26	46 / 22	42 / 19
	B16	8'-8	215 / 196	178 / 147	149 / 113	127 / 89	110 / 71	96 / 58	84 / 48	74 / 40	66 / 34	60 / 29	54 / 24
2	B24	5'-10	124 / 153	103 / 115	86 / 88	74 / 70	64 / 56	56 / 45	49 / 37	43 / 31	39 / 26	35 / 22	31 / 19
	B22	6'-11	100 / 213	83 / 160	70 / 124	59 / 97	51 / 78	45 / 63	39 / 52	35 / 43	31 / 37	28 / 31	25 / 27
	B20	7'-9	128 / 267	106 / 201	89 / 155	76 / 122	66 / 97	57 / 79	51 / 65	45 / 54	40 / 46	36 / 39	32 / 33
	B19	8'-5	150 / 320	124 / 240	104 / 185	89 / 145	77 / 116	67 / 95	59 / 78	52 / 65	47 / 55	42 / 47	38 / 40
	B18	9'-1	169 / 369	140 / 277	118 / 213	101 / 168	87 / 134	76 / 109	67 / 90	59 / 75	53 / 63	48 / 54	43 / 46
	B16	10'-3	213 / 471	176 / 354	149 / 273	127 / 214	110 / 172	95 / 140	84 / 115	74 / 96	66 / 81	60 / 69	54 / 59
3	B24	5'-10	154 / 120	128 / 90	108 / 69	92 / 55	79 / 44	69 / 35	61 / 29	54 / 24	48 / 21	43 / 17	39 / 15
	B22	6'-11	124 / 167	103 / 126	87 / 97	74 / 76	64 / 61	56 / 50	49 / 41	43 / 34	39 / 29	35 / 24	31 / 21
	B20	7'-9	159 / 209	132 / 157	111 / 121	95 / 95	82 / 76	72 / 62	63 / 51	56 / 43	50 / 36	45 / 31	40 / 26
	B19	8'-5	186 / 250	154 / 188	130 / 145	111 / 114	96 / 91	84 / 74	74 / 61	65 / 51	58 / 43	52 / 37	47 / 31
	B18	9'-1	210 / 289	174 / 217	147 / 167	126 / 132	108 / 105	95 / 86	83 / 71	74 / 59	66 / 50	59 / 42	54 / 36
	B16	10'-3	264 / 369	219 / 277	185 / 214	158 / 168	136 / 135	119 / 109	105 / 90	93 / 75	83 / 63	74 / 54	67 / 46

Notes: 1. Minimum exterior bearing length required is 1.50 inches. Minimum interior bearing length required is 3.00 inches. If these minimum lengths are not provided, web crippling must be checked.
2. FM Global approved numbers and spans available on page 21.

TECHNICAL PRODUCT INFORMATION



Approximate Dimensions in Inches

	Deck Type	Gauge	Indiana C	Indiana P	Indiana T	Indiana B	Nebraska C	Nebraska P	Nebraska T	Nebraska B	South Carolina C	South Carolina P	South Carolina T	South Carolina B	Texas C	Texas P	Texas T	Texas B	Alabama / New York C	Alabama / New York P	Alabama / New York T	Alabama / New York B
ROOF	1.5B, 1.5BI, 1.5BA, 1.5BIA 1.5BSV	24 22 20 19 18 16	NA 36 36 36 36 36	6.00	3.50	1.75	30 36 36 36 36 36	6.00	3.50	1.75	36 36 36 36 36 36	6.00	3.50	1.75	NA 36 36 36 36 36	6.00	3.50	1.75	36 36 36 36 36 36	6.00	3.50	1.75
ROOF	1.5F	22 20 18	30	6.00	4.25	0.50	36	6.00	4.25	0.50	36	6.00	4.25	0.50	36	6.00	4.25	0.50	36	6.00	4.25	0.50
ROOF	1.5A	22 20 18	36	6.00	5.00	0.38	36	6.00	5.00	0.38	36	6.00	5.00	0.38	NA	-	-	-	NA	-	-	-
ROOF	3N, 3NI, 3NA, 3NIA	22 20 18 16	24	8.00	5.38	1.88	24	8.00	5.38	1.88	24	8.00	5.38	1.88	24	8.00	5.38	1.88	24	8.00	5.38	1.88
ROOF	1.0E	26 24 22 20	36	4.00	1.13	1.13	32	4.00	1.01	1.25	33	3.67	0.90	0.90	33	3.67	1.00	1.00	36	4.00	1.13	1.13
NON-COMPOSITE	0.6C and 0.6CSV	28 26 24 22	NA 30 30 NA	2.50	0.62	0.62	NA 36 36 36	3.04	0.63	0.63	35 35 35 35	2.50	0.75	0.75	30 35 35 35	2.50	0.62	0.62	30 30 30 30	2.50	0.75	0.75
NON-COMPOSITE	1.0C and 1.0CSV	26 24 22 20	36	4.00	1.13	1.13	32	4.00	1.25	1.01	33	3.67	0.90	0.90	33	3.67	1.00	1.00	36	4.00	1.13	1.13
NON-COMPOSITE	1.3C and 1.3CSV	26 24 22 20	NA	-	-	-	NA	-	-	-	NA	-	-	-	32	4.57	1.06	1.06	NA	-	-	-
NON-COMPOSITE	1.5C	24 22 20 18	NA 36 36 36	6.00	1.75	3.50	30 36 36 36	6.00	1.75	3.50	36 36 36 36	6.00	1.75	3.50	30 36 36 36	6.00	1.75	3.50	36 36 36 36	6.00	1.75	3.50
NON-COMPOSITE	2C	22 20 18 16	36	12.0	5.00	5.00	36	12.0	5.00	5.00	36	12.0	5.00	5.00	36	12.0	5.00	5.00	36	12.0	5.00	5.00
NON-COMPOSITE	3C	22 20 18 16	36	12.0	4.75	4.75	36	12.0	4.75	4.75	36	12.0	4.75	4.75	36	12.0	4.75	4.75	36	12.0	4.75	4.75
COMPOSITE	1.5VL and 1.5VLI	22 20 19 18 16	36	6.00	3.50	1.75	36	6.00	3.50	1.75	36	6.00	3.50	1.75	36	6.00	3.50	1.75	36	6.0	3.50	1.75
COMPOSITE	1.5VLR	22 20 19 18 16	36	6.00	1.75	3.50	36	6.00	1.75	3.50	36	6.00	1.75	3.50	36	6.00	1.75	3.50	36	6.0	1.75	3.50
COMPOSITE	2VLI	22 20 19 18 16	36	12.0	5.00	5.00	36	12.0	5.00	5.00	36	12.0	5.00	5.00	36	12.0	5.00	5.00	36	12.0	5.00	5.00
COMPOSITE	3VLI	22 20 19 18 16	36	12.0	4.75	4.75	36	12.0	4.75	4.75	36	12.0	4.75	4.75	36	12.0	4.75	4.75	36	12.0	4.75	4.75

Vulcraft Steel Deck — FM Global Approved Spans

Maximum Vulcraft deck spans approved for use in FM Global constructions are shown below. The Engineer of Record must investigate the design as published by FM Global for the required attachment of the steel deck to the supporting structure, deck-to-deck fastening, attachment of insulation to the roof deck, etc. Reference shall be made to: https://roofnav.fmglobal.com

Roof Deck

	FM Span / Profile					
Gauge	1.5B, 1.5BI	1.5BA, 1.5 BIA	1.5F	1.5A	3N, 3NI	3NA, 3NIA
22	6' - 0"	5' - 9"	4' - 11"	4' - 0"	12' - 0"	12' - 7"
20	6' - 6"	6' - 4"	5' - 5"	5' - 3"	13' - 5"	13' - 11"
18	7' - 5"	7' - 3"	6' - 3"	6' - 0"	15' - 10"	16' - 1"
16	9' - 4"	7' - 11"	—	—	18' - 1"	18' - 3"

Cellular Deck

	FM Span / Profile	
Gauges	1.5BP, 1.5BPA	3NP, 3NPA
20/20	6' - 6"	13' - 5"
20/18	6' - 6"	13' - 5"
18/20	7' - 5"	15' - 10"
18/18	7' - 5"	15' - 10"
18/16	7' - 5"	15' - 10"
16/18	9' - 4"	18' - 1"
16/16	9' - 4"	18' - 1"

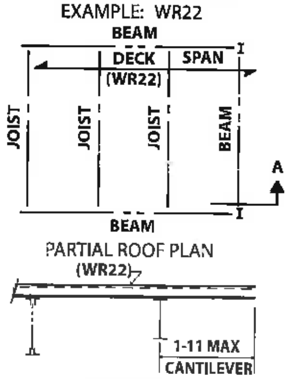
Steel Roof Deck

RECOMMENDED MAXIMUM SPANS FOR CONSTRUCTION AND MAINTENANCE LOADS STANDARD FOR 1½ INCH AND 3 INCH ROOF DECK

	TYPE	SPAN CONDITION	SPAN FT.-IN.	SPAN METERS	MAX. RECOMMENDED SPANS ROOF DECK CANTILEVER FT.-IN.	MAX. RECOMMENDED SPANS ROOF DECK CANTILEVER METERS
NARROW RIB DECK	NR22	1	3'-10"	1.15 m	1'-0"	.30 m
	NR22	2 or more	4'-9"	1.45 m		
	NR20	1	4'-10"	1.45 m	1'-2"	.35 m
	NR20	2 or more	5'-11"	1.80 m		
	NR18	1	5'-11"	1.80 m	1'-7"	.45 m
	NR18	2 or more	6'-11"	2.10 m		
INTERMEDIATE RIB DECK	IR22	1	4'-6"	1.35 m	1'-2"	.35 m
	IR22	2 or more	5'-6"	1.65 m		
	IR20	1	5'-3"	1.60 m	1'-5"	.40 m
	IR20	2 or more	6'-3"	1.90 m		
WIDE RIB DECK	WR22	1	5'-6"	1.65 m	1'-11"	.55 m
	WR22	2 or more	6'-6"	1.75 m		
	WR20	1	6'-3"	1.90 m	2'-4"	.70 m
	WR20	2 or more	7'-5"	2.25 m		
	WR18	1	7'-6"	2.30 m	2'-10"	.85 m
	WR18	2 or more	8'-10"	2.70 m		
DEEP RIB DECK	3DR22	1	11'-0"	3.35 m	3'-5"	1.05 m
	3DR22	2 or more	13'-0"	3.95 m		
	3DR20	1	12'-6"	3.80 m	3'-11"	1.20 m
	3DR20	2 or more	14'-8"	4.45 m		
	3DR18	1	15'-0"	4.55 m	4'-9"	1.45 m
	3DR18	2 or more	17'-8"	5.40 m		

CANTILEVER DESIGN

STEEL DECK CANTILEVER
EXAMPLE: WR22

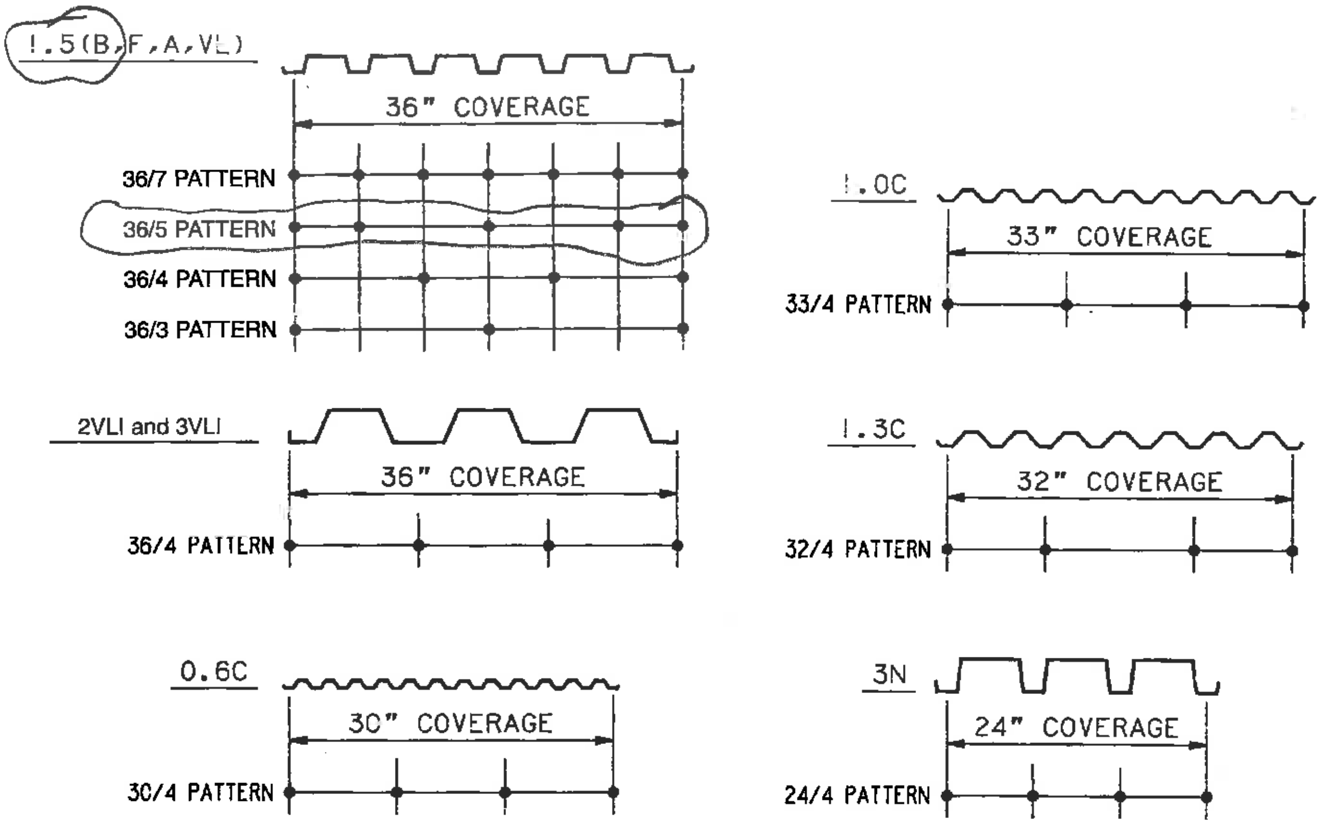


SECTION A

Notes:

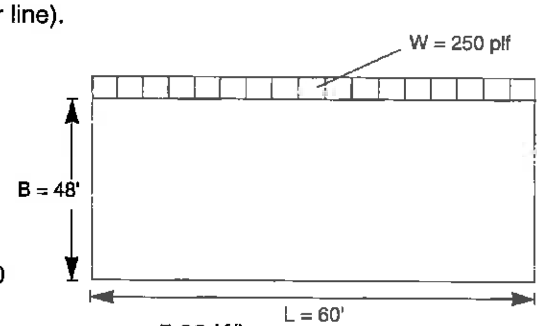
1. Adjacent span: Limited to those spans determined in Section 2.4 of Roof Deck Standards. In those instances where the adjacent span is less than 3 times the cantilever span, the individual manufacturer should be consulted for the appropriate cantilever span.
2. Sidelaps must be attached at end of cantilever and at a maximum of 12 inches (300 mm) on center from end.
3. No permanent suspended loads are to be supported by the steel deck.
4. The deck must be completely attached to the supports and at the sidelaps before any load is applied to the cantilever.
5. Service loads may be more severe than indicated in section 2.4.A.7.

TYPICAL FASTENER LAYOUT



DIAPHRAGM SHEAR STRENGTH AND STIFFNESS DESIGN EXAMPLE

For roof plan shown, calculate the deflection of diaphragm ($\Delta_{\mathbb{C}_L}$ center line).



Joist spacing = 5'-0"
Deck: 1.5B 22 (WR) in 15'-0" panels
(3 span condition)
Fasteners: Support – 36/3 pattern
W/ 5/8" puddle welds
Sidelap – 1 #10 TEK

From diaphragm strength tables: $K_1 = 0.617$, $D_B = 2209$, and $K_2 = 870$

$$G' = \frac{K_2}{3.78 + \frac{0.3D_B}{Span} + 3K_1\ Span} = \frac{870}{3.78 + \frac{0.3(2209)}{5} + 3(0.617)(5)} = 5.98\ K/in$$

$$\Delta_{\mathbb{C}_L} = \frac{WL^2}{8xBxG'} = \frac{0.250\ (60)^2}{8\ (48)\ (5.98)} = 0.39\ in$$

Strength Check

$$R = WL/2 = \frac{250\ (60)}{2} = 7500\ lbs \qquad S = \frac{7500}{48} = 156\ plf < 224\ plf\ (\text{from page 86})\ OK$$

1.5 (B, BI) 22 ALLOWABLE DIAPHRAGM SHEAR STRENGTH (PLF)
SUPPORT FASTENERS: 3/4" puddle welds
SIDELAP FASTENERS: welded[1]

Factor of safety = 2.35

	# OF SIDELAP FASTENERS	DIAPHRAGM SHEAR STRENGTH (PLF) — DECK SPAN (FT.-IN.) 3.00	3.50	4.00	4.50	5.00	5.50	6.00	6.50	7.00	7.50	8.00	8.50	9.00	9.50	10.00	K1
36/7	0	585	509	443	391	350	316	288	264	244	226	210	197	186	177	168	0.486
	1	734	643	572	514	461	417	380									0.287
	2	856	766	685	619	563	517	473	435	402	374	349	328	310			0.204
	3	982	877	790	717	656	603	558	519	481	448	419	384	343	308	278	0.158
	4	1083	977	886	808	742	685	635	592	554	494	434	384	343	308	278	0.129
	5	1169	1064	972	892	823	762	709	657	567	494	434	384	343	308	278	0.109
	6	1244	1142	1050	969	898	835	771	657	567	494	434	384	343	308	278	0.094
	7	1308	1210	1120	1039	967	902	771	657	567	494	434	384	343	308	278	0.083
	8	1362	1269	1182	1103	1030	918	771	657	567	494	434	384	343	308	278	0.074
	9	1409	1321	1238	1160	1088	918	771	657	567	494	434	384	343	308	278	0.067
	10	1450	1367	1287	1212	1111	918	771	657	567	494	434	384	343	308	278	0.061

D_B = 129 K2= 870

36/5	0	518	455	405	361	323	292	266	244	225	208	194	182	172	163	155	0.583
	1	641	572	514	466	426	392	358									0.319
	2	741	670	609	557	512	473	439	410	383	356	333	312	295			0.219
	3	821	752	691	637	590	548	511	478	449	423	399	378	343	308	278	0.167
	4	884	820	760	707	658	615	576	541	510	481	434	384	343	308	278	0.135
	5	934	875	819	767	719	675	635	599	566	494	434	384	343	308	278	0.113
	6	974	920	868	818	772	728	688	652	567	494	434	384	343	308	278	0.098
	7	1006	957	909	862	818	775	736	657	567	494	434	384	343	308	278	0.086
	8	1032	988	944	900	858	817	771	657	567	494	434	384	343	308	278	0.076
	9	1054	1014	973	933	893	854	771	657	567	494	434	384	343	308	278	0.069
	10	1071	1035	998	960	923	886	771	657	567	494	434	384	343	308	278	0.063

D_B = 758 K2= 870

36/4	0	396	349	310	273	244	219	199	182	168	155	144	135	127	121	115	0.728
	1	514	461	416	379	347	320	292									0.358
	2	602	550	504	463	428	397	370	346	324	303	283	266	251			0.237
	3	666	618	574	534	497	465	436	409	386	364	345	328	312	296	278	0.177
	4	714	671	630	592	556	523	493	466	441	418	397	378	343	308	278	0.142
	5	749	712	674	639	605	573	543	516	490	467	434	384	343	308	278	0.118
	6	776	743	710	677	645	615	586	559	534	494	434	384	343	308	278	0.101
	7	796	767	738	708	679	651	623	597	567	494	434	384	343	308	278	0.088
	8	812	787	761	734	707	681	655	630	567	494	434	384	343	308	278	0.078
	9	824	802	779	755	731	706	682	657	567	494	434	384	343	308	278	0.071
	10	834	815	794	773	750	728	706	657	567	494	434	384	343	308	278	0.064

D_B = 1072 K2= 870

36/3	0	331	296	267	242	217	195	177	162	149	137	128	119	113	107	101	0.971
	1	417	383	353	326	302	281	262									0.408
	2	471	442	414	389	365	343	323	305	288	273	259	247	235			0.258
	3	506	482	458	435	413	392	372	354	337	321	307	293	280	269	258	0.189
	4	529	509	489	469	449	430	412	394	378	362	347	333	320	308	278	0.149
	5	544	528	512	494	477	460	443	427	411	396	382	368	343	308	278	0.123
	6	555	542	528	513	498	483	468	453	439	424	411	384	343	308	278	0.105
	7	563	552	540	528	515	501	488	474	461	448	434	384	343	308	278	0.091
	8	569	560	550	539	527	516	504	492	479	467	434	384	343	308	278	0.081
	9	573	566	557	548	538	527	517	506	495	484	434	384	343	308	278	0.072
	10	577	570	563	555	546	537	527	517	507	494	434	384	343	308	278	0.066

D_B = 2209 K2= 870

1 The shaded values do not comply with the minimum spacing requirements for sidelap connections and shall not be used except with properly spaced button-punched sidelaps with 1.5BI deck.

$$G' = \frac{K_2}{3.78 + \frac{0.3 \cdot D_B}{SPAN} + 3 \cdot K_1 \cdot SPAN}, \text{ Kips/inch}$$

SPAN is in feet

DIAPHRAGM

1.5 (B, BI, F, A) 22 ALLOWABLE DIAPHRAGM SHEAR STRENGTH (PLF)
SUPPORT FASTENERS: 5/8" puddle welds[1]
SIDELAP FASTENERS: welded[2]

Factor of safety = 2.35

	# OF SIDELAP FASTENERS	DIAPHRAGM SHEAR STRENGTH (PLF) DECK SPAN (FT.-IN.) 3.00	3.50	4.00	4.50	5.00	5.50	6.00	6.50	7.00	7.50	8.00	8.50	9.00	9.50	10.00	K1
36/7	0	484	420	366	323	289	261	238	218	201	187	174	163	154	146	139	0.486
	1	630	554	493	443	400	362	330									0.287
	2	757	673	604	546	498	457	423	389	360	335	313	283	252			0.204
	3	865	778	704	641	587	542	502	467	417	363	319	283	252	226	204	0.158
	4	956	869	793	727	670	620	568	484	417	363	319	283	252	226	204	0.125
	5	1031	947	871	804	745	676	568	484	417	363	319	283	252	226	204	0.109
	6	1093	1013	940	873	813	676	568	484	417	363	319	283	252	226	204	0.094
	7	1145	1070	999	934	818	676	568	484	417	363	319	283	252	226	204	0.083
	8	1188	1118	1051	988	818	676	568	484	417	363	319	283	252	226	204	0.074
	9	1224	1160	1097	1009	818	676	568	484	417	363	319	283	252	226	204	0.067
	10	1254	1195	1136	1009	818	676	568	484	417	363	319	283	252	226	204	0.061

D_B = 129 D_F = 226 D_A = 356 K2= 870

>280#/FT MIN X 0.7 = 196#/FT

	# OF SIDELAP FASTENERS	3.00	3.50	4.00	4.50	5.00	5.50	6.00	6.50	7.00	7.50	8.00	8.50	9.00	9.50	10.00	K1
36/5	0	428	376	335	299	267	241	220	201	186	172	160	150	142	134	128	0.583
	1	549	491	443	402	368	338	312									0.319
	2	642	584	533	489	451	418	388	363	340	320	299	281	252			0.219
	3	713	658	608	564	524	488	457	428	403	363	319	283	252	226	204	0.167
	4	766	716	670	626	586	550	517	484	417	363	319	283	252	226	204	0.135
	5	807	762	719	678	640	604	568	484	417	363	319	283	252	226	204	0.113
	6	838	798	759	721	685	650	568	484	417	363	319	283	252	226	204	0.098
	7	862	827	792	757	723	676	568	484	417	363	319	283	252	226	204	0.086
	8	881	850	819	787	755	676	568	484	417	363	319	283	252	226	204	0.076
	9	896	869	841	812	782	676	568	484	417	363	319	283	252	226	204	0.069
	10	908	884	859	832	806	676	568	484	417	363	319	283	252	226	204	0.063

D_B = 758 D_F = 886 D_A = 974 K2= 870

	# OF SIDELAP FASTENERS	3.00	3.50	4.00	4.50	5.00	5.50	6.00	6.50	7.00	7.50	8.00	8.50	9.00	9.50	10.00	K1
36/4	0	328	288	256	226	201	181	165	151	139	128	119	112	105	100	95	0.728
	1	442	398	361	329	302	278	257									0.358
	2	522	480	442	409	379	353	329	309	290	273	258	242	229			0.237
	3	577	540	505	472	443	415	391	368	348	330	313	283	252	226	204	0.177
	4	615	583	552	522	494	467	443	420	399	363	319	283	252	226	204	0.142
	5	642	615	588	561	535	510	486	464	417	363	319	283	252	226	204	0.118
	6	662	639	615	591	568	545	522	484	417	363	319	283	252	226	204	0.101
	7	676	657	636	615	594	573	552	484	417	363	319	283	252	226	204	0.088
	8	687	670	653	634	615	596	568	484	417	363	319	283	252	226	204	0.078
	9	695	681	666	649	633	615	568	484	417	363	319	283	252	226	204	0.071
	10	702	690	676	662	647	631	568	484	417	363	319	283	252	226	204	0.064

D_B = 1072 D_F = 1216 D_A = 1282 K2= 870

	# OF SIDELAP FASTENERS	3.00	3.50	4.00	4.50	5.00	5.50	6.00	6.50	7.00	7.50	8.00	8.50	9.00	9.50	10.00	K1
36/3	0	274	245	221	200	179	161	147	134	123	114	105	99	93	88	84	0.971
	1	356	329	304	281	261	244	228									0.408
	2	403	381	359	339	320	302	285	270	256	243	231	221	211			0.258
	3	431	413	396	378	361	345	329	314	300	287	275	264	252	226	204	0.189
	4	448	434	420	406	391	377	363	349	336	323	311	283	252	226	204	0.149
	5	459	448	437	425	413	400	388	375	363	352	319	283	252	226	204	0.123
	6	467	458	449	439	428	418	407	395	385	363	319	283	252	226	204	0.105
	7	472	465	457	449	440	431	422	412	403	363	319	283	252	226	204	0.091
	8	476	470	464	457	449	441	433	425	416	363	319	283	252	226	204	0.081
	9	479	474	469	463	456	449	442	435	417	363	319	283	252	226	204	0.072
	10	481	477	472	467	462	456	449	443	417	363	319	283	252	226	204	0.066

D_B = 2209 D_F = 2428 D_A = 2442 K2= 870

1 A 3/8" x 1-1/4" arc seam weld shall be used with F deck or A deck.

2 The shaded values do not comply with the minimum spacing requirements for sidelap connections and shall not be used except with properly spaced button-punched sidelaps with 1.5Bi deck.

$$G' = \frac{K_2}{3.78 + \frac{0.3 \cdot D_X}{SPAN} + 3 \cdot K_1 \cdot SPAN}, \text{ Kips/inch}$$

SPAN is in feet. Substitute D_B, D_F, or D_A for D_X

DIAPHRAGM

1.5 (B, F, A) 22 ALLOWABLE DIAPHRAGM SHEAR STRENGTH (PLF)
SUPPORT FASTENERS: 5/8" puddle welds[1]
SIDELAP FASTENERS: #10 TEK screws

Factor of safety = 2.35

	# OF SIDELAP FASTENERS	3.00	3.50	4.00	4.50	5.00	5.50	6.00	6.50	7.00	7.50	8.00	8.50	9.00	9.50	10.00	K1
		DIAPHRAGM SHEAR STRENGTH (PLF) DECK SPAN (FT.-IN.)															
36/7	0	484	420	366	323	289											0.486
	1	557	487	432	383	343	310	283									0.377
	2	626	550	489	440	397	359	328	301	278	259	241	227	214			0.308
	3	691	610	545	491	447	408	373	343	317	295	275	258	244	226	204	0.261
	4	751	667	598	541	493	452	418	384	355	330	309	283	252	226	204	0.226
	5	806	720	648	588	537	494	457	425	394	363	319	283	252	226	204	0.199
	6	857	769	696	633	580	534	495	461	417	363	319	283	252	226	204	0.178
	7	903	816	741	676	621	574	532	484	417	363	319	283	252	226	204	0.161
	8	946	859	783	717	661	611	568	484	417	363	319	283	252	226	204	0.147
	9	985	899	823	757	698	648	568	484	417	363	319	283	252	226	204	0.135
	10	1021	936	860	794	735	676	568	484	417	363	319	283	252	226	204	0.125

D_B = 129 D_F = 226 D_A = 356 K2= 870

→280#/F x 0.7 = 196#/F

	# OF SIDELAP FASTENERS	3.00	3.50	4.00	4.50	5.00	5.50	6.00	6.50	7.00	7.50	8.00	8.50	9.00	9.50	10.00	K1
36/5	0	428	376	335	299	267											0.583
	1	490	435	389	352	321	290	265									0.433
	2	546	488	440	399	365	336	309	284	263	244	228	214	202			0.345
	3	594	536	486	443	407	376	348	325	301	280	261	245	232	220	204	0.286
	4	637	579	529	485	446	413	384	359	336	316	295	277	252	226	204	0.245
	5	675	618	567	523	483	449	419	392	368	346	319	283	252	226	204	0.214
	6	707	652	602	558	518	483	451	423	398	363	319	283	252	226	204	0.190
	7	736	683	634	590	550	514	482	453	417	363	319	283	252	226	204	0.171
	8	761	710	663	619	580	544	511	481	417	363	319	283	252	226	204	0.155
	9	782	735	689	647	607	571	538	484	417	363	319	283	252	226	204	0.142
	10	801	756	713	671	633	597	564	484	417	363	319	283	252	226	204	0.131

D_B = 758 D_F = 886 D_A = 974 K2= 870

	# OF SIDELAP FASTENERS	3.00	3.50	4.00	4.50	5.00	5.50	6.00	6.50	7.00	7.50	8.00	8.50	9.00	9.50	10.00	K1
36/4	0	328	288	256	226	201											0.728
	1	388	345	310	281	255	230	210									0.509
	2	439	395	358	326	299	276	255	234	216	200	186	175	165			0.391
	3	482	438	400	367	339	314	292	272	254	236	220	207	195	185	176	0.318
	4	518	476	438	405	375	349	325	305	286	270	254	238	225	213	203	0.267
	5	548	508	471	438	408	381	357	335	316	298	282	268	252	226	204	0.231
	6	573	535	500	467	438	411	386	364	343	325	308	283	252	226	204	0.203
	7	594	559	525	494	464	437	413	390	369	350	319	283	252	226	204	0.181
	8	611	579	547	517	489	462	437	415	394	363	319	283	252	226	204	0.164
	9	626	596	567	538	510	484	460	437	416	363	319	283	252	226	204	0.149
	10	639	611	583	556	530	504	481	458	417	363	319	283	252	226	204	0.137

D_B = 1072 D_F = 1216 D_A = 1282 K2= 870

	# OF SIDELAP FASTENERS	3.00	3.50	4.00	4.50	5.00	5.50	6.00	6.50	7.00	7.50	8.00	8.50	9.00	9.50	10.00	K1
36/3	0	274	245	221	200	179											0.971
	1	319	290	265	243	224	207	191									0.617
	2	354	327	302	279	260	242	226	212	199	185	173	162	153			0.452
	3	381	356	332	310	290	272	256	241	228	215	204	194	183	173	165	0.356
	4	401	378	357	336	317	299	282	267	253	240	229	218	208	199	190	0.294
	5	417	397	377	358	339	322	306	290	276	263	251	240	230	220	204	0.251
	6	429	411	393	375	358	342	326	311	297	284	272	260	250	226	204	0.218
	7	439	423	407	390	374	359	344	329	316	303	290	279	252	226	204	0.193
	8	446	432	418	403	388	373	359	345	332	319	307	283	252	226	204	0.173
	9	453	440	427	414	400	386	373	360	347	334	319	283	252	226	204	0.157
	10	458	447	435	423	410	397	385	372	360	348	319	283	252	226	204	0.144

D_B = 2209 D_F = 2428 D_A = 2442 K2= 870

[1] A 3/8" x 1-1/4" arc seam weld shall be used with F deck or A deck.

$$G' = \frac{K_2}{3.78 + \frac{0.3 \cdot D_X}{SPAN} + 3 \cdot K_1 \cdot SPAN}, \text{ Kips/inch}$$

SPAN is in feet

Substitute D_B, D_F, or D_A for D_X

DIAPHRAGM

1.5 (B, F, A) 22 ALLOWABLE DIAPHRAGM SHEAR STRENGTH (PLF)
SUPPORT FASTENERS: #12 TEK screws
SIDELAP FASTENERS: #10 TEK screws

Factor of safety = 2.35

	# OF SIDELAP FASTENERS	DIAPHRAGM SHEAR STRENGTH (PLF) DECK SPAN (FT.-IN.)															K1
		3.00	3.50	4.00	4.50	5.00	5.50	6.00	6.50	7.00	7.50	8.00	8.50	9.00	9.50	10.00	
	0	283	246	214	189	169											0.549
	1	355	311	276	248	223	202	184									0.414
	2	419	371	332	299	273	250	229	210	195	181	169	159	150			0.333
	3	475	424	382	347	317	292	270	251	233	217	203	190	180	170	162	0.278
	4	524	473	429	391	359	332	308	287	268	252	236	222	210	199	189	0.239
36/7	5	566	515	471	432	398	369	343	321	301	283	267	253	240	226	204	0.209
	6	602	553	508	469	435	404	377	353	332	313	295	280	252	226	204	0.186
	7	633	585	542	503	468	437	409	384	361	341	319	283	252	226	204	0.168
	8	659	614	572	534	499	467	439	413	389	363	319	283	252	226	204	0.152
	9	682	639	599	562	527	495	466	440	416	363	319	283	252	226	204	0.140
	10	701	661	623	587	553	521	492	466	417	363	319	283	252	226	204	0.129

$D_B = 129$ $D_F = 226$ $D_A = 356$ K2= 870

→1910#/F MIN SHEAR

	# OF SIDELAP FASTENERS	3.00	3.50	4.00	4.50	5.00	5.50	6.00	6.50	7.00	7.50	8.00	8.50	9.00	9.50	10.00	K1
	0	250	220	196	175	156											0.659
	1	310	276	249	225	206	189	173									0.474
	2	358	324	295	269	248	229	213	198	185	172	161	151	143			0.370
	3	397	364	334	308	285	265	247	231	217	205	193	183	173	164	155	0.304
	4	427	396	368	342	319	298	279	262	247	233	221	209	199	190	181	0.257
36/5	5	452	423	396	371	348	327	307	290	274	260	246	234	223	213	204	0.223
	6	471	445	420	396	373	352	333	315	299	284	270	258	246	226	204	0.197
	7	486	463	440	417	396	375	356	339	322	307	293	280	252	226	204	0.177
	8	499	478	456	435	415	395	377	359	343	328	314	283	252	226	204	0.160
	9	509	490	471	451	432	413	395	378	362	347	319	283	252	226	204	0.146
	10	518	500	483	464	446	429	412	395	379	363	319	283	252	226	204	0.134

$D_B = 758$ $D_F = 886$ $D_A = 974$ K2= 870

	# OF SIDELAP FASTENERS	3.00	3.50	4.00	4.50	5.00	5.50	6.00	6.50	7.00	7.50	8.00	8.50	9.00	9.50	10.00	K1
	0	191	169	150	132	118											0.823
	1	248	223	201	183	168	155	141									0.554
	2	291	266	244	224	207	192	179	167	157	147	137	129	121			0.417
	3	322	299	278	258	241	225	211	198	187	176	167	159	151	143	136	0.334
	4	345	325	305	286	269	253	239	226	214	202	192	183	175	167	160	0.279
36/4	5	362	344	326	309	293	277	263	250	237	226	215	206	197	188	181	0.240
	6	375	359	343	328	312	298	284	271	259	247	236	226	217	208	200	0.210
	7	385	371	357	343	329	315	302	289	277	266	255	245	235	226	204	0.187
	8	392	380	368	355	342	329	317	305	293	282	272	262	252	226	204	0.168
	9	398	388	377	365	353	342	330	319	308	297	287	277	252	226	204	0.153
	10	403	394	384	373	363	352	341	331	320	310	300	283	252	226	204	0.140

$D_B = 1072$ $D_F = 1216$ $D_A = 1282$ K2= 870

	# OF SIDELAP FASTENERS	3.00	3.50	4.00	4.50	5.00	5.50	6.00	6.50	7.00	7.50	8.00	8.50	9.00	9.50	10.00	K1
	0	160	143	129	117	105											1.098
	1	202	185	171	157	146	136	127									0.665
	2	228	214	200	188	176	166	156	147	139	132	126	119	114			0.477
	3	245	233	222	210	200	190	180	171	163	156	148	142	136	130	125	0.372
	4	255	246	236	227	217	208	199	191	183	175	168	161	155	149	143	0.305
36/3	5	263	255	247	239	231	222	214	207	199	192	185	178	172	166	160	0.258
	6	268	262	255	248	241	234	226	219	212	205	199	192	186	180	175	0.224
	7	272	267	261	255	249	242	236	229	223	217	210	204	198	193	187	0.198
	8	275	270	266	260	255	249	244	238	232	226	220	215	209	204	198	0.177
	9	277	273	269	265	260	255	250	245	239	234	229	223	218	213	204	0.160
	10	279	275	272	268	264	259	255	250	245	240	236	231	226	221	204	0.146

$D_B = 2209$ $D_F = 2428$ $D_A = 2442$ K2= 870

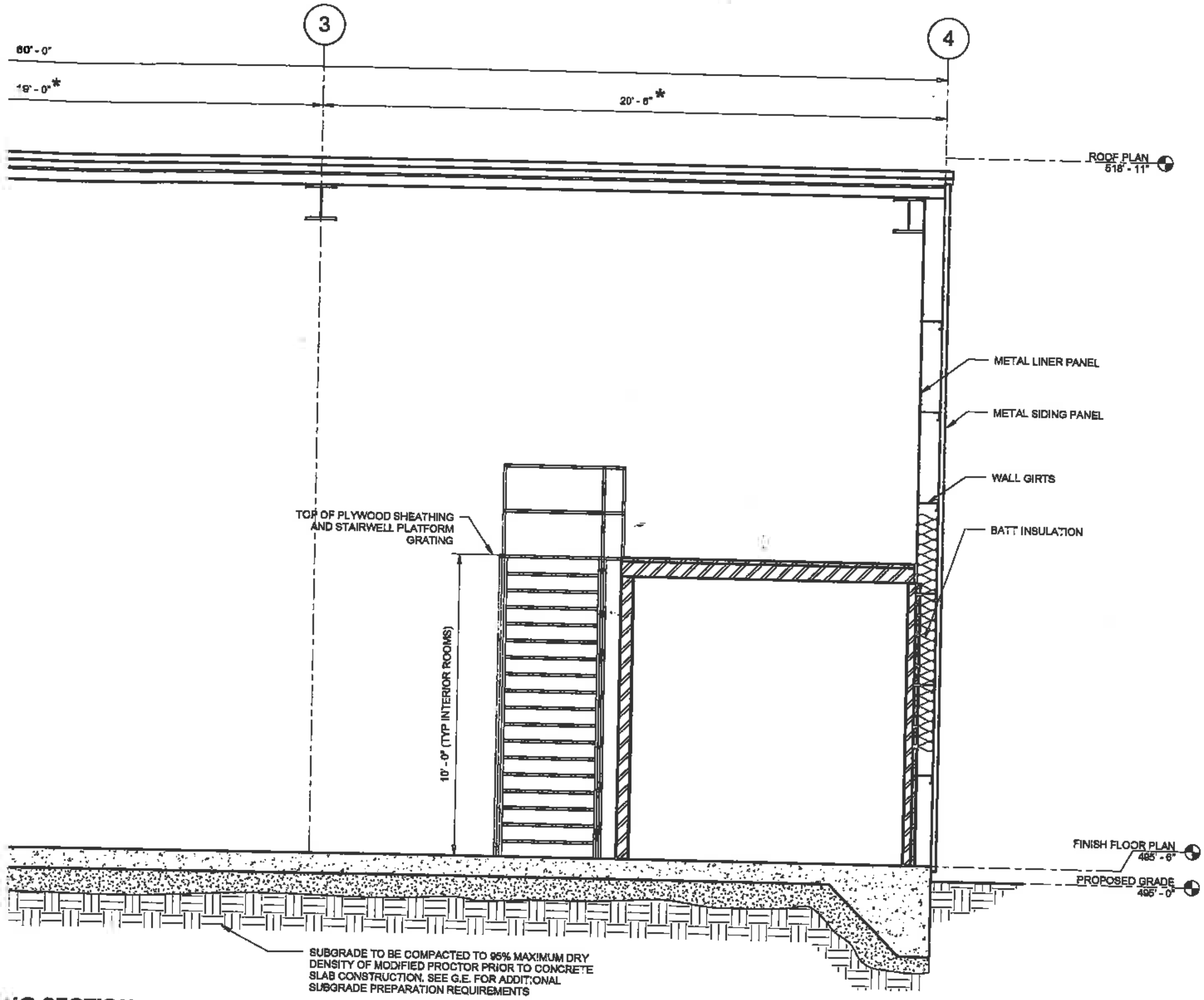
$$G' = \frac{K_2}{3.78 + \frac{0.3 \cdot D_X}{SPAN} + 3 \cdot K_1 \cdot SPAN}, \text{ Kips/inch}$$

SPAN is in feet

Substitute D_B, D_F, or D_A for D_X

DIAPHRAGM

6 7 8 9 10 I-33



NG SECTION

NOTES:

1. PHOTOVOLTAIC MODULES NOT SHOWN FOR CLARITY.

* COLUMN AND FOUNDATION LOCATIONS TO BE VERIFIED PER APPROVED PRE-ENGINEERED BUILDING COLUMN LOCATIONS.

- DRAFT -
NOT FOR
CONSTRUCTION

No.	Date	DESCRIPTION	GM/SPEC	DWN	CHKD	SUPV	APVD BY
C	12/30/14	SUPPLEMENTAL PRE-FINAL (90%) DESIGN SUBMITTAL		CMW	MSL	JB	RAK

REVISIONS

APPROVED BY		
	SO	
	SUPV	JB
	DSGN	MSL
	DWN	CMW
	CHKD	MSL
	OK	RAK
	DATE	12/30/14
	SCALES	NONE or AS SHOWN

TOPOCK GROUNDWATER REMEDIATION PROJECT

WORKSHOP BUILDING SECTION

GAS TRANSMISSION & DISTRIBUTION
PACIFIC GAS AND ELECTRIC COMPANY
SAN FRANCISCO, CALIFORNIA

MICROFILM	
BILL OF MATL	
DWG LIST	
SUPSDS	
SUPSD BY	
SHEET NO. of SHEETS	REV
S-15-09	

IND GUST) V=110 MPH - ULTIMATE, OR MINIMUM NET
- Iw = 1.0, WIND PRESSURE, Pnet = 20 PSF WHICHEVER IS GREATER

NCLOSED.
FICIENT - ±0.55.
DDING SHALL BE DESIGNED FOR THE CONDITIONS OF
RESSURES.

TOR - Ie=1.0.

3.5
COLUMN
10KIPS

NSE ACCELERATIONS - Ss=0.230, S1=0.120.
FFICIENTS - Sds=0.245, Sd1=0.186.
SYSTEMS:
ORDINARY STEEL MOMENT FRAMES
BASE SHEAR: V=1.79 KIPS (TO BE VERIFIED BY METAL BUILDING MFR)
~~N: ORDINARY STEEL CONCENTRICALLY BRACED FRAMES~~
~~GE SHEAR: V=1.69 KIPS (TO BER VERIFIED BY METAL BUILDING MFR)~~
UIVALENT LATERAL FORCE.

(ALONG COLUMN LINE 2&3)

S HAVE BEEN DESIGNED FOR THE FOLLOWING MAXIMUM
THE METAL BUILDING MANUFACTURER SHALL
SUCH THAT THE ACTUAL REACTIONS DO NOT EXCEED
REACTIONS EXCEED THOSE LISTED, THE CONTRACTOR
E-DESIGNING THE FOUNDATIONS TO THE SATISFACTION
DDITIONAL COST TO THE OWNER.

AR

ATION NOTES:

L OR GEOTECHNICAL ENGINEER DETERMINES THAT EXPANSIVE SOILS
UES OF CONCERN MAY BE PRESENT, THEN HE/SHE MAY REQUIRE THAT
MADE TO THE FOUNDATION DESIGN TO SAFEGUARD AGAINST DAMAGE
NESS OR OTHER GEOLOGIC ISSUES. IF THIS BECOMES THE SITUATION THEN
RUCTION MUST BE HALTED AND THE GEOTECHNICAL ENGINEER SHALL PROVIDE
T WITH RECOMMENDATIONS IN CONSIDERATION OF THE CONDITIONS.

NOTES AND STRUCTURAL SPECIFICATIONS FOR ADDTIONAL REQUIREMENTS.

RIAL: TO BE CRUSHED GRAVEL MEETING THE FOLLOWING GRADATION AND COMPACTED
ENSITY OF MODIFIED PROCTOR.

TAL PERCENT PASSING

100
70 TO 100
50 TO 90
30 TO 60
9 TO 33
0 TO 6

C. CONCRETE NOTES:

1. DETAILS, WORKMANSHIP, AND GENERAL PROCEDURE SHALL CONFORM TO ACI 318, ACI 315, ACI 301, ACI SP66 DETAILING MANUAL, AND CRSI MANUAL OF STANDARD PRACTICE, UNLESS OTHERWISE NOTED.
2. MINIMUM COMPRESSIVE STRENGTH AT 28 DAYS - 4,500 PSI.
3. BAR REINFORCING - ASTM A615 GRADE 60.
4. WELDED WIRE FABRIC REINFORCING - ASTM A185.
5. ALL LAP SPLICES SHALL BE CLASS B OR AS SHOWN.
6. CONCRETE COVER OVER REINFORCING:
   3" FOR CONCRETE CAST AGAINST EARTH.
   2" OTHERWISE.
   SLABS ON GRADE - AS SHOWN.
7. PLACE, SUPPORT AND SECURE REINFORCEMENT AGAINST DISPLACEMENT. DO NOT DEVIATE FROM REQUIRED POSITION.
8. ELASTOMERIC SEALANT FOR JOINTS SHALL BE SIKAFLEX -2C SL OR EQUAL.
9. PREFORMED PLASTIC ADHESIVE WATERSTOP (PPAWS FR)
   SINGLE COMPONENT SELF-SEALING PLASTIC ADHESIVE TYPE EXTRUDED ROPE FORM BETWEEN TWO PROTECTIVE SILICONE TREATED PAPERS, 1/2" X 1-1/8" SQUARE CROSS SECTION. 1 INCH LAP SPLICE FURNISH WITH PRIMER HENRY COMPANY PRODUCTS SF312-SYNKO-FLEX WATERSTOP FR OR AS APPROVED.

(FOR INTERIOR ROOM CEILING)

D. METAL DECK NOTES:

CLASS
280

TYPE	DEPTH (IN)	PANEL WIDTH (IN)	DESIGN THICKNESS (IN)	MIN. YIELD STREIGNTH Fy (KSI)	MIN. (+) S (IN3/FT)	MIN. (+) I (IN4/FT)	MIN. DIAPHRAGM SHEAR CAPACITY (LBS/FT)	FINISH
ROOF DECK	1-1/2	36	0.0295	33 (ASTM A653)	0.186	0.155	400	GALVANIZED*

* GALVANIZING SHALL CONFORM TO ASTM A924 WITH COATING VLASS OF G90 AS DEFINED IN ASTM A623.

1. DECK UNIT ANCHORAGE TO STEEL SUPPORTING MEMBERS UTILIZING ARC SPOT PUDDLE WELDS OR MECHANICAL FASTENERS BASED ON THE FOLLOWING MIMINUMS:
   A. ARC SPOT WELDS SHALL BE 5/8" MINIMUM VISIBLE DIAMETER OR
   B. #12-[illegible] TEKS (SELF-DRILLING FASTENERS BY ITW BUILDEX) WITH THE ATTACHMENT PATTERN OF 36/7 (36/5)
2. MINIMUM SIDE LAP ATTACHMENT SHALL BE 6 (4) FASTENERS PER SPAN AND SHALL BE ARC SPOT PUDDLE WELDS OR MECHANICAL FASTENERS:
   A. ARC SPOT PUDDLE WELDS SHALL BE 5/8" MINIMUM VISIBLE DIAMETER OR
   B. #10 TEK SCREW
3. MINIMUM EDGE ATTACHMENT SHALL BE 6" AND SHALL BE 5/8" MINIMUM VISIBLE DIAMETER.
4. DECKING SHALL BE INSTALLED CONTINUOUS OVER A MINIMUM OF 3 SPANS.

THE EXTERIOR BUILDING FRAME COLUMN (ALONG COLUMN LINE 1&4) FOUNDATIONS HAVE BEEN DESIGNED FOR 60% OF DOWNWARD & UPLIFT REACTIONS LISTED ABOVE FOR INTERIOR BUILDING FRAME COLUMN FOUNDATIONS

5. ALL STRUCTURAL STEEL & METAL DECK TO BE PRIMED PROPERLY AND FINISH PAINTED PER SPECIFICATION 09 90 00.

- DRAFT -
NOT FOR CONSTRUCTION

No.	Date	DESCRIPTION	GM/SPEC	DWN	CHKD	SUPV	APVD BY
B	12/30/14	SUPPLEMENTAL PRE-FINAL (90%) DESIGN SUBMITTAL		CMW	MSL	JB	RAK

REVISIONS

APPROVED BY: SO; SUPV JB; DSGN MSL; DWN CMW; CHKD MSL; OK RAK; DATE 12/30/14; SCALES NONE or AS SHOWN

TOPOCK GROUNDWATER REMEDIATION PROJECT
WORKSHOP BUILDING
GENERAL NOTES
GAS TRANSMISSION & DISTRIBUTION
PACIFIC GAS AND ELECTRIC COMPANY
SAN FRANCISCO, CALIFORNIA

MICROFILM
BILL OF MATL
DWG LIST
SUPSDS
SUPSD BY
SHEET NO. of SHEETS
S-15-01
REV

CEILING FRAMING

- LIVE LOAD = 50 psf
- DEAD LOAD = 3 psf 3/4" PLYWOOD + 1.78 #/FT METAL DECK + 5 psf MECH/ELEC = 9.78 psf

  TOTAL = 59.8 psf ≈ 60 psf × $\frac{10.33 \text{ FT c/c}}{2}$ = 310 #/FT ROOF LL & DL
  - 258 #/FT LL (1.0)
  - 52 #/FT DL (1.0)

- WALL DEAD LOAD = 4 psf (1" GYPSUM) × 2 = 8 psf

  = 8 psf × 10 FT TALL = 80 #/FT DL (1.0)

- SPAN = 11'-0" − (1'-1") + 5" STUD = 10.33 FT c/c
- REF SHT I-36 FOR TSN METAL STUD & JOIST INFORMATION

  ~ USE 600S162-54 (50 ksi) FLOOR JOIST STUDS
  - → 6", 54 mil, 1 5/8" FLANGE WIDTH
  - → 11'-2" MAX SPAN w/ l/480 DEFLECTION > 10.33 FT c/c SPAN & l/240 REQ'D ✓OK

Light Steel Framing Members

SSMA Sections

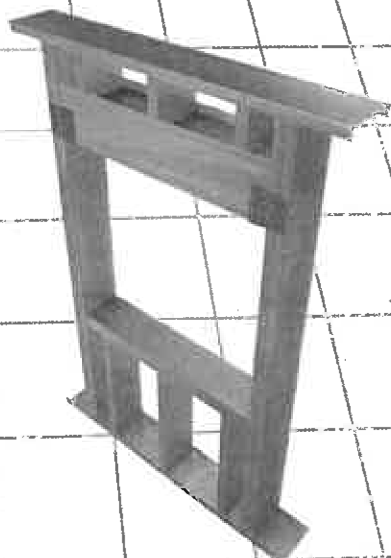
September 2005

I-36

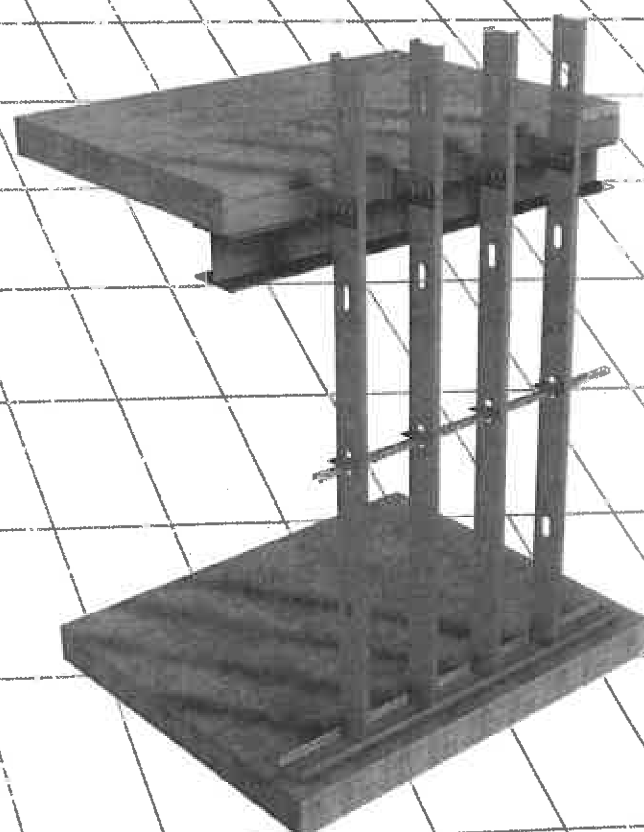
The Steel Network, Inc.

Your Link To The Steel Industry

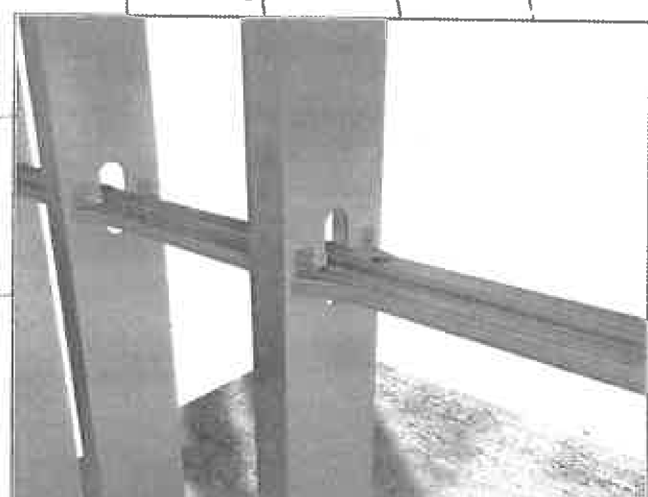
Load Bearing Studs



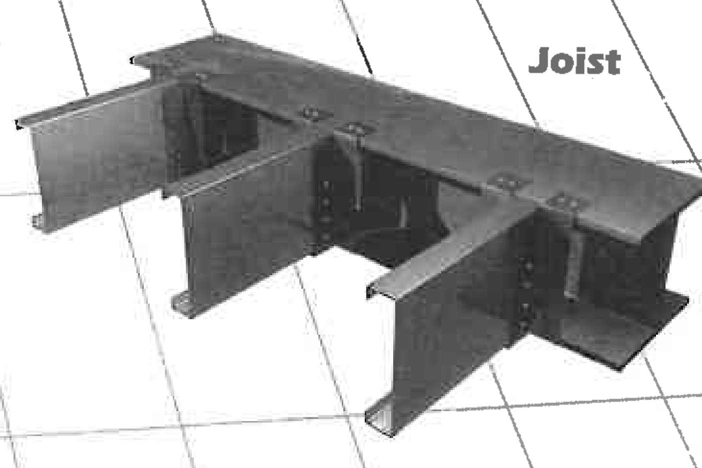
Curtain Wall Studs



Bridging



Joist



The Steel Network

www.steelnetwork.com • 888-474-4876

SSMA℠ (S) STUD SECTION

600S162-54

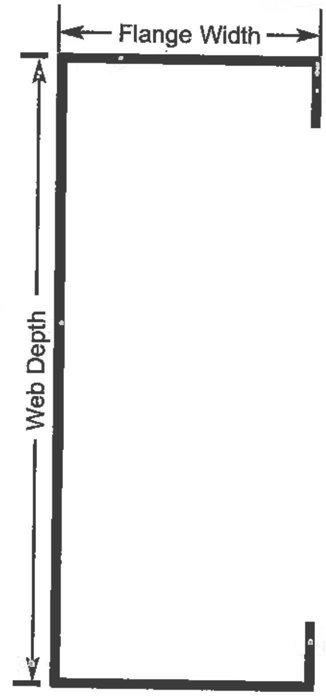
Member Depth:
(Example: 6" = 600 x 1/100 inches)
All member depths are taken in 1/100 inches. For all "T" sections, member depth is inside to inside dimension.

Material Thickness:
(Example: 0.054 in. = 54 mils; 1 mil = 1/1000 in.)
Material thickness is the minimum base metal thickness in mils. Minimum base metal thickness represents 95% of the design thickness.

Flange Width:
(Example: 1⅝" = 1.625" ≈ 162 x 1/100 inches)
All flange widths are taken in 1/100 inches.

Style:
(Example: Stud or Joist section = S)
The four alpha characters utilized by the designator system are:

S = Stud or Joist Sections
T = Track Sections
U = Channel Sections
F = Furring Channel Sections



CODE APPROVAL

Products manufactured by the members recognized by ICC (ICBO) Evaluation Service of the Steel Stud Manufacturers Association (SSMA) comply with the Uniform Building Code. See *ICC ES Legacy Report No. ER-4943P*. The Steel Network, Inc. is a Member Manufacturer of the SSMA.

MATERIAL SPECIFICATIONS

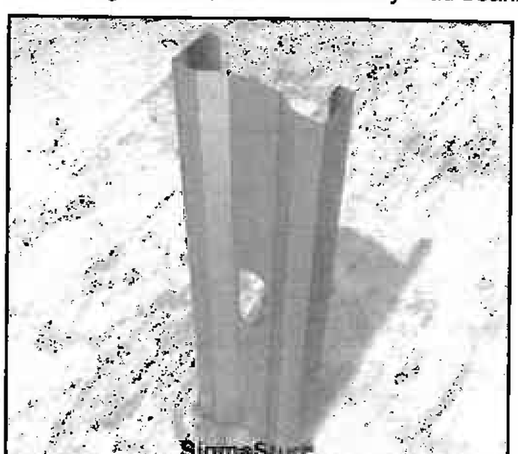
Products manufactured by SSMA members are formed from steel with a minimum yield stress of 33 ksi or 50 ksi. All products listed in this catalog are engineered to meet the 2001 Edition of the American Iron and Steel Institute (AISI) North American *Specification for the Design of Cold-Formed Steel Structural Members*. Material specification meets ASTM Standards A1003 and A653. The structural properties included in this brochure were computed based on Allowable Stress Design to conform with the same AISI standard.

LIGHT STEEL FRAMING VALUE

The increased use of light steel framing as a building component reflects upon its inherent benefits:

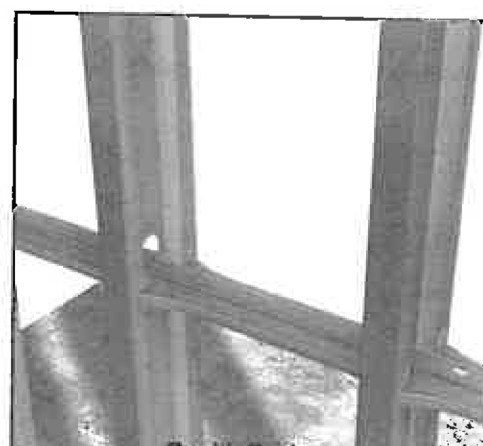
- High strength-to-weight ratio
- Lightweight for ease in handling
- Strength allows for longer clear-spans
- Longer clear spans provide design flexibility
- Uses for structural and non-structural applications
- Steel is a recyclable product

The Steel Network, the industry leader for light steel framing connection solutions, also delivers industry standard SSMA members, in addition to SigmaStud®, the revolutionary load bearing wall stud solution.



SigmaStud
Page 4 Load Bearing Wall Systems Catalog

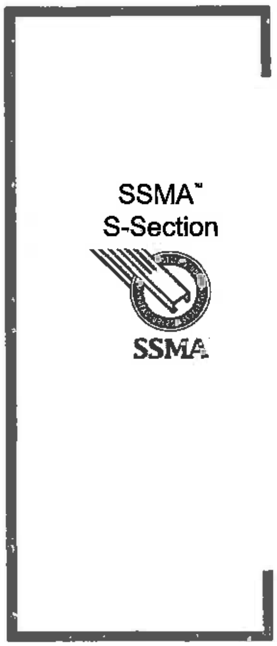
StiffWall
Page 30 Load Bearing Wall Systems Catalog



BuckleBridge
Page 38 Light Steel Framing Members Catalog

AVAILABLE SECTIONS

Members are available in many common web depths. Section properties and allowable load charts begin on page 5.



Each section is available in the following minimum delivered thicknesses:
33 mil – 20ga
43 mil – 18ga
54 mil – 16ga
68 mil – 14ga
97 mil – 12ga
118 mil – 10ga

Minimum Thickness[1] (mils)	Design Thickness (in)	Inside Corner Radii (in)	Reference Gauge No.
18	0.0188	0.0843	25
27	0.0283	0.0796	22
30	0.0312	0.0781	20 - Drywall
33	0.0346	0.0764	20 - Structural
43	0.0451	0.0712	18
54	0.0566	0.0849	16
68	0.0713	0.1069	14
97	0.1017	0.1525	12

[1] Minimum Thickness represents 95% of the design thickness and is the minimum acceptable thickness delivered to the job site based on Section A3.4 of the *AISI Specification.*

AVAILABLE STUD/JOIST/ TRACK DEPTHS:

162,250, 350, 362, 400, 550, 600, 800, 1000, 1200, 1400, 1600

AVAILABLE FLANGE DEPTHS:

125, 137, 162, 200, 250

Section	Flange Width	Stiffening Lip Length (in)
S125	1.25"	0.188
S137	1.375"	0.375
S162	1.625"	0.500
S200	2"	0.625
S250	2.5"	0.625

General Notes for All Tables

1. The strength increase due to cold-work of forming was incorporated for flexural strength as applicable per *AISI A7.2.*
2. The moment of inertia for deflection is calculated at a stress which results in an effective section modulus such that the stress multiplied by that section modulus is equal to the allowable moment. This follows Procedure 1 of the *AISI Specification.*
3. The yield stress (33ksi or 50ksi) used to calculate the tabulated values are indicated in the tables.
4. When provided, factory punchouts will be located along the centerline of the webs of the members and will have a minimum center-to-center spacing of 24". Punchouts will have a maximum width equal to half the member depth (d/2) or 2 1/2", whichever is less, and a maximum length which equals 4 1/2". The minimum distance between the end of the member and the near edge of the web punchout equals 10".
5. For those steels that have both 33 and 50 ksi listings, if the design is based upon 50ksi, the 50ksi steel needs to be specified by the contractor/purchaser (Example: 362S137-54 [50ksi]).

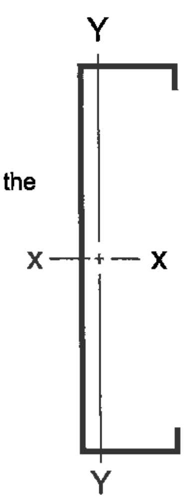
Symbol Definitions for Section Properties:

Gross Properties:

Ixx: Moment of inertia of the gross section about the X-X axis (strong axis).
Rx: Radius of gyration of the gross section about the X-X axis.
Iyy: Moment of inertia of the gross section about the Y-Y axis (weak axis).
Ry: Radius of gyration of the gross section about the Y-Y axis.

Effective Properties:

Ixx: Moment of inertia for deflection calculations based on "Procedure 1 for Deflection Determination" of the 2001 *AISI Specification.*
Sxx: Effective section modulus about the X-X axis (strong axis) Stress = Fy.
Ma: Allowable Bending Moment - Based on the effective section modulus and the allowable stress including the strength increase from cold-work of forming (*AISI 7.2*) where applicable.
Va: Allowable Shear Load
Ycg: Maximum distance from the outside of the compression flange to the center of gravity of the effective section



Torsional Properties:

J: St. Venant torsional constant.
Cw: Torsional warping constant.
Xo: Distance from the shear center to the centroid along the principal X-axis.
Ro: Polar radius of gyration about the centroidal principal axis.
β: 1 - $(Xo/Ro)^2$

STRUCTURAL (S) STUD SECTION PROPERTIES

Section	Design Thickness	Gross							Effective - 33ksi					Effective - 50ksi					Torsional				
		Area	Weight	Ixx	Sxx	Rx	Iyy	Ry	Ixx	Sxx	Ma	Va	Ycg	Ixx	Sxx	Ma	Va	Ycg	Jx1000	Cw	Xo	Ro	
	(in)	(in^2)	(lb/ft)	(in^4)	(in^3)	(in)	(in^4)	(in)	(in^4)	(in^3)	(in-k)	(lb)	(in)	(in^4)	(in^3)	(in-k)	(lb)	(in)	(in^4)	(in^6)	(in)	(in)	
250S137-33	0.0346	0.197	0.67	0.203	0.163	1.015	0.052	0.515	0.203	0.156	3.09	1040	1.272						0.079	0.075	-1.170	1.633	0.486
250S137-43	0.0451	0.255	0.87	0.261	0.208	1.010	0.067	0.511	0.261	0.205	4.53	1350	1.260						0.173	0.094	-1.158	1.620	0.489
250S137-54	0.0566	0.316	1.07	0.318	0.255	1.004	0.080	0.504	0.318	0.255	5.76	1656	1.250	0.318	0.244	8.220	2510	1.274	0.337	0.113	-1.150	1.608	0.488
250S137-68	0.0713	0.390	1.33	0.386	0.309	0.994	0.095	0.495	0.386	0.309	7.19	2017	1.250	0.386	0.308	10.65	3057	1.251	0.661	0.134	-1.142	1.593	0.486
250S162-33	0.0346	0.223	0.76	0.285	0.188	1.127	0.080	0.624	0.235	0.180	3.55	1040	1.272						0.089	0.144	-1.501	1.923	0.386
250S162-43	0.0451	0.289	0.98	0.367	0.242	1.022	0.111	0.520	0.302	0.240	5.22	1350	1.253						0.196	0.182	-1.489	1.909	0.390
250S162-54	0.0566	0.358	1.22	0.370	0.296	1.016	0.135	0.613	0.370	0.296	6.57	1666	1.250	0.370	0.296	8.42	2510	1.267	0.383	0.219	-1.482	1.894	0.391
250S162-68	0.0713	0.443	1.51	0.450	0.360	1.007	0.162	0.605	0.450	0.360	8.27	2017	1.250	0.450	0.357	12.10	3057	1.259	0.742	0.262	-1.474	1.885	0.390
350S162-33	0.0346	0.258	0.88	0.508	0.290	1.404	0.098	0.617	0.508	0.279	5.50	1046	1.779						0.103	0.273	-1.351	2.044	0.563
350S162-43	0.0451	0.334	1.14	0.654	0.374	1.400	0.125	0.612	0.654	0.372	8.08	1777	1.755						0.227	0.345	-1.339	2.031	0.565
350S162-54	0.0566	0.415	1.41	0.804	0.460	1.392	0.152	0.606	0.804	0.460	10.20	2403	1.750	0.804	0.447	13.37	3446	1.773	0.443	0.418	-1.331	2.019	0.566
350S162-68	0.0713	0.515	1.75	0.985	0.563	1.383	0.184	0.597	0.985	0.557	12.83	2959	1.750	0.985	0.557	16.89	4483	1.758	0.872	0.503	-1.321	2.004	0.565
362S137-33	0.0346	0.236	0.80	0.479	0.264	1.424	0.059	0.501	0.479	0.254	5.02	1039	1.842						0.094	0.162	-1.026	1.825	0.594
362S137-43	0.0451	0.306	1.04	0.616	0.340	1.419	0.075	0.497	0.616	0.334	7.38	1777	1.826						0.207	0.204	-1.015	1.814	0.597
362S137-54	0.0566	0.379	1.29	0.756	0.417	1.411	0.091	0.490	0.756	0.412	9.43	2497	1.812	0.756	0.400	13.43	3446	1.844	0.405	0.245	-1.006	1.801	0.600
362S137-68	0.0713	0.470	1.60	0.922	0.509	1.401	0.109	0.480	0.922	0.509	11.87	3016	1.812	0.922	0.508	17.56	4661	1.814	0.797	0.294	-0.996	1.784	0.600
362S162-33	0.0346	0.262	0.89	0.551	0.304	1.450	0.099	0.616	0.551	0.292	5.77	1039	1.843						0.105	0.293	-1.335	2.065	0.582
362S162-43	0.0451	0.340	1.16	0.710	0.392	1.445	0.127	0.610	0.710	0.389	8.46	1777	1.818						0.230	0.371	-1.323	2.052	0.585
362S162-54	0.0566	0.422	1.44	0.873	0.481	1.438	0.154	0.604	0.873	0.481	10.69	2497	1.812	0.873	0.468	14.00	3446	1.836	0.451	0.449	-1.314	2.040	0.585
362S162-68	0.0713	0.524	1.78	1.069	0.590	1.429	0.186	0.596	1.069	0.590	13.44	3076	1.812	1.069	0.584	19.80	4661	1.820	0.887	0.540	-1.305	2.024	0.585
362S200-33	0.0346	0.297	1.01	0.646	0.358	1.476	0.177	0.772	0.643	0.318	6.29	1039	1.888						0.119	0.571	-1.775	2.432	0.47
362S200-43	0.0451	0.385	1.31	0.835	0.461	1.474	0.227	0.767	0.835	0.448	8.85	1777	1.854						0.261	0.726	-1.764	2.419	0.47
362S200-54	0.0566	0.479	1.63	1.030	0.568	1.467	0.272	0.761	1.030	0.568	12.36	2497	1.812	1.030	0.509	15.25	3446	1.898	0.511	0.884	-1.750	2.407	0.471
362S200-68	0.0713	0.595	2.02	1.265	0.696	1.458	0.337	0.753	1.265	0.696	15.54	3076	1.812	1.265	0.673	22.34	4661	1.844	1.006	1.072	-1.741	2.390	0.470
400S137-33	0.0346	0.249	0.85	0.603	0.301	1.556	0.061	0.496	0.603	0.290	5.74	936	2.031						0.099	0.200	-0.987	1.908	0.732
400S137-43	0.0451	0.323	1.10	0.776	0.388	1.551	0.078	0.491	0.776	0.382	8.43	1777	2.014						0.219	0.253	-0.976	1.897	0.735
400S137-54	0.0566	0.401	1.36	0.953	0.477	1.542	0.094	0.484	0.953	0.477	10.78	2777	2.000	0.953	0.457	15.40	3446	2.034	0.428	0.305	-0.967	1.884	0.737
400S137-68	0.0713	0.497	1.69	1.165	0.582	1.531	0.112	0.475	1.165	0.582	13.58	3429	2.000	1.165	0.581	20.10	5196	2.002	0.842	0.365	-0.956	1.866	0.738
400S162-33	0.0346	0.275	0.94	0.692	0.346	1.588	0.103	0.611	0.692	0.332	6.57	936	2.032						0.105	0.258	-1.288	2.133	0.635
400S162-43	0.0451	0.357	1.21	0.892	0.446	1.581	0.131	0.606	0.892	0.443	9.61	1777	2.006						0.242	0.453	-1.276	2.121	0.636
400S162-54	0.0566	0.442	1.51	1.096	0.549	1.574	0.159	0.600	1.095	0.477	10.78	2777	2.000	1.096	0.533	15.96	3446	2.026	0.473	0.550	-1.266	2.108	0.638
400S162-68	0.0713	0.550	1.87	1.348	0.673	1.564	0.192	0.591	1.348	0.673	16.34	3429	2.000	1.348	0.666	22.30	5196	2.009	0.933	0.665	-1.256	2.092	0.63
400S200-33	0.0346	0.310	1.05	0.812	0.406	1.619	0.183	0.769	0.805	0.362	7.16	936	2.091						0.124	0.689	-1.715	2.481	0.522
400S200-43	0.0451	0.402	1.37	1.047	0.524	1.615	0.235	0.764	1.047	0.509	10.06	1777	2.023						0.272	0.876	-1.703	2.468	0.524
400S200-54	0.0566	0.500	1.70	1.292	0.646	1.608	0.287	0.758	1.292	0.646	14.06	2777	2.000	1.292	0.580	17.36	3446	2.091	0.534	1.068	-1.695	2.456	0.524
400S200-68	0.0713	0.622	2.12	1.589	0.795	1.599	0.349	0.750	1.589	0.795	17.68	3429	2.000	1.589	0.766	25.41	5196	2.035	1.054	1.295	-1.686	2.441	0.523
550S162-33	0.0346	0.327	1.11	1.458	0.530	2.112	0.113	0.588	1.458	0.512	10.11	670	2.767						0.130	0.704	-1.134	2.468	0.789
550S162-43	0.0451	0.424	1.44	1.883	0.685	2.107	0.145	0.584	1.883	0.681	14.79	1487	2.751						0.288	0.894	-1.123	2.459	0.791
550S162-54	0.0566	0.528	1.80	2.324	0.845	2.098	0.174	0.577	2.324	0.845	18.78	2799	2.750	2.324	0.821	24.58	2061	2.782	0.564	1.080	-1.114	2.445	0.792
550S162-68	0.0713	0.657	2.24	2.861	1.040	2.086	0.212	0.568	2.861	1.040	23.72	4442	2.750	2.861	1.031	34.04	5468	2.761	1.114	1.316	-1.100	2.427	0.793
600S137-33	0.0346	0.318	1.08	1.582	0.527	2.229	0.069	0.464	1.582	0.510	10.07	612	3.039						0.127	0.493	-0.823	2.421	0.884
600S137-43	0.0451	0.413	1.41	2.042	0.681	2.223	0.087	0.459	2.042	0.670	14.80	1358	3.018						0.280	0.625	-0.313	2.411	0.886
600S137-54	0.0566	0.514	1.75	2.518	0.839	2.213	0.105	0.452	2.518	0.839	18.98	2708	3.000	2.518	0.809	27.23	2708	3.042	0.549	0.757	-0.804	2.398	0.888
600S137-68	0.0713	0.640	2.18	3.094	1.031	2.200	0.125	0.443	3.094	1.031	24.05	4442	3.000	3.094	1.029	35.60	5468	3.002	1.084	0.911	-0.793	2.380	0.889
600S137-97	0.1017	0.889	3.03	4.188	1.396	2.170	0.159	0.422	4.188	1.396	34.48	7372	3.000	4.188	1.396	50.80	11124	3.000	3.066	1.179	-0.770	2.341	0.892
600S162-33	0.0346	0.344	1.17	1.793	0.598	2.282	0.116	0.581	1.793	0.577	11.41	612	3.039						0.137	0.853	-1.097	2.595	0.823
600S162-43	0.0451	0.447	1.52	2.316	0.772	2.276	0.148	0.576	2.316	0.767	16.66	1358	3.007						0.303	1.080	-1.081	2.585	0.825
600S162-54	0.0566	0.558	1.89	2.880	0.953	2.267	0.180	0.570	2.880	0.953	21.17	2708	3.000	2.880	0.927	27.75	2708	3.004	0.549	0.787	-0.804	2.398	0.888
600S162-68	0.0713	0.693	2.36	3.525	1.175	2.255	0.218	0.560	3.525	1.175	26.71	4442	3.000	3.525	1.164	39.46	5468	3.011	1.174	1.599	-1.072	2.572	0.826
600S162-97	0.1017	0.968	3.29	4.797	1.599	2.229	0.281	0.541	4.797	1.599	38.31	7372	3.000	4.797	1.599	56.73	11124	3.000	3.329	2.093	-1.038	2.518	0.830
600S200-33	0.0346	0.379	1.29	2.075	0.692	2.340	0.209	0.743	2.059	0.617	12.20	612	3.135						0.151	1.577	-1.479	2.866	0.734
600S200-43	0.0451	0.492	1.67	2.683	0.894	2.335	0.268	0.739	2.683	0.873	17.24	1358	3.028						0.334	2.012	-1.468	2.855	0.736
600S200-54	0.0566	0.613	2.09	3.319	1.106	2.327	0.328	0.732	3.319	1.106	24.07	2708	3.000	3.319	1.002	30.01	2708	3.117	0.655	2.461	-1.459	2.842	0.737
600S200-68	0.0713	0.764	2.60	4.101	1.367	2.316	0.400	0.723	4.101	1.367	30.42	4442	3.000	4.101	1.317	43.71	5468	3.047	1.295	2.997	-1.448	2.826	0.737
600S200-97	0.1017	1.087	3.63	5.612	1.871	2.293	0.530	0.705	5.612	1.871	43.49	7372	3.000	4.101	1.671	64.53	11124	3.000	3.679	3.981	-1.427	2.791	0.739
600S250-43	0.0451	0.537	1.83	3.042	1.027	2.395	0.456	0.921	3.042	0.918	18.54	1358	3.124						0.304	3.379	-1.894	3.392	0.847
600S250-54	0.0566	0.670	2.28	3.819	1.273	2.383	0.552	0.917	3.819	1.151	22.80	2708	3.115	3.780	1.099	30.00	2708	3.207	0.715	4.188	-1.888	3.380	0.847
600S250-68	0.0713	0.836	2.84	4.727	1.576	2.376	0.686	0.908	4.727	1.522	30.08	4442	3.046	4.727	1.342	40.19	5468	3.191	1.410	5.071	-1.878	3.364	0.847
600S250-97	0.1017	1.169	3.98	6.496	2.165	2.357	0.963	0.899	6.496	2.100	41.88	7372	3.000	6.496	2.053	64.38	11124	3.062	4.330	6.790	-1.857	3.130	0.848

[1] Web-height to thickness ratio exceeds 200. Web stiffeners are required at all support points and concentrated loads.
Gross properties are based on full-unreduced cross section, away from punchouts.

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COMBINED AXIAL AND LATERAL LOAD TABLE NOTES

- Allowable loads are based on specified weak axis and torsional bracing at 48" o.c. maximum for axial load calculation and continuous support of each flange for flexural calculation.
- Sections are punched with a standard punchout 1.5" wide, located on the centerline of the web 24" o.c.
- Allowable loads are based on a punched section for axial load calculation, and an unpunched section for flexural calculation as per *ICC-ES AC46-Appendix B.*
- Weak axis and torsional bracing should have sufficient stiffness and strength to resist axial load.
- Lateral load is multiplied by 0.75 for strength determination and by 0.70 for deflection determination. Axial load is not multiplied by any factor (Load factor = 1.0)
- Strength increase due to cold forming is incorporated in calculating allowable loads as per *AISI Specification Sec. A7.2.*
- Check lateral end reactions for web crippling if applicable.
- Loads in tables are in kips/stud.

TABLE BACKGROUND AND EXAMPLE

1. Basis for Tables:

The combined axial and lateral load tables in this catalog cover the following basic load combinations for the Allowable Stress Design (ASD) Method (IBC2003 and ASCE 7-02):

- D + L (Strength determination)
- D + 0.75L + 0.75W_{MWFRS^*} (Strength determination)
- 0.70$W_{C\&C^{**}}$ (Deflection determination)

* MWFRS: Main Wind Force Resisting System
** C&C: Component and Cladding

2. Design Example:

Given:

Service (Un-factored) Loads:

Axial Dead Load	= 1.6 kips
Axial Live Load	= 3.2 kips
Wind Pressure (MWFRS)	= 30 psf
Wind Pressure (C&C)	= 40 psf
Wall Width	= 6.0".
Stud Height	= 12.0 ft.
Stud Spacing	= 16" o.c.
Specified Deflection Limit	= L/600

Bridging (Lateral Bracing) at maximum vertical spacing of 48" o.c.

Calculations:

a) Use the D + L load combination to get the first estimate of the stud.

Combination total axial load = 1.6 + 3.2 = 4.8 kips

From the "No Lateral Load" table with a 12.0' wall height, choose 600S162-54 (50ksi) with an axial resistance of 5.57 kips > 4.8 kips OK

b) Check the D + 0.75L + 0.75W_{MWFRS} load combination for strength.

Combination total axial load = 1.6 + 0.75(3.2) = 4.0 kips

Go to the "Lateral Load = 30 psf" table with a 12.0' wall height and 16" stud spacing. The axial resistance for 600S162-54 (50ksi) is 4.14 kips > 4.0 kips OK

c) Check the 0.70$W_{C\&C}$ load combination for deflection. The specified limit is L/600.

Go to the "Lateral Load = 40 psf" table with a 12.0' wall height and 16" stud spacing. The deflection parameter for 600S162-54 (50ksi) is X, which means that deflection exceeds L/720 < L/600 OK

Conclusion:

Use 600S162-54 (50ksi) (with design thickness = 0.0566" and Fy = 50 ksi) spaced at 16" o.c. with 2 lines of bridging arranged so that the maximum spacing does not exceed 48" (4 ft.).

3. Extra Design Considerations:

a) Check lateral end reaction of the stud for web crippling using the Web Crippling Load Tables included in this catalog.

b) If the specified axial dead load acting on the stud is significantly larger than the specified axial live load, the following extra basic load combination needs to be checked as well:

- D + $W_{C\&C}$ (Strength determination)

There are no special tables for this load combination. However, you can still use the same tables by <u>scaling up</u> the $W_{C\&C}$ wind pressure value (use the table that corresponds to the scaled-up wind pressure) and then compare the table's axial resistance to the specified dead load.

No Lateral Load for Load Combination 1.0(D+L)

Wall Height (ft.)	Spacing (in.) o.c.	350S162-(mils)				362S137-(mils)				362S162-(mils)				362S200-(mils)			
		33 ksi		50 ksi		33 ksi		50 ksi		33 ksi		50 ksi		33 ksi		50 ksi	
		33	43	54	68	33	43	54	68	33	43	54	68	33	43	54	68
8	12	2.03	2.76	4.11	5.19	1.67	2.31	3.39	4.41	2.08	2.85	4.26	5.50	2.49	3.51	5.34	6.87
	16	2.03	2.76	4.11	5.19	1.67	2.31	3.39	4.41	2.08	2.85	4.26	5.50	2.49	3.51	5.34	6.87
	24	2.03	2.76	4.11	5.19	1.67	2.31	3.39	4.41	2.08	2.85	4.26	5.50	2.49	3.51	5.34	6.87
9	12	1.95	2.66	3.84	4.84	1.63	2.25	3.25	4.17	2.01	2.75	4.04	5.16	2.41	3.37	5.03	6.41
	16	1.95	2.66	3.84	4.84	1.63	2.25	3.25	4.17	2.01	2.75	4.04	5.16	2.41	3.37	5.03	6.41
	24	1.95	2.66	3.84	4.84	1.63	2.25	3.25	4.17	2.01	2.75	4.04	5.16	2.41	3.37	5.03	6.41
10	12	1.87	2.54	3.53	4.43	1.57	2.17	3.05	3.89	1.93	2.64	3.79	4.77	2.32	3.22	4.68	5.90
	16	1.87	2.54	3.53	4.43	1.57	2.17	3.05	3.89	1.93	2.64	3.79	4.77	2.32	3.22	4.68	5.90
	24	1.87	2.54	3.53	4.43	1.57	2.17	3.05	3.89	1.93	2.64	3.79	4.77	2.32	3.22	4.68	5.90
12	12	1.66	2.26	2.93	3.65	1.43	1.97	2.61	3.30	1.74	2.37	3.17	3.95	2.12	2.88	3.90	4.84
	16	1.66	2.26	2.93	3.65	1.43	1.97	2.61	3.30	1.74	2.37	3.17	3.95	2.12	2.88	3.90	4.84
	24	1.66	2.26	2.93	3.65	1.43	1.97	2.61	3.30	1.74	2.37	3.17	3.95	2.12	2.88	3.90	4.84
14	12	1.44	1.94	2.41	2.98	1.26	1.74	2.19	2.73	1.52	2.07	2.61	3.24	1.85	2.50	3.18	3.93
	16	1.44	1.94	2.41	2.98	1.26	1.74	2.19	2.73	1.52	2.07	2.61	3.24	1.85	2.50	3.18	3.93
	24	1.44	1.94	2.41	2.98	1.26	1.74	2.19	2.73	1.52	2.07	2.61	3.24	1.85	2.50	3.18	3.93
16	12	1.21	1.60	1.98	2.45	1.08	1.47	1.82	2.25	1.29	1.74	2.16	2.66	1.57	2.11	2.61	3.22
	16	1.21	1.60	1.98	2.45	1.08	1.47	1.82	2.25	1.29	1.74	2.16	2.66	1.57	2.11	2.61	3.22
	24	1.21	1.60	1.98	2.45	1.08	1.47	1.82	2.25	1.29	1.74	2.16	2.66	1.57	2.11	2.61	3.22

No Lateral Load for Load Combination 1.0(D+L)

Wall Height (ft.)	Spacing (in.) o.c.	400S137-(mils)				400S162-(mils)				400S200-(mils)				550S162-(mils)			
		33 ksi		50 ksi		33 ksi		50 ksi		33 ksi		50 ksi		33 ksi		50 ksi	
		33	43	54	68	33	43	54	68	33	43	54	68	33	43	54	68
8	12	1.78	2.47	3.73	5.02	2.22	3.05	4.72	6.23	2.63	3.76	5.92	7.72	2.52	3.48	5.70	7.59
	16	1.78	2.47	3.73	5.02	2.22	3.05	4.72	6.23	2.63	3.76	5.92	7.72	2.52	3.48	5.70	7.59
	24	1.78	2.47	3.73	5.02	2.22	3.05	4.72	6.23	2.63	3.76	5.92	7.72	2.52	3.48	5.70	7.59
9	12	1.74	2.42	3.61	4.89	2.17	2.97	4.53	5.98	2.57	3.65	5.65	7.36	2.50	3.46	5.63	7.53
	16	1.74	2.42	3.61	4.89	2.17	2.97	4.53	5.98	2.57	3.65	5.65	7.36	2.50	3.46	5.63	7.53
	24	1.74	2.42	3.61	4.89	2.17	2.97	4.53	5.98	2.57	3.65	5.65	7.36	2.50	3.46	5.63	7.53
10	12	1.70	2.36	3.48	4.66	2.10	2.88	4.32	5.68	2.49	3.52	5.35	6.96	2.47	3.42	5.54	7.41
	16	1.70	2.36	3.48	4.66	2.10	2.88	4.32	5.68	2.49	3.52	5.35	6.96	2.47	3.42	5.54	7.41
	24	1.70	2.36	3.48	4.66	2.10	2.88	4.32	5.68	2.49	3.52	5.35	6.96	2.47	3.42	5.54	7.41
12	12	1.59	2.21	3.11	4.06	1.93	2.65	3.81	4.93	2.32	3.22	4.66	6.03	2.40	3.32	5.30	7.08
	16	1.59	2.21	3.11	4.06	1.93	2.65	3.81	4.93	2.32	3.22	4.66	6.03	2.40	3.32	5.30	7.08
	24	1.59	2.21	3.11	4.06	1.93	2.65	3.81	4.93	2.32	3.22	4.66	6.03	2.40	3.32	5.30	7.08
14	12	1.44	2.00	2.70	3.43	1.74	2.38	3.23	4.08	2.11	2.88	3.92	4.95	2.29	3.17	4.95	6.61
	16	1.44	2.00	2.70	3.43	1.74	2.38	3.23	4.08	2.11	2.88	3.92	4.95	2.29	3.17	4.95	6.61
	24	1.44	2.00	2.70	3.43	1.74	2.38	3.23	4.08	2.11	2.88	3.92	4.95	2.29	3.17	4.95	6.61
16	12	1.27	1.76	2.30	2.86	1.52	2.09	2.73	3.37	1.85	2.51	3.28	4.07	2.15	2.98	4.50	6.02
	16	1.27	1.76	2.30	2.86	1.52	2.09	2.73	3.37	1.85	2.51	3.28	4.07	2.15	2.98	4.50	6.02
	24	1.27	1.76	2.30	2.86	1.52	2.09	2.73	3.37	1.85	2.51	3.28	4.07	2.15	2.98	4.50	6.02

1 = Deflection Exceeds L/120
2 = Deflection Exceeds L/240
3 = Deflection Exceeds L/360
6 = Deflection Exceeds L/600
7 = Deflection Exceeds L/720
If not noted, deflection is less than L/720

Important Notes:

- Allowable loads are based on specified weak axis and torsional bracing at 48" o.c. maximum for axial load calculation and continuous support of each flange for flexural calculation.
- Sections are punched with a standard punchout 1.5" wide, located on the centerline of the web 24" o.c.
- Allowable loads are based on a punched section for axial load calculation, and an unpunched section for flexural calculation as per *ICC-ES AC46-Appendix B.*
- Weak axis and torsional bracing should have sufficient stiffness and strength to resist axial load.
- Lateral load is multiplied by 0.75 for strength determination and by 0.70 for deflection determination. Axial load is not multiplied by any factor (Load factor = 1.0)
- Strength increase due to cold forming is incorporated in calculating allowable loads as per *AISI Specification Sec. A7.2.*
- Check lateral end reactions for web crippling if applicable.
- Loads in tables are in kips/stud.

Lateral Load = 15 psf (Multiplied by 0.75 for Strength & by 0.70 for Deflection Determinations)

Wall Height (ft.)	Spacing (in.) o.c.	350S162-(mils)				362S137-(mils)				362S162-(mils)				362S200-(mils)			
		33 ksi		50 ksi		33 ksi		50 ksi		33 ksi		50 ksi		33 ksi		50 ksi	
		33	43	54	68	33	43	54	68	33	43	54	68	33	43	54	68
8	12	1.55	2.30	3.71	4.78	1.29	1.90	3.05	4.04	1.62	2.39	3.87	5.09	1.98	2.97	4.86	6.41
	16	1.40	2.15	3.58	4.64	1.18	1.77	2.94	3.92	1.47	2.25	3.74	4.95	1.81	2.80	4.70	6.26
	24	1.12	1.87	3.33	4.39	0.95[7]	1.52	2.72	3.69	1.20	1.97	3.50	4.69	1.51	2.48	4.41	5.98
9	12	1.36	2.07	3.34	4.32	1.15	1.73	2.81	3.71	1.43	2.17	3.54	4.64	1.76	2.70	4.42	5.83
	16	1.18	1.80	3.19	4.16	1.01	1.57	2.67	3.58	1.26	2.00	3.39	4.47	1.57	2.49	4.23	5.65
	24	0.86	1.56	2.89	3.85	0.74	1.27	2.41	3.28	0.83	1.67	3.09	4.16	1.20	2.10	3.87	5.30
10	12	1.15	1.83	2.94	3.82	1.00[7]	1.53	2.52	3.33	1.23	1.93	3.18	4.14	1.54	2.40	3.95	5.21
	16	0.96[6]	1.62	2.77	3.64	0.83[6]	1.35[7]	2.36	3.16	1.03[7]	1.73	3.00	3.95	1.31	2.16	3.73	5.00
	24	0.60[6]	1.25[6]	2.44[7]	3.29	0.53[3]	1.01[6]	2.06[6]	2.84[7]	0.67[6]	1.35[3]	2.66[7]	3.60	0.90[6]	1.72[7]	3.32	4.61
12	12	0.76	1.33	2.20	2.89	0.69	1.12	1.93	2.57	0.84	1.44	2.41	3.16	1.06	1.79	2.98	3.97
	16	0.54	1.09	2.00	2.68	0.49	0.90	1.74	2.37	0.61	1.20	2.20	2.94	0.82	1.51	2.73	3.73
	24	0.15	0.67	1.64	2.30	0.15	0.51	1.40	2.00	0.21	0.77	1.83	2.54	0.36	1.01	2.28	3.29
14	12	0.43	0.89[3]	1.59[6]	2.13[6]	0.40	0.75[3]	1.41[6]	1.91[6]	0.49	0.99[6]	1.76[6]	2.35[6]	0.67[7]	1.24[6]	2.16[6]	2.97[7]
	16	0.21	0.65[3]	1.39	1.92[6]	0.20	0.52[3]	1.21	1.70[6]	0.26	0.74[3]	1.55[3]	2.12[6]	0.40	0.95[3]	1.91[6]	2.71[6]
	24		0.23[2]	1.03[2]	1.53[3]		0.12[2]	0.87[2]	1.33[3]		0.30[2]	1.17[2]	1.72[3]		0.45[2]	1.47[3]	2.27
16	12	0.18	0.54	1.14	1.56	0.18	0.44	1.00	1.39	0.23	0.69	1.27	1.73	0.35	0.80	1.58	2.21
	16		0.31	0.94	1.35		0.22	0.81	1.19		0.38	1.06	1.51	0.09	0.52	1.31	1.96
	24			0.60	0.98			0.48	0.83			0.70	1.12		0.04	0.89	1.53

Lateral Load = 15 psf (Multiplied by 0.75 for Strength & by 0.70 for Deflection Determinations)

Wall Height (ft.)	Spacing (in.) o.c.	400S137-(mils)				400S162-(mils)				400S200-(mils)				550S162-(mils)			
		33 ksi		50 ksi		33 ksi		50 ksi		33 ksi		50 ksi		33 ksi		50 ksi	
		33	43	54	68	33	43	54	68	33	43	54	68	33	43	54	68
8	12	1.43	2.10	3.41	4.66	1.80	2.63	4.35	5.83	2.17	3.27	5.47	7.28	2.23	3.20	5.44	7.31
	16	1.32	1.98	3.30	4.54	1.66	2.50	4.23	5.70	2.02	3.11	5.32	7.14	2.13	3.10	5.35	7.22
	24	1.11	1.74	3.10	4.32	1.40	2.24	3.99	5.44	1.73	2.81	5.03	6.87	1.94	2.92	5.18	7.04
9	12	1.31	1.94	3.20	4.43	1.63	2.44	4.06	5.46	1.98	3.02	5.07	6.80	2.12	3.08	5.29	7.17
	16	1.17	1.79	3.07	4.28	1.46	2.28	3.91	5.30	1.79	2.83	4.89	6.62	2.00	2.97	5.18	7.05
	24	0.91	1.51	2.82	3.99	1.15	1.96	3.62	4.96	1.45	2.46	4.54	6.27	1.76	2.73	4.97	6.81
10	12	1.16	1.77	2.96	4.08	1.44	2.22	3.73	5.04	1.77	2.75	4.63	6.26	2.01	2.96	5.12	6.95
	16	1.00[7]	1.59	2.80	3.90	1.25	2.03	3.55	4.84	1.55	2.52	4.42	6.04	1.86	2.81	4.98	6.80
	24	0.71[6]	1.25[6]	2.50[7]	3.56	0.89[6]	1.66	3.21	4.46	1.15[7]	2.09	4.01	5.63	1.57	2.52	4.71	6.50
12	12	0.86	1.38	2.40	3.26	1.05	1.75	3.01	4.05	1.32	2.16	3.70	5.07	1.72	2.65	4.67	6.39
	16	0.66	1.15	2.20	3.05	0.82	1.50	2.78	3.80	1.06	1.88	3.43	4.80	1.52	2.44	4.47	6.16
	24	0.31	0.75	1.83	2.65	0.40	1.06	2.37	3.35	0.59	1.36	2.94	4.30	1.13	2.04	4.09	5.74
14	12	0.56	0.99[6]	1.84	2.51[7]	0.69	1.28[6]	2.29[6]	3.08	0.90	1.59[6]	2.80[7]	3.85	1.40	2.26	4.09	5.65
	16	0.35	0.74[3]	1.62[6]	2.27[6]	0.44	1.01[6]	2.05[6]	2.81[6]	0.62	1.28[6]	2.51[6]	3.56[7]	1.14[6]	2.00	3.83	5.36
	24		0.31[2]	1.23[3]	1.84		0.53[3]	1.62[3]	2.34[3]	0.12[2]	0.73[3]	2.00[3]	3.05[6]	0.67[6]	1.50[6]	3.35[7]	4.82
16	12	0.31	0.84	1.38	1.87	0.38	0.87	1.70	2.30	0.54	1.10	2.08	2.90	1.06	1.85	3.44	4.80
	16	0.09	0.39	1.14	1.63	0.13	0.60	1.46	2.04	0.25	0.78	1.79	2.62	0.77	1.54	3.14	4.46
	24			0.76	1.21		0.13	1.04	1.59		0.24	1.30	2.12	0.25	0.98	2.60	3.84

1 = Deflection Exceeds L/120
2 = Deflection Exceeds L/240
3 = Deflection Exceeds L/360
6 = Deflection Exceeds L/600
7 = Deflection Exceeds L/720
If not noted, deflection is less than L/720

Important Notes:

- Allowable loads are based on specified weak axis and torsional bracing at 48" o.c. maximum for axial load calculation and continuous support of each flange for flexural calculation.
- Sections are punched with a standard punchout 1.5" wide, located on the centerline of the web 24" o.c.
- Allowable loads are based on a punched section for axial load calculation, and an unpunched section for flexural calculation as per *ICC-ES AC46-Appendix B.*
- Weak axis and torsional bracing should have sufficient stiffness and strength to resist axial load.
- Lateral load is multiplied by 0.75 for strength determination and by 0.70 for deflection determination. Axial load is not multiplied by any factor (Load factor = 1.0)
- Strength increase due to cold forming is incorporated in calculating allowable loads as per *AISI Specification Sec. A7.2.*
- Check lateral end reactions for web crippling if applicable.
- Loads in tables are in kips/stud.

LATERAL LOAD = 15 PSF (MULTIPLIED BY 0.75 FOR STRENGTH & BY 0.70 FOR DEFLECTION DETERMINATIONS)

Wall Height (ft.)	Spacing (in.) o.c.	800S137-(mils)					800S162-(mils)					800S200-(mils)				
		33 ksi		50 ksi			33 ksi		50 ksi			33 ksi		50 ksi		
		33	43	54	68	97	33	43	54	68	97	33	43	54	68	97
8	12	1.65	2.38	3.72	4.95	7.45	2.30	3.27	5.50	7.32	11.25	2.71	4.13	7.24	9.70	15.18
	16	1.58	2.31	3.65	4.88	7.39	2.21	3.19	5.43	7.25	11.17	2.61	4.03	7.15	9.61	15.07
	24	1.43	2.15	3.53	4.75	7.27	2.04	3.02	5.28	7.09	10.99	2.43	3.83	6.96	9.42	14.86
9	12	1.59	2.32	3.66	4.89	7.40	2.22	3.20	5.43	7.25	11.17	2.61	4.01	7.08	9.49	14.88
	16	1.49	2.21	3.58	4.80	7.32	2.11	3.09	5.34	7.15	11.06	2.49	3.88	6.94	9.37	14.74
	24	1.30	2.02	3.41	4.63	7.16	1.90	2.88	5.15	6.94	10.83	2.25	3.63	6.69	9.13	14.47
10	12	1.51	2.24	3.59	4.82	7.33	2.12	3.10	5.35	7.16	11.07	2.49	3.86	6.84	9.23	14.51
	16	1.39	2.11	3.49	4.71	7.23	1.98	2.97	5.23	7.03	10.92	2.34	3.70	6.69	9.08	14.34
	24	1.16	1.87	3.29	4.50	7.02	1.72	2.71	4.99	6.77	10.63	2.05	3.39	6.38	8.78	14.00
12	12	1.34	2.05	3.43	4.64	7.16	1.87	2.83	5.00	6.84	10.80	2.22	3.51	6.28	8.56	13.55
	16	1.16	1.87	3.27	4.46	7.00	1.68	2.64	4.82	6.64	10.57	2.01	3.26	6.06	8.34	13.29
	24	0.83[7]	1.52	2.97	4.17	6.69	1.32	2.28	4.47	6.26	10.12	1.61	2.85	5.63	7.91	12.79
14	12	1.12	1.82	3.21	4.41	6.92	1.58	2.50	4.52	6.23	10.14	1.89	3.08	5.59	7.71	12.29
	16	0.90[7]	1.57	3.00	4.18	6.69	1.34	2.25	4.28	5.96	9.81	1.62	2.78	5.29	7.42	11.94
	24	0.47[6]	1.12[6]	2.59[7]	3.75	6.26	0.89[6]	1.78[7]	3.82	5.45	9.19	1.12[6]	2.23	4.74	6.85	11.26
16	12	0.88[7]	1.55	2.95	4.11	6.60	1.26[7]	2.12	3.93	5.47	8.97	1.53	2.60	4.80	6.73	10.81
	16	0.61[2]	1.24[6]	2.67[7]	3.81	6.28	0.98[6]	1.82[7]	3.64	5.14	8.66	1.21[6]	2.25	4.45	6.37	10.37
	24	0.11[1]	0.69[2]	2.16[3]	3.25[6]	5.70	0.46[1]	1.27[3]	3.10[7]	4.53	7.80	0.84[2]	1.61[7]	3.81[7]	5.70	9.56

LATERAL LOAD = 15 PSF (MULTIPLIED BY 0.75 FOR STRENGTH & BY 0.70 FOR DEFLECTION DETERMINATIONS)

Wall Height (ft.)	Spacing (in.) o.c.	800S250-(mils)				800S137-(mils)					800S162-(mils)				
		33ksi	50 ksi			33 ksi		50 ksi			33 ksi		50 ksi		
		43	54	68	97	33	43	54	68	97	33	43	54	68	97
8	12	4.58	8.10	11.52	17.84	1.64	2.35	3.51	4.68	7.18	2.29	3.25	5.35	7.16	11.19
	16	4.48	8.00	11.41	17.73	1.59	2.29	3.47	4.64	7.14	2.23	3.19	5.30	7.10	11.14
	24	4.27	7.80	11.19	17.52	1.48	2.19	3.39	4.56	7.07	2.10	3.06	5.19	6.99	11.03
9	12	4.45	7.90	11.23	17.45	1.59	2.30	3.47	4.66	7.15	2.24	3.20	5.31	7.11	11.14
	16	4.32	7.77	11.08	17.31	1.53	2.24	3.42	4.60	7.10	2.16	3.12	5.24	7.04	11.07
	24	4.06	7.52	10.80	17.03	1.40	2.10	3.32	4.49	7.01	1.99	2.96	5.09	6.90	10.94
10	12	4.30	7.67	10.88	16.98	1.55	2.25	3.44	4.61	7.11	2.18	3.14	5.25	7.06	11.09
	16	4.14	7.51	10.70	16.80	1.46	2.17	3.37	4.54	7.05	2.07	3.04	5.16	6.97	11.00
	24	3.82	7.19	10.35	16.45	1.30	2.01	3.24	4.41	6.94	1.87	2.84	4.99	6.79	10.84
12	12	3.94	7.10	10.03	15.79	1.43	2.14	3.34	4.51	7.02	2.03	2.99	5.12	6.92	10.96
	16	3.71	6.87	9.77	15.53	1.31	2.02	3.25	4.42	6.94	1.88	2.84	4.99	6.79	10.83
	24	3.26	6.41	9.26	15.01	1.06	1.78	3.06	4.22	6.77	1.58	2.55	4.73	6.52	10.58
14	12	3.51	6.41	8.99	14.32	1.29	1.99	3.23	4.39	6.92	1.85	2.81	4.95	6.75	10.79
	16	3.20	6.10	8.64	13.95	1.13	1.83	3.09	4.26	6.79	1.65	2.61	4.77	6.56	10.61
	24	2.62	5.50	7.98	13.25	0.82	1.51	2.83	3.99	6.55	1.25	2.21	4.41	6.18	10.25
16	12	3.07	5.64	7.85	12.84	1.13	1.83	3.09	4.25	6.78	1.64	2.60	4.75	6.52	10.57
	16	2.65	5.26	7.41	12.18	0.93	1.61	2.91	4.07	6.62	1.38	2.33	4.50	6.27	10.32
	24	1.98[7]	4.55[7]	6.83	11.33	0.53[7]	1.20	2.57	3.71	6.29	0.88	1.82	4.03	5.77	9.82

1 = Deflection Exceeds L/120
2 = Deflection Exceeds L/240
3 = Deflection Exceeds L/360
6 = Deflection Exceeds L/600
7 = Deflection Exceeds L/720
If not noted, deflection is less than L/720

Important Notes:

- Allowable loads are based on specified weak axis and torsional bracing at 48" o.c. maximum for axial load calculation and continuous support of each flange for flexural calculation.
- Sections are punched with a standard punchout 1.5" wide, located on the centerline of the web 24" o.c.
- Allowable loads are based on a punched section for axial load calculation, and an unpunched section for flexural calculation as per *ICC-ES AC46-Appendix B*.
- Weak axis and torsional bracing should have sufficient stiffness and strength to resist axial load.
- Lateral load is multiplied by 0.75 for strength determination and by 0.70 for deflection determination. Axial load is not multiplied by any factor (Load factor = 1.0)
- Strength increase due to cold forming is incorporated in calculating allowable loads as per *AISI Specification Sec. A7.2.*
- Check lateral end reactions for web crippling if applicable.
- Loads in tables are in kips/stud.

Lateral Load = 15 psf (x 0.75 for Strength & by 0.70 for Deflection Determinations)

Wall Height (ft.)	Spacing (in.) o.c.	800S200-(mils)					800S250-(mils)			
		33 ksi		50 ksi			33 ksi	50 ksi		
		33	43	54	68	97	43	54	68	97
8	12	2.86	4.38	7.66	10.20	15.87	4.90	8.76	12.54	19.75
	16	2.78	4.31	7.60	10.14	15.81	4.83	8.69	12.46	19.67
	24	2.64	4.18	7.47	10.02	15.67	4.69	8.55	12.31	19.52
9	12	2.80	4.32	7.61	10.15	15.82	4.83	8.66	12.41	19.57
	16	2.70	4.24	7.52	10.07	15.73	4.74	8.57	12.32	19.47
	24	2.52	4.06	7.35	9.91	15.56	4.65	8.39	12.12	19.28
10	12	2.73	4.26	7.54	10.09	15.75	4.74	8.54	12.27	19.34
	16	2.61	4.15	7.44	9.99	15.64	4.62	8.43	12.15	19.22
	24	2.39	3.94	7.24	9.79	15.42	4.40	8.21	11.90	18.98
12	12	2.56	4.10	7.38	9.93	15.57	4.52	8.23	11.89	18.75
	16	2.40	3.94	7.23	9.78	15.40	4.36	8.07	11.71	18.57
	24	2.07	3.83	6.93	9.49	15.07	4.03	7.74	11.35	18.21
14	12	2.33	3.84	7.02	9.57	15.29	4.25	7.82	11.29	17.92
	16	2.11	3.62	6.81	9.36	15.05	4.02	7.59	11.04	17.67
	24	1.68	3.20	6.40	8.95	14.57	3.58	7.15	10.55	17.17
16	12	2.07	3.52	6.54	8.99	14.46	3.92	7.30	10.52	16.85
	16	1.79	3.25	6.26	8.72	14.14	3.62	7.00	10.19	16.52
	24	1.25	2.72	5.73	8.18	13.51	3.06	6.44	9.56	15.86

Lateral Load = 20 psf

Wall Height (ft.)	Spacing (in.) o.c.	350S162-(mils)				362S137-(mils)			
		33 ksi		50 ksi		33 ksi		50 ksi	
		33	43	54	68	33	43	54	68
8	12	1.40	2.15	3.58	4.64	1.18	1.77	2.94	3.92
	16	1.21	1.96	3.42	4.47	1.03	1.60	2.79	3.77
	24	0.86[6]	1.60[7]	3.10	4.14	0.74[6]	1.29[7]	2.52	3.47
9	12	1.18	1.89	3.19	4.16	1.01	1.57	2.87	3.56
	16	0.96	1.67	2.99	3.95	0.83	1.36	2.49	3.37
	24	0.56	1.25	2.82	3.58	0.49	0.99	2.16	3.02
10	12	0.96[6]	1.62	2.77	3.64	0.83[6]	1.35[7]	2.36	3.16
	16	0.71[6]	1.37[6]	2.55[7]	3.40	0.63[6]	1.12[6]	2.16[7]	2.94
	24	0.27[3]	0.91[6]	2.14[3]	2.97[6]	0.26[2]	0.69[3]	1.79[6]	2.54[6]
12	12	0.54	1.09	2.00	2.69	0.49	0.90	1.74	2.37
	16	0.27	0.81	1.75	2.42	0.26	0.64	1.51	2.12
	24		0.31	1.32	1.95		0.17	1.10	1.68
14	12	0.21[2]	0.65[3]	1.39[6]	1.92[6]	0.20[2]	0.52[3]	1.21[3]	1.70[6]
	16		0.36[2]	1.15[3]	1.65[3]		0.24[2]	0.98[2]	1.45[3]
	24			0.72[2]	1.20[2]			0.57[2]	1.00[2]
16	12		0.31	0.94	1.35		0.22	0.81	1.19
	16		0.04	0.71	1.10			0.56	0.94
	24			0.31	0.86			0.20	0.52

Lateral Load = 20 psf (Multiplied by 0.75 for Strength & by 0.70 for Deflection Determinations)

Wall Height (ft.)	Spacing (in.) o.c.	362S162-(mils)				362S200-(mils)				400S137-(mils)				400S162-(mils)			
		33 ksi		50 ksi		33 ksi		50 ksi		33 ksi		50 ksi		33 ksi		50 ksi	
		33	43	54	68	33	43	54	68	33	43	54	68	33	43	54	68
8	12	1.47	2.25	3.74	4.95	1.81	2.80	4.70	6.26	1.32	1.98	3.30	4.54	1.66	2.50	4.23	5.70
	16	1.29	2.06	3.58	4.78	1.61	2.59	4.50	6.07	1.18	1.82	3.17	4.39	1.49	2.33	4.07	5.53
	24	0.94[7]	1.71	3.27	4.44	1.22[7]	2.17	4.12	5.70	0.91[7]	1.52	2.90	4.10	1.15	1.99	3.77	5.20
9	12	1.26	2.00	3.39	4.47	1.57	2.49	4.23	5.65	1.17	1.79	3.07	4.28	1.46	2.28	3.91	5.30
	16	1.04	1.77	3.19	4.26	1.32	2.23	3.99	5.42	1.00	1.60	2.80	4.09	1.25	2.06	3.72	5.08
	24	0.63	1.36	2.81	3.86	0.87	1.74	3.53	4.97	0.67	1.23	2.57	3.72	0.86	1.66	3.35	4.66
10	12	1.03[7]	1.73	3.00	3.95	1.31	2.16	3.73	5.00	1.00[7]	1.59	2.80	3.90	1.25	2.03	3.55	4.84
	16	0.79[6]	1.48[6]	2.77	3.71	1.03[3]	1.86[7]	3.46	4.73	0.80[6]	1.36[7]	2.60	3.67	1.01[6]	1.78	3.32	4.59
	24	0.35[3]	1.01[6]	2.35[6]	3.27[7]	0.53[6]	1.32[6]	2.95[6]	4.24[7]	0.43[3]	0.94[6]	2.22[3]	3.24[7]	0.56[3]	1.31[6]	2.89[7]	4.11
12	12	0.61	1.20	2.20	2.94	0.62	1.51	2.73	3.73	0.66	1.15	2.20	3.65	0.82	1.50	2.78	3.80
	16	0.34	0.91	1.95	2.67	0.51	1.17	2.42	3.43	0.42	0.88	1.95	2.78	0.53	1.20	2.50	3.50
	24		0.39	1.49	2.18		0.57	1.88	2.89		0.39	1.50	2.28	0.03	0.86	2.00	2.94
14	12	0.26[2]	0.74[3]	1.55[3]	2.12[6]	0.40[1]	0.95[3]	1.91[6]	2.71[6]	0.35[1]	0.74[2]	1.62[6]	2.27[6]	0.44[1]	1.01[6]	2.05[6]	2.81[6]
	16		0.44[2]	1.29[3]	1.85[3]	0.08[2]	0.61[3]	1.61[3]	2.41[6]	0.09	0.44[2]	1.36[2]	1.97[3]	0.14[1]	0.68[3]	1.75[3]	2.49[3]
	24			0.84[2]	1.36[2]		0.01[2]	1.08[2]	1.88[3]			0.89[2]	1.46[3]		0.12[2]	1.24[3]	1.93[3]
16	12		0.38	1.06	1.51	0.09	0.52	1.31	1.96	0.09	0.39	1.14	1.83	0.13	0.60	1.48	2.04
	16		0.09	0.81	1.24		0.19	1.02	1.67		0.10	0.88	1.34		0.28	1.17	1.73
	24			0.39	0.78			0.52	1.16			0.42	0.86			0.88	1.19

1 = Deflection Exceeds L/120
2 = Deflection Exceeds L/240
3 = Deflection Exceeds L/360
6 = Deflection Exceeds L/600
7 = Deflection Exceeds L/720
If not noted, deflection is less than L/720

Important Notes:

- Allowable loads are based on specified weak axis and torsional bracing at 48" o.c. maximum for axial load calculation and continuous support of each flange for flexural calculation.
- Sections are punched with a standard punchout 1.5" wide, located on the centerline of the web 24" o.c.
- Allowable loads are based on a punched section for axial load calculation, and an unpunched section for flexural calculation as per *ICC-ES AC46-Appendix B*.
- Weak axis and torsional bracing should have sufficient stiffness and strength to resist axial load.
- Lateral load is multiplied by 0.75 for strength determination and by 0.70 for deflection determination. Axial load is not multiplied by any factor (Load factor = 1.0)
- Strength increase due to cold forming is incorporated in calculating allowable loads as per *AISI Specification Sec. A7.2.*
- Check lateral end reactions for web crippling if applicable.
- Loads in tables are in kips/stud.

Lateral Load = 20 psf (Multiplied by 0.75 for Strength & by 0.70 for Deflection Determinations)

Wall Height (ft.)	Spacing (in.) o.c.	400S200-(mils)				550S162-(mils)				600S137-(mils)				
		33 ksi		50 ksi		33 ksi		50 ksi		33 ksi		50 ksi		
		33	43	54	68	33	43	54	68	33	43	54	68	97
8	12	2.02	3.11	5.32	7.14	2.13	3.10	5.35	7.22	1.58	2.31	3.65	4.88	7.39
	16	1.83	2.91	5.13	6.96	2.00	2.98	5.24	7.10	1.48	2.20	3.57	4.79	7.31
	24	1.46	2.52	4.76	6.60	1.75	2.74	5.02	6.85	1.28	1.99	3.40	4.62	7.14
9	12	1.79	2.83	4.89	6.62	2.00	2.97	5.15	7.05	1.49	2.21	3.58	4.80	7.32
	16	1.56	2.58	4.65	6.39	1.84	2.81	5.04	6.89	1.36	2.08	3.47	4.69	7.21
	24	1.12	2.11	4.20	5.94	1.53	2.50	4.75	6.58	1.11	1.82	3.25	4.47	7.00
10	12	1.55	2.52	4.42	6.04	1.86	2.81	4.98	6.80	1.39	2.11	3.49	4.71	7.23
	16	1.28[7]	2.23	4.14	5.77	1.66	2.62	4.80	6.60	1.23	1.95	3.35	4.57	7.09
	24	0.78[3]	1.69[6]	3.62	5.24	1.29	2.24	4.45	6.21	0.93	1.62	3.09	4.29	6.82
12	12	1.06[1]	1.88[1]	3.43	4.80	1.52	2.44	4.47	6.18	1.18	1.87	3.27	4.48	7.00
	16	0.74[1]	1.52[1]	3.10[1]	4.48	1.26	2.17	4.21	5.88	0.94	1.63	3.07	4.27	6.79
	24	0.17[1]	0.90[1]	2.50[1]	3.84[1]	0.76[1]	1.86	3.72	5.33	0.52[1]	1.18[1]	2.68	3.86	6.39
14	12	0.62[3]	1.28[6]	2.51[6]	3.56[7]	1.14[6]	2.00	3.83	5.36	0.90[7]	1.57	3.00	4.18	6.69
	16	0.27[1]	0.90[3]	2.16[6]	3.21[6]	0.82[6]	1.66[6]	3.51[7]	4.99	0.61[6]	1.26[7]	2.73	3.89	6.40
	24		0.25[2]	1.56[3]	2.59[3]	0.24[3]	1.05[6]	2.91[6]	4.32[6]	0.09[3]	0.69[6]	2.21[6]	3.33[7]	5.84
16	12	0.25[1]	0.78[1]	1.79[1]	2.62[1]	0.77[1]	1.54[1]	3.14[1]	4.46	0.61[1]	1.24[1]	2.67[1]	3.81	6.28
	16		0.41	1.45[1]	2.28[1]	0.42[1]	1.15[1]	2.77[1]	4.04[1]	0.27[1]	0.87[1]	2.32[1]	3.43[1]	5.89
	24			0.87[1]	1.88		0.48[1]	2.12[1]	3.29[1]		0.20[1]	1.69[1]	2.74[1]	5.16[1]

Lateral Load = 20 psf (Multiplied by 0.75 for Strength & by 0.70 for Deflection Determinations)

Wall Height (ft.)	Spacing (in.) o.c.	600S162-(mils)					600S200-(mils)					600S250-(mils)			
		33 ksi		50 ksi			33 ksi		50 ksi			33 ksi	50 ksi		
		33	43	54	68	97	33	43	54	68	97	43	54	68	97
8	12	2.21	3.19	5.43	7.25	11.17	2.61	4.03	7.15	9.61	15.07	4.48	8.00	11.41	17.73
	16	2.10	3.08	5.33	7.14	11.05	2.49	3.90	7.02	9.48	14.93	4.34	7.86	11.26	17.59
	24	1.87	2.86	5.13	6.93	10.82	2.24	3.64	6.77	9.24	14.66	4.07	7.60	10.97	17.30
9	12	2.11	3.09	5.34	7.15	11.08	2.49	3.88	6.94	9.37	14.74	4.32	7.77	11.08	17.31
	16	1.97	2.95	5.21	7.01	10.91	2.33	3.71	6.77	9.21	14.58	4.15	7.60	10.90	17.12
	24	1.68	2.67	4.96	6.74	10.61	2.02	3.38	6.45	8.89	14.20	3.81	7.27	10.52	16.75
10	12	1.98	2.97	5.23	7.03	10.92	2.34	3.70	6.69	9.08	14.34	4.14	7.51	10.70	16.80
	16	1.81	2.79	5.07	6.86	10.73	2.15	3.50	6.48	8.88	14.11	3.93	7.30	10.47	16.56
	24	1.46	2.45	4.75	6.52	10.35	1.77	3.09	6.08	8.49	13.66	3.51	6.88	10.00	16.10
12	12	1.68	2.64	4.82	6.64	10.57	2.01	3.28	6.06	8.34	13.29	3.71	6.87	9.77	15.53
	16	1.44	2.40	4.59	6.38	10.27	1.74	2.99	5.77	8.05	12.95	3.41	6.56	9.43	15.18
	24	0.98[6]	1.92	4.14	5.88	9.89	1.23[7]	2.43	5.21	7.49	12.30	2.82	5.97	8.77	14.50
14	12	1.34	2.25	4.28	5.96	9.81	1.62	2.78	5.29	7.42	11.94	3.20	6.10	8.64	13.95
	16	1.03[6]	1.93[7]	3.97	5.61	9.39	1.28[7]	2.41	4.92	7.04	11.48	2.81	5.70	8.20	13.48
	24	0.47[6]	1.34[3]	3.39[6]	4.97	8.60	0.66[6]	1.72[6]	4.22[7]	6.32	10.62	2.08[7]	4.94	7.36	12.59
16	12	0.98[1]	1.62[1]	3.64	5.14	8.56	1.21[1]	2.25	4.45	6.37	10.37	2.65	5.26	7.41	12.18
	16	0.82[1]	1.45[1]	3.27[1]	4.73	8.05	0.82[1]	1.82[1]	4.02	5.92	9.82	2.18	4.78	6.88	11.61
	24		0.77[1]	2.61[1]	3.97[1]	7.11[1]	0.12[1]	1.03[1]	3.23[1]	5.09[1]	8.81	1.34[1]	3.90[1]	5.91[1]	10.55

1 = Deflection Exceeds L/120
2 = Deflection Exceeds L/240
3 = Deflection Exceeds L/360
6 = Deflection Exceeds L/600
7 = Deflection Exceeds L/720
If not noted, deflection is less than L/720

Important Notes:
- Allowable loads are based on specified weak axis and torsional bracing at 48" o.c. maximum for axial load calculation and continuous support of each flange for flexural calculation.
- Sections are punched with a standard punchout 1.5" wide, located on the centerline of the web 24" o.c.
- Allowable loads are based on a punched section for axial load calculation, and an unpunched section for flexural calculation as per *ICC-ES AC46-Appendix B*.
- Weak axis and torsional bracing should have sufficient stiffness and strength to resist axial load.
- Lateral load is multiplied by 0.75 for strength determination and by 0.70 for deflection determination. Axial load is not multiplied by any factor (Load factor = 1.0)
- Strength increase due to cold forming is incorporated in calculating allowable loads as per *AISI Specification Sec. A7.2.*
- Check lateral end reactions for web crippling if applicable.
- Loads in tables are in kips/stud.

Maximum Distance Between Anchorge Points of Wall Bridging (ft.)

Stud Designation (All Studs 50ksi)	Bridging Method	8' Wall Height, 1 Bridging Row, 16" o.c.	8' Wall Height, 1 Bridging Row, 24" o.c.	9' & 10' Wall Hgt, 2 Bridging Rows, 16" o.c.	9' & 10' Wall Hgt, 2 Bridging Rows, 24" o.c.	12' Wall Height, 2 Bridging Rows, 16" o.c.	12' Wall Height, 2 Bridging Rows, 24" o.c.
362SG200-33mil	BB150 (p.39) w/BC3 (p.40)						
362SG250-33mil							
362SG200-43mil							
362SG250-43mil							
362SG200-54mil							
362SG250-54mil							
362SG200-68mil							
362SG250-68mil							
362SG200-97mil							
362SG250-97mil							
600SG162-33mil	BB150 (p 39) w/BC600 (p 40)						
600SG162-43mil							
600SG200-33mil							
600SG250-33mil							
600SG200-43mil							
600SG250-43mil							
600SG200-54mil							
600SG250-54mil							
600SG200-68mil							
800SG162-33mil	BB150 (p.39) w/BC800 (p.40)						
800SG162-43mil							
800SG200-33mil							
800SG250-33mil							
800SG200-43mil							
800SG250-43mil							
800SG200-54mil							
800SG250-54mil							
600SG162-33mil	Buckle Bridge™ (p 39)						
600SG162-43mil							
600SG200-33mil							
600SG250-33mil							
600SG200-43mil							
600SG250-43mil							
600SG200-54mil							
600SG250-54mil							
600SG200-68mil							
600SG250-68mil							
600SG200-97mil							
600SG250-97mil							
800SG162-33mil	Buckle Bridge™ (p 39)						
800SG162-43mil							
800SG200-33mil							
800SG250-33mil							
800SG200-43mil							
800SG250-43mil							
800SG200-54mil							
800SG250-54mil							
800SG200-68mil							
800SG250-68mil							
800SG200-97mil							
800SG250-97mil							

Labels printed in the table: Anchorage at 18ft (max.) / Anchorage at 12ft (max) / Anchorage at 8ft (max) / Anchorage at 8ft (max)
Anchorage at 12ft. (max)
Anchorage at 18ft (max.)
Anchorage at 18ft (max.) / Anchorage at 12ft (max)

Table Key:

- [white] = Anchorage @ 18ft (max)
- [light] = Anchorage @ 12ft (max)
- [grey] = Anchorage @ 8ft (max)
- [dark] = Anchorage @ less than 8ft

Accumulative Lateral Bracing (Bridging) Force,

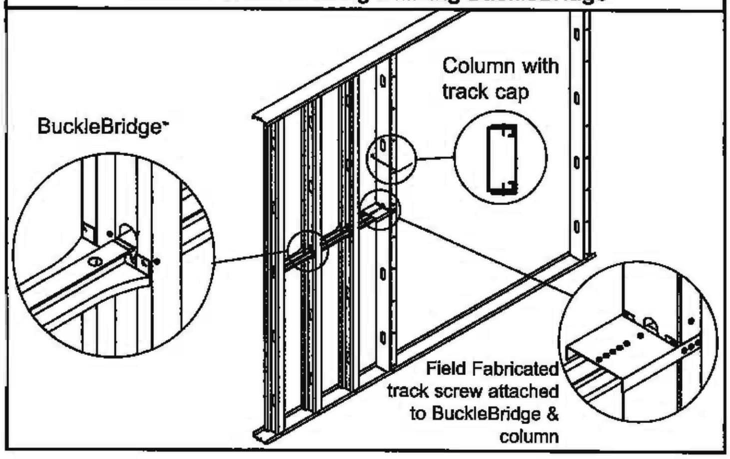
$$P_{Brace} = 0.02 \times \text{Single Stud Axial Load} \times (\text{Wall Anchorage Spacing} / \text{Stud Spacing})$$

Important Notes:

- Lateral bracing (bridging) design is calculated according to the requirements of *AISI Wall Stud Design Standard 2004*.
- Bridging is located at 48" o.c. maximum spacing.
- The above table is applicable for load bearing walls having additional wind pressure up to 5 psf.
- For wind pressure higher than 5psf acting with axial loads, use the bridging design for the higher effect of the axial load or the wind load.

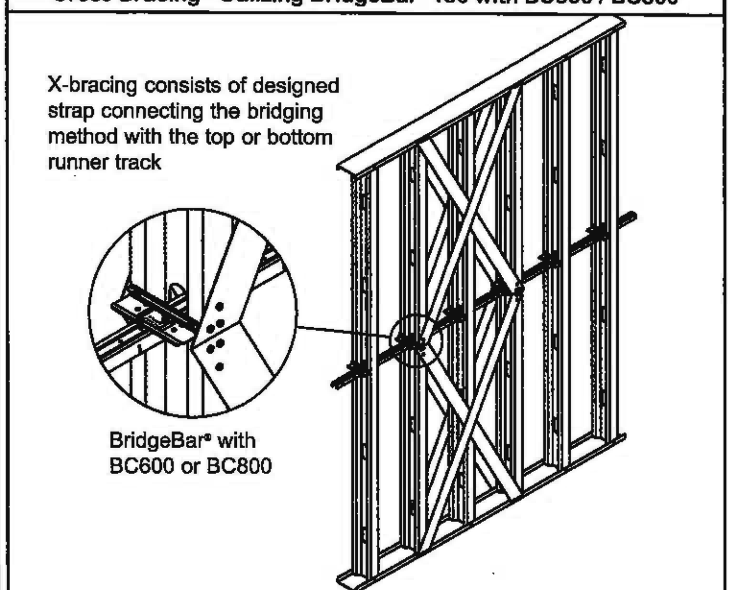
Removal of Accumulative Bridging Loads

Load Bearing Wall Bridging Row Anchored to Jamb Stud or End Column - Track Bracing Utilizing BuckleBridge



Removal of Accumulative Bridging Loads

Load Bearing Wall Bridging Row Anchored to Floor System Through Cross Bracing - Utilizing BridgeBar® 150 with BC600 / BC800



Important Notes:
1. Web punchouts were not considered for shear or web crippling. Shear and web crippling reduction factors required for web punchouts, per *ICC-ES Acceptance Criteria AC46, Appendix B.*
2. Spans are based on continuous lateral support of the compression flange.
3. For two equal spans, the listed span is the distance from either end support to the center support. Joists must be continuous over the center support.
4. Web crippling capacity is based on a 3.5" bearing length at end and interior supports.
5. Joists must be braced against rotation at all supports by track or blocking.
6. Joist spans are based on 50ksi for the 54, 68, and 97 mil thicknesses, and 33ksi for thinner members.
7. Total load deflection = L/240. Live load as noted.
8. Live load has been checked for unbalanced load conditions.

Floor joist bridging may be spaced as follows, except where member design requires or will accommodate an alternate spacing.

Span (ft)	Minimum Number of Rows
Up to 14ft	1 row at mid-span
14ft to 20ft	2 rows at one-third points
20ft to 26ft	3 rows at one-fourth points

10 PSF DEAD LOAD AND 20 PSF LIVE LOAD

Member	Live Load Deflection L/360						Live Load Deflection L/480					
	Single Span			Two Equal Spans			Single Span			Two Equal Spans		
	Spacing (in) o.c.			Spacing (in) o.c.			Spacing (in) o.c.			Spacing (in) o.c.		
	12	16	24	12	16	24	12	16	24	12	16	24
600S162-33	15' 9"	13' 9" e	11' 3" e	15' 11" i	13' 9" i	11' 3" a	14' 3"	13' 0" e	11' 3" e	15' 11" i	13' 9" i	11' 3" a
600S200-33	16' 5" e	14' 3" e	11' 7" e	16' 5" i	14' 3" i	11' 6" a	14' 11"	13' 7" e	11' 7" e	16' 5" i	14' 3" i	11' 6" a
600S162-43	17' 2"	15' 7"	13' 7"	19' 9" i	16' 8" i	15' 7" i	15' 7"	14' 2"	12' 4"	17' 6" i	15' 10" i	13' 7" i
600S200-43	18' 0"	16' 4"	13' 10"	19' 6" i	16' 11" i	13' 10" i	16' 4"	14' 10"	13' 0"	18' 4" i	16' 6" i	13' 10" i
600S250-43	18' 10"	17' 1"	14' 2"	20' 0" i	17' 4" i	14' 2" i	17' 1"	15' 7"	13' 7"	19' 3" i	17' 4" i	14' 2" i
600S162-54	18' 5"	16' 8"	14' 7"	20' 8"	18' 9" i	16' 4" i	16' 8"	15' 2"	13' 3"	18' 9"	17' 0"	14' 10" i
600S200-54	19' 4"	17' 7"	15' 4"	21' 8"	19' 8" i	17' 3" i	17' 7"	15' 11"	13' 11"	19' 8"	17' 11"	15' 8" i
600S250-54	20' 2"	18' 3"	16' 0"	22' 7"	20' 7" i	17' 11" i	18' 3"	16' 7"	14' 6"	20' 7"	18' 8"	16' 4" i
600S162-68	19' 8"	17' 11"	15' 8"	22' 2"	20' 11"	17' 7"	17' 11"	16' 3"	14' 2"	20' 1"	15' 9"	15' 11"
600S200-68	20' 6"	18' 10"	16' 5"	23' 3"	21' 2"	18' 6"	18' 10"	17' 1"	14' 11"	21' 2"	19' 8"	16' 9"
600S250-68	21' 9"	19' 9"	17' 3"	24' 5"	22' 2"	19' 4" i	19' 9"	17' 11"	15' 8"	22' 2"	20' 2"	17' 7"
600S162-97	21' 10"	19' 10"	17' 4"	24' 6"	22' 3"	19' 6"	19' 10"	18' 0"	15' 9"	22' 3"	20' 3"	17' 8"
600S200-97	23' 0"	20' 11"	18' 3"	25' 10"	23' 6"	20' 6"	20' 11"	19' 0"	16' 7"	23' 6"	21' 4"	18' 8"
600S250-97	24' 2"	21' 11"	19' 2"	27' 2"	24' 8"	21' 8"	21' 11"	19' 11"	17' 5"	24' 8"	22' 5"	19' 7"
800S162-33	18' 2" e	15' 9" e	12' 10" e	17' 8" a	14' 5" a	10' 8" a	16' 6" e	15' 9" e	12' 10" e	17' 8" a	14' 5" a	10' 8" a
800S200-33	18' 10" e	16' 4" e	13' 4" e	18' 1" a	14' 0" a	10' 10" a	18' 10" e	16' 4" e	13' 4" e	18' 1" a	14' 0" a	10' 10" a
800S162-43	21' 7"	19' 6"	15' 11" e	22' 6" i	19' 6" i	15' 11" i	19' 7"	17' 10"	15' 7" e	22' 0" i	19' 6" i	15' 11" i
800S200-43	22' 7"	20' 6" e	16' 10" e	23' 9" i	20' 7" i	16' 10" i	20' 6"	18' 8"	16' 3" e	23' 0" i	20' 7" i	16' 10" i
800S250-43	23' 7"	20' 9" e	16' 11" e	24' 0" i	20' 9" i	16' 11" i	21' 5"	19' 5"	16' 11" e	24' 0" i	20' 9" i	16' 11" i
800S162-54	22' 2"	21' 1"	18' 4"	26' 0" i	23' 8" i	20' 8" i	21' 1"	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
800S200-54	24' 3"	22' 1"	19' 3"	27' 3" i	24' 9" i	21' 7" i	22' 1"	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
800S250-54	25' 3"	22' 11"	20' 0"	28' 4" i	25' 9" i	22' 6" i	22' 11"	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
800S162-68	24' 11"	22' 7"	19' 9"	27' 11"	25' 5"	22' 2" i	22' 7"	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
800S200-68	26' 1"	23' 8"	20' 8"	29' 3"	26' 7"	23' 3" i	23' 8"	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
800S250-68	27' 3"	24' 9"	21' 7"	30' 7"	27' 9" i	24' 3" i	24' 9"	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
800S162-97	27' 1"	26' 1"	21' 11"	31' 1"	28' 2"	24' 8"	25' 1"	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
800S200-97	29' 0"	26' 4"	23' 0"	32' 7"	29' 7"	25' 10"	26' 4"	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
800S250-97	30' 4"	27' 6"	24' 1"	34' 0"	30' 11"	27' 0"	27' 6"	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1000S162-43	24' 11" e	21' 6" e	17' 7" e	24' 11" a	21' 6" a	16' 6" a	23' 7" e	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1000S200-43	26' 4" e	22' 9" e	18' 7" e	26' 4" a	22' 8" a	17' 0" a	24' 7" e	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1000S250-43	26' 7" e	23' 0" e	18' 10" e	26' 7" a	22' 10" a	17' 1" a	25' 6" e	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1000S162-54	27' 10"	25' 4"	22' 11"	31' 4" i	28' 5" i	23' 10" i	25' 4"	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1000S200-54	29' 1"	26' 5"	23' 11"	32' 8" i	29' 8" i	24' 6" i	26' 5"	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1000S250-54	30' 2"	27' 5"	24' 0"	33' 11" i	30' 7" i	25' 0" i	27' 5"	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1000S162-68	29' 11"	27' 2"	23' 9"	33' 7"	30' 6" i	26' 8" i	27' 2"	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1000S200-68	31' 3"	28' 4"	24' 9"	35' 1"	31' 10" i	27' 10" i	28' 4"	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1000S250-68	32' 6"	29' 6"	25' 9"	36' 6" i	33' 2" i	28' 11" i	29' 6"	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1000S162-97	33' 4"	30' 3"	26' 5"	37' 5"	34' 0"	29' 8"	30' 3"	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1000S200-97	34' 9"	31' 7"	27' 7"	39' 1"	35' 6"	31' 0"	31' 7"	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1000S250-97	36' 3"	32' 11"	28' 5"	40' 8"	36' 11"	32' 3"	32' 11"	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1200S162-54	32' 6" e	29' 6" e	25' 9" e	36' 6" a	31' 9" a	25' 5" a	29' 6" e	26' 10" e	23' 5" e	33' 2" a	30' 1" a	25' 5" a
1200S200-54	33' 9" e	30' 8" e	26' 8" e	37' 9" a	32' 8" a	25' 10" a	30' 8" e	27' 10" e	24' 4" e	34' 5" a	31' 3" a	25' 10" a
1200S250-54	35' 0" e	31' 9" e	27' 3" e	38' 7" a	33' 5" a	26' 2" a	31' 9" e	28' 11" e	25' 3" e	35' 8" a	32' 5" a	28' 2" a
1200S162-68	34' 11"	31' 8"	27' 8"	39' 2" i	35' 7" i	31' 1" i	31' 8"	28' 10"	25' 2"	35' 7"	32' 4" i	28' 3" i
1200S200-68	36' 3"	33' 0"	28' 10"	40' 5" i	37' 0" i	32' 4" i	33' 0"	29' 11"	26' 2"	37' 0"	33' 8" i	29' 4" i
[illegible]	37' 8"	34' 2"	29' 10"	42' 3" i	38' 5" i	34' 4" i	34' 2"	31' 1"	27' 2"	38' 5" i	34' 11" i	30' 6" i
1200S162-97	38' 10"	35' 4"	30' 10"	43' 8"	39' 8"	34' 8"	35' 4"	32' 1"	28' 0"	39' 8"	36' 0"	31' 6"
1200S200-97	40' 6"	36' 9"	32' 1"	45' 5"	41' 3"	36' 1"	36' 9"	33' 5"	29' 2"	41' 3"	37' 6"	32' 9"
1200S250-97	42' 0"	38' 2"	33' 4"	47' 2"	42' 10"	37' 5" i	38' 2"	34' 8"	30' 3"	42' 10"	38' 11"	34' 0"

"e" Requires web stiffeners at end supports. "i" Requires web stiffeners at interior supports. "a" Requires web stiffeners at all supports.

X
-Bridging @ mid-span
-Notes 4, 5, 6 &

10.33 FT C/C SPAN = 0.34 IN = L/360 0.26 IN = L/480

10 PSF DEAD LOAD AND 50 PSF LIVE LOAD

Member	Live Load Deflection L/360						Live Load Deflection L/480					
	Single Span			Two Equal Spans			Single Span			Two Equal Spans		
	Spacing (in) o.c.			Spacing (in) o.c.			Spacing (in) o.c.			Spacing (in) o.c.		
	12	16	24	12	16	24	12	16	24	12	16	24
600S162-33	11' 3" e	9' 9" e	7' 11" e	11' 3" a	9' 3" a	6' 10" a	10' 6" e	9' 7" e	7' 11" e	11' 3" a	9' 3" a	6' 10" a
600S200-33	11' 7" e	10' 0" e	8' 2" e	11' 6" a	9' 5" a	7' 0" a	11' 0" e	10' 0" e	8' 2" e	11' 6" a	9' 5" a	7' 0" a
600S162-43	12' 7"	11' 5" e	9' 7" e	13' 7" i	11' 9" i	9' 7" i	11' 5"	10' 5"	9' 1" e	12' 10" i	11' 8" i	9' 7" i
600S200-43	13' 3"	11' 11" e	9' 9" e	13' 10" i	11' 11" i	9' 9" i	12' 0"	10' 11"	9' 6" e	13' 6" i	11' 11" i	9' 9" i
600S250-43	13' 10"	12' 3" e	10' 0" e	14' 2" i	12' 3" i	10' 0" a	12' 7"	11' 5" e	10' 0" e	14' 2" i	12' 3" i	10' 0" a
600S162-54	13' 6"	12' 3"	10' 9"	15' 2" i	13' 10" i	12' 1" i	12' 3"	11' 2"	9' 9"	13' 10"	12' 6" i	10' 11" i
600S200-54	14' 3"	12' 11"	11' 3"	16' 0" i	14' 6" i	12' 8" i	12' 11"	11' 9"	10' 3"	14' 6" i	13' 2" i	11' 6" i
600S250-54	14' 10"	13' 6"	11' 9"	16' 8" i	15' 1" i	13' 2" i	13' 6"	12' 3"	10' 8"	15' 1" i	13' 9" i	12' 0" i
600S162-68	14' 6"	13' 2"	11' 6"	16' 4"	14' 10"	12' 11" i	13' 2"	12' 0"	10' 5"	14' 10"	13' 5"	11' 9" i
600S200-68	15' 3"	13' 10"	12' 1"	17' 2"	15' 7"	13' 7" i	13' 10"	12' 7"	11' 0"	15' 7"	14' 2"	12' 4" i
600S250-68	16' 0"	14' 6"	12' 8"	18' 0"	16' 4" i	14' 3" i	14' 6"	13' 2"	11' 6"	16' 4"	14' 10"	12' 11" i
600S162-97	16' 1"	14' 7"	12' 9"	18' 1"	16' 5"	14' 4"	14' 7"	13' 3"	11' 7"	16' 5"	14' 11"	13' 0"
600S200-97	16' 11"	15' 5"	13' 5"	19' 0"	17' 3"	15' 1"	15' 5"	14' 0"	12' 3"	17' 3"	15' 8"	13' 9"
600S250-97	17' 10"	16' 2"	14' 1"	20' 0"	18' 2"	15' 10"	16' 2"	14' 8"	12' 10"	18' 2"	16' 6"	14' 5"
800S162-33	12' 10" e	11' 1" e	7' 6" e	10' 8" a	8' 7" a	6' 0" a	12' 10" e	11' 1" e	7' 6" e	10' 8" a	8' 7" a	6' 0" a
800S200-33	13' 4" e	11' 4" e	7' 6" e	10' 10" a	8' 8" a	6' 0" a	13' 4" e	11' 4" e	7' 6" e	10' 10" a	8' 8" a	6' 0" a
800S162-43	15' 11" e	13' 9" e	11' 3" e	15' 11" i	13' 9" a	10' 5" a	14' 5" e	13' 1" e	11' 3" e	15' 11" i	13' 9" a	10' 5" a
800S200-43	16' 8" e	14' 7" e	11' 10" e	16' 10" i	14' 4" a	10' 9" a	15' 1" e	13' 9" e	11' 10" e	16' 10" i	14' 4" a	10' 9" a
800S250-43	16' 11" e	14' 8" e	12' 0" e	16' 11" i	14' 5" a	10' 10" a	15' 9" e	14' 4" e	12' 0" e	16' 11" i	14' 5" a	10' 10" a
800S162-54	17' 1"	15' 6"	13' 7" e	19' 2" i	17' 5" i	15' 2" i	15' 6"	14' 1"	12' 4"	17' 5" i	15' 10" i	13' 10" i
800S200-54	17' 10"	16' 3"	14' 2" e	20' 1" i	18' 3" i	15' 7" i	16' 3"	14' 9"	12' 10"	18' 3" i	16' 7" i	14' 6" i
800S250-54	18' 7"	16' 10"	14' 9" e	20' 10" i	18' 11" i	15' 11"	16' 10"	15' 4"	13' 5"	18' 11" i	17' 3" i	15' 0" i
800S162-68	18' 4"	16' 8"	14' 6"	20' 7"	18' 8" i	16' 4" i	16' 8"	15' 1"	13' 2"	18' 8"	17' 0" i	14' 10" i
800S200-68	19' 2"	17' 5"	15' 3"	21' 7" i	19' 7" i	17' 1" i	17' 5"	15' 10"	13' 10"	19' 7"	17' 9" i	15' 6" i
800S250-68	20' 0"	18' 2"	15' 11"	22' 6" i	20' 5"	17' 10" i	18' 2"	16' 6"	14' 5"	20' 5"	18' 7" i	16' 3" i
800S162-97	20' 4"	18' 6"	16' 2"	22' 10"	20' 9"	18' 2"	18' 6"	16' 10"	14' 8"	20' 9"	18' 10"	16' 6"
800S200-97	21' 4"	19' 5"	16' 11"	24' 0"	21' 9"	19' 0"	19' 5"	17' 7"	15' 5"	21' 9"	19' 9"	17' 3"
800S250-97	22' 4"	20' 3"	17' 8"	25' 1"	22' 9"	19' 11" i	20' 3"	18' 5"	16' 1"	22' 9"	20' 8"	18' 1"
1000S162-43	17' 7" e	15' 3" e	12' 5" e	16' 6" a	13' 4" a	9' 10" a	17' 4" e	15' 3" e	12' 5" e	16' 6" a	13' 4" a	9' 10" a
1000S200-43	18' 7" e	16' 1" e	13' 2" e	17' 0" a	13' 9" a	10' 1" a	18' 1" e	16' 1" e	13' 2" e	17' 0" a	13' 9" a	10' 1" a
1000S250-43	18' 10" e	16' 3" e	13' 3" e	17' 1" a	13' 10" a	10' 1" a	18' 10" e	16' 3" e	13' 3" e	17' 1" a	13' 10" a	10' 1" a
1000S162-54	20' 6"	18' 8" e	16' 3" e	23' 1" i	20' 8" i	16' 0" i	18' 8"	16' 11"	14' 9" e	20' 11" i	19' 0" i	16' 0" i
1000S200-54	21' 5"	19' 5" e	17' 0" e	24' 0" i	21' 2" i	16' 3" i	19' 5"	17' 8"	15' 5" e	21' 10" i	19' 10" i	16' 3" i
1000S250-54	22' 3"	20' 2" e	17' 8" e	25' 0" i	21' 7" i	16' 6" a	20' 2"	18' 4"	16' 0" e	22' 8" i	20' 7" i	16' 6" a
1000S162-68	22' 1"	20' 0"	17' 6"	24' 9" i	22' 6" i	19' 8" i	20' 0"	18' 2"	15' 11"	22' 6" i	20' 5" i	17' 10" i
1000S200-68	23' 0"	20' 11"	18' 3"	25' 10" i	23' 6" i	20' 6" i	20' 11"	19' 0"	16' 7"	23' 6" i	21' 4" i	18' 7" i
1000S250-68	23' 11"	21' 9"	19' 0"	26' 10" i	24' 5" i	21' 0" i	21' 9"	19' 9"	17' 3"	24' 5" i	22' 2" i	19' 4" i
1000S162-97	24' 8"	22' 3"	19' 6"	27' 7"	25' 0"	21' 10" i	22' 3"	20' 3"	17' 8"	25' 0"	22' 9"	19' 10"
1000S200-97	25' 7"	23' 3"	20' 4"	28' 9"	26' 2"	22' 10" i	23' 3"	21' 2"	18' 6"	26' 2"	23' 9"	20' 9"
1000S250-97	26' 8"	24' 3"	21' 2"	30' 0"	27' 3"	23' 9" i	24' 3"	22' 0"	19' 3"	27' 3"	24' 9"	21' 7" i
1200S162-54	23' 11" e	21' 9" e	18' 4" e	25' 5" a	20' 9" a	15' 5" a	21' 9" e	19' 9" e	17' 3" e	24' 5" a	20' 9" a	15' 5" a
1200S200-54	24' 10" e	22' 7" e	18' 10" e	25' 10" a	21' 1" a	15' 7" a	22' 7" e	20' 6" e	17' 11" e	25' 4" a	21' 1" a	15' 7" a
1200S250-54	25' 9" e	23' 5" e	19' 3" e	26' 2" a	21' 4" a	15' 9" a	23' 5" e	21' 3" e	18' 7" e	26' 2" a	21' 4" a	15' 9" a
1200S162-68	25' 6"	23' 4"	20' 5" e	28' 10" i	26' 3" i	22' 1" i	23' 4"	21' 3"	18' 6" e	26' 3" i	23' 10" i	20' 10" i
1200S200-68	26' 9"	24' 3"	21' 2" e	30' 0" i	27' 3" i	23' 3" i	24' 3"	22' 1"	19' 3" e	27' 3" i	24' 9" i	21' 8" i
1200S250-68	27' 9"	25' 2"	22' 0" e	31' 2" i	28' 0" i	22' 10" i	25' 2"	22' 11"	20' 0" e	28' 3" i	25' 8" i	22' 5" i
1200S162-97	28' 8"	26' 0"	22' 9"	32' 2"	29' 2"	25' 6" i	26' 0"	23' 8"	20' 8"	29' 2"	26' 6"	23' 2" i
1200S200-97	29' 10"	27' 1"	23' 8"	33' 6"	30' 5" i	26' 7" i	27' 1"	24' 7"	21' 6"	30' 5"	27' 7"	24' 1" i
1200S250-97	30' 11"	28' 1"	24' 7"	34' 9"	31' 7" i	27' 7" i	28' 1"	25' 6"	22' 4"	31' 7"	28' 8"	25' 0" i

"e" Requires web stiffeners at end supports.
"i" Requires web stiffeners at interior supports.
"a" Requires web stiffeners at all supports.

See page 43 for Allowable Floor Span Table Notes.

40 PSF DEAD LOAD AND 125 PSF LIVE LOAD

Member	Live Load Deflection L/360						Live Load Deflection L/480					
	Single Span			Two Equal Spans			Single Span			Two Equal Spans		
	Spacing (in) o.c.			Spacing (in) o.c.			Spacing (in) o.c.			Spacing (in) o.c.		
	12	16	24	12	16	24	12	16	24	12	16	24
600S162-33	6' 9" e	5' 6" e	3' 8" e	5' 5" a	4' 4" a	2' 11" a	6' 9" e	5' 6" e	3' 8" e	5' 5" a	4' 4" a	2' 11" a
600S200-33	7' 0" e	5' 6" e	3' 8" e	5' 6" a	4' 4" a	2' 11" a	7' 0" e	5' 6" e	3' 8" e	5' 6" a	4' 4" a	2' 11" a
600S162-43	8' 2" e	7' 1" e	5' 9" e	8' 2" a	7' 0" e	5' 3" a	8' 2" e	7' 1" e	5' 9" e	8' 2" e	7' 0" a	5' 3" a
600S200-43	8' 4" e	7' 2" e	5' 10" e	8' 4" a	7' 1" a	5' 3" a	8' 4" e	7' 2" e	5' 10" e	8' 4" a	7' 1" a	5' 3" a
600S250-43	8' 6" e	7' 4" e	6' 0" e	8' 6" a	7' 2" a	5' 4" a	8' 6" e	7' 4" e	6' 0" e	8' 6" a	7' 2" a	5' 4" a
600S162-54	10' 0"	9' 1" e	7' 5" e	10' 7"	9' 2"	7' 5" a	9' 1"	8' 3" e	7' 2" e	10' 2"	9' 2"	7' 5" a
600S200-54	10' 6"	9' 6" e	7' 9" e	11' 0"	9' 6"	7' 9" a	9' 6"	8' 8" e	7' 6" e	10' 8"	9' 6"	7' 9" a
600S250-54	10' 11" e	9' 10" e	8' 0" e	11' 4"	9' 10"	8' 0" a	9' 11"	9' 0" e	7' 10" e	11' 2"	9' 10"	8' 0" a
600S162-68	10' 8"	9' 8"	8' 5" e	12' 0"	10' 11"	8' 11"	9' 8"	8' 10"	7' 8"	10' 11"	9' 11"	8' 8"
600S200-68	11' 3"	10' 2"	8' 11" e	12' 7"	11' 6"	9' 4"	10' 2"	9' 3"	8' 1"	11' 6"	10' 5"	9' 1"
600S250-68	11' 9"	10' 8"	9' 0" e	12' 8"	11' 0"	9' 0"	10' 6"	9' 9"	8' 6" e	12' 0"	10' 11"	9' 0"
600S162-97	11' 10"	10' 9"	9' 5"	13' 4"	12' 1"	10' 7"	10' 9"	9' 9"	8' 6"	12' 1"	11' 0"	9' 7"
600S200-97	12' 6"	11' 4"	9' 11"	14' 0"	12' 9"	11' 1"	11' 4"	10' 4"	9' 0"	12' 9"	11' 7"	10' 1"
600S250-97	13' 1"	11' 11"	10' 5"	14' 9"	13' 4"	11' 8"	11' 11"	10' 10"	9' 5"	13' 4"	12' 2"	10' 7"
800S162-33	5' 6" e	4' 1" e	2' 9" e	4' 4" a	3' 3" a	2' 2" a	5' 6" e	4' 1" e	2' 9" e	4' 4" a	3' 3" a	2' 2" a
800S200-33	5' 8" e	4' 1" a	2' 9" e	4' 4" a	3' 3" a	2' 2" a	5' 6" e	4' 1" e	2' 9" e	4' 4" a	3' 3" a	2' 2" a
800S162-43	9' 7" e	8' 3" e	6' 1" e	8' 3" a	6' 8" a	4' 10" a	9' 7" e	8' 3" e	6' 1" e	8' 3" a	6' 8" a	4' 10" a
800S200-43	10' 1" e	8' 9" e	6' 1" e	8' 6" a	6' 10" a	4' 10" a	10' 1" e	8' 9" e	6' 1" e	8' 6" a	6' 10" a	4' 10" a
800S250-43	10' 2" e	8' 10" e	6' 1" e	8' 7" a	6' 10" a	4' 10" a	10' 2" e	8' 10" e	6' 1" e	8' 7" a	6' 10" a	4' 10" a
800S162-54	12' 7" e	11' 3" e	9' 2" e	13' 0"	10' 10" a	8' 1" a	11' 5" e	10' 4" e	9' 1" e	12' 10"	10' 10" a	8' 1" a
800S200-54	13' 2" e	11' 6" e	9' 5" e	13' 4" a	11' 0" a	8' 2" a	11' 11" e	10' 10" e	9' 5" e	13' 4" a	11' 0" a	8' 2" a
800S250-54	13' 6" e	11' 9" e	9' 7" e	13' 6" e	11' 1" a	8' 3" e	12' 5" e	11' 3" e	9' 7" e	13' 6" a	11' 1" a	8' 3" a
800S162-68	13' 6"	12' 3" e	10' 8" e	15' 2"	13' 5"	10' 11" a	12' 3"	11' 2"	9' 9" e	13' 9"	12' 6"	10' 11" a
800S200-68	14' 2"	12' 10" e	11' 2" e	15' 10"	14' 0"	11' 5" a	12' 10"	11' 8" e	10' 2" e	14' 5"	13' 1"	11' 5" a
800S250-68	14' 9"	13' 5" e	11' 0" e	15' 6"	13' 5"	11' 0" a	13' 5"	12' 2" e	10' 8" e	15' 1"	13' 5"	11' 0" a
800S162-97	15' 0"	13' 7"	11' 11"	16' 10"	15' 3"	13' 2"	13' 7"	12' 4"	10' 10"	15' 3"	13' 11"	12' 2"
800S200-97	15' 9"	14' 3"	12' 6"	17' 8"	16' 0"	13' 11"	14' 3"	13' 0"	11' 4"	16' 0"	14' 7"	12' 9"
800S250-97	16' 5"	14' 11"	13' 0"	18' 5"	16' 9"	14' 4"	14' 11"	13' 7"	11' 10"	16' 9"	15' 3"	13' 4"
1000S162-43	9' 8" e	7' 3" e	4' 10" e	7' 8" a	5' 9" a	3' 10" a	9' 8" e	7' 3" e	4' 10" e	7' 8" a	5' 9" a	3' 10" a
1000S200-43	9' 8" e	7' 3" e	4' 10" e	7' 9" a	5' 9" a	3' 10" a	9' 8" e	7' 3" e	4' 10" e	7' 9" a	5' 9" a	3' 10" a
1000S250-43	9' 8" e	7' 3" e	4' 10" e	7' 9" a	5' 9" a	3' 10" a	9' 8" e	7' 3" e	4' 10" e	7' 9" a	5' 9" a	3' 10" a
1000S162-54	14' 4" e	12' 5" e	9' 7" e	12' 9" a	10' 3" a	7' 6" a	13' 9" e	12' 5" e	9' 7" e	12' 9" a	10' 3" a	7' 6" a
1000S200-54	14' 9" e	12' 9" e	9' 7" e	12' 11" a	10' 5" a	7' 7" a	14' 4" e	12' 9" e	9' 7" e	12' 11" a	10' 5" a	7' 7" a
1000S250-54	15' 0" e	13' 0" e	9' 7" e	13' 1" a	10' 6" a	7' 7" a	14' 11" e	13' 0" e	9' 7" e	13' 1" a	10' 6" a	7' 7" a
1000S162-68	16' 3" e	14' 9" e	12' 2" e	17' 3"	14' 11" a	11' 8" a	14' 9" e	13' 5" e	11' 8" e	16' 7"	14' 11" a	11' 8" a
1000S200-68	16' 11" e	15' 5" e	12' 10" e	18' 2"	15' 9" a	12' 0" a	15' 5" e	14' 0" e	12' 2" e	17' 3"	15' 8" a	12' 0" a
1000S250-68	17' 7" e	15' 6" e	12' 8" e	17' 11"	15' 6" a	11' 11" a	16' 0" e	14' 6" e	12' 8" e	17' 11"	15' 6" a	11' 11" a
1000S162-97	18' 1"	16' 5"	14' 4"	20' 3"	18' 5"	15' 7"	16' 5"	14' 11"	13' 0"	18' 5"	16' 9"	14' 7"
1000S200-97	18' 10"	17' 2"	15' 0" e	21' 2"	19' 3"	16' 5"	17' 2"	15' 7"	13' 7"	19' 3"	17' 6"	15' 3"
1000S250-97	19' 8"	17' 10"	15' 7" e	22' 1"	20' 1"	16' 10"	17' 10"	16' 3"	14' 2"	20' 1"	18' 2"	15' 11"
1200S162-54	15' 7" e	12' 0" e	8' 0" e	12' 0" a	9' 7" a	6' 4" a	15' 7" e	12' 0" e	8' 0" e	12' 0" a	9' 7" a	6' 4" a
1200S200-54	16' 0" e	12' 0" e	8' 0" e	12' 2" a	9' 7" a	6' 4" a	16' 0" e	12' 0" e	8' 0" e	12' 2" a	9' 7" a	6' 4" a
1200S250-54	16' 0" e	12' 0" e	8' 0" e	12' 4" a	9' 7" a	6' 4" a	16' 0" e	12' 0" e	8' 0" e	12' 4" a	9' 7" a	6' 4" a
1200S162-68	18' 10" e	16' 4" e	13' 4" e	18' 6" a	15' 2" a	11' 3" a	17' 2" e	15' 7" e	13' 4" e	18' 6" a	15' 2" a	11' 3" a
1200S200-68	19' 8" a	17' 2" e	14' 0" e	19' 1" a	15' 7" a	11' 6" a	17' 11" e	16' 3" e	14' 0" e	19' 1" a	15' 7" a	11' 6" a
1200S250-68	19' 6" a	16' 10" e	13' 9" e	18' 11" a	15' 5" a	11' 5" a	18' 7" e	16' 10" e	13' 9" e	18' 11" a	15' 5" a	11' 5" a
1200S162-97	21' 1"	19' 2"	16' 9" e	23' 8" i	21' 6" i	21' 6" i	17' 11" i	19' 2"	17' 5"	15' 2" e	21' 6" i	17' 1" i
1200S200-97	21' 11"	19' 11"	17' 5" e	24' 8" i	22' 5" i	22' 5" i	18' 9" a	19' 11"	18' 1"	15' 10" e	22' 5" i	17' 9" i
1200S250-97	22' 9"	20' 8"	18' 1" e	25' 7" i	23' 3" i	23' 3" i	19' 2" a	20' 8"	18' 10"	16' 5" e	23' 3" i	18' 5" i

"e" Requires web stiffeners at end supports.
"i" Requires web stiffeners at interior supports.
"a" Requires web stiffeners at all supports.

See page 43 for Allowable Floor Span Table Notes.

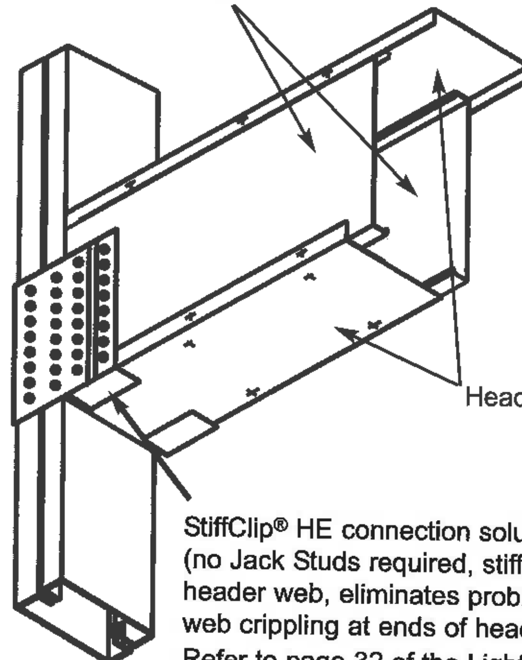
HEADER LOAD TABLE NOTES

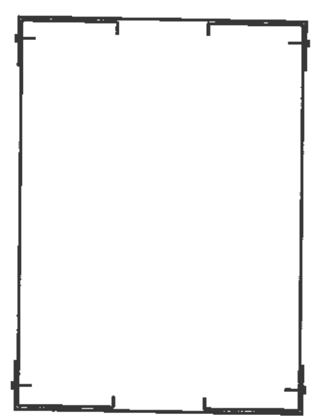
1. Deflection limit is L/360.
2. Allowable loads have not been modified for wind or earthquake loading.
3. Headers are made from two "boxed" or back-to-back members.
4. Allowable moment, shear and web crippling are based on twice the capacity of a single member. The moment of inertia is based on twice the value of the single member.
5. Bearing length for web crippling = 1" minimum.
6. Values are for unpunched members.
7. Members are assumed to be adequately braced to resist bending.
8. Allowable loads are for simply supported headers with uniform bending loads only.

HEADER ALLOWABLE UNIFORM LOADS (LBS/FT)

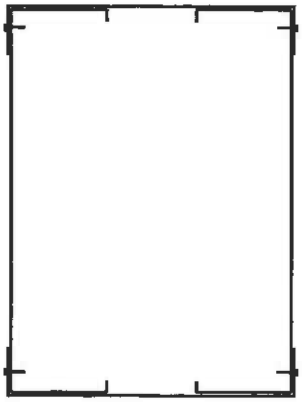
Section	Yield Strength (ksi)	SPAN 3 (ft)	4 (ft)	5 (ft)	6 (ft)	8 (ft)	10 (ft)	12 (ft)
550S162-33	33	893 e	670 e	536 e	374 e	210 e	127 e	73 e
550S162-43	33	1982 e	1232 e	789 e	547 e	308 e	164 e	95
550S162-54	33	2779 e	1563 e	1000 e	694 e	390 e	203	117
550S162-54	50	3643 e	2049 e	1311 e	910 e	396 e	203	117
550S162-68	33	3514 e	1976 e	1265 e	878 e	488 e	250	144
550S162-68	50	5176 e	2911 e	1863 e	1157 e	488	250	144
600S137-33	33	816 e	612 e	489 e	373 e	209 e	134 e	80 e
600S162-33	33	816 e	612 e	488 e	406 e	237 e	152 e	90 e
600S200-33	33	816 e	612 e	489 e	406 e	264 e	162 e	104 e
600S137-43	33	1810 e	1233 e	789 e	548 e	308 e	178 e	103
600S162-43	33	1810 e	1357 e	889 e	617 e	347 e	202 e	117 e
600S200-43	33	1810 e	1357 e	919 e	638 e	359 e	229 e	135 e
600S250-43	33	1810 e	1357 e	967 e	671 e	377 e	241 e	155 e
600S137-54	33	2812 e	1581 e	1012 e	703 e	395 e	220 e	127
600S162-54	33	3135 e	1763 e	1126 e	783 e	440 e	250 e	144
600S200-54	33	3566 e	2006 e	1283 e	891 e	501 e	290 e	167
600S250-54	33	3392 e	1908 e	1221 e	848 e	477 e	305 e	193 e
600S137-54	50	3610 e	2269 e	1452 e	1008 e	429 e	220	127
600S162-54	50	3610 e	2313 e	1480 e	1028 e	488 e	250	144
600S200-54	50	3610 e	2500 e	1600 e	1111 e	566 e	290 e	167
600S250-54	50	3610 e	2666 e	1706 e	1185 e	641 e	328 e	190
600S137-68	33	3562 e	2004 e	1282 e	890 e	501 e	270	156
600S162-68	33	3968 e	2232 e	1428 e	992 e	558 e	308	178
600S200-68	33	4506 e	2534 e	1622 e	1126 e	633 e	358 e	207
600S250-68	33	4456 e	2506 e	1604 e	1114 e	626 e	401 e	239
600S137-68	50	5274 e	2966 e	1898 e	1252 e	528 e	270	156
600S162-68	50	5846 e	3288 e	2104 e	1426 e	601 e	308	178
600S200-68	50	6475 e	3642 e	2331 e	1618 e	700 e	358	207
600S250-68	50	5954 e	3349 e	2143 e	1488 e	807 e	413 e	239
600S137-97	33	5108 e	2873 e	1839 e	1277 e	715	366	211
600S162-97	33	5685 e	3197 e	2046 e	1421 e	799	419	242
600S200-97	33	6443 e	3624 e	2319 e	1610 e	906 e	490	283
[illegible]50-97	33	7229 e	4066 e	2602 e	1807 e	1016 e	567	328
600S137-97	50	7526 e	4233 e	2709 e	1694 e	715	366	211
600S162-97	50	8403 e	4727 e	3025 e	1941 e	819	419	242
600S200-97	50	9560 e	5377 e	3441 e	2270 e	958	490	283
600S250-97	50	10277 e	5781 e	3700 e	2569 e	1109 e	567	328

"e" Web stiffeners required at supports.

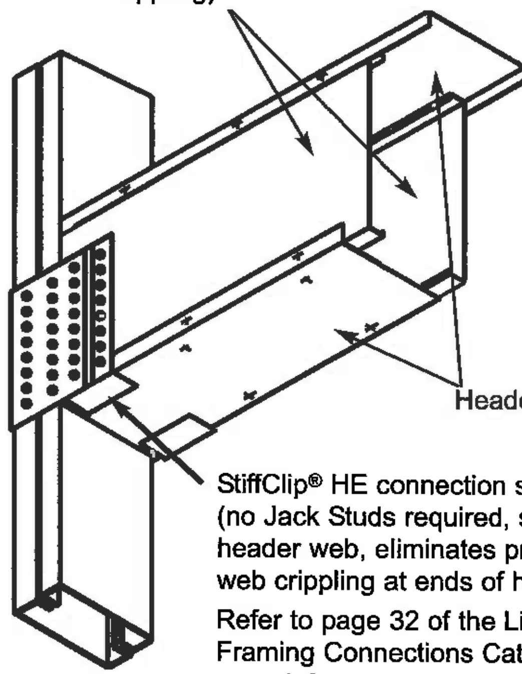




Box Header consists of two stud sections oriented horizontally and capped at top and bottom with tracks connected through track flanges with required fasteners at designed spacing.



Box Header consists of two stud sections oriented horizontally and capped at top and bottom with tracks connected through track flanges with required fasteners at designed spacing.



HEADER ALLOWABLE UNIFORM LOADS (LBS/FT)

Section	Yield Strength (ksi)	SPAN 3 (ft)	4 (ft)	5 (ft)	6 (ft)	8 (ft)	10 (ft)	12 (ft)
800S137-33	33	606 e	454 e	363 e	303 e	227 e	174 e	121 e
800S162-33	33	606 e	454 e	363 e	303 e	227 e	181 e	138 e
800S200-33	33	606 e	454 e	363 e	303 e	227 e	181 e	148 e
800S137-43	33	1344 e	1008 e	806 e	672 e	425 e	272 e	189 e
800S162-43	33	1344 e	1008 e	806 e	672 e	478 e	305 e	211 e
800S200-43	33	1344 e	1008 e	806 e	672 e	504 e	340 e	236 e
800S250-43	33	1344 e	1008 e	806 e	672 e	504 e	346 e	240 e
800S137-54	33	2674 e	2005 e	1541 e	1070 e	602 e	385 e	258 e
800S162-54	33	2674 e	2005 e	1604 e	1178 e	663 e	424 e	290 e
800S200-54	33	2674 e	2005 e	1604 e	1324 e	744 e	476 e	331 e
800S250-54	33	2674 e	2005 e	1604 e	1252 e	704 e	451 e	313 e
800S137-54	50	2674 e	2005 e	1604 e	1337 e	778 e	446 e	258 e
800S162-54	50	2674 e	2005 e	1604 e	1337 e	871 e	501 e	290 e
800S200-54	50	2674 e	2005 e	1604 e	1337 e	919 e	574 e	332 e
800S250-54	50	2674 e	2005 e	1604 e	1337 e	951 e	608 e	373 e
800S137-68	33	5397 e	3061 e	1959 e	1360 e	765 e	489 e	318 e
800S162-68	33	5397 e	3367 e	2155 e	1496 e	841 e	538 e	358 e
800S200-68	33	5397 e	3774 e	2415 e	1677 e	943 e	603 e	411 e
800S250-68	33	5397 e	3688 e	2360 e	1639 e	922 e	590 e	409 e
800S137-68	50	5397 e	4048 e	2901 e	2014 e	1076 e	550 e	318
800S162-68	50	5397 e	4048 e	3177 e	2206 e	1215 e	619 e	358 e
800S200-68	50	5397 e	4048 e	3298 e	2415 e	1358 e	711 e	411 e
800S250-68	50	5397 e	4048 e	3197 e	2220 e	1249 e	799 e	408 e
800S137-97	33	7865 e	4424 e	2831 e	1966 e	1106 e	707 e	434
800S162-97	33	8632 e	4856 e	3107 e	2158 e	1214 e	777 e	491
800S200-97	33	9647 e	5426 e	3473 e	2411 e	1356 e	868 e	566 e
800S250-97	33	10675 e	6005 e	3843 e	2668 e	1501 e	960 e	646 e
800S137-97	50	11568 e	6510 e	4171 e	2897 e	1467 e	751	434
800S162-97	50	12761 e	7178 e	4594 e	3190 e	1659 e	849 e	491
800S200-97	50	14514 e	8052 e	5153 e	3578 e	1912 e	979 e	566
800S250-97	50	14632 e	8557 e	5477 e	3803 e	2195 e	1117 e	646
1000S162-43	33	1069 e	801 e	641 e	534 e	400 e	320 e	258 e
1000S200-43	33	1069 e	801 e	641 e	534 e	400 e	320 e	287 e
1000S250-43	33	1069 e	801 e	641 e	534 e	400 e	320 e	287 e
1000S162-54	33	2124 e	1593 e	1274 e	1062 e	796 e	524 e	364 e
1000S200-54	33	2124 e	1593 e	1274 e	1062 e	796 e	594 e	412 e
1000S250-54	33	2124 e	1593 e	1274 e	1062 e	796 e	598 e	416 e
1000S162-54	50	2124 e	1593 e	1274 e	1062 e	796 e	637 e	474 e
1000S200-54	50	2124 e	1593 e	1274 e	1062 e	796 e	637 e	500 e
1000S250-54	50	2124 e	1593 e	1274 e	1062 e	796 e	637 e	520 e
[illegible]	33	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

"e" Web stiffeners required at supports.

HEADER ALLOWABLE UNIFORM LOADS (LBS/FT)

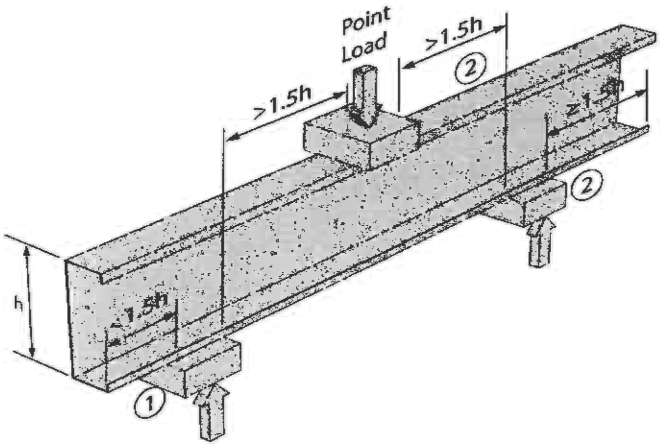
Section	Yield Strength (ksi)	SPAN 3 (ft)	4 (ft)	5 (ft)	6 (ft)	8 (ft)	10 (ft)	12 (ft)
1000S200-68	33	4278 e	3206 e	2567 e	2139 e	1297 e	830 e	576 e
1000S250-68	33	4278 e	3206 e	2567 e	2139 e	1257 e	804 e	558 e
1000S162-68	50	4278 e	3206 e	2567 e	2139 e	1537 e	984 e	623 e
1000S200-68	50	4278 e	3208 e	2567 e	2139 e	1604 e	1095 e	707 e
1000S250-68	50	4278 e	3208 e	2567 e	2139 e	1604 e	1068 e	740 e
1000S162-97	33	12049 e	6765 e	4342 e	3016 e	1696 e	1085 e	754 e
1000S200-97	33	12049 e	7493 e	4795 e	3330 e	1873 e	1198 e	832 e
1000S250-97	33	12049 e	8199 e	5247 e	3644 e	2049 e	1311 e	911 e
1000S162-97	50	12614 e	9460 e	6420 e	4458 e	2507 e	1483 e	858 e
1000S200-97	50	12614 e	9460 e	7115 e	4941 e	2779 e	1690 e	978 e
1000S250-97	50	12614 e	9460 e	7500 e	5208 e	2929 e	1875 e	1104 e
1200S162-54	33	1761 e	1321 e	1056 e	880 e	660 e	528 e	427 e
1200S200-54	33	1761 e	1321 e	1056 e	880 e	660 e	528 e	440 e
1200S250-54	33	1761 e	1321 e	1056 e	880 e	660 e	528 e	440 e
1200S162-54	50	1761 e	1321 e	1056 e	880 e	660 e	528 e	440 e
1200S200-54	50	1761 e	1321 e	1056 e	880 e	660 e	528 e	440 e
1200S250-54	50	1761 e	1321 e	1056 e	880 e	660 e	528 e	440 e
1200S162-68	33	3543 e	2657 e	2126 e	1771 e	1328 e	857 e	595 e
1200S200-68	33	3543 e	2657 e	2126 e	1771 e	1328 e	1063 e	753 e
1200S250-68	33	3543 e	2657 e	2126 e	1771 e	1328 e	1044 e	726 e
1200S162-68	50	3543 e	2657 e	2126 e	1771 e	1328 e	1063 e	618 e
1200S200-68	50	3543 e	2657 e	2126 e	1771 e	1328 e	1063 e	665 e
1200S250-68	50	3543 e	2657 e	2126 e	1771 e	1328 e	1063 e	872 e
1200S162-97	33	10418 e	7814 e	5751 e	3994 e	2246 e	1438 e	998 e
1200S200-97	33	10418 e	7814 e	6251 e	4365 e	2455 e	1571 e	1091 e
1200S250-97	33	10418 e	7814 e	6251 e	4733 e	2662 e	1704 e	1183 e
1200S162-97	50	10418 e	7814 e	6251 e	5209 e	3321 e	2125 e	1364 e
1200S200-97	50	10418 e	7814 e	[illegible]	[illegible]	3043 e	2351 e	1538 e
1200S250-97	50	10418 e	7814 e	6251 e	5208 e	3815 e	2442 e	1695 e

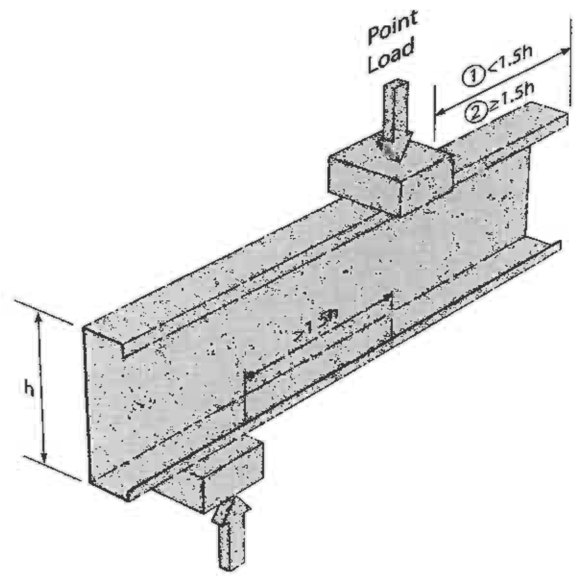
"e" Web stiffeners required at supports.

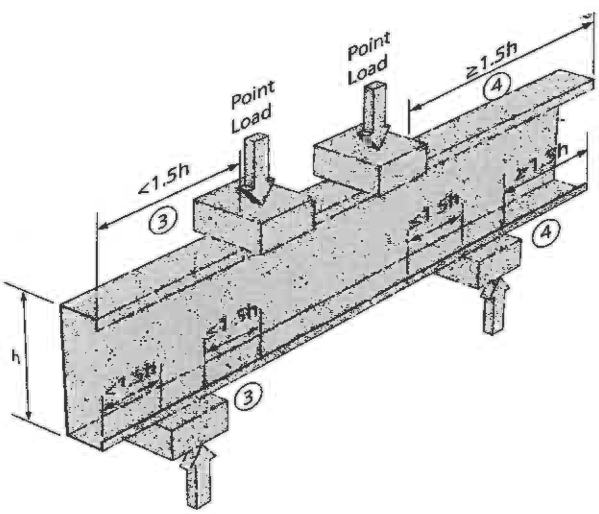
WEB-CRIPPLING LOAD TABLE NOTES

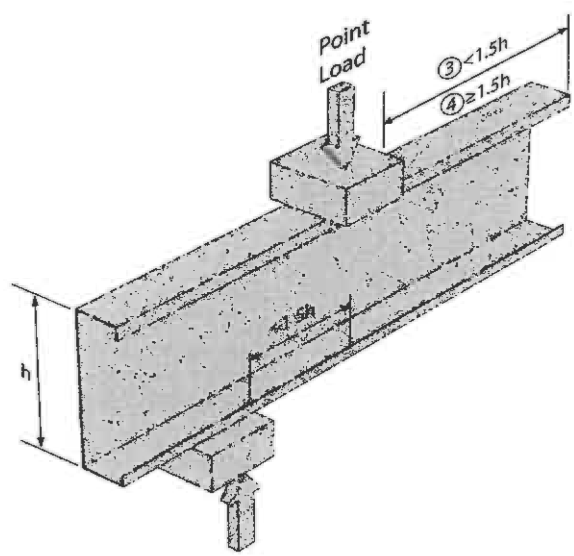
1. Only members with stiffened flanges are considered.
2. For multiple members, multiply the listed capacity of a single member by the number of members in the assembly.
3. For back-to-back members table, listed web crippling values are for the total system of two members.
4. For back-to-back members, the distance between the web connectors and the flange shall be kept to a minimum.
5. Web punchouts are not considered for web crippling tables. A web crippling reduction factor is to be applied for web punchouts, per *ICC-ES Acceptance Criteria AC46, Appendix B.*

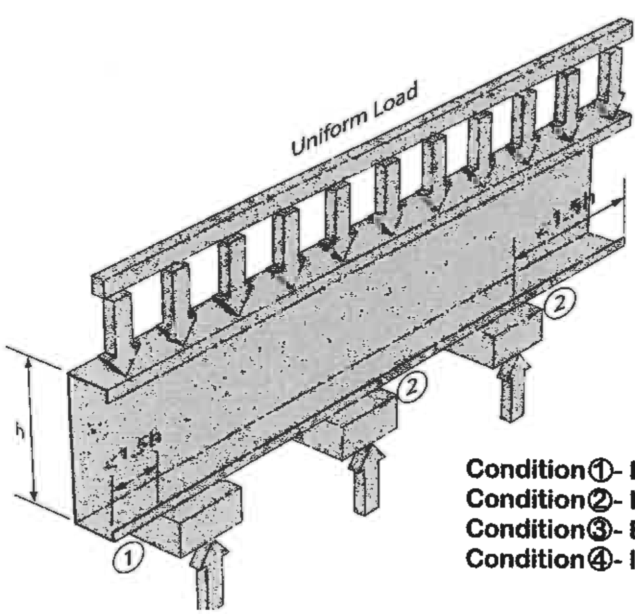
WEB CRIPPLING CONDITIONS











Condition①- End Reaction - One Flange (Point Load > 1.5h from other loads)
Condition②- Interior Reaction - One Flange (Point Load > 1.5h from other loads)
Condition③- End Reaction - Two Flanges (Point Loads ≤ 1.5h from each other)
Condition④- Interior Reaction - Two Flanges (Point Loads ≤ 1.5h from each other)

ALLOWABLE WEB CRIPPLING LOADS (LBS) - SINGLE MEMBER

Web Size	Design Thickness (in.)	Thickness (mils)	Yield Strength (ksi)	Condition 1 Bearing Length (in.)				Condition 2 Bearing Length (in.)				Condition 3 Bearing Length (in.)				Condition 4 Bearing Length (in.)			
				1	2.5	4	6	1	2.5	4	6	1	2.5	4	6	1	2.5	4	6
162	0 0188	18	33	42	78	85	114	100	204	225	310	29	55	60	80	97	113	116	128
162	0 0283	27	33	128	212	229	296	241	408	446	596	92	152	164	212	266	295	301	324
162	0 0312	30	33	163	262	282	361	296	479	522	692	117	189	203	260	334	367	374	400
162	0 0346	33	33	209	326	350	444	367	568	616	810	151	235	252	320	423	461	469	500
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	80	[illegible]	[illegible]	[illegible]
250	0 0283	27	33	[illegible]	199	214	277	230	[illegible]	[illegible]	369	[illegible]	140	151	[illegible]	238	264	[illegible]	[illegible]
250	0 0312	30	[illegible]	[illegible]	249	266	341	284	[illegible]	[illegible]	584	100	175	188	241	302	332	[illegible]	363
250	0 0346	33	33	[illegible]	310	332	421	353	547	594	790	[illegible]	[illegible]	[illegible]	[illegible]	387	423	[illegible]	[illegible]
250	0 0451	43	33	[illegible]	636	[illegible]	708	[illegible]	[illegible]	[illegible]	1178	[illegible]	354	[illegible]	[illegible]	718	765	778	[illegible]
250	[illegible]	54	33	[illegible]	[illegible]	840	1013	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	606	732	[illegible]	1248	[illegible]	[illegible]
[illegible]	[illegible]	54	[illegible]	[illegible]	1001	1056	1274	1291	[illegible]	[illegible]	2201	[illegible]	723	762	921	[illegible]	1604	[illegible]	1752
250	0 0713	68	33	[illegible]	[illegible]	[illegible]	1464	[illegible]	1847	1915	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	2017	2070
[illegible]	0 0713	[illegible]	[illegible]	1140	[illegible]	[illegible]	1841	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1041	[illegible]	[illegible]	[illegible]	[illegible]	2701	[illegible]
350	0 0188	18	33	33	61	67	90	85	173	191	263	21	39	43	58	61	70	72	80
350	0 0283	27	33	111	183	198	256	218	368	402	538	76	125	135	175	205	228	232	250
350	0 0312	30	33	144	231	248	318	270	437	476	631	99	159	171	219	266	293	298	319
350	0.0346	33	33	187	291	312	396	338	523	568	746	130	202	217	275	347	378	384	410
350	0 0451	43	33	352	511	543	671	594	824	887	1138	249	361	384	474	663	710	719	756
350	0 0566	54	33	559	768	810	978	936	1191	1272	1596	399	549	579	698	1104	1166	1179	1228
350	0 0566	54	50	702	966	1019	1230	1258	1601	1709	2144	502	690	727	878	1483	1567	1583	1650
350	0.0713	68	33	881	1152	1207	1424	1479	1810	1876	2257	634	829	868	1025	1822	1904	1920	1985
350	0 0713	68	50	1108	1449	1517	1790	1987	2432	2521	3033	798	1043	1092	1288	2448	2558	2580	2667
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	54	[illegible]	[illegible]	[illegible]	21	[illegible]	[illegible]	[illegible]	[illegible]	68	[illegible]	[illegible]
362	0 0283	27	33	[illegible]	182	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	76	[illegible]	133	172	201	223	226	[illegible]
362	0 0312	[illegible]	33	142	229	245	315	[illegible]	434	[illegible]	627	[illegible]	157	169	215	[illegible]	288	293	[illegible]
362	0 0346	33	33	185	[illegible]	310	393	335	520	564	742	128	200	215	272	342	373	379	404
362	0 0451	43	33	350	[illegible]	540	[illegible]	[illegible]	[illegible]	[illegible]	1133	247	359	[illegible]	471	656	702	711	748
362	0 0566	54	33	[illegible]	[illegible]	806	973	933	[illegible]	[illegible]	1591	396	546	576	694	1096	1157	1169	[illegible]
362	0 0566	54	50	[illegible]	962	1014	1224	[illegible]	[illegible]	[illegible]	2137	499	686	723	[illegible]	1472	1554	1571	[illegible]
362	0 0713	68	33	[illegible]	[illegible]	[illegible]	[illegible]	1476	1805	1871	2252	631	828	[illegible]	1020	1811	1893	1909	[illegible]
362	0 0713	68	50	[illegible]	[illegible]	[illegible]	1784	1983	[illegible]	[illegible]	3026	[illegible]	1038	1087	[illegible]	2434	2543	2564	[illegible]
400	0 0283	27	33	106	176	190	245	211	358	390	522	72	118	128	165	189	210	214	231
400	0 0312	30	33	138	222	239	306	263	426	464	615	94	151	163	208	248	273	278	297
400	0 0346	33	33	181	282	302	383	330	511	555	729	124	194	208	263	326	356	362	386
400	0 0451	43	33	344	499	531	655	584	810	872	1119	241	350	372	460	636	680	689	725
400	0 0566	54	33	548	754	795	960	924	1176	1256	1575	389	536	565	682	1070	1130	1142	1190
400	0 0566	54	50	690	948	1000	1207	1241	1580	1687	2116	490	673	710	857	1437	1518	1534	1599
400	0 0713	68	33	869	1136	1190	1404	1464	1791	1857	2234	623	814	853	1006	1779	1859	1875	1939
400	0 0713	68	50	1093	1429	1496	1765	1967	2407	2495	3001	783	1024	1072	1265	2390	2497	2519	2604
400	0 1017	97	33	1761	2155	2234	2550	2971	3450	3545	3928	1275	1560	1617	1845	3809	3929	3953	4049
400	0 1017	97	50	2215	2710	2810	3206	3992	4634	4763	5277	1603	1962	2034	2321	5117	5278	5310	5440
[illegible]	0 0283	27	[illegible]	93	[illegible]	165	[illegible]	192	[illegible]	[illegible]	475	50	97	105	135	141	156	158	[illegible]
[illegible]	0 0312	30	33	123	[illegible]	212	271	242	392	427	566	79	128	137	176	194	213	217	232
550	0 0346	33	33	162	254	272	345	307	475	516	678	107	167	179	227	265	288	294	314
550	0 0451	43	33	319	463	492	[illegible]	554	759	827	1061	218	316	336	415	554	592	600	631
550	0 0566	54	33	518	712	751	907	887	1129	1205	1512	361	496	523	632	987	1021	1032	1075
550	0 0566	54	50	651	896	945	1140	1191	1516	1619	2031	454	624	658	795	1299	1372	1385	1445
550	0 0713	68	33	832	1085	1139	1343	1419	1736	1798	2165	588	786	805	950	1650	1724	1738	1796
550	0 0713	68	50	1046	1368	1432	1689	1906	2332	2417	2908	739	987	1012	1194	2217	2316	2336	2415
550	0 1017	97	33	1710	2093	2169	2476	2908	3376	3470	3844	1227	1502	1557	1776	3626	3740	3763	3854
[illegible]	0 1017	[illegible]	50	[illegible]	[illegible]	2728	3113	3907	4538	[illegible]	5165	1543	[illegible]	1958	2234	4871	5024	5055	5172
600	0 0312	30	33	117	188	203	260	235	381	415	550	74	120	129	165	176	193	197	211
600	0 0346	33	33	156	244	262	332	299	463	503	661	102	159	170	216	245	267	272	289
600	0 0451	43	33	310	451	479	592	544	755	812	1042	210	305	324	400	526	563	571	600
600	0.0566	54	33	508	698	736	869	874	1113	1189	1491	351	483	510	615	933	985	995	1037
600	0 0566	54	50	639	878	926	1118	1175	1495	1597	2003	442	608	641	774	1253	1323	1337	1394
600	0 0713	68	33	819	1071	1122	1323	1403	1717	1780	2141	576	754	789	931	1607	1679	1693	1751
600	0 0713	68	50	1031	1347	1411	1664	1885	2307	2391	2877	725	948	992	1171	2159	2256	2275	2352
600	0 1017	97	33	1693	2072	2148	2451	2887	3352	3445	3817	1211	1482	1536	1753	3565	3677	3700	3789
600	0 1017	97	50	2129	2606	2701	3082	3878	4503	4628	5127	1523	1864	1932	2205	4789	4940	4970	5091

JOIST

See page 51 for Web Crippling Table Notes

3 1/2" STUD   4" STUD   * ALL GREATER THAN 563# TOTAL LOAD = 1.0DL + 1.0LL

Allowable Web Crippling Loads (lbs) - Single Members

Web Size	Design Thickness (in)	Thickness (mils)	Yield Stress (ksi)	Condition 1 Bearing Length (in.)				Condition 2 Bearing Length (in.)				Condition 3 Bearing Length (in.)				Condition 4 Bearing Length (in.)			
				1	3.5	4	6	1	3.5	4	6	1	3.5	4	6	1	3.5	4	6
800	0.0451	43	33	277	403	428	529	503	699	752	964	179	260	276	341	417	446	452	475
800	0.0566	54	33	467	642	678	818	825	1050	1121	1407	313	431	455	549	795	840	849	885
800	0.0566	54	50	587	808	852	1028	1108	1411	1507	1890	394	542	572	690	1069	1129	1140	1188
800	0.0713	68	33	770	1007	1054	1243	1343	1643	1703	2049	530	693	726	856	1435	1499	1512	1564
800	0.0713	68	[illegible]	[illegible]	1766	1325	1564	1904	2207	2286	2752	667	872	913	1077	1920	2014	2031	2101
800	0.1017	97	33	1625	1989	2081	2357	2803	3254	3344	3705	1147	1404	1456	1661	3320	3425	3446	3530
800	0.1017	97	50	2043	2501	2592	2958	3765	4371	4492	4977	1440	1756	1831	2089	4461	4601	4630	4742
1000	0.0566	54	33	427	557	519	747	776	997	1058	1323	275	370	400	482	658	695	702	732
1000	0.0566	54	50	536	738	779	939	1042	1329	1416	1777	346	476	512	606	864	934	944	983
1000	0.0713	68	33	720	942	986	1153	1282	1569	1626	1956	464	633	682	781	1263	1320	1331	1376
1000	0.0713	68	50	[illegible]	[illegible]	[illegible]	[illegible]	1722	2107	2184	2628	808	796	833	983	1657	1773	1798	1849
1000	0.1017	97	33	[illegible]	[illegible]	[illegible]	[illegible]	2718	3158	3243	3593	1064	1326	1375	1566	3076	3173	3193	3270
1000	0.1017	97	50	1958	2396	2484	2834	3652	4240	4357	4828	1363	1668	1729	1973	4133	4263	4289	4394
1200	0.0713	68	33	671	877	918	1083	1221	1494	1549	1863	437	572	599	706	1091	1140	1150	1189
1200	0.0713	68	50	843	1103	1155	1362	1641	2007	2081	2503	550	719	753	888	1466	1531	1544	1597
1200	0.1017	97	33	1489	1822	1888	2155	2634	3058	3143	3482	1020	1248	1294	1477	2832	2922	2939	3011
1200	0.1017	97	50	1872	2291	2375	2710	3538	4108	.4222	4678	1283	1570	1627	1857	3805	3925	3949	4045

See page 51 for Web Crippling Table Notes.

Allowable Web Crippling Loads (lbs) - Back to Back Members

Web Size	Design Thickness (in)	Thickness in mils	Yield Stress (ksi)	Condition 1 Bearing Length (in.)				Condition 2 Bearing Length (in.)				Condition 3 Bearing Length (in.)				Condition 4 Bearing Length (in.)			
				1	3.5	4	6	1	3.5	4	6	1	3.5	4	6	1	3.5	4	6
162	0.0188	18	33	246	348	362	416	394	604	636	744	142	202	210	242	382	586	616	720
162	0.0283	27	33	492	674	700	794	806	1200	1260	1464	322	442	458	520	796	1184	1242	1444
162	0.0312	30	33	582	792	822	930	958	1418	1486	1722	392	532	554	626	946	1400	1468	1702
162	0.0346	33	33	696	940	976	1102	1152	1692	1772	2050	482	652	676	764	1140	1676	1754	2030
250	0.0188	18	33	260	366	382	435	394	604	636	744	134	190	198	226	354	544	572	670
250	0.0283	27	33	510	700	728	826	806	1200	1260	1464	310	424	440	500	778	1160	1216	1412
250	0.0312	30	33	602	820	852	964	958	1418	1486	1722	376	514	534	604	938	1386	1454	1686
250	0.0346	33	33	716	970	1006	1138	1152	1692	1772	2050	468	632	658	740	1140	1676	1754	2030
250	0.0451	43	33	1138	1504	1560	1748	1860	2676	2798	3220	812	1074	1114	1246	1852	2656	2786	3206
250	0.0566	54	33	1696	2206	2282	2544	2824	3994	4168	4774	1318	1712	1770	1974	2828	4000	4174	4780
250	0.0566	54	50	2570	3342	3456	3854	3060	4332	4520	5176	1318	1712	1770	1974	2828	4000	4174	4780
250	0.0713	68	33	2562	3272	3378	3746	4350	6046	6298	7174	2176	2780	2870	3182	4388	6100	6352	7236
250	0.0713	68	50	3852	4660	5118	5676	4716	6556	6828	7778	2176	2780	2870	3182	4388	6100	6352	7236
350	0.0188	18	33	268	378	396	452	394	604	636	744	124	176	184	210	324	496	522	612
350	0.0283	27	33	532	730	758	860	806	1200	1260	1464	294	404	420	478	736	1096	1150	1336
350	0.0312	30	33	626	852	884	1002	958	1418	1486	1722	362	492	512	580	892	1320	1382	1604
350	0.0346	33	33	744	1004	1044	1178	1152	1692	1772	2050	450	608	632	712	1092	1604	1680	1944
350	0.0451	43	33	1170	1546	1602	1798	1860	2676	2798	3220	790	1044	1082	1214	1834	2642	2762	3178
350	0.0566	54	33	1734	2256	2332	2600	2824	3994	4168	4774	1288	1674	1732	1932	2828	4000	4174	4780
350	0.0566	54	50	2628	3416	3534	3940	3060	4332	4520	5176	1288	1674	1732	1932	2828	4000	4174	4780
350	0.0713	68	33	2608	3332	3440	3814	4350	6046	6298	7174	2138	2732	2820	3128	4388	6100	6352	7236
350	0.0713	68	50	3952	5048	5210	5778	4716	6556	6828	7778	2138	2732	2820	3128	4388	6100	6352	7236

See page 51 for Web Crippling Table Notes.

Allowable Web Crippling Loads (lbs) - Back to Back Members

Web Size	Design Thickness (in)	Thickness (mils)	Yield Stress (ksi)	Condition 1 Bearing Length (in.)				Condition 2 Bearing Length (in.)				Condition 3 Bearing Length (in.)				Condition 4 Bearing Length (in.)			
				1	3.5	4	6	1	3.5	4	6	1	3.5	4	6	1	3.5	4	6
362	0.0188	18	33	268	378	396	452	394	604	636	744	124	174	182	208	320	490	516	604
362	0.0283	27	33	534	734	762	866	806	1200	1260	1464	294	402	418	474	730	1088	1142	1326
362	0.0312	30	33	628	856	888	1006	958	1418	1486	1722	360	490	510	576	886	1310	1374	1594
362	0.0346	33	33	748	1008	1048	1182	1152	1692	1772	2050	448	604	628	710	1086	1594	1670	1934
362	0.0451	43	33	1174	1552	1606	1804	1860	2676	2798	3220	766	1040	1076	1210	1826	2630	2750	3164
362	0.0566	54	33	1740	2262	2338	2608	2824	3994	4168	4774	1284	1670	1728	1926	2828	4000	4174	4780
362	0.0566	54	50	2636	3426	3544	3952	3060	4332	4520	5176	1284	1670	1728	1926	2828	4000	4174	4780
362	0.0713	68	33	2614	3340	3446	3822	4350	6046	6298	7174	2134	2726	2814	3120	4388	6100	6352	7236
362	0.0713	68	50	3960	5060	5222	5790	4716	6556	6828	7778	2134	2728	2814	3120	4388	6100	6352	7236
400	0.0283	27	33	542	744	774	878	806	1200	1260	1464	288	394	410	465	714	1066	1118	1298
400	0.0312	30	33	638	868	902	1020	958	1418	1486	1722	354	482	502	568	868	1286	1348	1562
400	0.0346	33	33	756	1022	1060	1198	1152	1692	1772	2050	442	596	620	698	1068	1568	1642	1900
400	0.0451	43	33	1186	1568	1624	1822	1860	2676	2798	3220	778	1030	1066	1196	1804	2598	2714	3124
400	0.0566	54	33	1754	2280	2358	2630	2824	3994	4168	4774	1274	1656	1712	1910	2828	4000	4174	4780
400	0.0566	54	50	2658	3454	3572	3984	3060	4332	4520	5176	1274	1656	1712	1910	2828	4000	4174	4780
400	0.0713	68	33	2630	3362	3470	3846	4350	6046	6298	7174	2120	2708	2796	3100	4388	6100	6352	7236
400	0.0713	68	50	3986	5092	5258	5828	4716	6556	6828	7778	2120	2708	2796	3100	4388	6100	6352	7236
400	0.1017	97	33	4968	6186	6368	6996	8606	11638	12088	13654	4736	5898	6070	6670	8798	11898	12358	13958
400	0.1017	97	50	7528	9374	9648	10600	9332	12618	13106	14802	4736	5898	6070	6670	8798	11898	12358	13958
550	0.0283	27	33	552	758	788	884	806	1200	1260	1464	266	366	380	432	652	970	1018	1182
550	0.0312	30	33	658	896	932	1054	958	1418	1486	1722	330	450	468	530	800	1184	1242	1440
550	0.0346	33	33	792	1070	1112	1254	1152	1692	1772	2050	416	562	582	658	994	1458	1528	1768
550	0.0451	43	33	1232	1630	1688	1894	1860	2676	2798	3220	744	984	1020	1144	1712	2464	2576	2964
550	0.0566	54	33	1810	2354	2434	2714	2824	3994	4168	4774	1230	1600	1654	1846	2718	3846	4014	4596
550	0.0566	54	50	2744	3566	3688	4114	3060	4332	4520	5176	1230	1600	1654	1846	2718	3846	4014	4596
550	0.0713	68	33	2700	3450	3560	3946	4350	6046	6298	7174	2064	2638	2722	3018	4350	6048	6300	7174
550	0.0713	68	50	4090	5226	5396	5982	4716	6556	6828	7778	2064	2638	2722	3018	4350	6048	6300	7174
550	0.1017	97	33	5062	6304	6488	7128	8606	11638	12088	13654	4650	5792	5960	6550	8798	11898	12358	13958
550	0.1017	97	50	7670	9550	9830	10800	9332	12618	13106	14802	4650	5792	5960	6550	8798	11898	12358	13958
600	0.0312	30	33	658	896	932	1054	958	1418	1486	1722	324	440	456	518	778	1150	1206	1398
600	0.0346	33	33	792	1070	1112	1254	1152	1692	1772	2050	406	550	570	644	968	1422	1490	1724
600	0.0451	43	33	1248	1650	1710	1918	1860	2676	2798	3220	734	970	1004	1128	1680	2420	2530	2910
600	0.0566	54	33	1830	2378	2460	2744	2824	3994	4168	4774	1216	1582	1636	1824	2680	3794	3958	4532
600	0.0566	54	50	2772	3604	3728	4156	3060	4332	4520	5176	1216	1582	1636	1824	2680	3794	3958	4532
600	0.0713	68	33	2722	3478	3592	3982	4350	6046	6298	7174	2046	2614	2698	2990	4304	5984	6232	7098
600	0.0713	68	50	4126	5272	5442	6032	4716	6556	6828	7778	2046	2614	2698	2990	4304	5984	6232	7098
600	0.1017	97	33	5094	6342	6528	7172	8606	11638	12088	13654	4622	5756	5924	6508	8798	11898	12358	13958
600	0.1017	97	50	7716	9610	9890	10866	9332	12618	13106	14802	4622	5756	5924	6508	8798	11898	12358	13958
800	0.0451	43	33	1280	1692	1754	1966	1860	2676	2798	3220	688	910	944	1056	1556	2242	2344	2696
800	0.0566	54	33	1906	2478	2562	2856	2824	3994	4168	4774	1158	1506	1558	1738	2530	3580	3736	4278
800	0.0566	54	50	2888	3754	3882	4330	3060	4332	4520	5176	1158	1506	1558	1738	2530	3580	3736	4278
800	0.0713	68	33	2816	3596	3712	4116	4350	6046	6298	7174	1970	2518	2600	2882	4118	5726	5964	6794
800	0.0713	68	50	4266	5450	5626	6236	4716	6556	6828	7778	1970	2518	2600	2882	4118	5726	5964	6794
800	0.1017	97	33	5218	6498	6688	7348	8606	11638	12088	13654	4508	5614	5778	6348	8704	11770	12226	13808
800	0.1017	97	50	7906	9844	10132	11132	9332	12618	13106	14802	4508	5614	5778	6348	8704	11770	12226	13808
1000	0.0566	54	33	1936	2516	2602	2902	2824	3994	4168	4774	1102	1432	1480	1652	2380	3368	3514	4024
1000	0.0566	54	50	2932	3812	3942	4396	3060	4332	4520	5176	1102	1432	1480	1652	2380	3368	3514	4024
1000	0.0713	68	33	2908	3714	3834	4250	4350	6046	6298	7174	1896	2422	2500	2772	3934	5468	5696	6488
1000	0.0713	68	50	4404	5628	5810	6440	4716	6556	6828	7778	1896	2422	2500	2772	3934	5468	5696	6488
1000	0.1017	97	33	5342	6652	6846	7522	8606	11638	12088	13654	4394	5470	5630	6186	8444	11418	11860	13396
1000	0.1017	97	50	8094	10080	10374	11398	9332	12618	13106	14802	4394	5470	5630	6186	8444	11418	11860	13396
1200	0.0713	68	33	2956	3776	3898	4322	4350	6046	6298	7174	1822	2328	2402	2664	3748	5212	5428	6182
1200	0.0713	68	50	4478	5722	5908	6548	4716	6556	6828	7778	1822	2328	2402	2664	3748	5212	5428	6182
1200	0.1017	97	33	5466	6808	7006	7698	8606	11638	12088	13654	4278	5328	5484	6026	8184	11066	11494	12982
1200	0.1017	97	50	8282	10314	10616	11664	9332	12618	13106	14802	4278	5328	5484	6026	8184	11066	11494	12982

See page 51 for Web Crippling Table Notes.

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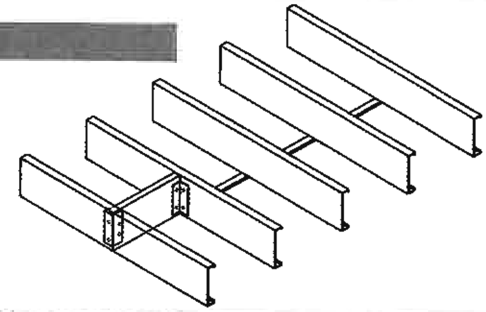
CEILING SPAN TABLE NOTES

1. Values are for single spans.
2. Allowable ceiling span calculations based on 33ksi yield strength steel.
3. For fully-braced ceilings, use mid-span braced values.
4. End bearing length = 1" minimum.



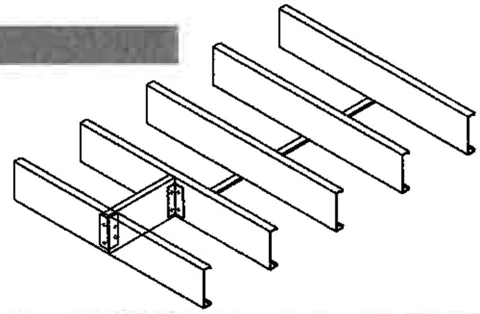
ALLOWABLE CEILING SPANS - DEFLECTION LIMIT L/240

Section	Thickness (mils)	4 psf, Unsupported, 12	4 psf, Unsupported, 16	4 psf, Unsupported, 24	4 psf, Midspan, 12	4 psf, Midspan, 16	4 psf, Midspan, 24	8 psf, Unsupported, 12	8 psf, Unsupported, 16	8 psf, Unsupported, 24	8 psf, Midspan, 12	8 psf, Midspan, 16	8 psf, Midspan, 24	13 psf, Unsupported, 12	13 psf, Unsupported, 16	13 psf, Unsupported, 24	13 psf, Midspan, 12	13 psf, Midspan, 16	13 psf, Midspan, 24
162S125	18	7' 2"	6' 6"	5' 11"	8' 2"	7' 5"	6' 6"	6' 5"	5' 11"	5' 2"	7' 2"	6' 6"	5' 8"	5' 0"	4' 6"	3' 10"e	5' 6"	5' 0"e	4' 1"e
	27	8' 7"	7' 11"	7' 1"	9' 7"	8' 9"	7' 7"	7' 8"	7' 1"	6' 2"	8' 5"	7' 7"	6' 8"	6' 0"	6' 5"	4' 8"	6' 6"	5' 11"	5' 1"
	30	9' 0"	8' 3"	7' 4"	9' 11"	9' 0"	7' 10"	8' 0"	7' 4"	6' 6"	8' 8"	7' 10"	6' 10"	6' 4"	5' 9"	4' 11"	6' 8"	6' 1"	5' 3"
	33	9' 6"	8' 8"	7' 8"	10' 3"	9' 4"	8' 1"	8' 4"	7' 8"	6' 10"	8' 11"	8' 1"	7' 1"	6' 8"	6' 1"	5' 3"	6' 11"	6' 3"	5' 6"
162S137	27	9' 11"	9' 2"	8' 0"	10' 1"	9' 1"	8' 0"	8' 10"	8' 0"	7' 0"	8' 10"	8' 5"	7' 0"	6' 0"	6' 2"	5' 5"	6' 9"	6' 2"	5' 5"
	33	10' 9"	9' 9"	8' 6"	10' 9"	9' 9"	8' 6"	9' 4"	8' 6"	7' 5"	9' 4"	8' 6"	7' 5"	7' 3"	6' 7"	5' 9"	7' 3"	6' 7"	5' 9"
250S125	18	8' 4"	7' 8"	6' 9"	11' 4"	10' 3"	9' 0"	7' 4"	6' 9"	6' 1"	9' 10"	9' 0"	7' 8"e	5' 11"e	5' 6"e	4' 9"e	7' 5"e	6' 6"e	5' 5"e
	27	9' 8"	8' 11"	7' 11"	13' 3"	12' 1"	10' 6"	8' 7"	7' 11"	7' 1"	11' 7"	10' 6"	9' 2"	6' 11"	6' 5"	5' 8"	8' 11"	7' 11"	6' 8"
	30	10' 0"	9' 3"	8' 3"	13' 9"	12' 5"	10' 11"	8' 11"	8' 3"	7' 4"	12' 0"	10' 11"	9' 6"	7' 2"	6' 8"	5' 11"	9' 3"	8' 4"	7' 0"
	33	10' 5"	9' 7"	8' 7"	14' 2"	12' 10"	11' 3"	9' 3"	8' 7"	7' 7"	12' 5"	11' 3"	9' 10"	7' 5"	6' 10"	6' 2"	9' 7"	8' 8"	7' 6"
	43	11' 9"	10' 3"	9' 6"	15' 5"	14' 0"	12' 3"	10' 5"	9' 6"	8' 5"	13' 6"	12' 3"	10' 8"	8' 3"	7' 7"	6' 9"	10' 5"	9' 5"	8' 3"
250S137	27	10' 11"	10' 1"	8' 11"	13' 0"	12' 2"	11' 1"	9' 10"	9' 1"	8' 2"	12' 2"	11' 1"	9' 8"	8' 0"	7' 5"	6' 7"	9' 5"	8' 7"	7' 6"
	33	11' 9"	10' 10"	9' 8"	14' 11"	13' 6"	11' 10"	10' 6"	9' 8"	8' 8"	13' 0"	11' 10"	10' 4"	8' 5"	7' 10"	7' 0"	10' 0"	9' 1"	8' 0"
	43	13' 2"	12' 1"	10' 8"	16' 2"	14' 8"	12' 10"	11' 8"	10' 9"	9' 7"	14' 2"	12' 10"	11' 2"	9' 4"	8' 7"	7' 8"	10' 11"	9' 11"	8' 8"
250S162	33	13' 5"	12' 5"	11' 1"	15' 8"	14' 2"	12' 5"	12' 0"	11' 1"	9' 11"	13' 8"	12' 5"	10' 10"	9' 9"	9' 0"	8' 0"	10' 7"	9' 7"	8' 4"
	43	14' 11"	13' 9"	12' 3"	17' 0"	15' 5"	13' 6"	13' 3"	12' 3"	10' 11"	14' 10"	13' 6"	11' 9"	10' 8"	9' 10"	8' 9"	11' 6"	10' 5"	9' 1"
350S125	18	9' 4"	8' 8"	7' 8"	13' 1"	12' 1"	10' 0"e	8' 4"	7' 8"	6' 10"e	11' 8"e	10' 8"e	9' 2"e	6' 8"e	6' 2"e	5' 6"e	8' 10"e	7' 10"e	6' 8"e
	27	10' 7"	9' 9"	8' 0"	15' 1"	14' 0"	12' 5"	9' 6"	8' 9"	7' 10"	13' 6"	12' 5"	10' 11"	7' 5"	7' 1"	6' 5"	10' 7"	9' 0"	8' 1"
	30	10' 11"	10' 1"	9' 0"	15' 6"	14' 4"	12' 11"	9' 9"	9' 0"	8' 1"	13' 11"	12' 11"	11' 5"	7' 11"	7' 4"	6' 7"	11' 1"	10' 0"	8' 6"
	33	11' 4"	10' 6"	9' 4"	16' 1"	14' 10"	13' 4"	10' 1"	9' 4"	8' 5"	14' 5"	13' 4"	11' 11"	8' 2"	7' 7"	6' 9"	11' 8"	10' 7"	9' 0"
	43	12' 7"	11' 7"	10' 4"	17' 8"	16' 3"	14' 6"	11' 2"	10' 4"	9' 2"	16' 9"	14' 8"	13' 0"	9' 0"	8' 3"	7' 5"	12' 8"	11' 8"	10' 2"
350S137	27	11' 11"	11' 1"	9' 11"	17' 3"	16' 0"	14' 4"	10' 9"	9' 11"	8' 11"	15' 6"	14' 4"	12' 6"	8' 9"	8' 2"	7' 4"	12' 2"	11' 0"	9' 4"e
	33	12' 9"	11' 10"	10' 7"	18' 3"	16' 11"	15' 2"	11' 5"	10' 7"	9' 6"	16' 5"	15' 2"	13' 4"	9' 4"	8' 7"	7' 9"	13' 0"	11' 10"	10' 3"
	43	14' 2"	13' 0"	11' 7"	19' 11"	18' 5"	16' 6"	12' 7"	11' 7"	10' 4"	17' 10"	16' 6"	14' 6"	10' 2"	9' 4"	8' 5"	14' 2"	12' 10"	11' 3"
350S162	33	14' 7"	13' 6"	12' 1"	20' 3"	18' 5"	16' 1"	13' 0"	12' 1"	10' 10"	17' 8"	16' 1"	14' 0"	10' 7"	9' 10"	8' 10"	13' 8"	12' 5"	10' 10"
	43	16' 0"	14' 9"	13' 2"	22' 0"	20' 0"	17' 6"	14' 4"	13' 2"	11' 10"	19' 3"	17' 6"	15' 3"	11' 7"	10' 8"	9' 7"	14' 10"	13' 6"	11' 9"
362S125	18	9' 5"	8' 9"	7' 9"	13' 3"	12' 3"e	10' 10"e	8' 6"	7' 9"	6' 11"e	11' 10"e	10' 10"e	9' 3"e	6' 9"e	6' 2"e	5' 7"e	9' 0"e	7' 11"e	6' 7"e
	27	10' 8"	9' 11"	8' 10"	15' 3"	14' 2"	12' 7"	9' 7"	8' 10"	7' 11"	13' 8"	12' 7"	11' 1"	7' 9"	7' 2"	6' 6"	10' 9"	9' 8"	8' 3"
	30	11' 0"	10' 2"	9' 2"	15' 8"	14' 6"	13' 1"	9' 10"	9' 2"	8' 2"	14' 1"	13' 1"	11' 7"	8' 0"	7' 5"	6' 8"	11' 3"	10' 2"	8' 9"
	33	11' 5"	10' 7"	9' 5"	16' 3"	15' 0"	13' 6"	10' 3"	9' 5"	8' 6"	14' 6"	13' 6"	12' 1"	8' 3"	7' 8"	6' 10"	11' 9"	10' 9"	9' 2"
	43	12' 9"	11' 8"	10' 5"	17' 9"	16' 5"	14' 8"	11' 4"	10' 5"	9' 3"	15' 11"	14' 8"	13' 1"	9' 1"	8' 4"	7' 6"	12' 10"	11' 9"	10' 4"
362S137	27	12' 1"	11' 2"	10' 1"	17' 5"	16' 2"	14' 6"	10' 10"	10' 1"	9' 1"	15' 8"	14' 6"	12' 10"	8' 10"	8' 3"	7' 5"	12' 6"	11' 2"	9' 6"e
	33	12' 11"	11' 11"	10' 8"	18' 6"	17' 1"	15' 4"	11' 7"	10' 8"	9' 7"	16' 7"	15' 4"	13' 8"	9' 5"	8' 8"	7' 10"	13' 4"	12' 2"	10' 6"
	43	14' 3"	13' 2"	11' 9"	20' 1"	18' 7"	16' 7"	12' 8"	11' 9"	10' 5"	18' 0"	16' 7"	14' 10"	10' 3"	9' 5"	8' 5"	14' 6"	13' 3"	11' 6"
362S162	33	14' 8"	13' 7"	12' 2"	20' 9"	18' 11"	16' 6"	13' 2"	12' 2"	10' 11"	18' 2"	16' 6"	14' 5"	10' 9"	9' 11"	8' 11"	14' 0"	12' 9"	11' 1"
	43	16' 2"	14' 11"	13' 4"	22' 7"	20' 7"	17' 11"	14' 5"	13' 4"	11' 11"	19' 9"	17' 11"	15' 8"	11' 8"	10' 9"	9' 8"	15' 3"	13' 10"	12' 1"
400S125	27	11' 0"	10' 2"	9' 1"	15' 8"	14' 7"	13' 1"	9' 10"	9' 1"	8' 2"	14' 2"	13' 1"	11' 7"	8' 0"	7' 5"	6' 8"	11' 3"	10' 2"	8' 9"e
	30	11' 4"	10' 6"	9' 5"	16' 2"	15' 0"	13' 5"	10' 2"	9' 5"	8' 5"	14' 6"	13' 5"	12' 0"	8' 3"	7' 8"	6' 10"	11' 9"	10' 5"	9' 2"
	33	11' 0"	10' 10"	9' 8"	16' 9"	15' 6"	13' 10"	10' 6"	9' 9"	8' 8"	15' 0"	13' 10"	12' 5"	8' 6"	7' 11"	7' 1"	12' 2"	11' 2"	9' 5"
	43	13' 0"	12' 0"	10' 8"	18' 3"	16' 10"	15' 1"	11' 7"	10' 8"	9' 6"	16' 4"	15' 1"	13' 6"	9' 4"	8' 7"	7' 8"	13' 3"	12' 2"	10' 9"
400S137	27	12' 5"	11' 6"	10' 4"	17' 11"	16' 7"	15' 0"	11' 2"	10' 4"	9' 4"	16' 2"	15' 0"	13' 4"	9' 1"	8' 5"	7' 7"	13' 0"	11' 9"	10' 0"e
	33	13' 3"	12' 3"	11' 0"	18' 11"	17' 7"	15' 10"	11' 10"	11' 0"	9' 10"	17' 0"	15' 10"	14' 2"	9' 8"	8' 11"	8' 1"	13' 10"	12' 8"	11' 0"
	43	14' 7"	13' 6"	12' 0"	20' 7"	19' 1"	17' 1"	13' 0"	12' 0"	10' 9"	18' 5"	17' 1"	15' 4"	10' 6"	9' 8"	8' 8"	15' 0"	13' 9"	12' 1"
400S162	33	15' 1"	13' 11"	12' 8"	21' 8"	20' 1"	17' 10"	13' 8"	12' 6"	11' 3"	19' 6"	17' 10"	15' 6"	11' 0"	10' 3"	9' 3"	15' 2"	13' 9"	12' 0"
	43	16' 7"	15' 3"	13' 8"	23' 5"	21' 8"	19' 4"	14' 9"	13' 8"	12' 2"	21' 0"	19' 4"	16' 11"	11' 11"	11' 1"	9' 11"	16' 5"	14' 11"	13' 1"
600S125	27	12' 4"e	11' 5"e	10' 4"e	17' 10"e	16' 7"e	14' 11"e	11' 1"e	10' 4"e	9' 3"e	16' 1"e	14' 11"e	13' 5"e	9' 1"e	8' 5"e	7' 7"e	13' 2"e	12' 2"e	10' 9"e
	30	12' 9"	11' 9"	10' 7"	18' 4"	17' 0"	15' 4"	11' 5"	10' 7"	9' 6"	16' 6"	15' 4"	13' 9"	9' 4"	8' 8"	7' 10"	13' 6"	12' 6"	11' 2"e
	33	13' 2"	12' 2"	10' 11"	18' 10"	17' 6"	15' 9"	11' 9"	10' 11"	9' 10"	17' 0"	15' 9"	14' 2"	9' 7"	8' 11"	8' 0"	13' 10"	12' 10"	11' 7"
	43	14' 5"	13' 3"	11' 10"	20' 5"	18' 11"	16' 11"	12' 10"	11' 10"	10' 7"	18' 4"	16' 11"	15' 3"	10' 5"	9' 7"	8' 7"	14' 11"	13' 10"	12' 5"
600S137	33	14' 10"	13' 9"	12' 4"	21' 4"	19' 10"	17' 10"	13' 1"	12' 4"	11' 1"	19' 2"	17' 10"	16' 1"	10' 10"	10' 1"	9' 1"	15' 8"	14' 7"	13' 1"
	43	16' 2"	14' 11"	13' 4"	23' 0"	21' 4"	19' 2"	14' 6"	13' 4"	12' 0"	20' 8"	19' 2"	17' 3"	11' 9"	10' 10"	9' 9"	16' 10"	15' 6"	14' 1"
600S162	33	16' 10"	15' 7"	14' 0"	24' 4"	22' 7"	20' 4"	15' 2"	14' 0"	12' 8"	21' 11"	20' 4"	18' 4"	12' 5"	11' 6"	10' 4"	18' 0"	16' 8"	14' 8"e
	43	18' 4"	16' 11"	15' 2"	26' 3"	24' 4"	21' 10"	16' 5"	15' 2"	13' 8"	23' 7"	21' 10"	19' 8"	13' 4"	12' 4"	11' 1"	19' 3"	17' 11"	15' 11"

"e" Web stiffeners required at supports.

CEILING SPAN TABLE NOTES

1. Values are for single spans.
2. Allowable ceiling span calculations based on 33ksi yield strength steel.
3. For fully-braced ceilings, use mid-span braced values.
4. End bearing length = 1" minimum.



ALLOWABLE CEILING SPANS - DEFLECTION LIMIT L/360

Section	Thickness (mils)	4 psf						6 psf						13 psf					
		Lateral Support of Compression Flange						Lateral Support of Compression Flange						Lateral Support of Compression Flange					
		Unsupported			Midspan			Unsupported			Midspan			Unsupported			Midspan		
		Joist Spacing (in) o.c.			Joist Spacing (in) o.c.			Joist Spacing (in) o.c.			Joist Spacing (in) o.c.			Joist Spacing (in) o.c.			Joist Spacing (in) o.c.		
		12	16	24	12	16	24	12	16	24	12	16	24	12	16	24	12	16	24
162S125	18	7' 2"	6' 6"	5' 8"	7' 2"	6' 6"	5' 8"	6' 3"	5' 8"	4' 11"	6' 3"	5' 8"	4' 11"	4' 10"	4' 4"	3' 10"e	4' 10"	4' 4"	3' 10"e
	27	8' 5"	7' 7"	6' 8"	8' 5"	7' 7"	6' 8"	7' 4"	6' 8"	5' 10"	7' 4"	6' 8"	5' 10"	5' 8"	5' 2"	4' 6"	5' 8"	5' 2"	4' 6"
	30	8' 8"	7' 10"	6' 10"	8' 8"	7' 10"	6' 10"	7' 7"	6' 10"	6' 0"	7' 7"	6' 10"	6' 0"	5' 10"	5' 3"	4' 7"	5' 10"	5' 3"	4' 7"
	33	8' 11"	8' 1"	7' 1"	8' 11"	8' 1"	7' 1"	7' 10"	7' 1"	6' 2"	7' 10"	7' 1"	6' 2"	6' 0"	5' 6"	4' 9"	6' 0"	5' 6"	4' 9"
162S137	27	8' 10"	8' 0"	7' 0"	[illegible]	[illegible]	[illegible]	7' 6"	7' 0"	6' 1"	7' 6"	7' 0"	6' 1"	5' 11"	5' 6"	4' 8"	5' 11"	5' 5"	4' 8"
	33	9' 4"	8' 6"	7' 5"	9' 4"	8' 6"	7' 5"	8' 2"	7' 5"	6' 6"	8' 2"	7' 5"	6' 6"	6' 4"	5' 9"	5' 0"	6' 4"	5' 9"	5' 0"
250S125	18	8' 4"	7' 8"	6' 9"	9' 10"	9' 0"	7' 10"	7' 4"	6' 9"	6' 1"	8' 7"	7' 10"	6' 10"e	5' 11"e	5' 6"e	4' 9"e	6' 8"e	6' 0"e	5' 3"e
	27	9' 8"	8' 11"	7' 11"	11' 7"	10' 6"	9' 2"	8' 7"	7' 11"	7' 1"	10' 1"	9' 2"	8' 0"	6' 11"	6' 5"	5' 8"	7' 10"	7' 1"	6' 2"
	30	10' 0"	9' 3"	8' 3"	12' 0"	10' 11"	9' 6"	8' 11"	8' 3"	7' 4"	10' 5"	9' 6"	8' 3"	7' 2"	6' 8"	5' 11"	8' 1"	7' 4"	6' 5"
	33	10' 5"	9' 7"	8' 7"	12' 5"	11' 3"	9' 10"	9' 3"	8' 7"	7' 7"	10' 10"	9' 10"	8' 7"	7' 5"	6' 10"	6' 2"	8' 4"	7' 7"	6' 7"
	43	11' 9"	10' 9"	9' 6"	13' 6"	12' 3"	10' 8"	10' 5"	9' 6"	8' 5"	11' 9"	10' 8"	9' 4"	8' 3"	7' 7"	6' 9"	9' 1"	8' 3"	7' 2"
250S137	27	10' 11"	10' 1"	8' 11"	12' 2"	11' 1"	9' 8"	9' 10"	9' 1"	8' 2"	10' 8"	9' 8"	8' 5"	8' 0"	7' 5"	6' 6"	8' 3"	7' 8"	6' 6"
	33	11' 9"	10' 10"	9' 8"	13' 0"	11' 10"	10' 4"	10' 6"	9' 8"	8' 8"	11' 4"	10' 4"	9' 0"	8' 6"	7' 10"	6' 11"	8' 9"	8' 0"	6' 11"
	43	13' 2"	12' 1"	10' 9"	14' 2"	12' 10"	11' 2"	11' 8"	10' 9"	9' 7"	12' 4"	11' 2"	9' 9"	9' 4"	8' 7"	7' 7"	9' 6"	8' 8"	7' 7"
250S162	33	13' 5"	12' 5"	10' 10"	13' 8"	12' 5"	10' 10"	11' 11"	10' 10"	9' 5"	11' 11"	10' 10"	9' 5"	9' 2"	8' 4"	7' 4"	9' 2"	8' 4"	7' 4"
	43	14' 10"	13' 6"	11' 9"	14' 10"	13' 6"	11' 9"	13' 0"	11' 9"	10' 3"	13' 0"	11' 9"	10' 3"	10' 0"	9' 1"	7' 11"	10' 0"	9' 1"	7' 11"
350S125	18	9' 4"	8' 8"	7' 6"	12' 11"	11' 8"	10' 3"e	8' 4"	7' 6"	6' 10"e	11' 3"e	10' 3"e	8' 11"e	6' 8"e	6' 2"e	5' 6"e	8' 5"e	7' 10"e	6' 6"e
	27	10' 7"	9' 9"	8' 9"	15' 0"	13' 8"	11' 11"	9' 6"	8' 9"	7' 10"	13' 1"	11' 11"	10' 5"	7' 8"	7' 1"	6' 5"	10' 1"	9' 2"	8' 0"
	30	10' 11"	10' 1"	9' 0"	15' 6"	14' 1"	12' 4"	9' 9"	9' 0"	8' 1"	13' 7"	12' 4"	10' 9"	7' 11"	7' 4"	6' 7"	10' 6"	9' 6"	8' 4"
	33	11' 4"	10' 6"	9' 4"	16' 1"	14' 7"	12' 9"	10' 1"	9' 4"	8' 5"	14' 0"	12' 9"	11' 1"	8' 2"	7' 7"	6' 9"	10' 10"	9' 10"	8' 7"
	43	12' 7"	11' 7"	10' 4"	17' 6"	15' 11"	13' 10"	11' 2"	10' 4"	9' 2"	15' 3"	13' 10"	12' 1"	9' 0"	8' 3"	7' 5"	11' 10"	10' 9"	9' 4"
350S137	27	11' 11"	11' 1"	9' 11"	15' 10"	14' 4"	12' 6"	10' 9"	9' 11"	8' 11"	13' 10"	12' 6"	10' 11"	8' 9"	8' 2"	7' 4"	10' 8"	9' 8"	8' 5"
	33	12' 9"	11' 10"	10' 7"	16' 10"	15' 4"	13' 4"	11' 5"	10' 7"	9' 6"	14' 9"	13' 4"	11' 8"	9' 4"	8' 7"	7' 9"	11' 4"	10' 4"	9' 0"
	43	14' 2"	13' 0"	11' 7"	18' 4"	16' 8"	14' 6"	12' 7"	11' 7"	10' 4"	16' 0"	14' 6"	12' 8"	10' 2"	9' 4"	8' 5"	12' 4"	11' 3"	9' 10"
350S162	33	14' 7"	13' 6"	12' 1"	17' 8"	16' 1"	14' 0"	13' 0"	12' 1"	10' 10"	15' 5"	14' 0"	12' 2"	10' 7"	9' 10"	8' 10"	11' 11"	10' 10"	9' 5"
	43	16' 0"	14' 9"	13' 2"	19' 3"	17' 6"	15' 3"	14' 4"	13' 2"	11' 10"	16' 9"	15' 3"	13' 4"	11' 7"	10' 8"	9' 7"	13' 0"	11' 9"	10' 3"
362S125	18	9' 5"	8' 9"	7' 9"	13' 3"	12' 0"	10' 6"e	8' 6"	7' 9"	6' 11"e	11' 7"e	10' 6"e	9' 2"e	6' 9"e	6' 2"e	5' 7"e	8' 11"e	7' 11"e	6' 7"e
	27	10' 8"	9' 11"	8' 10"	15' 3"	14' 0"	12' 3"	9' 7"	8' 10"	7' 11"	13' 6"	12' 3"	10' 8"	7' 9"	7' 2"	6' 6"	10' 5"	9' 5"	8' 3"
	30	11' 0"	10' 2"	9' 2"	15' 8"	14' 6"	12' 8"	9' 10"	9' 2"	8' 2"	13' 11"	12' 8"	11'1"	8' 0"	7' 5"	6' 8"	10' 9"	9' 9"	8' 6"
	33	11' 5"	10' 7"	9' 5"	16' 3"	15' 0"	13' 1"	10' 3"	9' 5"	8' 6"	14' 5"	13' 1"	11' 5"	8' 3"	7' 8"	6' 10"	11' 2"	10' 1"	8' 10"
	43	12' 9"	11' 8"	10' 5"	17' 9"	16' 4"	14' 3"	11' 4"	10' 5"	9' 3"	15' 8"	14' 3"	12' 5"	9' 1"	8' 4"	7' 6"	12' 1"	11' 0"	9' 7"
362S137	27	12' 1"	11' 2"	10' 1"	16' 3"	14' 9"	12' 11"	10' 10"	10' 1"	9' 1"	14' 2"	12' 11"	11' 3"	8' 10"	8' 3"	7' 5"	10' 11"	9' 11"	8' 8"e
	33	12' 11"	11' 11"	10' 8"	17' 4"	15' 9"	13' 9"	11' 7"	10' 8"	9' 7"	15' 2"	13' 9"	12' 0"	9' 5"	8' 8"	7' 10"	11' 8"	10' 7"	9' 3"
	43	14' 3"	13' 2"	11' 9"	18' 10"	17' 1"	14' 11"	12' 9"	11' 9"	10' 6"	16' 5"	14' 11"	13' 1"	10' 3"	9' 5"	8' 5"	12' 8"	11' 6"	10' 1"
362S162	33	14' 8"	13' 7"	12' 2"	18' 2"	16' 6"	14' 5"	13' 2"	12' 2"	10' 11"	15' 10"	14' 5"	12' 7"	10' 9"	9' 11"	8' 11"	12' 3"	11' 1"	9' 8"
	43	16' 2"	14' 11"	13' 4"	19' 9"	17' 11"	15' 8"	14' 5"	13' 4"	11' 11"	17' 3"	15' 8"	13' 8"	11' 8"	10' 9"	9' 8"	13' 4"	12' 1"	10' 7"
400S125	27	11' 0"	10' 2"	9' 1"	16' 3"	14' 7"	13' 1"	9' 10"	9' 1"	8' 2"	14' 2"	13' 1"	11' 6"	8' 0"	7' 5"	6' 8"	11' 3"	10' 2"	8' 9"e
	30	11' 4"	10' 6"	9' 5"	16' 2"	15' 0"	13' 5"	10' 2"	9' 5"	8' 5"	14' 6"	13' 5"	11' 11"	8' 3"	7' 8"	6' 10"	11' 8"	10' 7"	9' 2"
	33	11' 9"	10' 10"	9' 6"	16' 8"	15' 8"	13' 10"	10' 6"	9' 9"	8' 8"	15' 0"	13' 10"	12' 4"	8' 6"	7' 11"	7' 1"	12' 0"	10' 11"	9' 6"
	43	13' 0"	12' 0"	10' 8"	18' 3"	16' 10"	15' 1"	11' 7"	10' 8"	9' 6"	16' 4"	15' 1"	13' 6"	9' 4"	8' 7"	7' 8"	13' 1"	11' 11"	10' 5"
400S137	27	12' 5"	11' 6"	10' 4"	17' 6"	15' 11"	13' 11"	11' 2"	10' 4"	9' 4"	15' 4"	13' 11"	12' 2"	9' 1"	8' 5"	7' 7"	11' 10"	10' 9"	9' 5"e
	33	13' 3"	12' 3"	11' 0"	18' 8"	17' 0"	14' 10"	11' 10"	11' 0"	9' 10"	16' 4"	14' 10"	12' 11"	9' 8"	8' 11"	8' 1"	12' 7"	11' 5"	10' 0"
	43	14' 7"	13' 6"	12' 0"	20' 4"	18' 6"	16' 2"	13' 0"	12' 0"	10' 9"	17' 9"	16' 2"	14' 1"	10' 6"	9' 8"	8' 8"	13' 9"	12' 6"	10' 11"
400S162	33	15' 1"	13' 11"	12' 6"	19' 7"	17' 10"	15' 6"	13' 6"	12' 6"	11' 3"	17' 1"	15' 6"	13' 7"	11' 0"	10' 3"	9' 2"	13' 3"	12' 0"	10' 6"
	43	16' 7"	15' 3"	13' 8"	21' 4"	19' 4"	16' 11"	14' 9"	13' 8"	12' 2"	18' 7"	16' 11"	14' 9"	11' 11"	11' 1"	9' 11"	14' 5"	13' 1"	11' 5"
600S125	27	12' 4"e	11' 5"e	10' 4"e	17' 10"e	16' 7"e	14' 11"e	11' 1"e	10' 4"e	9' 3"e	16' 1"e	14' 11"e	13' 5"e	9' 1"e	8' 5"e	7' 7"e	13' 2"e	12' 2"e	10' 9"e
	30	12' 9"	11' 9"	10' 7"	18' 4"	17' 0"	15' 4"	11' 5"	10' 7"	9' 6"	16' 6"	15' 4"	13' 9"	9' 4"	8' 8"	7' 10"	13' 6"	12' 6"	11' 2"e
	33	13' 2"	12' 2"	10' 11"	18' 10"	17' 6"	15' 9"	11' 9"	10' 11"	9' 10"	17' 0"	15' 9"	14' 2"	9' 7"	8' 11"	8' 0"	13' 10"	12' 10"	11' 7"
	43	14' 5"	13' 3"	11' 10"	20' 5"	18' 11"	16' 11"	12' 10"	11' 10"	10' 7"	18' 4"	16' 11"	15' 3"	10' 5"	9' 7"	8' 7"	14' 11"	13' 10"	12' 5"
[illegible]	33	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	13' 4"	12' 4"	11' 1"	16' 2"	[illegible]	[illegible]	10' 10"	10' 1"	9' 1"	15' 9"	14' 7"	13' 1"e
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	17' 3"	11' 9"	10' 10"	[illegible]	16' 10"	15' 8"	[illegible]
600S162	33	16' 10"	15' 7"	14' 0"	24' 4"	22' 7"	20' 4"	15' 2"	14' 0"	12' 8"	21' 11"	20' 4"	18' 4"	12' 5"	11' 6"	10' 4"	18' 0"	16' 6"	14' 5"e
	43	18' 4"	16' 11"	15' 2"	26' 3"	24' 4"	21' 10"	16' 5"	15' 2"	13' 8"	23' 7"	21' 10"	19' 8"	13' 4"	12' 4"	11' 1"	19' 3"	17' 11"	15' 8"

"e" Web stiffeners required at supports.

Raleigh, NC : Phone (919) 845-1025
Las Vegas, NV : Phone (702) 643-4330
Toll Free Nationwide Phone (888) 474-4876
www.steelnetwork.com

INTERIOR ROOM WALLS

- MINIMUM ASCE 7-10 WIND LOADS = 16psf ULTIMATE (1.0W) – CONSERVATIVE TO ASSUME FOR INTERIOR BLDG WALLS ← USE
- TSN METAL STUD MANUAL (SHT I-36) IS BASED ON IBC 2003 & ASCE 7-02 ~ D+0.75L + 0.75W$_{MWRFS}$ (STRENGTH) ← 0.75×10psf MIN = 7.5psf
  0.7W$_{C\&C}$ (DEFLECTION) ← UNFACTORED LOADS
- TO BE CONSERVATIVE, WE WILL USE ULTIMATE (FACTORED) ASCE 7-10 MINIMUM WIND LOAD IN THESE EQUATIONS, ULTIMATE MIN 16psf ≈ 15psf TABLE-STUDS
  ASCE 7-10 D+0.75L+(0.75×0.6)W ← (0.75×0.6×16psf) = 7.2psf
  0.6D+0.6W ← LOAD COMBINATIONS COMPARE TO ASCE 7-02

→ 0.75×15psf = 11.25psf > 7.5psf (METAL STUD DESIGN – ASCE 7-02)
> 7.2psf (" " " – ASCE 7-10)

- TOTAL DEAD LOAD = 1.0DL = [(10psf CEILING × 1.33 FT O/C) + 1.89#/FT] × 10.75 FT O/ / 2
  = 81.8#/FT + [(8psf WALL DL × 10 FT TALL × 1.33 FT O/C) + (1.5#/FT STUD DL × 10 FT)]
  = 203.4# ↓
- TOTAL LIVE LOAD = 50psf × 1.33 FT O/C × 10.75 FT O/ / 2 = 358.2# ↓
  → TOTAL LOAD = 1.0D+1.0L = 0.563K
- REF SHT I-38 COMBINED AXIAL & LATERAL LOAD DESIGN EXAMPLE FOR THIS PROJECTS WALL SPECIFIC CALCS

~USE 362S162-43 (33ksi) WALL STUDS

I-38

COMBINED AXIAL AND LATERAL LOAD TABLE NOTES

- Allowable loads are based on specified weak axis and torsional bracing at 48" o.c. maximum for axial load calculation and continuous support of each flange for flexural calculation.
- Sections are punched with a standard punchout 1.5" wide, located on the centerline of the web 24" o.c.
- Allowable loads are based on a punched section for axial load calculation, and an unpunched section for flexural calculation as per *ICC-ES AC46-Appendix B.*
- Weak axis and torsional bracing should have sufficient stiffness and strength to resist axial load.
- Lateral load is multiplied by 0.75 for strength determination and by 0.70 for deflection determination. Axial load is not multiplied by any factor (Load factor = 1.0)
- Strength increase due to cold forming is incorporated in calculating allowable loads as per *AISI Specification Sec. A7.2.*
- Check lateral end reactions for web crippling if applicable.
- Loads in tables are in kips/stud.

TABLE BACKGROUND AND EXAMPLE

1. Basis for Tables:

The combined axial and lateral load tables in this catalog cover the following basic load combinations for the Allowable Stress Design (ASD) Method (IBC2003 and ASCE 7-02):

- D + L (Strength determination)
- D + 0.75L + $0.75W_{MWFRS^*}$ (Strength determination)
- $0.70W_{C\&C^{**}}$ (Deflection determination)

* MWFRS: Main Wind Force Resisting System
** C&C: Component and Cladding

2. Design Example:

Given:

Service (Un-factored) Loads:

Axial Dead Load	= ~~1.6 kips~~ 0.204K
Axial Live Load	= ~~3.2 kips~~ 0.359K
Wind Pressure (MWFRS)	= ~~20~~ psf 15 psf
Wind Pressure (C&C)	= ~~40~~ psf 15 psf
Wall Width	= ~~6.0"~~ 4"
Stud Height	= ~~12.0 ft.~~ 10 ft
Stud Spacing	= 16" o.c. ✓
Specified Deflection Limit	= L/600 ✓

Bridging (Lateral Bracing) at maximum vertical spacing of 48" o.c. ✓

Calculations:

a) Use the D + L load combination to get the first estimate of the stud.

Combination total axial load = ~~1.6 + 3.2~~
= ~~4.8 kips~~ 0.563K

From the "No Lateral Load" table with a ~~12.0'~~ 10' wall height, choose ~~600S162-54 (50ksi)~~ (362 43 33) with an axial resistance of ~~5.62~~ 2.64K kips > ~~4.8~~ 0.563K kips OK ✓

b) Check the D + 0.75L + $0.75W_{MWFRS}$ load combination for strength.

Combination total axial load = ~~1.6 + 0.75(3.2)~~
= ~~4.0 kips~~ 0.473K

Go to the "Lateral Load = ~~20~~ 15 psf" table with a ~~12.0'~~ 10' wall height and 16" stud spacing. The axial resistance for ~~600S162-54 (50ksi)~~ 362 43 33 is ~~4.44~~ 1.73K kips > ~~4.0~~ 0.473K kips OK ✓

c) Check the $0.70W_{C\&C}$ load combination for deflection. The specified limit is L/600.

Go to the "Lateral Load = ~~40~~ 15 psf" table with a ~~12.0'~~ 10' wall height and 16" stud spacing. The deflection parameter for ~~600S162-54 (50ksi)~~ 362 43 33 is X (nothing), which means that deflection ~~exceeds~~ is less than L/720 < L/600 OK ✓

Conclusion:

Use ~~600~~ 362S162-54 (50ksi) (with design thickness = 0.0566" and Fy = 50 ksi) spaced at 16" o.c. with 2 lines of bridging arranged so that the maximum spacing does not exceed 48" (4 ft.). ✓

3. Extra Design Considerations:

a) Check lateral end reaction of the stud for web crippling using the Web Crippling Load Tables included in this catalog.

b) If the specified axial dead load acting on the stud is significantly larger than the specified axial live load, the following extra basic load combination needs to be checked as well:

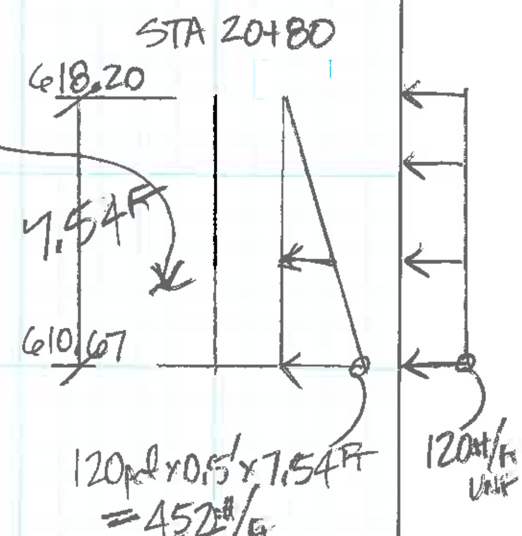
- D + $W_{C\&C}$ (Strength determination)

There are no special tables for this load combination. However, you can still use the same tables by <u>scaling up</u> the $W_{C\&C}$ wind pressure value (use the table that corresponds to the scaled-up wind pressure) and then compare the table's axial resistance to the specified dead load.

ARCADIS	SUBJECT: TOPOCK CA – AREA 7 RETAINING WALL
JOB NO:	
BY: MSL	DATE: 10/27/15
CHKD:	DATE:
PAGE J-1	SHEET 1

AREA 7 RETAINING WALL

- REF SHT J-2 FOR RETAINING WALL GRADE & J-3 FOR RETAINING WALL CROSS SECTION.
- REF SHT J-4 & J-5 FOR RETAINING WALL DESIGN SPREADSHEETS
- WALL REBAR



- $V_{UNF} = W + wl = 1704^{\#} + 905^{\#} = 2609^{\#}$
- $M_{UNF} = \frac{wl}{3} + \frac{wl^2}{2} = (4.28 + 3.41)^{K\text{-}FT} = 7.69^{K\text{-}FT}$
- USE 10" thick wall ~ $d = 10" - 2"\text{COVER} - 5/16" = 7.7"$
- $\phi V_C = 2\phi\sqrt{f'_c}\,bd = 8.17^K > V_{ACI} = 2.61^K \times 1.6_{ACI} = 4.17^K$ ✓OK
- $R = M_u / \phi b d^2 = 230.6 \rightarrow \rho = 0.0040 \rightarrow A_s = 0.37\ IN^2/FT$

  ~ USE #5 @ 10" O/C ($A_s = 0.37\ IN^2/FT$)

~ACI 318 10.6.4 SPACING CHECK ~ $f_s = \frac{M_{unf}}{7/8\, d A_s} = 37.0$ KSI

- $S_{MAX} = \frac{540}{f_s} - 2.5C_c = 9.6" \rightarrow$ USE #5 @ 9" O/C VERT OF ($C_c = 2"$)

~ACI 318 T&S ~ $A_{S\,REQ'D} = \frac{0.0018\,bh}{2\ FACES} = 0.11\ IN^2/FT$ ($b = 12$, $h = 10$)

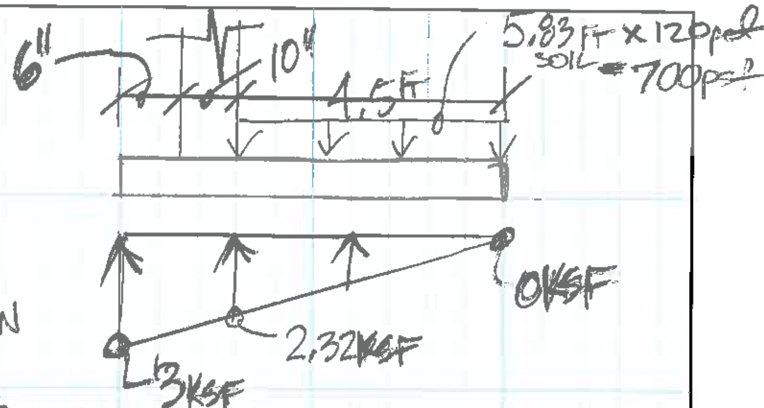
~USE #5 @ 12" O/C EF HORIZ & IF VERT ($A_s = 0.31\ IN^2/FT$)

AGM Form 30 12-01

ARCADIS

SUBJECT: TOPOK, CA – AREA 7 RETAINING WALL
BY: MSL DATE: 10/27/15
PAGE J-1A
CHKD: DATE:
SHEET 1
JOB NO:

BASE SLAB DESIGN



BOT STL → CONSERVATIVE LOADING DIAGRAM

d = 1'-0" – 3" COVER – 6/16" = 8.6 IN

• $M_{UNF} = \frac{W\ell}{3} = \frac{(2.32KSF \times 4.92FT \times 0.5) \times 4.92FT}{3} = 9.36^{K\text{-}FT}$

• $V_{UNF} = W = 5.71^{K}$

• $\phi V_c = 2\phi\sqrt{f'_c}\,bd = 9.79^K > V_{ACI} = 5.71^K \times 1.6_{ACI} = 9.14^K$ ✓OK

• $R = M_u/\phi bd^2 = 224.9 \rightarrow \rho = 0.0039 \rightarrow A_s = 0.40\ IN^2/FT$

~~#5@9" o/c BOT (A_s=0.41 IN²/FT)~~

~ ACI 318 10.6.4 SPACING ~ $f_s = 36.41$ ksi, $S_{MAX} = 7.33$ IN

~ USE #5@8" o/c BOT (A_s=0.46 IN²/FT) ~ $\ell_{dh} = \left(\frac{0.02\beta\lambda f_y}{\sqrt{f'_c}}\right) d_b \times 0.7 = 8.3\text{IN} < \ell_{dh} = 8.6"$ PROV WALL VERTS

• ACI 318 T&S → $A_{S\,REQ'D} = \frac{0.0018bh}{2\ FACES} = 0.13\ IN^2/FT$

~ USE #5@12" o/c (A_s=0.31 IN²/FT)

$< \ell_{dh\,PROV} = 13"$ TOP STL ✓OK

TOP STL ~ 4.92 FT CANTILEVER w/ (3' + 5.83' SOIL) × 120pcf = 1060 psf

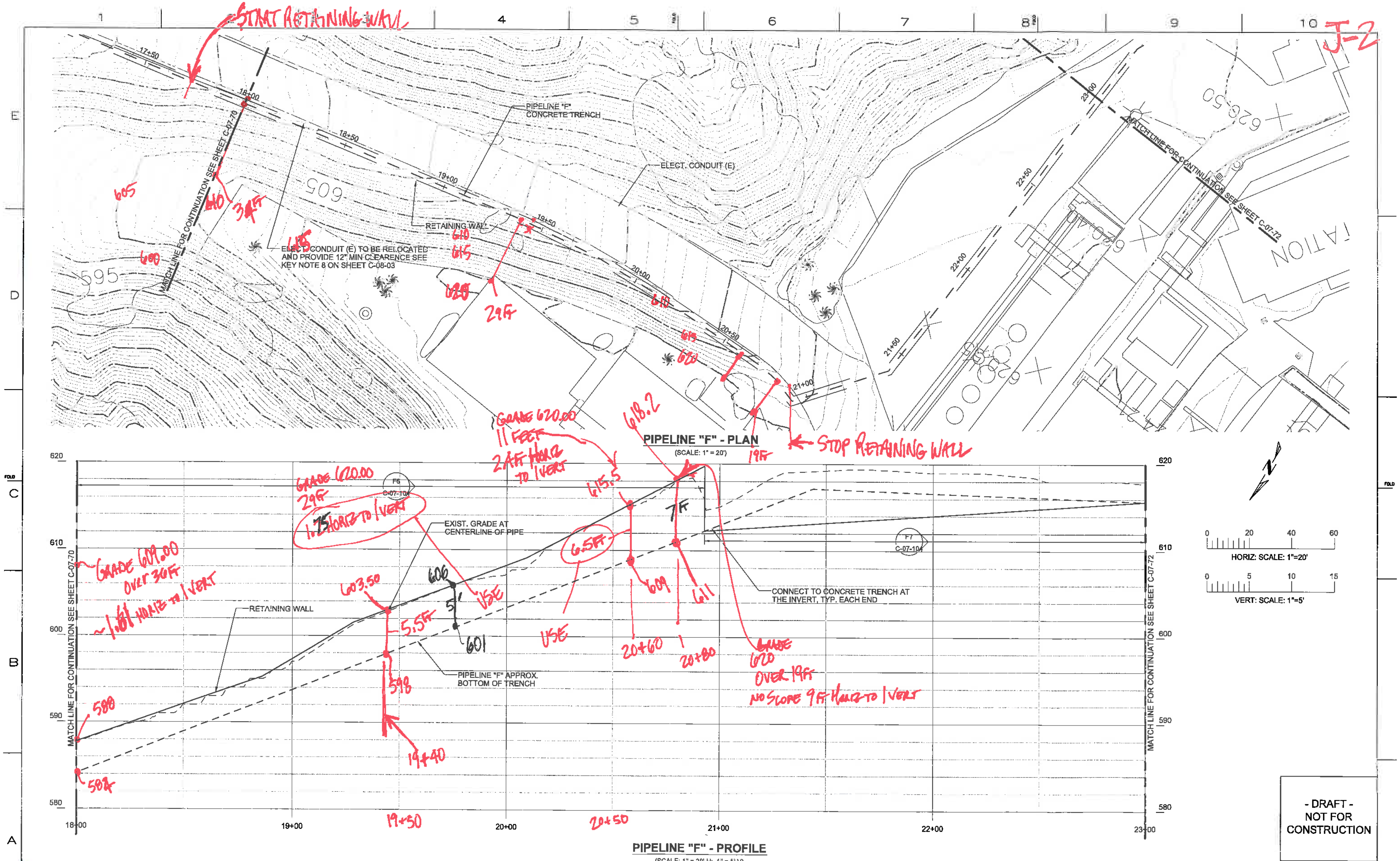
• $M_{UNF} = w\ell^2/2 = 12.83^{K\text{-}FT}$

• $V_{UNF} = w\ell = 5.22^K$

• $\phi V_c \Rightarrow d = 9.6" = 10.93^K > V_{ACI} = 5.22^K \times 1.6_{ACI} = 8.35^K$ ✓OK

• $R = M_u/\phi bd^2 = 247.5 \Rightarrow \rho = 0.0043 \Rightarrow A_s = 0.50\ IN^2/FT \rightarrow$ USE #5@7" o/c

~ NO NEED TO CHECK ACI 318 10.6.4 ...



- DRAFT -
NOT FOR CONSTRUCTION

ETIC ENGINEERING

ARCADIS

NO.	DATE	DESCRIPTION					
1	9/8/14	PRE-FINAL (90%) DESIGN					
0	4/5/13	INTERMEDIATE (60%) DESIGN					

REVISIONS

SO	XXXXX
SUPV	PD
DSGN	GO
DWN	LD
CHKD	JM
OK	PD
DATE	9/8/14
SCALES	1" = 20'-0"

TOPOCK GROUNDWATER REMEDIATION PROJECT
PLAN AND PROFILE
PIPELINE "F"
STA 18+00 TO STA 23+00
GAS TRANSMISSION & DISTRIBUTION
PACIFIC GAS AND ELECTRIC COMPANY
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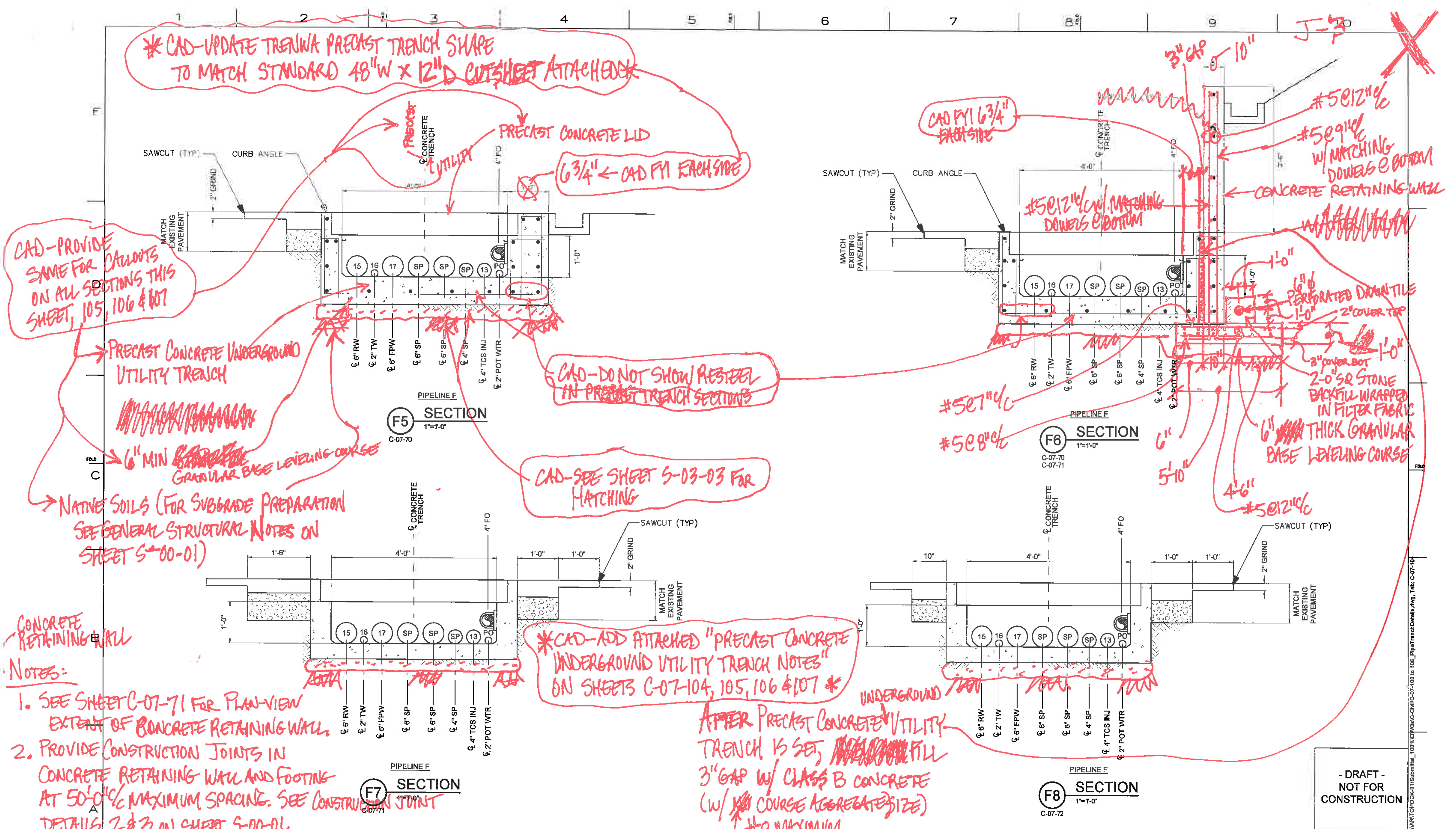
SHEET NO. C-07-71
REV 1



- DRAFT -
NOT FOR CONSTRUCTION

ETIC ENGINEERING | ARCADIS

NO.	DATE	DESCRIPTION	GM/SPEC	DWN	CHKD	SUPV	APVD BY
1	9/8/14	PRE-FINAL (90%) DESIGN					
0	4/5/13	INTERMEDIATE (60%) DESIGN					

REVISIONS

SUPV	PD
DSGN	TL
DWN	TL
CHKD	JM
OK	PD
DATE	9/8/14
SCALES	1" = 1'-0"

TOPOCK GROUNDWATER REMEDIATION PROJECT

PIPELINE SECTIONS

GAS TRANSMISSION & DISTRIBUTION
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SAN FRANCISCO, CALIFORNIA

SHEET NO. C-07-104 REV 1

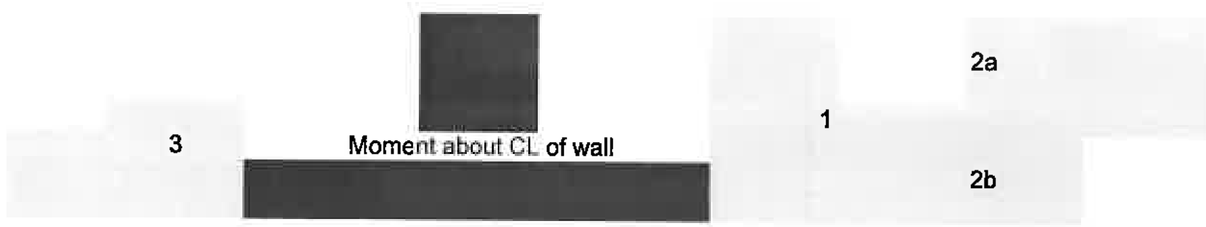
TO JA/JB 10/27/15

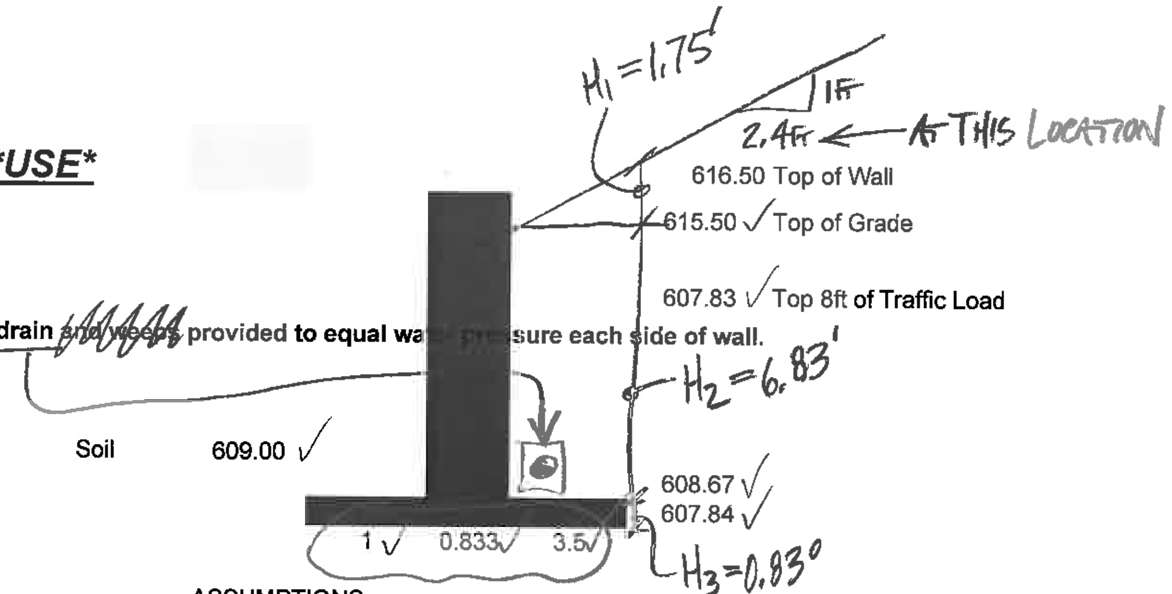
J-4

Topok CA - Area 7 - Site Retaining Wall at Station 20+60 - Section 1 - *USE* Backfill with Traffic*

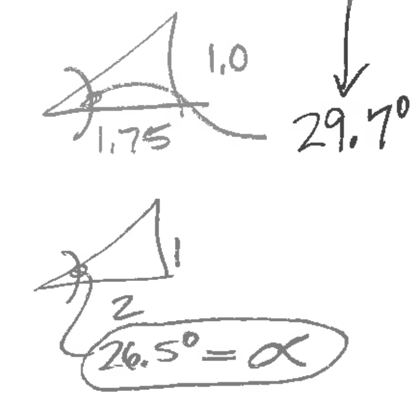
** Conservative to assume traffic since back of hillside but ok*

No need to analyze water level since drain and weeps provided to equal water pressure each side of wall.





ϕ - 32 TO 35° ~ SAND & SILT



ASSUMPTIONS:

ASSSUME SAND BKFL ON OPP SIDE

y=	120	PCF	** Conservative b/c geotech says 120*
y CONC=	150	PCF	
y water =	62.4	PCF	
LAT dry =	60.0		
LAT wet =	96.2		
y rock =	100.0	PCF	*conservative*

LOADS:

1 LAT dry * HEIGHT OF WALL(FT) * 1(FT) SECTION
459.8 LBS / FT

2 Traffic = 2ft Soil * 0.5 * y Soil
120 LBS / FT ** Equivalent to 2ft of surcharge load for first 8ft, then 1ft from their down*

3 LAT dry * HEIGHT OF WALL(FT) * 1(FT) SECTION
70.0 LBS / FT

Ka =	0.3	Kr =	0.5
Kp =	3.0		

			FS Over	FS Sliding	Max Bearing ksf	Min Bearing ksf
1.50	0.83	3.00	1.64	0.63	2.04	-0.48
1.00	0.83	3.50	1.68	0.68	2.26	-0.56
0.50	0.83	4.00	1.70	0.73	2.53	-0.67

H1 = (TRIANGULAR SOIL CONDITION) HEIGHT OF WALL / 3
H1 = 2.554 ✓ FT

H2a= Soil Height / 2
H2a= 3.83 ✓ FT

H2b= Soil Height / 2
H2b= 0.00 FT

H3 = (TRIANGULAR SOIL CONDITION) HEIGHT OF WALL / 3
H3 = 0.389 ✓ FT

W/ HILLSIDE LOADS

$H' = H_1 + H_2 + H_3 = 9.4167^{FT}$

PER FT OF WALL →

$P_R = \frac{1}{2}\gamma(H'^2)(K_r) = 2.66^K$

$P_V = P_r \sin\alpha = 1.187^K$

$P_h = P_r \cos\alpha = 2.38^K + 0.92^K_{H2b\ TRAFFIC} = 3.3^K$ ←

$160^{\#} \times 0.88^{FT}$

$M_0 = [P_h(H'/3)] + (P_{2A} + H_{2A}) - (P_3 \times H_3) = 7.396 + 3.52 - 0.14 = 10.78^{K\text{-}FT}$

SAFETY FACTOR AGAINST OVERTURNING:

OVERTURNING MOMENT						
	FORCE	MOMENT ARM		MOMENT	
H1	1/2 * HEIGHT OF WALL(FT) * LOAD 1 (K/FT) 1761.6 LBS ✓	2.554	FT	4.50	K*FT
H2a	HEIGHT OF WALL(FT) * LOAD 2 (K/FT) 920.4 LBS ✓	3.828	FT	3.52	K*FT
H2b	HEIGHT OF WALL(FT) * LOAD 2 (K/FT) -0.4 LBS	-0.003	FT	0.00	K*FT
H3	1/2 * HEIGHT OF WALL(FT) * LOAD 3 (K/FT) 40.8 LBS	0.389	FT	0.02	K*FT
TOTAL				8.01	K*FT

RIGHTING MOMENT					
FORCE		MOMENT ARM		MOMENT	
W1	HEIGHT OF WALL(FT) * THICKNESS OF WALL(FT) * γCONC (PCF) * 1(FT) SECTION 978.3585 ✓ LBS	1.42	FT	1.39	K*FT
W2	WIDTH OF FTG(FT) * THICKNESS OF FTG(FT) * γCONC (PCF) * 1(FT) SECTION 666.35835 ✓ LBS	2.67	FT	1.78	K*FT
W3	HEIGHT OF WALL(FT) * WIDTH OF ROCK ON FTG(FT) * γ (PCF) * 1(FT) SECTION 39.96 LBS	0.50	FT	0.02	K*FT
W4	HEIGHT OF WALL(FT) * WIDTH OF SOIL ON FTG(FT) * γ (PCF) * 1(FT) SECTION 2868.6 ✓ LBS	3.58	FT	10.28	K*FT
TOTAL	ΣW = 4553.3#			13.46	K*FT

→ 10.78 K·FT w/ HILLSIDE ~ FS = 1.25 ✓ OK

W3 (sketch) — 2.67′
1.5FT + 0.33′ + 0.83′
= 2.67′ × 120 pcf × 0.5
= 160#
HAVE 1.5FT OF SOIL PUSHING BACK

SF AGAINST OVERTURNING = 1.68 ← CONSERVATIVE B/C HAVE 18" SOIL ON LEFT SIDE OF TRENCH TO PROVIDE LATERAL RESISTANCE

SAFETY FACTOR AGAINST SLIDING: u = 0.35 on granular fill

		Consider Active Earth Resisting Force
FORCE CAUSING SLIDING =	2682 LBS ✓	2682 LBS ✓
RESISTING FORCE = uRv =	1634.433577 LBS	1813.895 LBS ← 1593# ← (uΣW)
SF AGAINST SLIDING =	0.61	0.68

+ [(3 − 0.3) × 120 pcf × 2.67FT] × 2.67FT × 0.5 = 1052#

ΣResisting = 2745# < 3.33K w/ TRAFFIC — NO GOOD
FS = 0.82 w/ TRAFFIC
> 2.38K NO TRAFFIC
FS = 1.15 ← NO GOOD W/O TRAFFIC

USE 10"W × 1′-6" KEY
→ RESISTING
• 4.167FT × 120 pcf × (3 − 0.3) = 1350 psf
• (4.167FT × 0.5 × 2813 (1350 psf) + 1593# +
(10" WIDE × 1.5FT TALL × 150 pcf × 0.35u) 68#
+ (0.83′W × 1.5′ KEY × 150 pcf × 0.35u) 65#
= 4.54K 1703.5 VNF

← SLIDING
• P_R = 3.57K
• P_h = 3.20K + (8′ × 120 pcf)
= 4.16K ← TOO CONSERVATIVE
FS = 1.09 w/ TRAFFIC
FS = 1.42 < 1.5 w/o TRAFFIC

✱ USE 2′-0" DEEP KEYWAY × 10" THICK TO GET FS = 1.5

NO GOOD ~ TOO MUCH CONCRETE, EXTRA STEP ~ IN ADDITION TO 1′/0.83′/3.5

CHECK FTG PRESSURES:

q = (P/A)+(My/I)
2.26 KSF

q = (P/A)−(My/I)
−0.56 KSF ← NO GOOD

P = SUM F	P=	4.55327685 K ✓	P/A =	0.85
A = 1*WIDTH OF FTG	A =	5.333 FT2 ✓	M/S=	1.41
MOMENT about CL =		6.69 K*FT	qmax =	2.53
y = 1/2 * WIDTH OF FTG	y =	2.6665 FT ✓		
I = (1/12)*B*H^3	I =	12.63960509 FT^4 ✓		

$M_{ABOUT\ \mathcal{C}}$ = 8.01 K·FT + 0.00 + 1.167 − (2868# × 0.9167FT)
= 6.65 K·FT

e = M/P = 1.46FT

fp × 1FT × 0.5 × [3 × (2.67′ − 1.46′)] = 4.55K (3.62FT)

fp = 2.51 KSF ≮ 2 KSF NET ALLOWABLE

+ [(615.5 + 607.84) × 110 pcf] 843 psf

= 2.84 KSF GROSS ALLOW. ✓ OK

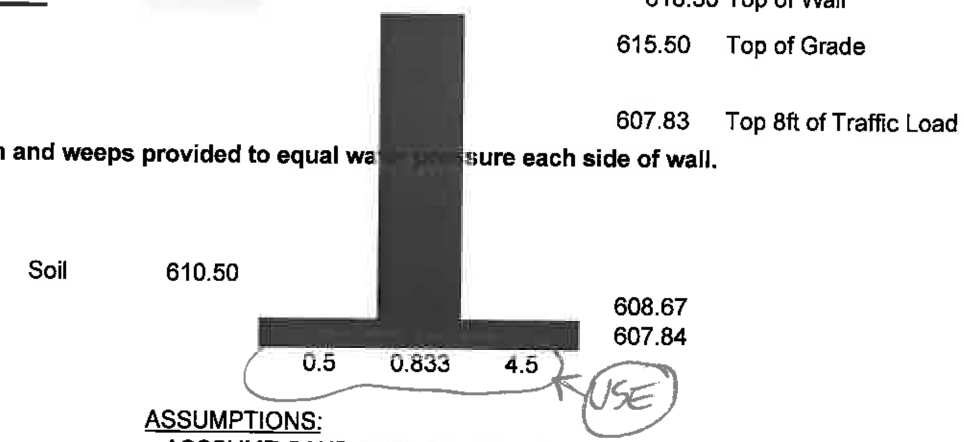
J-4A

CONTROLS

Topok CA - Area 7 - Site Retaining Wall at Station 20+60 - Section 1 - *USE* Backfill with Traffic*

** Conservative to assume traffic since back of hillside but ok*

No need to analyze water level since drain and weeps provided to equal wa[illegible]sure each side of wall.



LOADS:

1 LAT dry * HEIGHT OF WALL(FT) * 1(FT) SECTION
459.8 LBS / FT

2 Traffic = 2ft Soil * 0.5 * y Soil
120 LBS / FT **** Equivalent to 2ft of surcharge load for first 8ft, then 1ft from their down***

3 LAT dry * HEIGHT OF WALL(FT) * 1(FT) SECTION
160.0 LBS / FT

H1 = (TRIANGULAR SOIL CONDITION) HEIGHT OF WALL / 3
H1 = 2.554 FT

H2a= Soil Height / 2
H2a= 3.83 FT

H2b= Soil Height / 2
H2b= 0.00 FT

H3 = (TRIANGULAR SOIL CONDITION) HEIGHT OF WALL / 3
H3 = 0.889 FT

SAFETY FACTOR AGAINST OVERTURNING:

OVERTURNING MOMENT					
FORCE		MOMENT ARM		MOMENT	
H1	1/2 * HEIGHT OF WALL(FT) * LOAD 1 (K/FT) 1761.6 LBS	2.554	FT	4.50	K*FT
H2a	HEIGHT OF WALL(FT) * LOAD 2 (K/FT) 920.4 LBS	3.828	FT	3.52	K*FT
H2b	HEIGHT OF WALL(FT) * LOAD 2 (K/FT) -0.4 LBS	-0.003	FT	0.00	K*FT
H3	1/2 * HEIGHT OF WALL(FT) * LOAD 3 (K/FT) 213.2 LBS	0.889	FT	0.19	K*FT
TOTAL				7.83	K*FT

ASSUMPTIONS:

ASSSUME SAND BKFL ON OPP SIDE

y=	120	PCF	** Conservative b/c geotech says 120*
y CONC=	150	PCF	
y water =	62.4	PCF	
LAT dry =	60.0		
LAT wet =	96.2		
y rock =	100.0	PCF	*conservative*

Ka = 0.3 Kr = 0.5
Kp = 3.0

			FS Over	FS Sliding	Max Bearing ksf	Min Bearing ksf
1.50	0.83	3.00	1.64	0.63	2.04	-0.48
1.00	0.83	3.50	1.68	0.68	2.26	-0.56
0.50	0.83	4.00	1.70	0.73	2.53	-0.67
5.25	0.83	0.50	1.77	0.87	1.21	-0.19
1.00	0.83	4.00	2.07	1.11	2.10	-0.31
0.50	0.83	4.50	2.08	1.15	2.29	-0.40

W3  W4

RIGHTING MOMENT		
FORCE	MOMENT ARM	MOMENT
W1 HEIGHT OF WALL(FT) * THICKNESS OF WALL(FT) * yCONC (PCF) * 1(FT) SECTION 978.3585 LBS	0.92 FT	0.90 K*FT
W2 WIDTH OF FTG(FT) * THICKNESS OF FTG(FT) * yCONC (PCF) * 1(FT) SECTION 728.83335 LBS	2.92 FT	2.13 K*FT
W3 HEIGHT OF WALL(FT) * WIDTH OF ROCK ON FTG(FT) * y (PCF) * 1(FT) SECTION 109.98 LBS	0.25 FT	0.03 K*FT
W4 HEIGHT OF WALL(FT) * WIDTH OF SOIL ON FTG(FT) * y (PCF) * 1(FT) SECTION 3688.2 LBS	3.58 FT	13.21 K*FT
TOTAL 5505.3719		**16.26** K*FT

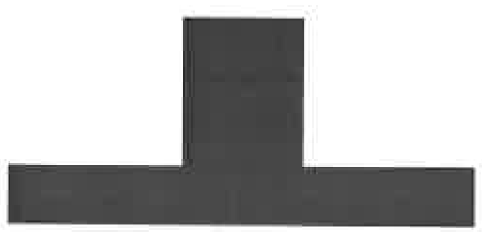
SF AGAINST OVERTURNING = 2.08

SAFETY FACTOR AGAINST SLIDING: u = 0.35 on granular fill

		Consider Active Earth Resisting Force
FORCE CAUSING SLIDING =	2682 LBS	2682 LBS
RESISTING FORCE = uRv =	2140.106827 LBS	3078.3042 LBS
SF AGAINST SLIDING =	0.80	1.15

× 0.35 = u → 1927# + ([2.67FT × 120pcf × (3-0.3)] × 2.67' × 0.5) [1152#] + (2'T × 4'W × 0.5 × 120pcf × 0.35u) [168#]
= 3247# ≈ 3.3K w/ TRAFFIC = FS = 1.0
> 2.38K w/o TRAFFIC
FS = 1.36 > 1.25 √OK

CHECK FTG PRESSURES:



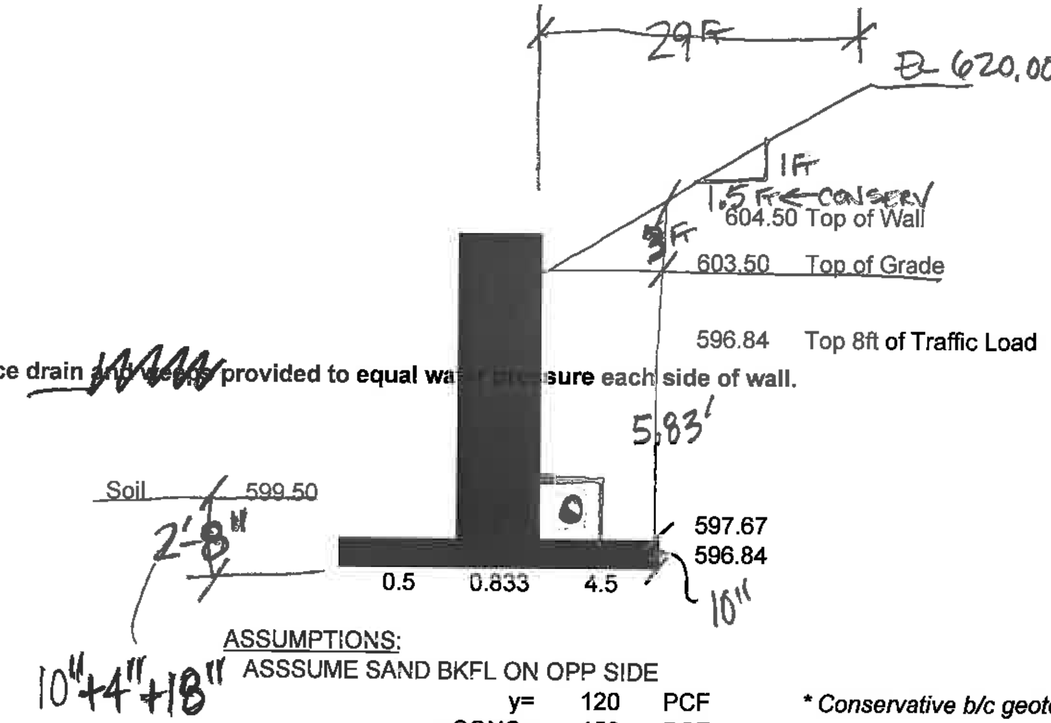
q = (P/A)+(My/I)
2.29 KSF

q = (P/A)-(My/I)
-0.40 KSF

P = SUM F	P=	5.50537185 K	P/A =	0.94
A = 1*WIDTH OF FTG	A =	5.833 FT2	M/S=	1.34
MOMENT about CL =		7.63 K*FT	qmax =	2.40
y = 1/2 * WIDTH OF FTG	y =	2.9165 FT		
I = (1/12)*B*H^3	I =	16.53844538 FT^4		

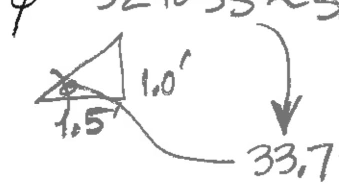
Topok CA - Area 7 - Site Retaining Wall at Station 19+40 - Section 2
Backfill with Traffic*

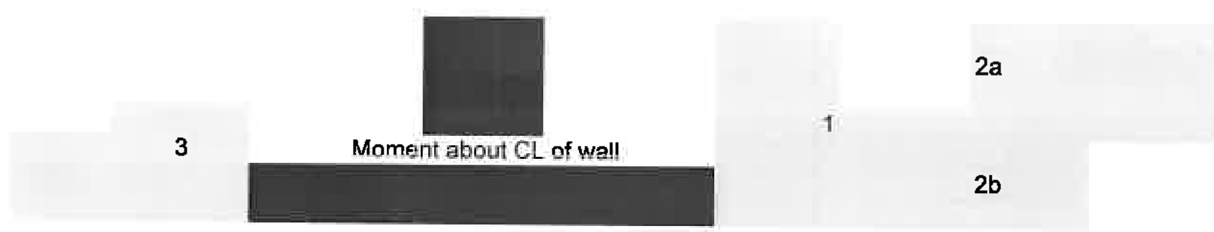
** Conservative to assume traffic since back of hillside but ok*



No need to analyze water level since drain and weeps provided to equal water pressure each side of wall.

ϕ = 32 TO 35° ~ SAND & SILT





ASSUMPTIONS:

ASSSUME SAND BKFL ON OPP SIDE

y=	120	PCF	** Conservative b/c geotech says 120*
y CONC=	150	PCF	
y water =	62.4	PCF	
LAT dry =	60.0		
LAT wet =	96.2		
y rock =	100.0	PCF	*conservative*

LOADS:

1. LAT dry * HEIGHT OF WALL(FT) * 1(FT) SECTION
   399.8 LBS / FT
2. Traffic = 2ft Soil * 0.5 * y Soil
   120 LBS / FT **** Equivalent to 2ft of surcharge load for first 8ft, then 1ft from their down***
3. LAT dry * HEIGHT OF WALL(FT) * 1(FT) SECTION
   160.0 LBS / FT

Ka = 0.3 Kr = 0.5
Kp = 3.0

				FS Over	FS Sliding	Max Bearing ksf	Min Bearing ksf
4.83	1.50	0.83	2.50	1.68	0.64	1.73	-0.38
4.83	1.00	0.83	3.00	1.73	0.69	1.93	-0.44
4.83	0.50	0.83	3.50	1.75	0.75	2.17	-0.55
From Sta 20+60	1.00	0.83	4.50	2.62 ✓	1.34 ✓	1.77 ✓	-0.11 ✓

H1 = (TRIANGULAR SOIL CONDITION) HEIGHT OF WALL / 3
H1 = 2.221 FT

H2a= Soil Height / 2
H2a= 3.33 FT

H2b= Soil Height / 2
H2b= 0.00 FT

H3 = (TRIANGULAR SOIL CONDITION) HEIGHT OF WALL / 3
H3 = 0.889 FT

SAFETY FACTOR AGAINST OVERTURNING:

OVERTURNING MOMENT					
	FORCE	MOMENT ARM		MOMENT	
H1	1/2 * HEIGHT OF WALL(FT) * LOAD 1 (K/FT) 1331.9 LBS	2.221	FT	2.96	K*FT
H2a	HEIGHT OF WALL(FT) * LOAD 2 (K/FT) 799.6 LBS	3.332	FT	2.66	K*FT
H2b	HEIGHT OF WALL(FT) * LOAD 2 (K/FT) 0.0 LBS	0.000	FT	0.00	K*FT
H3	1/2 * HEIGHT OF WALL(FT) * LOAD 3 (K/FT) 213.2 LBS	0.889	FT	0.19	K*FT
TOTAL				5.43	K*FT

W/ HILLSIDE LOADS

$H' = H_1 + H_2 + H_3 = 9.67'$

PER FT OF WALL →

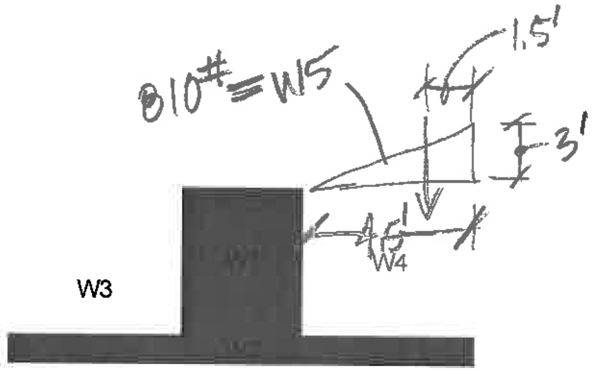
$P_R = \frac{1}{2}\gamma (H'^2)(K_r) = 2.805^K$

$P_V = P_R \sin\alpha = 1.556^K$

$P_h = P_r \cos\alpha = 2.33^K + (120\#/ft \times 8 ft) = 3.29^K$ (960# TRAFFIC)

$M_0 = [P_h (H'/3)] + [P_{2A} + H_{2A}] - [P_3 \times H_3] =$ (2.33; 7.51 K/FT; 5.44 K/FT; 5.67 FT; 142.2# /FT)

$= 13.09$ K/FT



RIGHTING MOMENT		
FORCE	MOMENT ARM	MOMENT
W1 HEIGHT OF WALL(FT) * THICKNESS OF WALL(FT) * yCONC (PCF) * 1(FT) SECTION 853.4085 LBS	0.92 FT	0.78 K*FT
W2 WIDTH OF FTG(FT) * THICKNESS OF FTG(FT) * yCONC (PCF) * 1(FT) SECTION 728.83335 LBS	2.92 FT	2.13 K*FT
W3 HEIGHT OF WALL(FT) * WIDTH OF ROCK ON FTG(FT) * y (PCF) * 1(FT) SECTION 109.98 LBS	0.25 FT	0.03 K*FT
W4 HEIGHT OF WALL(FT) * WIDTH OF SOIL ON FTG(FT) * y (PCF) * 1(FT) SECTION 3148.2 LBS	3.58 FT	11.28 K*FT
W5 810#	4.33 FT	3.51
TOTAL ΣW = 5650#		~~14.22~~ 17.73 K*FT > 13.09 K-FT ~ FS = 1.35 ✓ OK

SF AGAINST OVERTURNING = 2.62 ✓

SAFETY FACTOR AGAINST SLIDING: u = 0.35 on granular fill

		Consider Active Earth Resisting Force
FORCE CAUSING SLIDING =	2131 LBS	2131 LBS
RESISTING FORCE = uRv =	1907.374327 LBS	2845.5717 LBS
SF AGAINST SLIDING =	0.89	1.34 ✓

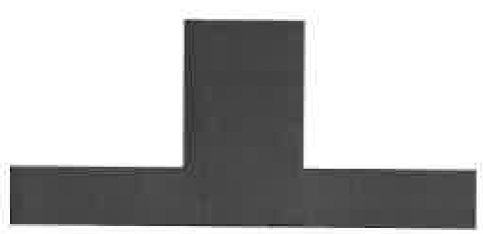
× 0.35 u = 1978# + ([(3 − 0.3) × 120 pcf × 2.67 FT] × 2.67 FT × 0.5) (1154#)

= 3131# ≈ 3290# TRAFFIC ~ FS = 0.95

→ 2330# w/o TRAFFIC

→ FS = 1.34

CHECK FTG PRESSURES:



q = (P/A)+(My/I) 1.77 KSF ✓

q = (P/A)-(My/I) -0.11 KSF ✓

~ USE 1'-0" THICK FTG FOR EXTRA DL & SLIDING RESISTANCE → OVERTURNING

P = SUM F	P =	4.84042185 K	P/A =	0.83
A = 1*WIDTH OF FTG	A =	5.833 FT2	M/S=	0.94
	MOMENT about CL =	5.33 K*FT	qmax =	1.78
y = 1/2 * WIDTH OF FTG	y =	2.9165 FT		
I = (1/12)*B*H^3	I =	16.53844538 FT^4		

Final (100%) Design Submittal for the Final Groundwater Remedy
PG&E Topock Compressor Station
Needles, California

Structural Calculations
(for Attached Table of Contents)

11/18/2015

Prepared for:

Pacific Gas and Electric Company

Prepared and Reviewed by:

Matthew Lotycz
Project Structural Engineer
Arcadis, U.S., Inc.

REGISTERED PROFESSIONAL ENGINEER
MATTHEW S. LOTYCZ
C81650
EXP. 9/30/17
CIVIL
STATE OF CALIFORNIA
11/18/15

ARCADIS Design & Consultancy for natural and built assets

MARQUEE

FIRE PROTECTION

LICENSED FIRE PROTECTION CONTRACTOR
MARQUEE FIRE PROTECTION ENGINEERING
CLASSIFICATION
C-16
LICENSE No.
570970
STATE OF CALIFORNIA

Marquee Fire Protection
710 West Stadium Lane
Sacramento, CA 95843
916-641-7997

Job Name	:	TOPOCK CARBON AMENDMENT BUILDING
Drawing	:	MW-20 BENCH
Location	:	NEEDLES, CA
Remote Area	:	ONE
Contract	:	1814-695
Data File	:	PGE AREA 1.WXF

Hydraulic Design Information Sheet

Name - TOPOCK CARBON AMENDMENT BUILDING Date - 10-14-15
Location - NEEDLES, CA
Building - MW-20 BENCH System No. - ONE
Contractor - ETIC ENGINEERING Contract No. - 1814-695
Calculated By - T. HINTZ Drawing No. - FP-2
Construction: ( ) Combustible (X) Non-Combustible Ceiling Height - VARIES
Occupancy -

SYSTEM DESIGN

(X) NFPA 13 ( ) Lt. Haz. Ord.Haz.Gp. ( ) 1 (X) 2 ( ) Ex.Haz.
( ) NFPA 231 ( ) NFPA 231C ( ) Figure Curve
Other
Specific Ruling Made By Date

Area of Sprinkler Operation - 1500		System Type	Sprinkler/Nozzle
Density	- 0.2	(X) Wet	Make VIKING
Area Per Sprinkler	- 124	( ) Dry	Model MFAST
Elevation at Highest Outlet	- 11.25	( ) Deluge	Size 1/2"
Hose Allowance - Inside	-	( ) Preaction	K-Factor 5.6
Rack Sprinkler Allowance	-	( ) Other	Temp.Rat.200
Hose Allowance - Outside	- 250		

Note

Calculation Summary: Flow Required - 433.026 Press Required - 40.11 At BOR
C-Factor Used: 120 Overhead N/A Underground

WATER SUPPLY

Water Flow Test:	Pump Data:	Tank or Reservoir:
Date of Test -		Cap. -
Time of Test -	Rated Cap.-	Elev.-
Static Press -	@ Press -	
Residual Press -	Elev. -	Well
Flow -		Proof Flow
Elevation -		

Location -

Source of Information -

COMM STORAGE

Commodity Class Location
Storage Ht. Area Aisle W.
Storage Method: Solid Piled % Palletized % Rack

RACK

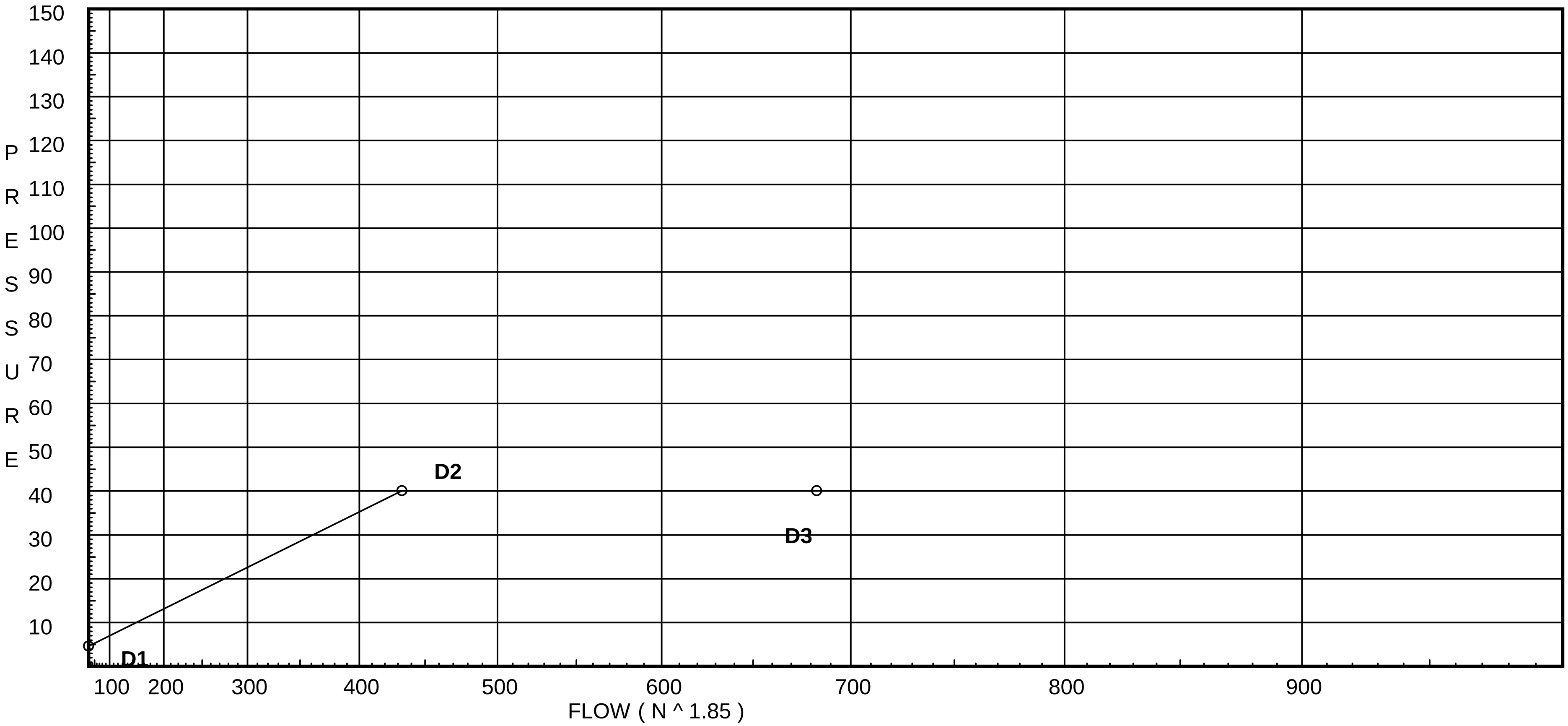
( ) Single Row ( ) Conven. Pallet ( ) Auto. Storage ( ) Encap.
( ) Double Row ( ) Slave Pallet ( ) Solid Shelf ( ) Non
( ) Mult. Row ( ) Open Shelf

Flue Spacing Clearance:Storage to Ceiling
Longitudinal Transverse

Horizontal Barriers Provided:

Demand:

D1 - Elevation	: 4.656
D2 - System Flow	: 433.026
D2 - System Pressure	: 40.110
Hose (Demand)	: 250
D3 - System Demand	: 683.026
Safety Margin	: ________



Fittings Used Summary

Fitting Legend

Abbrev.	Name	½	¾	1	1¼	1½	2	2½	3	3½	4	5	6	8	10	12	14	16	18	20	24
B	NFPA 13 Butterfly Valve	0	0	0	0	0	6	7	10	0	12	9	10	12	19	21	0	0	0	0	0
E	NFPA 13 90' Standard Elbow	1	2	2	3	4	5	6	7	8	10	12	14	18	22	27	35	40	45	50	61
T	NFPA 13 90' Flow thru Tee	3	4	5	6	8	10	12	15	17	20	25	30	35	50	60	71	81	91	101	121

Unit Summary

Diameter Units	Inches
Length Units	Feet
Flow Units	US Gallons per Minute
Pressure Units	Pounds per Square Inch

Note: Fitting Legend provides equivalent pipe lengths for fittings types of various diameters. Equivalent lengths shown are standard for actual diameters of Sched 40 pipe and CFactors of 120 except as noted with *. The fittings marked with a * show equivalent lengths values supplied by manufacturers based on specific pipe diameters and CFactors and they require no adjustment. All values for fittings not marked with a * will be adjusted in the calculation for CFactors of other than 120 and diameters other than Sched 40 per NFPA.

Pressure / Flow Summary - STANDARD

Node No.	Elevation	K-Fact	Pt Actual	Pn	Flow Actual	Density	Area	Press Req.
S9	11.25	5.6	19.61	na	24.8	0.2	124	7.0
S8	11.25	5.6	21.36	na	25.88	0.2	124	7.0
S7	11.25	5.6	23.08	na	26.9	0.2	124	7.0
R3	11.25		25.18	na				
M3	9.5		29.23	na				
M2	9.5		29.88	na				
M1	9.5		30.84	na				
TOR1	9.5		32.76	na				
BOR1	0.5		40.11	na	250.0			
S3	11.25	5.6	20.8	na	25.54	0.2	98	7.0
S2	11.25	5.6	22.64	na	26.65	0.2	98	7.0
S1	11.25	5.6	24.46	na	27.69	0.2	98	7.0
R1	11.25		26.64	na				
M5	9.5		28.68	na				
M4	9.5		28.76	na				
S6	11.25	5.6	20.15	na	25.14	0.2	53	7.0
S5	11.25	5.6	21.94	na	26.23	0.2	53	7.0
S4	11.25	5.6	23.7	na	27.26	0.2	53	7.0
R2	11.25		25.78	na				
S13	11.25	5.6	16.8	na	22.95	0.2	111	7.0
S12	11.25	5.6	18.27	na	23.93	0.2	111	7.0
S11	11.25	5.6	19.72	na	24.87	0.2	111	7.0
S10	11.25	5.6	22.9	na	26.8	0.2	111	7.0
R4	11.25		25.0	na				
S17	11.25	5.6	16.74	na	22.91	0.2	111	7.0
S16	11.25	5.6	18.21	na	23.9	0.2	111	7.0
S15	11.25	5.6	19.65	na	24.83	0.2	111	7.0
S14	11.25	5.6	22.82	na	26.75	0.2	111	7.0
R5	11.25		24.92	na				

The maximum velocity is 17.13 and it occurs in the pipe between nodes S1 and R1

Node1 to Node2	Elev1 Elev2	K Fact	Qa Qt	Nom Act	Fitting or Eqv.	Ln.	Pipe Ftng's Total	CFact Pf/Ft	Pt Pe Pf	******* Notes ******
*EQUIVALENT K'S										
*REMOTE HEAD TO SUPPLY										
S9	11.25	5.60	24.80	1		0.0	9.000	120	19.612	
to						0.0	0.0		0.0	
S8	11.25		24.8	1.049		0.0	9.000	0.1938	1.744	Vel = 9.21
S8	11.25	5.60	25.88	1.25		0.0	9.000	120	21.356	
to						0.0	0.0		0.0	
S7	11.25		50.68	1.38		0.0	9.000	0.1911	1.720	Vel = 10.87
S7	11.25	5.60	26.90	1.25	E	3.0	2.000	120	23.076	
to						0.0	3.000		0.0	
R3	11.25		77.58	1.38		0.0	5.000	0.4202	2.101	Vel = 16.64
R3	11.25		0.0	1.25	T	6.0	1.833	120	25.177	
to						0.0	6.000		0.758	
M3	9.5		77.58	1.38		0.0	7.833	0.4203	3.292	Vel = 16.64
M3	9.5		196.94	3		0.0	9.833	120	29.227	
to						0.0	0.0		0.0	
M2	9.5		274.52	3.26		0.0	9.833	0.0662	0.651	Vel = 10.55
M2	9.5		78.62	3		0.0	9.083	120	29.878	
to						0.0	0.0		0.0	
M1	9.5		353.14	3.26		0.0	9.083	0.1054	0.957	Vel = 13.57
M1	9.5		79.89	3	E	9.408	3.125	120	30.835	
to						0.0	9.408		0.0	
TOR1	9.5		433.03	3.26		0.0	12.533	0.1538	1.927	Vel = 16.64
TOR1	9.5		0.0	3	B	13.44	9.000	120	32.762	
to						0.0	13.440		3.898	
BOR1	0.5		433.03	3.26		0.0	22.440	0.1537	3.450	Vel = 16.64
			250.00							Qa = 250.00
BOR1			683.03						40.110	K Factor = 107.85
*NEW PATH										
S3	11.25	5.60	25.54	1		0.0	9.000	120	20.800	
to						0.0	0.0		0.0	
S2	11.25		25.54	1.049		0.0	9.000	0.2046	1.841	Vel = 9.48
S2	11.25	5.60	26.65	1.25		0.0	9.000	120	22.641	
to						0.0	0.0		0.0	
S1	11.25		52.19	1.38		0.0	9.000	0.2018	1.816	Vel = 11.19
S1	11.25	5.60	27.69	1.25	E	3.0	1.920	120	24.457	
to						0.0	3.000		0.0	
R1	11.25		79.88	1.38		0.0	4.920	0.4437	2.183	Vel = 17.13
R1	11.25		0.0	1.25	T	6.0	1.750	120	26.640	
to						0.0	6.000		0.758	
M1	9.5		79.88	1.38		0.0	7.750	0.4435	3.437	Vel = 17.13
			0.0							
M1			79.88						30.835	K Factor = 14.39
*NEW PATH										
M5	9.5		98.39	3		0.0	9.000	120	28.675	
to						0.0	0.0		0.0	
M4	9.5		98.39	3.26		0.0	9.000	0.0099	0.089	Vel = 3.78

Node1 to Node2	Elev1 Elev2	K Fact	Qa Qt	Nom Act	Fitting or Eqv.	Ln.	Pipe Ftng's Total	CFact Pf/Ft	Pt Pe Pf	******* Notes ******
M4	9.5		98.55	3		0.0	12.917	120	28.764	
to						0.0	0.0		0.0	
M3	9.5		196.94	3.26		0.0	12.917	0.0358	0.463	Vel = 7.57
			0.0							
M3			196.94						29.227	K Factor = 36.43
*NEW PATH										
S6	11.25	5.60	25.14	1		0.0	9.000	120	20.148	
to						0.0	0.0		0.0	
S5	11.25		25.14	1.049		0.0	9.000	0.1987	1.788	Vel = 9.33
S5	11.25	5.60	26.22	1.25		0.0	9.000	120	21.936	
to						0.0	0.0		0.0	
S4	11.25		51.36	1.38		0.0	9.000	0.1959	1.763	Vel = 11.02
S4	11.25	5.60	27.27	1.25	E	3.0	1.833	120	23.699	
to						0.0	3.000		0.0	
R2	11.25		78.63	1.38		0.0	4.833	0.4308	2.082	Vel = 16.87
R2	11.25		0.0	1.25	T	6.0	1.750	120	25.781	
to						0.0	6.000		0.758	
M2	9.5		78.63	1.38		0.0	7.750	0.4308	3.339	Vel = 16.87
			0.0							
M2			78.63						29.878	K Factor = 14.39
*NEW PATH										
S13	11.250	5.60	22.95	1		0.0	8.750	120	16.799	
to						0.0	0.0		0.0	
S12	11.25		22.95	1.049		0.0	8.750	0.1679	1.469	Vel = 8.52
S12	11.25	5.60	23.94	1.25		0.0	8.750	120	18.268	
to						0.0	0.0		0.0	
S11	11.25		46.89	1.38		0.0	8.750	0.1655	1.448	Vel = 10.06
S11	11.25	5.60	24.86	1.25		0.0	8.750	120	19.716	
to						0.0	0.0		0.0	
S10	11.25		71.75	1.38		0.0	8.750	0.3637	3.182	Vel = 15.39
S10	11.25	5.60	26.80	1.5	E	4.0	2.792	120	22.898	
to						0.0	4.000		0.0	
R4	11.25		98.55	1.61		0.0	6.792	0.3089	2.098	Vel = 15.53
R4	11.25		0.0	1.5	T	8.0	1.750	120	24.996	
to						0.0	8.000		0.758	
M4	9.5		98.55	1.61		0.0	9.750	0.3087	3.010	Vel = 15.53
			0.0							
M4			98.55						28.764	K Factor = 18.38
*NEW PATH										
S17	11.250	5.60	22.91	1		0.0	8.750	120	16.743	
to						0.0	0.0		0.0	
S16	11.25		22.91	1.049		0.0	8.750	0.1674	1.465	Vel = 8.50
S16	11.25	5.60	23.90	1.25		0.0	8.750	120	18.208	
to						0.0	0.0		0.0	
S15	11.25		46.81	1.38		0.0	8.750	0.1650	1.444	Vel = 10.04
S15	11.25	5.60	24.83	1.25		0.0	8.750	120	19.652	
to						0.0	0.0		0.0	
S14	11.25		71.64	1.38		0.0	8.750	0.3626	3.173	Vel = 15.37

Final Calculations - Hazen-Williams

Node1 to Node2	Elev1 Elev2	K Fact	Qa Qt	Nom Act	Fitting or Eqv.	Ln.	Pipe Ftng's Total	CFact Pf/Ft	Pt Pe Pf	******* Notes ******
S14	11.25	5.60	26.75	1.5	E	4.0	2.792	120	22.825	
to						0.0	4.000		0.0	
R5	11.25		98.39	1.61		0.0	6.792	0.3079	2.091	Vel = 15.51
R5	11.25		0.0	1.5	T	8.0	1.750	120	24.916	
to						0.0	8.000		0.758	
M5	9.5		98.39	1.61		0.0	9.750	0.3078	3.001	Vel = 15.51
			0.0							
M5			98.39						28.675	K Factor = 18.37

MARQUEE

FIRE PROTECTION

LICENSED FIRE PROTECTION CONTRACTOR
MARQUEE FIRE PROTECTION ENGINEERING
CLASSIFICATION
C–16
LICENSE No.
570970
STATE OF CALIFORNIA

Marquee Fire Protection
710 West Stadium Lane
Sacramento, CA 95843
916-641-7997

Job Name	:	PGE-OPERATIONS BLDG
Drawing	:	TRANSWESTERN BENCH
Location	:	NEEDLES, CA
Remote Area	:	ONE
Contract	:	1814-695
Data File	:	PGE-OPERATION Area 1.WXF

Hydraulic Design Information Sheet

Name - TOPOCK OPERATIONS BUILDING   Date - 10-14-15
Location - NEEDLES, CA
Building - TRANSWESTERN BENCH   System No. - ONE
Contractor - ETIC ENGINEERING   Contract No. - 1814-695
Calculated By - T. HINTZ   Drawing No. - FP-2
Construction: (X) Combustible ( ) Non-Combustible   Ceiling Height - VARIES
Occupancy -

SYSTEM DESIGN

(X) NFPA 13 (X) Lt. Haz. Ord.Haz.Gp. (X) 1 ( ) 2 ( ) Ex.Haz.
( ) NFPA 231 ( ) NFPA 231C ( ) Figure Curve
Other
Specific Ruling   Made By   Date

Area of Sprinkler Operation	- 1500	System Type	Sprinkler/Nozzle
Density	- .10/.15	(X) Wet	Make VIKING
Area Per Sprinkler	- 148	( ) Dry	Model MFAST
Elevation at Highest Outlet	- 17.91	( ) Deluge	Size 1/2"
Hose Allowance - Inside	-	( ) Preaction	K-Factor 5.6
Rack Sprinkler Allowance	-	( ) Other	Temp.Rat.200
Hose Allowance - Outside	- 250		

Note

Calculation Summary

Flow Required - 428.91 Press Required - 40.187 At BOR
C-Factor Used: 120 Overhead N/A Underground

WATER SUPPLY

Water Flow Test:	Pump Data:	Tank or Reservoir:
Date of Test -		Cap. -
Time of Test -	Rated Cap.-	Elev.-
Static Press -	@ Press -	
Residual Press -	Elev. -	Well
Flow -		Proof Flow
Elevation -		

Location -

Source of Information -

COMMODITY

Commodity   Class   Location
Storage Ht.   Area   Aisle W.
Storage Method: Solid Piled % Palletized % Rack

STORAGE RACK

( ) Single Row	( ) Conven. Pallet	( ) Auto. Storage	( ) Encap.
( ) Double Row	( ) Slave Pallet	( ) Solid Shelf	( ) Non
( ) Mult. Row		( ) Open Shelf	

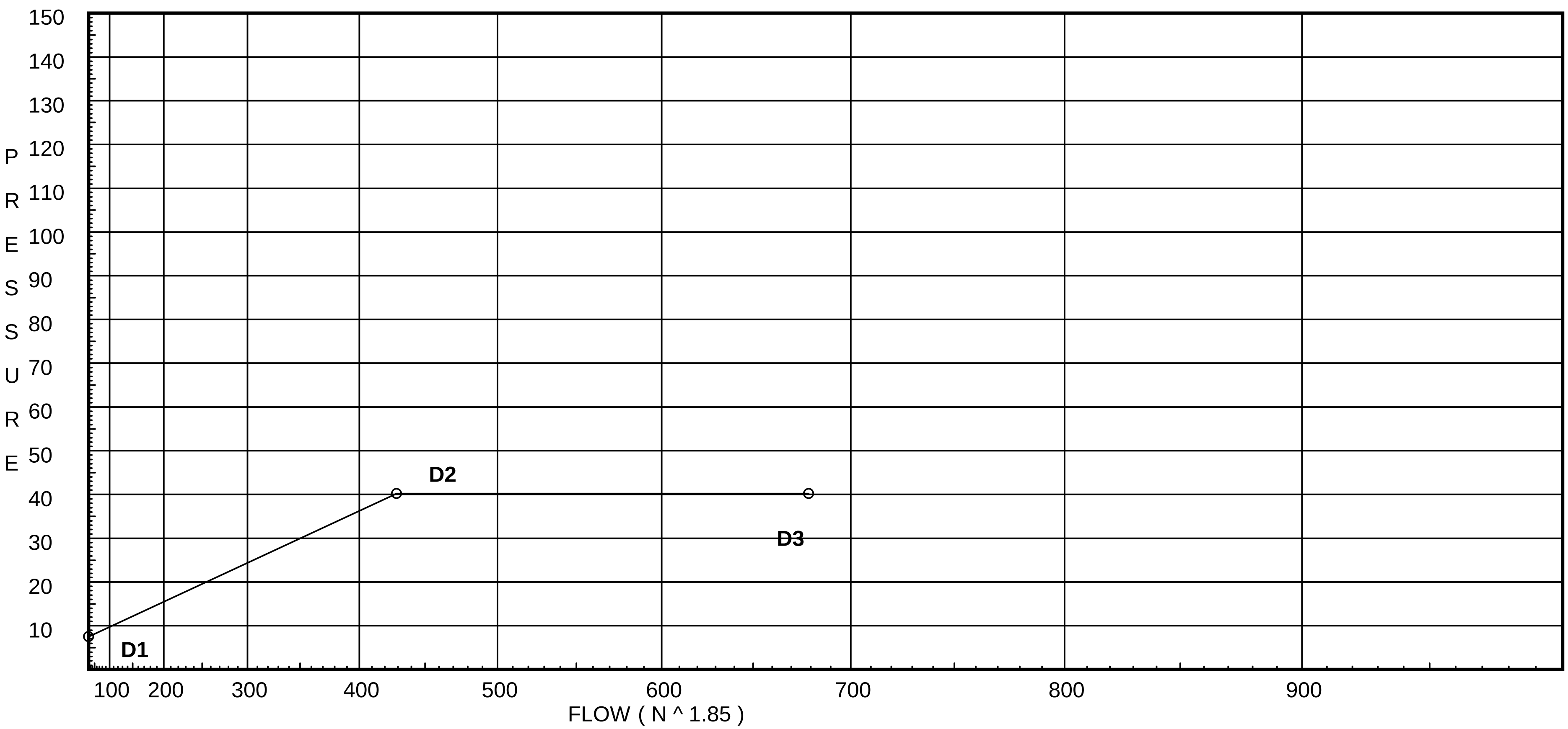
Flue Spacing   Clearance:Storage to Ceiling
Longitudinal   Transverse

Horizontal Barriers Provided:

Water Supply Curve C

Demand:

D1 - Elevation	: 7.540
D2 - System Flow	: 428.907
D2 - System Pressure	: 40.187
Hose (Demand)	: 250
D3 - System Demand	: 678.907
Safety Margin	: ________



Fittings Used Summary

Marquee Fire Protection
PGE-OPERATIONS BLDG

Fitting Legend

Abbrev.	Name	½	¾	1	1¼	1½	2	2½	3	3½	4	5	6	8	10	12	14	16	18	20	24
B	NFPA 13 Butterfly Valve	0	0	0	0	0	6	7	10	0	12	9	10	12	19	21	0	0	0	0	0
E	NFPA 13 90' Standard Elbow	1	2	2	3	4	5	6	7	8	10	12	14	18	22	27	35	40	45	50	61
T	NFPA 13 90' Flow thru Tee	3	4	5	6	8	10	12	15	17	20	25	30	35	50	60	71	81	91	101	121

Unit Summary

Diameter Units	Inches
Length Units	Feet
Flow Units	US Gallons per Minute
Pressure Units	Pounds per Square Inch

Note: Fitting Legend provides equivalent pipe lengths for fittings types of various diameters. Equivalent lengths shown are standard for actual diameters of Sched 40 pipe and CFactors of 120 except as noted with *. The fittings marked with a * show equivalent lengths values supplied by manufacturers based on specific pipe diameters and CFactors and they require no adjustment. All values for fittings not marked with a * will be adjusted in the calculation for CFactors of other than 120 and diameters other than Sched 40 per NFPA.

Node No.	Elevation	K-Fact	Pt Actual	Pn	Flow Actual	Density	Area	Press Req.
DP01	7.5	5.6	7.0	na	14.82	0.1	46	7.0
EQ01	16.36		3.97	na				
S8	17.91	5.6	7.0	na	14.82	0.1	69	7.0
9	16.36		8.24	na				
S10	14.7	5.6	9.74	na	17.48	0.1	78	7.0
R5	14.42		10.76	na				
M5	12.5		13.23	na				
M6	12.5		13.35	na				
M7	12.5		13.61	na				
M8	12.5		13.82	na				
M12	10.58		23.8	na				
M13	10.58		24.89	na				
M14	10.58		27.82	na				
TOR	10.58		32.27	na				
BOR	0.5		40.19	na	250.0			
S9	16.36	K = K @ EQ01	7.4	na	20.21			
S5	17.4	5.6	9.08	na	16.88	0.1	91	7.0
6	14.88		11.35	na				
R3	14.42		12.06	na				
M3	12.5		13.67	na				
S6	14.88	5.6	10.73	na	18.34	0.15	104	7.0
S1	16.94	5.6	9.28	na	17.06	0.1	57	7.0
S2	14.88	5.6	11.15	na	18.7	0.15	91	7.0
R1	14.42		11.88	na				
M1	12.5		13.51	na				
M2	12.5		13.55	na				
S11	16.77	5.6	9.28	na	17.06	0.1	70	7.0
S12	14.71	5.6	11.15	na	18.7	0.15	78	7.0
R6	14.42		11.72	na				
S3	16.42	5.6	9.76	na	17.49	0.1	19	7.0
4	14.88		11.2	na				
R2	14.42		11.92	na				
S4	14.88	5.6	10.48	na	18.13	0.15	104	7.0
S13	16.26	5.6	9.9	na	17.62	0.1	32	7.0
S14	14.71	5.6	11.35	na	18.87	0.15	78	7.0
R7	14.42		11.94	na				
S7	14.85	5.6	10.94	na	18.52	0.1	95	7.0
R4	14.42		11.59	na				
M4	12.5		13.22	na				
S16	12.59	5.6	18.75	na	24.25	0.1	64	7.0
S17	11.99	5.6	20.49	na	25.35	0.1	64	7.0
R10	11.76		21.7	na				
M10	10.58		23.53	na				
M11	10.58		23.67	na				
S19	12.59	5.6	19.89	na	24.97	0.1	62	7.0
S20	11.99	5.6	21.71	na	26.09	0.1	63	7.0
R13	11.76		22.99	na				
S15	12.1	5.6	20.31	na	25.24	0.1	86	7.0
R9	11.76		21.77	na				
M9	10.58		23.51	na				
S18	11.94	5.6	20.91	na	25.61	0.1	55	7.0
R11	11.76		21.88	na				
S21	12.1	5.6	24.16	na	27.53	0.1	86	7.0
R14	11.76		25.86	na				

The maximum velocity is 25.23 and it occurs in the pipe between nodes M14 and TOR

Node1 to Node2	Elev1 Elev2	K Fact	Qa Qt	Nom Act	Fitting or Eqv.	Ln.	Pipe Ftng's Total	CFact Pf/Ft	Pt Pe Pf	******* Notes ******
*EQUIVALENT K'S										
DP01	7.500	5.60	14.82	1	E	2.0	8.860	120	7.000	
to						0.0	2.000		-3.837	
EQ01	16.36		14.82	1.049		0.0	10.860	0.0747	0.811	Vel = 5.50
			0.0							
EQ01			14.82						3.974	K Factor = 7.43
*REMOTE HEAD TO SUPPLY										
S8	17.91	5.60	14.82	1		0.0	7.560	120	7.000	
to						0.0	0.0		0.671	
9	16.36		14.82	1.049		0.0	7.560	0.0747	0.565	Vel = 5.50
9	16.36		20.21	1.25		0.0	8.140	120	8.236	
to						0.0	0.0		0.719	
S10	14.7		35.03	1.38		0.0	8.140	0.0966	0.786	Vel = 7.51
S10	14.7	5.60	17.48	1.25	E	3.0	1.410	120	9.741	
to						0.0	3.000		0.121	
R5	14.42		52.51	1.38		0.0	4.410	0.2041	0.900	Vel = 11.26
R5	14.42		0.0	1.25	T	6.0	2.000	120	10.762	
to						0.0	6.000		0.832	
M5	12.5		52.51	1.38		0.0	8.000	0.2040	1.632	Vel = 11.26
M5	12.5		18.52	2.5		0.0	8.230	120	13.226	
to						0.0	0.0		0.0	
M6	12.5		71.03	2.635		0.0	8.230	0.0153	0.126	Vel = 4.18
M6	12.5		35.75	2.5		0.0	7.800	120	13.352	
to						0.0	0.0		0.0	
M7	12.5		106.78	2.635		0.0	7.800	0.0326	0.254	Vel = 6.28
M7	12.5		36.50	2.5		0.0	3.740	120	13.606	
to						0.0	0.0		0.0	
M8	12.5		143.28	2.635		0.0	3.740	0.0559	0.209	Vel = 8.43
M8	12.5		106.60	2.5	2T	32.948	25.410	120	13.815	
to						0.0	32.948		0.832	
M12	10.58		249.88	2.635		0.0	58.358	0.1568	9.148	Vel = 14.70
M12	10.58		100.43	2.5		0.0	3.740	120	23.795	
to						0.0	0.0		0.0	
M13	10.58		350.31	2.635		0.0	3.740	0.2930	1.096	Vel = 20.61
M13	10.58		51.07	2.5		0.0	7.780	120	24.891	
to						0.0	0.0		0.0	
M14	10.58		401.38	2.635		0.0	7.780	0.3767	2.931	Vel = 23.61
M14	10.58		27.53	2.5		0.0	10.440	120	27.822	
to						0.0	0.0		0.0	
TOR	10.58		428.91	2.635		0.0	10.440	0.4259	4.446	Vel = 25.23
TOR	10.58		0.0	3	B	13.44	10.080	120	32.268	
to						0.0	13.440		4.366	
BOR	0.5		428.91	3.26		0.0	23.520	0.1511	3.553	Vel = 16.49
			250.00							Qa = 250.00
BOR			678.91						40.187	K Factor = 107.10
*NEW PATH										
S9	16.36	7.43	20.21	1	T	5.0	1.333	120	7.396	K = K @ EQ01
to						0.0	5.000		0.0	
9	16.36		20.21	1.049		0.0	6.333	0.1326	0.840	Vel = 7.50

Node1 to Node2	Elev1 Elev2	K Fact	Qa Qt	Nom Act	Fitting or Eqv.	Ln.	Pipe Ftng's Total	CFact Pf/Ft	Pt Pe Pf	******* Notes ******
			0.0							
9			20.21						8.236	K Factor = 7.04
*NEW PATH										
S5	17.4	5.60	16.88	1		0.0	12.350	120	9.082	
to						0.0	0.0		1.091	
6	14.88		16.88	1.049		0.0	12.350	0.0951	1.174	Vel = 6.27
6	14.88		18.34	1.25	E	3.0	2.260	120	11.347	
to						0.0	3.000		0.199	
R3	14.42		35.22	1.38		0.0	5.260	0.0975	0.513	Vel = 7.55
R3	14.42		0.0	1.25	T	6.0	2.000	120	12.059	
to						0.0	6.000		0.832	
M3	12.5		35.22	1.38		0.0	8.000	0.0974	0.779	Vel = 7.55
M3	12.5		71.38	2.5		0.0	4.480	120	13.670	
to						0.0	0.0		0.0	
M8	12.5		106.6	2.635		0.0	4.480	0.0324	0.145	Vel = 6.27
			0.0							
M8			106.60						13.815	K Factor = 28.68
*NEW PATH										
S6	14.88	5.60	18.34	1	T	5.0	0.590	120	10.727	
to						0.0	5.000		0.0	
6	14.88		18.34	1.049		0.0	5.590	0.1109	0.620	Vel = 6.81
			0.0							
6			18.34						11.347	K Factor = 5.44
*NEW PATH										
S1	16.94	5.60	17.06	1		0.0	10.120	120	9.280	
to						0.0	0.0		0.892	
S2	14.88		17.06	1.049		0.0	10.120	0.0970	0.982	Vel = 6.33
S2	14.88	5.60	18.70	1.25	E	3.0	2.260	120	11.154	
to						0.0	3.000		0.199	
R1	14.42		35.76	1.38		0.0	5.260	0.1004	0.528	Vel = 7.67
R1	14.42		0.0	1.25	T	6.0	2.000	120	11.881	
to						0.0	6.000		0.832	
M1	12.5		35.76	1.38		0.0	8.000	0.1001	0.801	Vel = 7.67
M1	12.5		0.0	2.5		0.0	7.910	120	13.514	
to						0.0	0.0		0.0	
M2	12.5		35.76	2.635		0.0	7.910	0.0043	0.034	Vel = 2.10
M2	12.5		35.62	2.5		0.0	7.880	120	13.548	
to						0.0	0.0		0.0	
M3	12.5		71.38	2.635		0.0	7.880	0.0155	0.122	Vel = 4.20
			0.0							
M3			71.38						13.670	K Factor = 19.31
*NEW PATH										
S11	16.77	5.60	17.06	1		0.0	10.120	120	9.276	
to						0.0	0.0		0.892	
S12	14.71		17.06	1.049		0.0	10.120	0.0969	0.981	Vel = 6.33
S12	14.71	5.60	18.69	1.25	E	3.0	1.430	120	11.149	
to						0.0	3.000		0.126	
R6	14.42		35.75	1.38		0.0	4.430	0.1002	0.444	Vel = 7.67

Node1 to Node2	Elev1 Elev2	K Fact	Qa Qt	Nom Act	Fitting or Eqv.	Ln.	Pipe Ftng's Total	CFact Pf/Ft	Pt Pe Pf	******* Notes ******
R6	14.42		0.0	1.25	T	6.0	2.000	120	11.719	
to						0.0	6.000		0.832	
M6	12.5		35.75	1.38		0.0	8.000	0.1001	0.801	Vel = 7.67
			0.0							
M6			35.75						13.352	K Factor = 9.78
*NEW PATH										
S3	16.42	5.60	17.49	1		0.0	7.590	120	9.760	
to						0.0	0.0		0.667	
4	14.88		17.49	1.049		0.0	7.590	0.1016	0.771	Vel = 6.49
4	14.88		18.13	1.25	E	3.0	2.260	120	11.198	
to						0.0	3.000		0.199	
R2	14.42		35.62	1.38		0.0	5.260	0.0994	0.523	Vel = 7.64
R2	14.42		0.0	1.25	T	6.0	2.000	120	11.920	
to						0.0	6.000		0.832	
M2	12.5		35.62	1.38		0.0	8.000	0.0995	0.796	Vel = 7.64
			0.0							
M2			35.62						13.548	K Factor = 9.68
*NEW PATH										
S4	14.88	5.60	18.13	1	T	5.0	1.640	120	10.477	
to						0.0	5.000		0.0	
4	14.88		18.13	1.049		0.0	6.640	0.1086	0.721	Vel = 6.73
			0.0							
4			18.13						11.198	K Factor = 5.42
*NEW PATH										
S13	16.26	5.60	17.62	1		0.0	7.590	120	9.902	
to						0.0	0.0		0.671	
S14	14.71		17.62	1.049		0.0	7.590	0.1030	0.782	Vel = 6.54
S14	14.71	5.60	18.87	1.25	E	3.0	1.430	120	11.355	
to						0.0	3.000		0.126	
R7	14.42		36.49	1.38		0.0	4.430	0.1038	0.460	Vel = 7.83
R7	14.42		0.0	1.25	T	6.0	2.000	120	11.941	
to						0.0	6.000		0.832	
M7	12.5		36.49	1.38		0.0	8.000	0.1041	0.833	Vel = 7.83
			0.0							
M7			36.49						13.606	K Factor = 9.89
*NEW PATH										
S7	14.85	5.60	18.52	1	E	2.0	2.120	120	10.943	
to						0.0	2.000		0.186	
R4	14.42		18.52	1.049		0.0	4.120	0.1129	0.465	Vel = 6.88
R4	14.42		0.0	1	T	5.0	2.000	120	11.594	
to						0.0	5.000		0.832	
M4	12.5		18.52	1.049		0.0	7.000	0.1129	0.790	Vel = 6.88
M4	12.5		0.0	2.5		0.0	7.790	120	13.216	
to						0.0	0.0		0.0	
M5	12.5		18.52	2.635		0.0	7.790	0.0013	0.010	Vel = 1.09
			0.0							
M5			18.52						13.226	K Factor = 5.09

Node1 to Node2	Elev1 Elev2	K Fact	Qa Qt	Nom Act	Fitting or Eqv.	Ln.	Pipe Ftng's Total	CFact Pf/Ft	Pt Pe Pf	******* Notes ******
*NEW PATH										
S16	12.59	5.60	24.25	1		0.0	7.970	120	18.748	
to						0.0	0.0		0.260	
S17	11.99		24.25	1.049		0.0	7.970	0.1857	1.480	Vel = 9.00
S17	11.99	5.60	25.35	1.25	E	3.0	3.070	120	20.488	
to						0.0	3.000		0.100	
R10	11.76		49.6	1.38		0.0	6.070	0.1837	1.115	Vel = 10.64
R10	11.76		0.0	1.25	T	6.0	1.180	120	21.703	
to						0.0	6.000		0.511	
M10	10.58		49.6	1.38		0.0	7.180	0.1836	1.318	Vel = 10.64
M10	10.58		25.23	2.5		0.0	7.880	120	23.532	
to						0.0	0.0		0.0	
M11	10.58		74.83	2.635		0.0	7.880	0.0169	0.133	Vel = 4.40
M11	10.58		25.61	2.5		0.0	4.480	120	23.665	
to						0.0	0.0		0.0	
M12	10.58		100.44	2.635		0.0	4.480	0.0290	0.130	Vel = 5.91
			0.0							
M12			100.44						23.795	K Factor = 20.59
*NEW PATH										
S19	12.59	5.60	24.97	1		0.0	7.970	120	19.887	
to						0.0	0.0		0.260	
S20	11.99		24.97	1.049		0.0	7.970	0.1962	1.564	Vel = 9.27
S20	11.99	5.60	26.10	1.25	E	3.0	3.070	120	21.711	
to						0.0	3.000		0.100	
R13	11.76		51.07	1.38		0.0	6.070	0.1939	1.177	Vel = 10.95
R13	11.76		0.0	1.25	T	6.0	1.180	120	22.988	
to						0.0	6.000		0.511	
M13	10.58		51.07	1.38		0.0	7.180	0.1939	1.392	Vel = 10.95
			0.0							
M13			51.07						24.891	K Factor = 10.24
*NEW PATH										
S15	12.1	5.60	25.24	1	E	2.0	4.560	120	20.307	
to						0.0	2.000		0.147	
R9	11.76		25.24	1.049		0.0	6.560	0.2002	1.313	Vel = 9.37
R9	11.76		0.0	1	T	5.0	1.180	120	21.767	
to						0.0	5.000		0.511	
M9	10.58		25.24	1.049		0.0	6.180	0.2002	1.237	Vel = 9.37
M9	10.58		0.0	2.5		0.0	7.910	120	23.515	
to						0.0	0.0		0.0	
M10	10.58		25.24	2.635		0.0	7.910	0.0021	0.017	Vel = 1.48
			0.0							
M10			25.24						23.532	K Factor = 5.20
*NEW PATH										
S18	11.94	5.60	25.61	1	E	2.0	2.370	120	20.908	
to						0.0	2.000		0.078	
R11	11.76		25.61	1.049		0.0	4.370	0.2055	0.898	Vel = 9.51
R11	11.76		0.0	1	T	5.0	1.180	120	21.884	
to						0.0	5.000		0.511	
M11	10.58		25.61	1.049		0.0	6.180	0.2055	1.270	Vel = 9.51

Node1 to Node2	Elev1 Elev2	K Fact	Qa Qt	Nom Act	Fitting or Eqv.	Ln.	Pipe Ftng's Total	CFact Pf/Ft	Pt Pe Pf	******* Notes ******
 M11			0.0 25.61						 23.665	 K Factor = 5.26
*NEW PATH										
S21 to R14	12.1 11.76	5.60	27.53 27.53	1 1.049	E	2.0 0.0 0.0	4.590 2.000 6.590	120 0.2349	24.163 0.147 1.548	 Vel = 10.22
R14 to M14	11.76 10.58		0.0 27.53	1 1.049	T	5.0 0.0 0.0	1.180 5.000 6.180	120 0.2351	25.858 0.511 1.453	 Vel = 10.22
 M14			0.0 27.53						 27.822	 K Factor = 5.22

MARQUEE

FIRE PROTECTION

LICENSED FIRE PROTECTION CONTRACTOR
MARQUEE FIRE PROTECTION ENGINEERING
CLASSIFICATION C-16
LICENSE No. 570970
STATE OF CALIFORNIA

Marquee Fire Protection
710 West Stadium Lane
Sacramento, CA 95843
916-641-7997

Job Name	:	TOPOCK WORKSHOP
Drawing	:	Workshop
Location	:	Needles, CA
Remote Area	:	One
Contract	:	1814-771
Data File	:	TOPOCK WORKSHOP AREA 1.WXF

Hydraulic Design Information Sheet

Name - Topock Workshop
Date - 12-5-14
Location - Needles, CA
Building - Workshop
System No. - One
Contractor - ETIC Engineering
Contract No. - 1814-771
Calculated By - T. Hintz
Drawing No. - FP-2
Construction: ( ) Combustible (X) Non-Combustible
Ceiling Height -
Occupancy -

SYSTEM DESIGN

(X) NFPA 13 ( ) Lt. Haz. Ord.Haz.Gp. ( ) 1 (X) 2 ( ) Ex.Haz.
( ) NFPA 231 ( ) NFPA 231C ( ) Figure Curve
Other
Specific Ruling Made By Date

Area of Sprinkler Operation - 1500	System Type	Sprinkler/Nozzle
Density - 0.2	(X) Wet	Make VIKING
Area Per Sprinkler - 128	( ) Dry	Model MMATIC
Elevation at Highest Outlet - 20.33	( ) Deluge	Size 3/4"
Hose Allowance - Inside -	( ) Preaction	K-Factor 8.0
Rack Sprinkler Allowance -	( ) Other	Temp.Rat.200
Hose Allowance - Outside - 250		

Note

Calculation Summary
Flow Required - 499.353 Press Required - 43.372 At BOR
C-Factor Used: 120 Overhead N/A Underground

WATER SUPPLY

Water Flow Test:	Pump Data:	Tank or Reservoir:
Date of Test -		Cap. -
Time of Test -	Rated Cap.-	Elev.-
Static Press -	@ Press -	
Residual Press -	Elev. -	Well
Flow -		Proof Flow
Elevation -		

Location -

Source of Information -

COMMODITY

Commodity Class Location
Storage Ht. Area Aisle W.
Storage Method: Solid Piled % Palletized % Rack

STORAGE — RACK

( ) Single Row ( ) Conven. Pallet ( ) Auto. Storage ( ) Encap.
( ) Double Row ( ) Slave Pallet ( ) Solid Shelf ( ) Non
( ) Mult. Row ( ) Open Shelf

Flue Spacing Clearance:Storage to Ceiling
Longitudinal Transverse

Horizontal Barriers Provided:

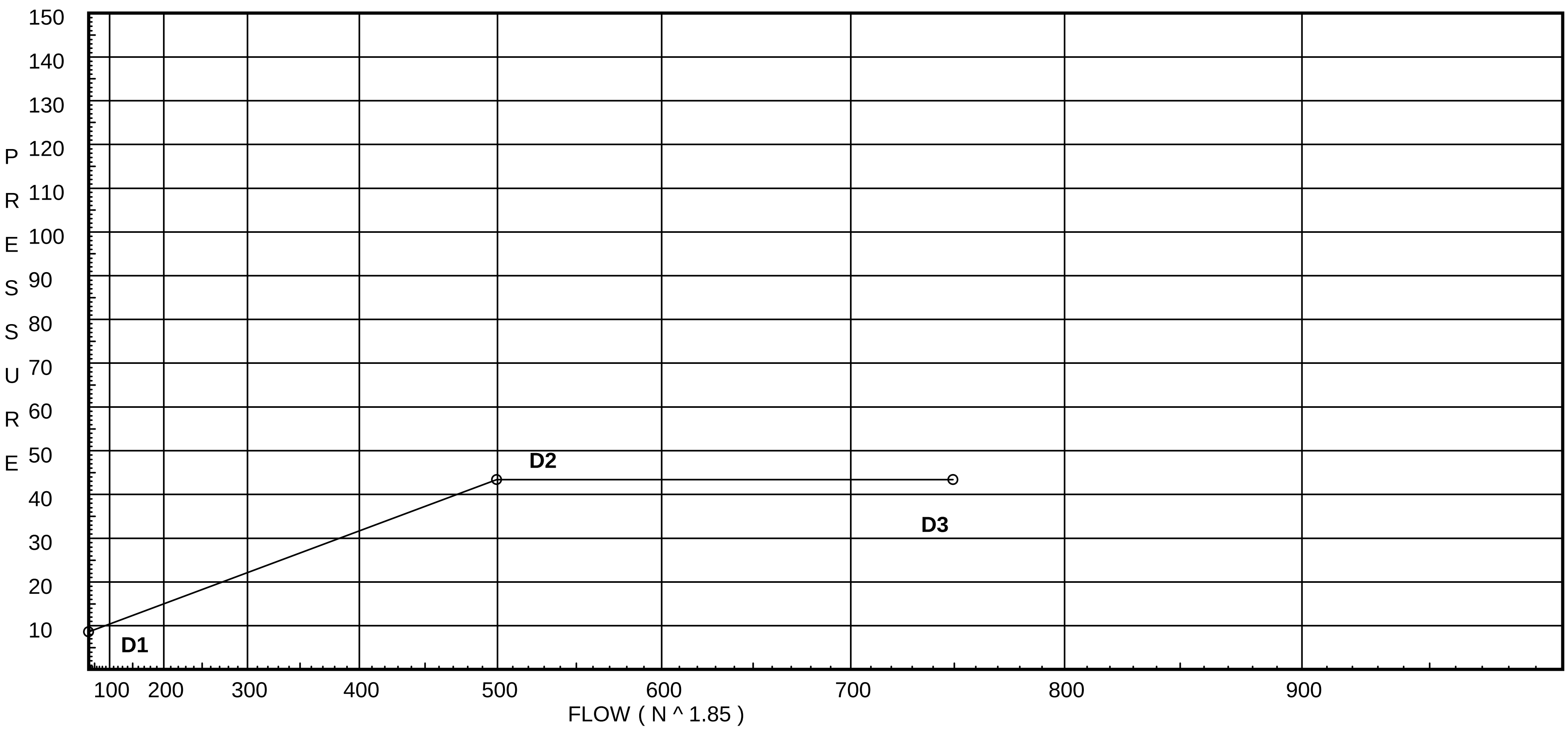
Water Supply Curve C

Marquee Fire Protection
TOPOCK WORKSHOP

Page 2
Date 12-5-14

Demand:

D1 - Elevation	: 8.588
D2 - System Flow	: 499.353
D2 - System Pressure	: 43.372
Hose (Demand)	: 250
D3 - System Demand	: 749.353
Safety Margin	: ________



Fitting Legend

Abbrev.	Name	½	¾	1	1¼	1½	2	2½	3	3½	4	5	6	8	10	12	14	16	18	20	24
E	NFPA 13 90' Standard Elbow	1	2	2	3	4	5	6	7	8	10	12	14	18	22	27	35	40	45	50	61
T	NFPA 13 90' Flow thru Tee	3	4	5	6	8	10	12	15	17	20	25	30	35	50	60	71	81	91	101	121

Unit Summary

Diameter Units	Inches
Length Units	Feet
Flow Units	US Gallons per Minute
Pressure Units	Pounds per Square Inch

Note: Fitting Legend provides equivalent pipe lengths for fittings types of various diameters. Equivalent lengths shown are standard for actual diameters of Sched 40 pipe and CFactors of 120 except as noted with *. The fittings marked with a * show equivalent lengths values supplied by manufacturers based on specific pipe diameters and CFactors and they require no adjustment. All values for fittings not marked with a * will be adjusted in the calculation for CFactors of other than 120 and diameters other than Sched 40 per NFPA.

Pressure / Flow Summary - STANDARD

Marquee Fire Protection
TOPOCK WORKSHOP

Node No.	Elevation	K-Fact	Pt Actual	Pn	Flow Actual	Density	Area	Press Req.
S12A	20.33	8	8.12	na	22.8	0.2	54	7.0
S12	20.33	8	9.92	na	25.2	0.2	126	7.0
S13	20.33	8	11.39	na	27.0	0.2	119	7.0
S14	20.33	8	16.33	na	32.32	0.2	119	7.0
S15	20.33	8	20.85	na	36.53	0.2	119	7.0
R3	20.33		24.47	na				
M3	18.71		31.15	na				
TOR	18.71		34.5	na				
BOR	0.5		43.37	na	250.0			
S7	20.33	8	8.07	na	22.73	0.2	61	7.0
7	20.33		8.72	na				
S8	20.33	8	10.61	na	26.06	0.2	97	7.0
S9	20.33	8	14.09	na	30.03	0.2	128	7.0
S10	20.33	8	18.2	na	34.13	0.2	128	7.0
S11	20.33	8	25.21	na	40.17	0.2	128	7.0
R2	20.33		27.05	na				
M2	18.71		30.86	na				
S6	20.33	8	8.39	na	23.17	0.2	40	7.0
S1	20.33	8	8.38	na	23.16	0.2	77	7.0
S2	20.33	8	9.66	na	24.86	0.2	92	7.0
S3	20.33	8	11.21	na	26.78	0.2	98	7.0
S4	20.33	8	14.97	na	30.95	0.2	98	7.0
S5	20.33	8	18.12	na	34.05	0.2	92	7.0
R1	20.33		26.87	na				
M1	18.71		30.78	na				
S5A	20.33	8	24.28	na	39.42	0.2	77	7.0

The maximum velocity is 22.67 and it occurs in the pipe between nodes S15 and R3

Node1 to Node2	Elev1 Elev2	K Fact	Qa Qt	Nom Act	Fitting or Eqv.	Ln.	Pipe Ftng's Total	CFact Pf/Ft	Pt Pe Pf	******* Notes ******
*EQUIVALENT K'S										
*REMOTE HEAD TO SUPPLY										
S12A	20.330	8.00	22.80	1	E	2.0	8.875	120	8.120	
to						0.0	2.000		0.0	
S12	20.33		22.8	1.049		0.0	10.875	0.1657	1.802	Vel = 8.46
S12	20.33	8.00	25.20	1.25		0.0	8.500	120	9.922	
to						0.0	0.0		0.0	
S13	20.33		48.0	1.38		0.0	8.500	0.1729	1.470	Vel = 10.30
S13	20.33	8.00	27.00	1.25		0.0	12.500	120	11.392	
to						0.0	0.0		0.0	
S14	20.33		75.0	1.38		0.0	12.500	0.3947	4.934	Vel = 16.09
S14	20.33	8.00	32.32	1.5		0.0	12.500	120	16.326	
to						0.0	0.0		0.0	
S15	20.33		107.32	1.61		0.0	12.500	0.3615	4.519	Vel = 16.91
S15	20.33	8.00	36.53	1.5	E	4.0	1.830	120	20.845	
to						0.0	4.000		0.0	
R3	20.33		143.85	1.61		0.0	5.830	0.6216	3.624	Vel = 22.67
R3	20.33		0.0	1.5	T	8.0	1.620	120	24.469	
to						0.0	8.000		0.702	
M3	18.71		143.85	1.61		0.0	9.620	0.6216	5.980	Vel = 22.67
M3	18.71		355.50	4	2E	26.334	35.160	120	31.151	
to						0.0	26.334		0.0	
TOR	18.71		499.35	4.26		0.0	61.494	0.0544	3.344	Vel = 11.24
TOR	18.71		0.0	4		0.0	18.210	120	34.495	
to						0.0	0.0		7.887	
BOR	0.5		499.35	4.26		0.0	18.210	0.0544	0.990	Vel = 11.24
			250.00							Qa = 250.00
BOR			749.35						43.372	K Factor = 113.78
*NEW PATH										
S7	20.33	8.00	22.73	1		0.0	3.960	120	8.069	
to						0.0	0.0		0.0	
7	20.33		22.73	1.049		0.0	3.960	0.1649	0.653	Vel = 8.44
7	20.33		23.16	1.25	T	6.0	5.890	120	8.722	
to						0.0	6.000		0.0	
S8	20.33		45.89	1.38		0.0	11.890	0.1591	1.892	Vel = 9.84
S8	20.33	8.00	26.07	1.25		0.0	9.500	120	10.614	
to						0.0	0.0		0.0	
S9	20.33		71.96	1.38		0.0	9.500	0.3656	3.473	Vel = 15.44
S9	20.33	8.00	30.02	1.5		0.0	12.500	120	14.087	
to						0.0	0.0		0.0	
S10	20.33		101.98	1.61		0.0	12.500	0.3290	4.113	Vel = 16.07
S10	20.33	8.00	34.13	1.5		0.0	12.500	120	18.200	
to						0.0	0.0		0.0	
S11	20.33		136.11	1.61		0.0	12.500	0.5612	7.015	Vel = 21.45
S11	20.33	8.00	40.17	2	E	5.0	1.830	120	25.215	
to						0.0	5.000		0.0	
R2	20.33		176.28	2.067		0.0	6.830	0.2681	1.831	Vel = 16.85

Node1 to Node2	Elev1 Elev2	K Fact	Qa Qt	Nom Act	Fitting or Eqv.	Ln.	Pipe Ftng's Total	CFact Pf/Ft	Pt Pe Pf	******* Notes ******
R2	20.33		0.0	2	T	10.0	1.620	120	27.046	
to						0.0	10.000		0.702	
M2	18.71		176.28	2.067		0.0	11.620	0.2682	3.116	Vel = 16.85
M2	18.71		179.23	4		0.0	9.870	120	30.864	
to						0.0	0.0		0.0	
M3	18.71		355.51	4.26		0.0	9.870	0.0291	0.287	Vel = 8.00
			0.0							
M3			355.51						31.151	K Factor = 63.70
*NEW PATH										
S6	20.33	8.00	23.17	1		0.0	1.960	120	8.387	
to						0.0	0.0		0.0	
7	20.33		23.17	1.049		0.0	1.960	0.1709	0.335	Vel = 8.60
			0.0							
7			23.17						8.722	K Factor = 7.85
*NEW PATH										
S1	20.33	8.00	23.16	1		0.0	7.458	120	8.382	
to						0.0	0.0		0.0	
S2	20.33		23.16	1.049		0.0	7.458	0.1707	1.273	Vel = 8.60
S2	20.33	8.00	24.86	1.25		0.0	8.958	120	9.655	
to						0.0	0.0		0.0	
S3	20.33		48.02	1.38		0.0	8.958	0.1730	1.550	Vel = 10.30
S3	20.33	8.00	26.78	1.25		0.0	9.583	120	11.205	
to						0.0	0.0		0.0	
S4	20.33		74.8	1.38		0.0	9.583	0.3928	3.764	Vel = 16.04
S4	20.33	8.00	30.95	1.5		0.0	8.953	120	14.969	
to						0.0	0.0		0.0	
S5	20.33		105.75	1.61		0.0	8.953	0.3518	3.150	Vel = 16.67
S5	20.33	8.00	34.05	1.5	T	8.0	6.833	120	18.119	
to						0.0	8.000		0.0	
R1	20.33		139.8	1.61		0.0	14.833	0.5897	8.747	Vel = 22.03
R1	20.33		39.42	2	T	10.0	1.620	120	26.866	
to						0.0	10.000		0.702	
M1	18.71		179.22	2.067		0.0	11.620	0.2765	3.213	Vel = 17.14
M1	18.71		0.0	4		0.0	10.250	120	30.781	
to						0.0	0.0		0.0	
M2	18.71		179.22	4.26		0.0	10.250	0.0081	0.083	Vel = 4.03
			0.0							
M2			179.22						30.864	K Factor = 32.26
*NEW PATH										
S5A	20.330	8.00	39.42	1	T	5.0	0.667	120	24.278	
to						0.0	5.000		0.0	
R1	20.33		39.42	1.049		0.0	5.667	0.4567	2.588	Vel = 14.63
			0.0							
R1			39.42						26.866	K Factor = 7.61

Final (100%) Design Submittal for the Final Groundwater Remedy
PG&E Topock Compressor Station
Needles, California

Sand Separator System

11/18/2015

Prepared for:

Pacific Gas and Electric Company

Reviewed by:

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Arcadis, U.S., Inc.

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ARCADIS Design & Consultancy for natural and built assets

Sand Concentrator Calculation for High Purge Rate and High Purge Frequency

			Purge Rate (gpm) =	300			
			Purge Duration (sec) =	15			
			Purge Volume (gal) =	60			
			Purge Frequency (min) =	15			
			Sand Concentrator flowrate (gpm) =	4			
			Number of holes per row =	40			
			100% Open Screen Area				
Q (cfs)	Nominal Dia (in)	Dia (in)	Area (ft^2)	Vel (fps)	$V^2/2g$	Kirschmer's h_L (ft)	Orifice coefficient
0.00022	0.50	0.622	0.00211	0.11	0.00	0.00	0.93
0.00022	1.00	1.049	0.00600	0.04	0.00	0.00	0.93
0.00022	1.50	1.610	0.01414	0.02	0.00	0.00	0.93
0.00022	2.00	2.067	0.02330	0.01	0.00	0.00	0.93
			75% Open Screen Area				
Q (cfs)	Nominal Dia (in)	Dia (in)	Area (ft^2)	Vel (fps)	$V^2/2g$	Kirschmer's h_L (ft)	Orifice coefficient
0.00022	0.50	0.622	0.00158	0.14	0.00	0.00	0.75
0.00022	1.00	1.049	0.00450	0.05	0.00	0.00	0.75
0.00022	1.50	1.610	0.01060	0.02	0.00	0.00	0.75
0.00022	2.00	2.067	0.01748	0.01	0.00	0.00	0.75
			50% Open Screen Area				
Q (cfs)	Nominal Dia (in)	Dia (in)	Area (ft^2)	Vel (fps)	$V^2/2g$	Kirschmer's h_L (ft)	Orifice coefficient
0.00022	0.50	0.622	0.00106	0.21	0.00	0.00	0.59
0.00022	1.00	1.049	0.00300	0.07	0.00	0.00	0.59
0.00022	1.50	1.610	0.00707	0.03	0.00	0.00	0.59
0.00022	2.00	2.067	0.01165	0.02	0.00	0.00	0.59
			25% Open Screen Area				
Q (cfs)	Nominal Dia (in)	Dia (in)	Area (ft^2)	Vel (fps)	$V^2/2g$	Kirschmer's h_L (ft)	Orifice coefficient
0.00022	0.50	0.622	0.00053	0.42	0.00	0.02	0.41
0.00022	1.00	1.049	0.00150	0.15	0.00	0.00	0.41
0.00022	1.50	1.610	0.00353	0.06	0.00	0.00	0.41
0.00022	2.00	2.067	0.00583	0.04	0.00	0.00	0.41
			10% Open Screen Area				
Q (cfs)	Nominal Dia (in)	Dia (in)	Area (ft^2)	Vel (fps)	$V^2/2g$	Kirschmer's h_L (ft)	Orifice coefficient
0.00022	0.50	0.622	0.00021	1.06	0.02	0.23	0.28
0.00022	1.00	1.049	0.00060	0.37	0.00	0.03	0.28
0.00022	1.50	1.610	0.00141	0.16	0.00	0.01	0.28
0.00022	2.00	2.067	0.00233	0.10	0.00	0.00	0.28

Sand Concentrator Calculation for High Purge Rate and High Purge Frequency

5% Open Screen Area							
Q (cfs)	Nominal Dia (in)	Dia (in)	Area (ft^2)	Vel (fps)	$V^2/2g$	Kirschmer's h_L (ft)	Orifice coefficient
0.00022	0.50	0.622	0.00011	2.11	0.07	1.56	0.21
0.00022	1.00	1.049	0.00030	0.74	0.01	0.19	0.21
0.00022	1.50	1.610	0.00071	0.32	0.00	0.03	0.21
0.00022	2.00	2.067	0.00117	0.19	0.00	0.01	0.21
1% Open Screen Area							
Q (cfs)	Nominal Dia (in)	Dia (in)	Area (ft^2)	Vel (fps)	$V^2/2g$	Kirschmer's h_L (ft)	Orifice coefficient
0.00022	0.50	0.622	0.00002	10.56	1.73	127.47	0.12
0.00022	1.00	1.049	0.00006	3.71	0.21	15.76	0.12
0.00022	1.50	1.610	0.00014	1.58	0.04	2.84	0.12
0.00022	2.00	2.067	0.00023	0.96	0.01	1.05	0.12

Sand Concentrator Calculation for High Purge Rate and Low Purge Frequency

Purge Rate (gpm) =				300			
Purge Duration (sec) =				12			
Purge Volume (gal) =				60			
Purge Frequency (min) =				240			
Sand Concentrator flowrate (gpm) =				0.25			
Number of holes per row =				40			
100% Open Screen Area							
Q (cfs)	Nominal Dia (in)	Dia (in)	Area (ft^2)	Vel (fps)	$V^2/2g$	Kirschmer's h_L (ft)	Orifice coefficient
0.00001	0.50	0.622	0.00211	0.01	0.00	0.00	0.93
0.00001	1.00	1.049	0.00600	0.00	0.00	0.00	0.93
0.00001	1.50	1.610	0.01414	0.00	0.00	0.00	0.93
0.00001	2.00	2.067	0.02330	0.00	0.00	0.00	0.93
75% Open Screen Area							
Q (cfs)	Nominal Dia (in)	Dia (in)	Area (ft^2)	Vel (fps)	$V^2/2g$	Kirschmer's h_L (ft)	Orifice coefficient
0.00001	0.50	0.622	0.00158	0.01	0.00	0.00	0.75
0.00001	1.00	1.049	0.00450	0.00	0.00	0.00	0.75
0.00001	1.50	1.610	0.01060	0.00	0.00	0.00	0.75
0.00001	2.00	2.067	0.01748	0.00	0.00	0.00	0.75
50% Open Screen Area							
Q (cfs)	Nominal Dia (in)	Dia (in)	Area (ft^2)	Vel (fps)	$V^2/2g$	Kirschmer's h_L (ft)	Orifice coefficient
0.00001	0.50	0.622	0.00106	0.01	0.00	0.00	0.59
0.00001	1.00	1.049	0.00300	0.00	0.00	0.00	0.59
0.00001	1.50	1.610	0.00707	0.00	0.00	0.00	0.59
0.00001	2.00	2.067	0.01165	0.00	0.00	0.00	0.59
25% Open Screen Area							
Q (cfs)	Nominal Dia (in)	Dia (in)	Area (ft^2)	Vel (fps)	$V^2/2g$	Kirschmer's h_L (ft)	Orifice coefficient
0.00001	0.50	0.622	0.00053	0.03	0.00	0.00	0.41
0.00001	1.00	1.049	0.00150	0.01	0.00	0.00	0.41
0.00001	1.50	1.610	0.00353	0.00	0.00	0.00	0.41
0.00001	2.00	2.067	0.00583	0.00	0.00	0.00	0.41
10% Open Screen Area							
Q (cfs)	Nominal Dia (in)	Dia (in)	Area (ft^2)	Vel (fps)	$V^2/2g$	Kirschmer's h_L (ft)	Orifice coefficient
0.00001	0.50	0.622	0.00021	0.07	0.00	0.00	0.28
0.00001	1.00	1.049	0.00060	0.02	0.00	0.00	0.28
0.00001	1.50	1.610	0.00141	0.01	0.00	0.00	0.28
0.00001	2.00	2.067	0.00233	0.01	0.00	0.00	0.28

Sand Concentrator Calculation for High Purge Rate and Low Purge Frequency

5% Open Screen Area							
Q (cfs)	Nominal Dia (in)	Dia (in)	Area (ft^2)	Vel (fps)	$V^2/2g$	Kirschmer's h_L (ft)	Orifice coefficient
0.00001	0.50	0.622	0.00011	0.13	0.00	0.01	0.21
0.00001	1.00	1.049	0.00030	0.05	0.00	0.00	0.21
0.00001	1.50	1.610	0.00071	0.02	0.00	0.00	0.21
0.00001	2.00	2.067	0.00117	0.01	0.00	0.00	0.21
1% Open Screen Area							
Q (cfs)	Nominal Dia (in)	Dia (in)	Area (ft^2)	Vel (fps)	$V^2/2g$	Kirschmer's h_L (ft)	Orifice coefficient
0.00001	0.50	0.622	0.00002	0.66	0.01	0.50	0.12
0.00001	1.00	1.049	0.00006	0.23	0.00	0.06	0.12
0.00001	1.50	1.610	0.00014	0.10	0.00	0.01	0.12
0.00001	2.00	2.067	0.00023	0.06	0.00	0.00	0.12

Sand Concentrator Calculation for Low Purge Rate and High Purge Frequency

			Purge Rate (gpm) =	50			
			Purge Duration (sec) =	12			
			Purge Volume (gal) =	10			
			Purge Frequency (min) =	15			
			Sand Concentrator flowrate (gpm) =	0.67			
			Number of holes per row =	40			
100% Open Screen Area							
Q (cfs)	Nominal Dia (in)	Dia (in)	Area (ft^2)	Vel (fps)	$V^2/2g$	Kirschmer's h_L (ft)	Orifice coefficient
0.00004	0.50	0.622	0.00211	0.02	0.00	0.00	0.93
0.00004	1.00	1.049	0.00600	0.01	0.00	0.00	0.93
0.00004	1.50	1.610	0.01414	0.00	0.00	0.00	0.93
0.00004	2.00	2.067	0.02330	0.00	0.00	0.00	0.93
75% Open Screen Area							
Q (cfs)	Nominal Dia (in)	Dia (in)	Area (ft^2)	Vel (fps)	$V^2/2g$	Kirschmer's h_L (ft)	Orifice coefficient
0.00004	0.50	0.622	0.00158	0.02	0.00	0.00	0.75
0.00004	1.00	1.049	0.00450	0.01	0.00	0.00	0.75
0.00004	1.50	1.610	0.01060	0.00	0.00	0.00	0.75
0.00004	2.00	2.067	0.01748	0.00	0.00	0.00	0.75
50% Open Screen Area							
Q (cfs)	Nominal Dia (in)	Dia (in)	Area (ft^2)	Vel (fps)	$V^2/2g$	Kirschmer's h_L (ft)	Orifice coefficient
0.00004	0.50	0.622	0.00106	0.04	0.00	0.00	0.59
0.00004	1.00	1.049	0.00300	0.01	0.00	0.00	0.59
0.00004	1.50	1.610	0.00707	0.01	0.00	0.00	0.59
0.00004	2.00	2.067	0.01165	0.00	0.00	0.00	0.59
25% Open Screen Area							
Q (cfs)	Nominal Dia (in)	Dia (in)	Area (ft^2)	Vel (fps)	$V^2/2g$	Kirschmer's h_L (ft)	Orifice coefficient
0.00004	0.50	0.622	0.00053	0.07	0.00	0.00	0.41
0.00004	1.00	1.049	0.00150	0.02	0.00	0.00	0.41
0.00004	1.50	1.610	0.00353	0.01	0.00	0.00	0.41
0.00004	2.00	2.067	0.00583	0.01	0.00	0.00	0.41
10% Open Screen Area							
Q (cfs)	Nominal Dia (in)	Dia (in)	Area (ft^2)	Vel (fps)	$V^2/2g$	Kirschmer's h_L (ft)	Orifice coefficient
0.00004	0.50	0.622	0.00021	0.18	0.00	0.01	0.28
0.00004	1.00	1.049	0.00060	0.06	0.00	0.00	0.28
0.00004	1.50	1.610	0.00141	0.03	0.00	0.00	0.28
0.00004	2.00	2.067	0.00233	0.02	0.00	0.00	0.28

Sand Concentrator Calculation for Low Purge Rate and High Purge Frequency

5% Open Screen Area							
Q (cfs)	Nominal Dia (in)	Dia (in)	Area (ft^2)	Vel (fps)	$V^2/2g$	Kirschmer's h_L (ft)	Orifice coefficient
0.00004	0.50	0.622	0.00011	0.35	0.00	0.04	0.21
0.00004	1.00	1.049	0.00030	0.12	0.00	0.01	0.21
0.00004	1.50	1.610	0.00071	0.05	0.00	0.00	0.21
0.00004	2.00	2.067	0.00117	0.03	0.00	0.00	0.21
1% Open Screen Area							
Q (cfs)	Nominal Dia (in)	Dia (in)	Area (ft^2)	Vel (fps)	$V^2/2g$	Kirschmer's h_L (ft)	Orifice coefficient
0.00004	0.50	0.622	0.00002	1.76	0.05	3.54	0.12
0.00004	1.00	1.049	0.00006	0.62	0.01	0.44	0.12
0.00004	1.50	1.610	0.00014	0.26	0.00	0.08	0.12
0.00004	2.00	2.067	0.00023	0.16	0.00	0.03	0.12

Sand Concentrator

Low Purge Rate and Low Purge Frequency

Purge Rate (gpm) =				50			
Purge Duration (sec) =				12			
Purge Volume (gal) =				10			
Purge Frequency (min) =				240			
Sand Concentrator flowrate (gpm) =				0.04			
Number of holes per row =				40			
100% Open Screen Area							
Q (cfs)	Nominal Dia (in)	Dia (in)	Area (ft^2)	Vel (fps)	$V^2/2g$	Kirschmer's h_L (ft)	Orifice coefficient
0.00000	0.50	0.622	0.00211	0.00	0.00	0.00	0.93
0.00000	1.00	1.049	0.00600	0.00	0.00	0.00	0.93
0.00000	1.50	1.610	0.01414	0.00	0.00	0.00	0.93
0.00000	2.00	2.067	0.02330	0.00	0.00	0.00	0.93
75% Open Screen Area							
Q (cfs)	Nominal Dia (in)	Dia (in)	Area (ft^2)	Vel (fps)	$V^2/2g$	Kirschmer's h_L (ft)	Orifice coefficient
0.00000	0.50	0.622	0.00158	0.00	0.00	0.00	0.75
0.00000	1.00	1.049	0.00450	0.00	0.00	0.00	0.75
0.00000	1.50	1.610	0.01060	0.00	0.00	0.00	0.75
0.00000	2.00	2.067	0.01748	0.00	0.00	0.00	0.75
50% Open Screen Area							
Q (cfs)	Nominal Dia (in)	Dia (in)	Area (ft^2)	Vel (fps)	$V^2/2g$	Kirschmer's h_L (ft)	Orifice coefficient
0.00000	0.50	0.622	0.00106	0.00	0.00	0.00	0.59
0.00000	1.00	1.049	0.00300	0.00	0.00	0.00	0.59
0.00000	1.50	1.610	0.00707	0.00	0.00	0.00	0.59
0.00000	2.00	2.067	0.01165	0.00	0.00	0.00	0.59
25% Open Screen Area							
Q (cfs)	Nominal Dia (in)	Dia (in)	Area (ft^2)	Vel (fps)	$V^2/2g$	Kirschmer's h_L (ft)	Orifice coefficient
0.00000	0.50	0.622	0.00053	0.00	0.00	0.00	0.41
0.00000	1.00	1.049	0.00150	0.00	0.00	0.00	0.41
0.00000	1.50	1.610	0.00353	0.00	0.00	0.00	0.41
0.00000	2.00	2.067	0.00583	0.00	0.00	0.00	0.41
10% Open Screen Area							
Q (cfs)	Nominal Dia (in)	Dia (in)	Area (ft^2)	Vel (fps)	$V^2/2g$	Kirschmer's h_L (ft)	Orifice coefficient
0.00000	0.50	0.622	0.00021	0.01	0.00	0.00	0.28
0.00000	1.00	1.049	0.00060	0.00	0.00	0.00	0.28
0.00000	1.50	1.610	0.00141	0.00	0.00	0.00	0.28
0.00000	2.00	2.067	0.00233	0.00	0.00	0.00	0.28

Sand Concentrator
Low Purge Rate and Low Purge Frequency

5% Open Screen Area							
Q (cfs)	Nominal Dia (in)	Dia (in)	Area (ft^2)	Vel (fps)	$V^2/2g$	Kirschmer's h_L (ft)	Orifice coefficient
0.00000	0.50	0.622	0.00011	0.02	0.00	0.00	0.21
0.00000	1.00	1.049	0.00030	0.01	0.00	0.00	0.21
0.00000	1.50	1.610	0.00071	0.00	0.00	0.00	0.21
0.00000	2.00	2.067	0.00117	0.00	0.00	0.00	0.21
1% Open Screen Area							
Q (cfs)	Nominal Dia (in)	Dia (in)	Area (ft^2)	Vel (fps)	$V^2/2g$	Kirschmer's h_L (ft)	Orifice coefficient
0.00000	0.50	0.622	0.00002	0.11	0.00	0.01	0.12
0.00000	1.00	1.049	0.00006	0.04	0.00	0.00	0.12
0.00000	1.50	1.610	0.00014	0.02	0.00	0.00	0.12
0.00000	2.00	2.067	0.00023	0.01	0.00	0.00	0.12

Final (100%) Design Submittal for the Final Groundwater Remedy
PG&E Topock Compressor Station
Needles, California

Soluble Carbon Substrate and Emulsified Vegetable Oil Dosing Calculations

11/18/2015

Prepared for:

Pacific Gas and Electric Company

Reviewed by:

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Prepared by:

Geoffrey Rader, PE, Staff Engineer
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In Situ Reactive Zone Organic Carbon Dosing Calculations, Soluble Substrates

Volume of Substrate Required per Injection

Groundwater Flowrate * **Injection Frequency** * **Conversion Factor** * **Target TOC Concentration** * **Conversion Factor** * **Substrate Conversion Factor** = **Substrate Volume**

$$\frac{\textbf{X}\text{ gallons groundwater}}{\text{1 minute}} * \textbf{X}\text{ minutes between injections} * \frac{\text{3.78 liters}}{\text{1 gallon}} * \frac{\textbf{X}\text{ milligrams TOC}}{\text{1 liter groundwater}} * \frac{\text{kilogram TOC}}{\text{1,000 milligrams TOC}} * \frac{\text{gallon substrate}}{\textbf{X}\text{ kg TOC}} = \text{gallons of substrate per injection}$$

Substrate Conversion Factors

Stoichiometry / **Purity** / **Density** * **Conversion Factor** = **Gallons of Substrate**

Ethanol (EtOH):

$$\frac{\text{46 kilograms EtOH}}{\text{24 kilograms TOC}} * \frac{\text{100 kilograms 95\% EtOH}}{\text{95 kilograms EtOH}} * \frac{\text{1 liter 95\% EtOH}}{\text{0.789 kilograms 95\% EtOH}} * \frac{\text{1 gallon 95\% EtOH}}{\text{3.78 liters 95\% EtOH}} = 0.676 \text{ gallons 95\% EtOH per kg TOC}$$

Sodium Lactate (NaL):

$$\frac{\text{112 kilograms NaL}}{\text{36 kilograms TOC}} * \frac{\text{100 kilograms 60\% NaL}}{\text{60 kilograms NaL}} * \frac{\text{1 liter 60\% NaL}}{\text{1.31 kilograms 60\% NaL}} * \frac{\text{1 gallon 60\% NaL}}{\text{3.78 liters 60\% NaL}} = 1.047 \text{ gallons 60\% NaL per kg TOC}$$

Liquid Whey:

$$\frac{\text{100 kilograms whey}}{\text{5.5 kilograms TOC}} * \frac{\text{100 kilograms whey}}{\text{100 kilograms whey}} * \frac{\text{1 liter whey}}{\text{1 kilogram whey}} * \frac{\text{1 gallon whey}}{\text{3.78 liters whey}} = 4.810 \text{ gallons whey per kg TOC}$$

In Situ Reactive Zone Organic Carbon Substrate Dosing Calculations, Emulsified Vegetable Oil Conceptual Design Tool

Design Elements	Units	Values/Formulas
EVO Loading (L_{EVO})		
Sand with 12% silt/clay	wt oil/wt soil	0.0095
Sand with 9% silt/clay	wt oil/wt soil	0.0061
Sand with 7% silt/clay	wt oil/wt soil	0.0054
Clayey sand alluvium	wt oil/wt soil	0.0037
Gravelly sand	wt oil/wt soil	0.0002
Contaminant, Hydraulic, and Aquifer Data		
Mobile Porosity (θ_m)		**Site Specific Input Parameter**
Total Porosity (θ_t)		**Site Specific Input Parameter**
Immobile Porosity (θ_i)		$\theta_i=\theta_t-\theta_m$
Soil Specific Gravity (SG)	unitless	**Site Specific Input Parameter**
Density of water (ρ_w)	g/cm3	**Input Parameter**
Bulk Density (ρ_b)	g/cm^3	$\rho_b=(1-\theta_t)*SG*\rho_w$
Well Information		
Radius of Influence (ROI)	ft	**Design Parameter**
Screened Interval (h)	ft	**Design Parameter**
Total Number of Injection wells (N_{inj})	number wells	**Design Parameter**
Injection and Substrate Loading Information		
Per well total required injection volume (V_{inj})	gal	$V_{inj} = (\pi*ROI^2*h*\theta_m*7.48)$
Per well soil weight (SW)	lb	$SW=\rho_b*V_{inj}*(3.79*10^3/454)$
Per well EVO demand (DEVO)	lb	$D_{EVO}=L_{EVO}*SW$
Per well EVO volume (VEVO)	gal	$V_{EVO}=D_{EVO}/8.2$
Calculated EVO Injection Solution Strength (%EVO)		$\%EVO=V_{EVO}/V_{inj}$
Targeted EVO Injection Solution Strength (T%EVO)	%	2.5%, Based on ARCADIS Experience
Adjusted EVO solution strength (Adj_{EVO})	gal	$Adj_{EVO}=max(\%EVO,T\%EVO)$
Adjusted per well EVO solution strength (AdjEVO)	gal	$EVO=Adj_{EVO}*V_{inj}$
Total Volume per injection event	gal	$N_{inj} * V_{inj}$
Total EVO per injection event	gal	N_{inj} * EVO

References:

Solutions-IES, 2006. Protocol for Enhanced In Situ Bioremediation Using Emulsified Edible Oils. Environmental Security Technology Certification Program, Arlington, Virginia. (www.estcp.org)

Note: These calculations may underestimate the amount of oil retention and higher amounts of EVO than predicted may be needed, based on past experience.

Units

ft - feet
g/cm^3 - grams per centimeter cubed
gal- gallon
lb - pound
wt- weight

Final (100%) Design Submittal for the Final Groundwater Remedy
PG&E Topock Compressor Station
Needles, California

CHQ Lighting Calculations

11/18/2015

Prepared for:

Pacific Gas and Electric Company

Reviewed by:

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Prepared by:

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STATE OF CALIFORNIA

ARCADIS Design & Consultancy for natural and built assets

Project No. RC000753.0019
Client PGE Topock CHQ
Engineer: John Sidoti

Date 11-Nov-15
reflectance: 50% ceiling, 30% wall

Lighting Calculations																	
Room Data					Desired	Calc.	Lamp Data			Light Luminaire Data					Calc. #	Actual #	Actual
No.	Name	Length	Width	Mtg. Ht.	fc	RCR	Lumens	BF	LLD	Type	CU	# Lamps	LDD	S/MH	Fixtures	Luminaire	fc
	CHQ																
	Workshop	50	38.7	18	20	4.1	4400	1	0.9	B	0.51	2	0.9	1.25	10.65	16	30.06
	Sample Prep/Admin	29.25	10	10	20	6.7	2900	0.93	0.9	A2	0.25	2	0.9	1.25	5.36	5	18.67
	Water Lab	10	10	10	20	10.0	2900	0.93	0.9	A3	0.18	3	0.9	1.25	1.70	2	23.59
	Soil Lab	10	10	10	20	10.0	2800	0.93	0.9	A3	0.18	3	0.9	1.25	1.76	2	22.78
	Mech Room	7	4	10	20	19.6	2800	0.93	0.9	A2	0.15	2	0.9	1.25	0.88	1	22.60
	Restroom	8	7	10	20	13.4	2800	0.93	0.9	A2	0.15	2	0.9	1.25	1.77	1	11.30
	Clean Room	10	10	10	20	10.0	2800	0.93	0.9	A2	0.18	2	0.9	1.25	2.63	2	15.19
	Storage	40	10	10	10	6.3	2800	0.93	0.9	A2	0.28	2	0.9	1.25	3.39	4	11.81

Final (100%) Design Submittal for the Final Groundwater Remedy
PG&E Topock Compressor Station
Needles, California

Park Moabi Construction Headquarters
Yard Piping Head Loss and Tank Sizing Calculations

11/18/2015

Prepared for:

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Reviewed by:

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Prepared by:

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Caroline Eckel, P.E.
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ARCADIS Design & Consultancy for natural and built assets

CHQ Yard Piping Hydraulics

Pipe Network to	Branch Size (in)	Length (ft)	Load (gpm)	Load (cfs)	Velocity (ft/s)	psi loss/100 ft (for HDPE)	psi loss
To hydrant (by sewage tanks)	1.5	80	5	0.01114	0.91	0.09	0.07
Header	3	37.5	77	0.171556	3.49	0.67	0.25
To hydrant (by trailer)	1.5	70	5	0.01114	0.91	0.09	0.06
Workshop	3	62.5	28	0.062384	1.27	0.1	0.06
To bathrooms	3	175	49	0.109172	2.22	0.29	0.51
							0.96

Daily usage Calculations

I found several standard numbers for daily usage
Students in a school with cafeteria, gym and showers = 15 gal/day
General office Building = 35 gal/day
Office Building = 25 gal/day
Factory = 25 gal/day

I also took the gallons/use for running a sink (washing hands, getting a drink, coffee etc.), using the toilet, both low flow and standard, and taking a shower, and used these values to see a range of daily use.

		Minimum gallons (low flow options) Per use	Maximum gallons Per use
	sink	1	1
	Toilet	1.6	5
	Shower	7	7
Assumed use per person per day (gallons)	5 sinks	5	5
	3 toilet	4.8	15
	1 shower	7	7
	Total	16.8	27

		construction	post construction
People on site		100	25
Min gal/day	17	1700	425
max gal/day	27	2700	675
Min gal/week		8500	2125
Max gal/week		13500	3375
(5 days)			
Min gal/month		34000	8500
Max gal/month		54000	13500
(20 days)			

	sewage	
Min		
141.6667	gallons per building	675
0.09838	gallons per min	0.46875
566.6667		2700
0.393519		1.875

From these numbers I recommend we use the following…

Recommend 2 - 5,000 gallon water storage tanks
removing one from service after construction is complete

Recommend 2 - 7,500 gallon sewage storage tanks
Or 2 - 10,000 gallon sewage storage tanks
emptying twice as often (twice a month) during construction
emptying once a month post construction

ARCADIS

Arcadis, Inc.
Job No: RC000753.0028
Calc By: L. Tabat
Date: 04 Nov 15
Project: PG&E Topock Remediation Project

Sheet No: 1 of 1
Chkd By: ______________
Date: ________
Subject: Area 9 Structural Calculations

Reference:G:\WHI_ENG\Projects\Structural\MATHCAD\Units.xmcd

PG&E Topock Area 9 Structural Calculation Summary

Power Building

- Structural calculations
- Roof diaphragm calculations
- Wind calculations
- USGS Seismic Data
- Supporting Data

Miscellaneous electrical panel and guy wire supports

- Square D Service pack calculations
- Service pack wind calculations
- Conduit Riser calculations
- Conduit Riser wind calculations
- Double Unistrut Support calculations
- Double Unistrut Support wind calculations
- Guy Wire Anchor calculations

Waste Removal Containment Pad

- Pad calculations

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04 Nov 15
STRUCTURAL
STATE OF CALIFORNIA

Reference:G:\WHI_ENG\Projects\Structural\MATHCAD\Units.xmcd

Given Info: Building dimensions: $W := 17 \cdot ft$ $L := 25 \cdot ft + 4 \cdot in = 25.333\,ft$ $H_{eave} := 9.33 \cdot ft$ $H_{pk} := 10.08 \cdot ft$

CMU walls, 8": $f'_m := 1500 \cdot psi$ $E_m := 900 \cdot f'_m$ $E_s := 29000 \cdot ksi$ $n := \frac{E_s}{E_m}$ $n = 21.481$

$F_b := \frac{1}{3} \cdot f'_m$ $F_b = 500 \cdot psi$ $F_{vflex} := \sqrt{f'_m \cdot psi}$ $F_{vflex} = 38.73 \cdot psi$

Concrete: $f'_c := 4000 \cdot psi$ $f_y := 60 \cdot ksi$ $\gamma_c = 150 \cdot pcf$

Seismic: $S_{DS} := 0.245$ $S_{D1} := 0.186$ From USGS, see report $I_e := 1.0$

$R := 2$ $\Omega := 2.5$ For ordinary reinforced masonry

$C_s := \frac{S_{DS} \cdot I_e}{R} = 0.123$ $C_{smin} := 0.044 S_{DS} \cdot I_e = 0.011$ Seismic Design Category: C

$C_{sa} := 0.7 \cdot C_s = 0.086$ unfactored Vertical seismic: $C_{sva} := 0.7 \cdot 0.2 \cdot S_{DS} = 0.034$

Wind: Velocity = 110 MPH, see wind calc Loads unfactored

Perpendicular to ridge: $q_{AW} := 12.0 \cdot psf$ $q_{AL} := 5.71 \cdot psf$ $q_A := q_{AW} + q_{AL} = 17.71 \cdot psf$

Roof: $q_{Ar1} := -12.69 \cdot psf$ to ridge $q_{Ar2} := -8.12 \cdot psf$ beyond ridge

Parallel to ridge: $q_{BW} := 12.0 \cdot psf$ $q_{BL} := 4.57 \cdot psf$ $q_B := q_{BW} + q_{BL} = 16.57 \cdot psf$

Roof: $q_{Br1} := -12.69 \cdot psf$ to Heave $q_{Br2} := -8.12 \cdot psf$ Heave to 2 x Heave

$q_{Br3} := -5.84 \cdot psf$ beyond 2 x Heave

Dead Loads: $DL_r := (2.01 + 3) \cdot psf = 5.01 \cdot psf$ $DL_{cmu} := 66 \cdot psf$ cells grouted at 16" oc, normal weight

Live Loads: $LL_r := 20 \cdot psf$ $DL_{cmus} := 84 \cdot psf$ solid grouted

Geotechnical: $\gamma_{soil} := 120 \cdot pcf$ allowable bearing: 1500 psf $C_{fr} := 0.25$ friction factor

Roof Design: $DL_{dk} := 2.01 \cdot psf$ $DL_{pln} := 6.31 \cdot plf$

Deck span: $L_{dk} := \frac{(W - 12 \cdot in)}{4} = 4\,ft$ Loading: $p_{dk7} := q_{Ar1} + 0.6 \cdot DL_{dk} = -11.484 \cdot psf$

$p_{dk3} := DL_{dk} + LL_r = 22.01 \cdot psf$

$p_{dk6a} := DL_{dk} + 0.75 \cdot LL_r - 0.75 q_{Ar1} = 26.527 \cdot psf$

Vulcraft E20 deck: 152 psf for 4.5' span

Purlin info: 1000S350-97 $S_{xpln} := 5.63 \cdot in^3$ $V_{allow} := 7.177 \cdot kips$ $F_y := 50 \cdot ksi$

Purlin span: $L_{pln} := 24 \cdot ft$ $w_{pln} := DL_{pln} + L_{dk} \cdot p_{dk6a} = 112.42 \cdot plf$

$M_{pln} := \frac{w_{pln} \cdot L_{pln}^2}{8} = 8.094 \cdot ft \cdot k$ $F_{bpln} := 0.6 \cdot F_y = 30 \cdot ksi$ $F_{vpln} := 0.4 \cdot F_y = 20 \cdot ksi$

$f_{bpln} := \frac{M_{pln}}{S_{xpln}} = 17.252 \cdot ksi$ OK

$V_{pln} := 0.5 \cdot w_{pln} \cdot L_{pln} = 1.349 \cdot kips$ OK

See separate calc for diaphragm design

Wall Design:

Roof load on walls: E & W: $P_{ewDL} := \frac{L_{pln}}{2} \cdot DL_r = 60.12 \cdot plf$ $P_{ewLL} := \frac{L_{pln}}{2} \cdot LL_r = 240 \cdot plf$ $e_r := 4 \cdot in$

N & S: $P_{nsDL} := \frac{L_{dk}}{2} \cdot DL_{dk} = 4.02 \cdot plf$ $P_{nsLL} := \frac{L_{dk}}{2} \cdot LL_r = 40 \cdot plf$

Seismic load: $p_{cmus} := C_{sa} \cdot DL_{cmu} = 5.659 \cdot psf$

Wind governs, use: $p_w := 12 \cdot psf$

$M_{ew} := \frac{p_w \cdot H_{pk}^2}{8} = 0.152 \cdot \frac{ft \cdot k}{ft}$ $V_{ew} := p_w \cdot \frac{H_{pk}}{2} = 60.48 \cdot plf$ $P_{ew} := p_{dk6a} \cdot \frac{L_{pln}}{2} = 318.33 \cdot plf$

CMU Design - allowable strength design w/special inspection - load perpendicular to wall

North & South Walls

Given: Reinf cells Grouted $f'_m = 1.5 \times 10^3 \, psi$

Assumed reinforcement: $A_s := 0.31 \cdot in^2$ spaced at $b := 32 \cdot in$ [48" max]

Masonry section: $t := 7.625 \cdot in$ $d := 5.3 \cdot in$ $t_f := 1.25 \cdot in$ $h := 10.3 \cdot ft$ avg unit weight: $p := 66 \cdot psf$

From loading: $M_1 := M_{ew}$ $V_1 := V_{ew}$ $P_1 := P_{ew}$ $e := 4 \cdot in$

[face shell thickness, t_f: 8" = 1.25", 10" = 1.375", 12" = 1.5"]

Calculations per reinforcing bar:

$V := V_1 \cdot b$ $V = 161.28 \cdot lbf$ $P := P_1 \cdot b$ $P = 848.88 \cdot lbf$ $M := M_1 \cdot b + 0.5 \cdot P \cdot e$ $M = 547.906 \cdot ft \cdot lbf$

$np := n \cdot \frac{A_s}{b \cdot d}$ $np = 0.039$ $k := \sqrt{2 \cdot np + np^2} - np$ $k = 0.244$ $j := 1 - \frac{k}{3}$ $j = 0.919$ $\frac{2}{k \cdot j} = 8.932$

$k \cdot d = 1.292 \cdot in$ less than face shell thickness, therefore a tee-beam

Check steel stress: $f_s := \frac{M}{A_s \cdot j \cdot d}$ $f_s = 4.356 \cdot ksi$ [Okay,<1.33*24 ksi]

Check masonry bending stress: $f_m := \frac{M}{b \cdot d^2} \cdot \frac{2}{k \cdot j}$ $f_m = 65.336 \cdot psi$ [Okay <1.33*500psi]

Check axial stress:

$t_1 := t - 2 \cdot t_f$ $I_1 := \frac{(b - 8.5 \cdot in) \cdot \left(t^3 - t_1^3\right)}{12}$ $I_2 := \frac{8.5 \cdot in \cdot t^3}{12}$ $I := I_1 + I_2$ $I = 918.579 \cdot in^4$

$A := (b - 8.5 \cdot in) \cdot 2 \cdot t_f + t \cdot 8.5 \cdot in$ $A = 123.563 \cdot in^2$ Average wall thickness: $t_{avg} := \frac{A}{b}$ $t_{avg} = 3.861 \cdot in$

Radius of gyration: $r := \sqrt{\frac{I}{A}}$ $r = 2.727 \cdot in$ $\frac{h}{r} = 45.332$

$F_a := if\left[\frac{h}{r} < 99, \frac{f'_m}{4} \cdot \left[1 - \left(\frac{h}{140 \cdot r}\right)^2\right], \frac{f'_m}{4} \cdot \left(\frac{70 \cdot r}{h}\right)^2\right]$ $F_a = 335.683 \cdot psi$

$f_a := \frac{P}{t_{avg} \cdot b} + \frac{p \cdot h}{2 \cdot t_{avg}}$ $f_a = 14.206 \cdot psi$ [Okay < 1.33*Fa]

Check combined axial & bending: $\frac{f_m}{F_b} + \frac{f_a}{F_a} = 0.173$ [Okay < 1.33]

Check shear stress:

$f_v := \frac{V}{b \cdot d}$ $f_v = 0.951 \cdot psi$ $F_v := if\left[\sqrt{f'_m \cdot psi} > (35 \cdot psi), (35 \cdot psi), \sqrt{f'_m \cdot psi}\right]$ $F_v = 35 \cdot psi$ [Okay fv < Fv]

CMU beam at top of west wall: Wind load transfers to 24" deep bond beam at top of wall

$$w_{bm} := p_w \cdot \frac{H_{eave}}{2} = 55.98 \cdot plf \qquad M_{bm} := \frac{w_{bm} \cdot (W - t)^2}{8 \cdot 24 \cdot in} \qquad M_{bm} = 936.964 \frac{1}{ft} \cdot ft \cdot lbf$$

$$V_{bm} := \frac{w_{bm} \cdot (W - t)}{2 \cdot 24 \cdot in} = 229.022 \cdot plf$$

Given: Reinf cells Grouted $f'_m = 1.5 \times 10^3 \, psi$

Assumed reinforcement: $A_s := 0.31 \cdot in^2$ spaced at $b := 8 \cdot in$

Masonry section: $t := 7.625 \cdot in$ $d := 5.3 \cdot in$ $t_f := 1.25 \cdot in$ $h := 9.33 \cdot ft$ avg unit weight: $p := 88 \cdot psf$

From loading: $M_1 := M_{bm}$ $V_1 := V_{bm}$ $P_1 := 0 \cdot plf$ $e := 4 \cdot in$

[face shell thickness, t_f: 8" = 1.25", 10" = 1.375", 12" = 1.5"]

Calculations per reinforcing bar:

$$V := V_1 \cdot b \quad V = 152.682 \cdot lbf \qquad P := P_1 \cdot b \quad P = 0 \cdot lbf \qquad M := M_1 \cdot b + 0.5 \cdot P \cdot e \qquad M = 624.643 \cdot ft \cdot lbf$$

$$np := n \cdot \frac{A_s}{b \cdot d} \quad np = 0.157 \quad k := \sqrt{2 \cdot np + np^2} - np \quad k = 0.425 \quad j := 1 - \frac{k}{3} \quad j = 0.858 \quad \frac{2}{k \cdot j} = 5.483$$

$$k \cdot d = 2.252 \cdot in$$

Check steel stress: $f_s := \frac{M}{A_s \cdot j \cdot d}$ $f_s = 5.315 \cdot ksi$ [Okay,<1.33*24 ksi]

Check masonry bending stress: $f_m := \frac{M}{b \cdot d^2} \cdot \frac{2}{k \cdot j}$ $f_m = 182.878 \cdot psi$ [Okay <1.33*500psi]

Check axial stress:

$$t_1 := t - 2 \cdot t_f \qquad I_1 := \frac{(b - 8.5 \cdot in) \cdot \left(t^3 - t_1^3\right)}{12} \qquad I_2 := \frac{8.5 \cdot in \cdot t^3}{12} \qquad I := I_1 + I_2 \qquad I = 301.157 \cdot in^4$$

$A := (b - 8.5 \cdot in) \cdot 2 \cdot t_f + t \cdot 8.5 \cdot in$ $A = 63.562 \cdot in^2$ Average wall thickness: $t_{avg} := \frac{A}{b}$ $t_{avg} = 7.945 \cdot in$

Radius of gyration: $r := \sqrt{\frac{I}{A}}$ $r = 2.177 \cdot in$ $\frac{h}{r} = 51.436$

$$F_a := \mathrm{if}\left[\frac{h}{r} < 99, \frac{f'_m}{4} \cdot \left[1 - \left(\frac{h}{140 \cdot r}\right)^2\right], \frac{f'_m}{4} \cdot \left(\frac{70 \cdot r}{h}\right)^2\right] \qquad F_a = 324.382 \cdot psi$$

$f_a := \frac{P}{t_{avg} \cdot b} + \frac{p \cdot h}{2 \cdot t_{avg}}$ $f_a = 4.306 \cdot psi$ [Okay < 1.33*Fa]

Check combined axial & bending: $\frac{f_m}{F_b} + \frac{f_a}{F_a} = 0.379$ [Okay < 1.33]

Check shear stress:

$f_v := \frac{V}{b \cdot d}$ $f_v = 3.601 \cdot psi$ $F_v := \text{if}\left[\sqrt{f'_m \cdot psi} > (35 \cdot psi), (35 \cdot psi), \sqrt{f'_m \cdot psi}\right]$ $F_v = 35 \cdot psi$ [Okay fv < Fv]

Diaphragm design: See separate calculation

Transfer of lateral force to diaphragm: $k_a := 1 + \frac{L_{pln}}{100 \cdot ft} = 1.24$

$F_p := 0.4 \cdot S_{DS} \cdot k_a \cdot I_e \cdot p \cdot 0.5 \cdot H_{pk} \cdot 0.7 = 37.728 \cdot plf$ Wind: $F_w := p_w \cdot 0.5 \cdot H_{pk} = 60.48 \cdot plf$

Force for anchors: $F_{anc} := 2.5 \cdot F_p = 94.319 \cdot plf$ perpendicular to wall

Diaphagm shear into walls: $L_{dV} := 0.5 \cdot (W - 1.33 \cdot ft - 1.25 \cdot ft) = 7.21\,ft$

$F_{vs} := \frac{F_p \cdot \frac{L_{pln}}{2}}{L_{dV}} = 62.792 \cdot plf$ $F_{vw} := \frac{F_w \cdot \frac{L_{pln}}{2}}{L_{dV}} = 100.66 \cdot plf$

$F_{ancsw} := 2.5 \cdot F_{vs} = 156.98 \cdot plf$

Check Hilti HIT-HY 70 masonry anchor capacity: Edge distance perp. to wall: $x_{edge} := 2.875 \cdot in$

$C_{anch} := \frac{x_{edge} - 1.75 \cdot in}{(4 - 1.75) \cdot in} = 0.5$

Capacity of 1/2" Hilti HIT-HY 70 masonry anchor:

Perpindicular to wall: $F_{hanch1} := 345 \cdot lbf + C_{anch} \cdot (505 - 345) \cdot lbf = 425\,lbf$

Parallel to wall: $F_{hanch2} := 815 \cdot lbf + C_{anch} \cdot (1445 - 815) \cdot lbf = 1.13 \times 10^3\,lbf$

N & S walls: $S_{anchns} := \frac{F_{hanch1}}{F_{anc}} = 4.506\,ft$ Use 24" on center

E & W walls: $S_{anchew} := \frac{F_{hanch2}}{F_{ancsw}} = 7.198\,ft$ Use 32" on center

Shear wall design:

E & W walls: $v_{ew} := \frac{F_{vw}}{t_{avg}} = 1.056\,psi$ OK

N & S walls: $v_{ns} := \frac{\frac{2 \cdot ft \cdot V_{bm}}{L_{pln}}}{t_{avg}} = 0.2\,psi$ OK

Foundation Design

Walls: assume solid grouted, conservative

$$w_{ew} := \left(p_{dk6a} + 10\cdot psf\right)\cdot\frac{L}{2} + DL_{cmus}\cdot H_{eave} + 12\cdot plf = 1.258\times 10^{3}\cdot plf$$

E & W walls: Deck load comb 6a + purlins & misc + wall DL + metal stud wall

$$w_{ns} := \left(p_{dk6a}\right)\cdot\left(\frac{W}{2} + 12\cdot in\right) + DL_{cmus}\cdot H_{eave} = 1.036\times 10^{3}\cdot plf$$

N * S walls: Deck load comb 6a from purlin to overhang + wall DL

Wall footing:

$x_{ftg} := 3.5\cdot ft$ wall centered on ftg $t_{ftg} := 14\cdot in$ $t_{cvr} := 8\cdot in$

Static: $$W_{totstat} := w_{ew} + \frac{\left(x_{ftg} - t\right)}{2}\cdot t_{cvr}\cdot\left(\gamma_c + \gamma_{soil}\right) + \gamma_c\cdot t_{ftg}\cdot x_{ftg} = 2.129\times 10^{3}\cdot plf$$

Soil bearing: $q_{stat} := \dfrac{W_{totstat}}{x_{ftg}} = 608.204\cdot psf$ OK < 1500 psf

Seismic-shear wall:

Seismic N-S direction:

$$P_{sns} := F_p\cdot\frac{L_{pln}}{2} + C_{sa}\cdot\left[DL_{cmus}\cdot W\cdot H_{pk} + \left[\frac{\left(x_{ftg} - t\right)}{2}\cdot t_{cvr}\cdot\left(\gamma_c + \gamma_{soil}\right) + \gamma_c\cdot t_{ftg}\cdot x_{ftg}\right]\cdot\left(W + x_{ftg}\right)\right]$$

$$P_{sns} = 3.217\times 10^{3}\ lbf$$

Check sliding: $R_{sl} := C_{fr}\cdot W\cdot W_{totstat} = 9.047\times 10^{3}\ lbf$ OK

$P_{snsr} := F_p\cdot\dfrac{L_{pln}}{2} = 452.731\cdot lbf$ $z_{snsr} := H_{pk} + t_{cvr} + t_{ftg} = 11.913\ ft$

$P_{snswall} := C_{sa}\cdot\left(DL_{cmus}\cdot W\cdot H_{pk}\right) = 1.234\times 10^{3}\ lbf$ $z_{snswall} := 0.5\cdot\left(H_{pk} + t_{cvr}\right) + t_{ftg} = 6.54\ ft$

$P_{snscvr} := C_{sa}\cdot\left[\dfrac{\left(x_{ftg} - t\right)}{2}\cdot t_{cvr}\cdot\left(\gamma_c + \gamma_{soil}\right)\right]\cdot\left(W + x_{ftg}\right) = 453.202\ lbf$ $z_{snscvr} := \dfrac{t_{cvr}}{2} + t_{ftg} = 1.5\ ft$

$P_{snsftg} := C_{sa}\cdot\gamma_c\cdot t_{ftg}\cdot x_{ftg}\cdot\left(W + x_{ftg}\right) = 1.077\times 10^{3}\ lbf$ $z_{ftg} := 0.5\cdot t_{ftg} = 0.583\ ft$

$$M_{sot} := P_{snsr}\cdot z_{snsr} + P_{snswall}\cdot z_{snswall} + P_{snscvr}\cdot z_{snscvr} + P_{snsftg}\cdot z_{ftg} = 1.477\times 10^{4}\cdot ft\cdot lbf$$

$M_{sr} := W_{totstat}\cdot W^{2}\cdot 0.5 = 3.076\times 10^{5}\cdot ft\cdot lbf$ $FS_{sot} := \dfrac{M_{sr}}{M_{sot}} = 20.821$

Soil bearing:

$$x_{avg} := \frac{(M_{sr} - M_{sot})}{W_{totstat} \cdot W} = 8.092\,ft \qquad e_s := \frac{W}{2} - x_{avg} = 0.408\,ft$$

$$p_{smax} := \frac{W_{totstat} \cdot W}{W \cdot x_{ftg}} \cdot \left(1 + \frac{6 \cdot e_s}{W}\right) = 695.839 \cdot psf$$

$$p_{smin} := \frac{W_{totstat} \cdot W}{W \cdot x_{ftg}} \cdot \left(1 - \frac{6 \cdot e_s}{W}\right) = 520.569 \cdot psf$$

Wind-shear wall:

Wind N-S direction:

$$P_{wns} := F_w \cdot \frac{L_{pln}}{2} = 725.76\,lbf$$ Less than seismic force on shear wall, seismic governs

Wind-wall ftg, N-S direction:

$$P_{wftg} := p_w \cdot \frac{H_{pk}}{2} = 60.48 \cdot plf$$

Seismic-wall ftg, N-S direction:

$$P_{sftg} := C_{sa} \cdot DL_{cmu} \cdot 0.5H_{pk} + C_{sa} \cdot \left[\frac{(x_{ftg} - t)}{2} \cdot t_{cvr} \cdot (\gamma_c + \gamma_{soil}) + \gamma_c \cdot t_{ftg} \cdot x_{ftg}\right] = 103.153 \cdot plf$$

$$R_{wftg} := C_{fr} \cdot \left[DL_{cmu} \cdot H_{pk} + \left[\frac{(x_{ftg} - t)}{2} \cdot t_{cvr} \cdot (\gamma_c + \gamma_{soil}) + \gamma_c \cdot t_{ftg} \cdot x_{ftg}\right]\right] = 383.898 \cdot plf$$ OK

Check footing concrete:

$$M_{ftg} := \frac{(p_{smax} - \gamma_c \cdot t_{ftg}) \cdot [0.5 \cdot (x_{ftg} - t)]^2}{2} = 534.24 \cdot \frac{ft \cdot lbf}{ft}$$ working stress: $a := 1.76$

$d := t_{ftg} - 3.5 \cdot in = 10.5 \cdot in$ $\qquad A_s := \frac{0.520}{1.76 \cdot 10.5} = 0.028$ $\qquad$ Use #4@18"

Check generator load & slab:

$P_{gen} := 968 \cdot lbf$ $\quad x_{anch} := 26 \cdot in$ $\quad y_{anch} := 52 \cdot in$ Powerline model KS2300-T3 23 KWe

$z_{gencg} := 24 \cdot in$ Seismic: $a_p := 1.0 \; R_p := 2.5$

$$F_{pg} := \frac{0.4 \cdot S_{DS} \cdot a_p \cdot I_e}{R_p} \cdot P_{gen} = 37.946\, lbf$$

$$M_{got} := F_{pg} \cdot z_{gencg} = 75.891 \cdot ft \cdot lbf$$

$$M_{rg} := P_{gen} \cdot \frac{x_{anch}}{2} = 1.049 \times 10^3 \cdot ft \cdot lbf$$ OK no anchor tension

Use 4 Hilti 1/2" Kwikbolt TZ anchors with 3.25" embedment

Check slab: $t_{slab} := 6 \cdot in$ $\quad d_{slab} := 2.75 \cdot in$

Assume generator load spread over: $x_{sl} := 6 \cdot ft$ $\quad y_{sl} := 8 \cdot ft$

total DL: $P_{slgen} := P_{gen} + \gamma_c \cdot t_{slab} \cdot x_{sl} \cdot y_{sl} = 4.568 \times 10^3\, lbf$

$$M_{gotsl} := F_{pg} \cdot (z_{gencg} + t_{slab}) + C_{sa} \cdot \gamma_c \cdot t_{slab} \cdot x_{sl} \cdot y_{sl} \cdot 0.5 \cdot t_{slab} = 172.039 \cdot ft \cdot lbf$$

$$M_{rgsl} := P_{slgen} \cdot 0.5 \cdot x_{sl} = 1.37 \times 10^4 \cdot ft \cdot lbf$$

$$x_{avg} := \frac{(M_{rgsl} - M_{gotsl})}{P_{slgen}} = 2.962\, ft \qquad e_g := \frac{x_{sl}}{2} - x_{avg} = 0.038\, ft$$

$$p_{gmax} := \frac{P_{slgen}}{x_{sl} \cdot y_{sl}} \cdot \left(1 + \frac{6 \cdot e_g}{x_{sl}}\right) = 98.751 \cdot psf$$

$$p_{gmin} := \frac{P_{slgen}}{x_{sl} \cdot y_{sl}} \cdot \left(1 - \frac{6 \cdot e_g}{x_{sl}}\right) = 91.583 \cdot psf$$

Use #4@12" okay by inspection

Reference:G:\WHI_ENG\Projects\Structural\MATHCAD\Units.xmcd

Check Steel Deck Diaphragm for N-S Wind

$L_d := 25.33 \cdot ft$ max diaph span

$y_d := 8ft$ "beam depth"

$F_y := 50 \cdot ksi$ $F_b := 0.6 \cdot F_y = 30 \cdot ksi$ $F_v := 0.4 \cdot F_y = 20 \cdot ksi$

$F_t := 0.6 \cdot F_y = 30 \cdot ksi$

Diaph shear: (given) $v_d := 60.5plf$

$V_d := v_d \cdot \frac{L_d}{2} = 766.232 lbf$

Chord tension: $M_d := \frac{v_d \cdot L_d^2}{8} = 4.852 \cdot ft \cdot k$

$T_{chord} := \frac{M_d}{y_d} = 606.521 lbf$

$A_{tc} := 1.269in^2$ Area of Tension Chord, the purlin per plan. C10x1.25 12 gage, 1000T125-97

$\frac{T_{chord}}{A_{tc}} = 0.478 \cdot ksi$ Less than Ft OK

Check Horzontal Load Transfer

$Shear_{cap} := 199lbf$ 1/4" x 14 self tapping screw. This shear capacity is for 20gage steel. So the diaphragm needs to be 20gage instead of 26 gage.

$Quantity := \frac{V_d}{Shear_{cap}}$ Check how may screws required along shear length to transfer the shear

$Quantity = 3.85$ Need 4 screws

use screws @ 12" OC, which would be 8 screws total.

$t_{sheet} := 0.0785in$ Thickness of 14gage sheet metal

$\frac{V_d}{y_d \cdot t_{sheet}} = 0.102 \cdot ksi$ Check 14gage sheet metal - Less than F.v OK

Check Vertical Load Transfer

$LL := 20psf$ Live load given

$DL := 2.01psf$ Dead load = selfweight of 20gage 1.0E Vulcraft Deck

$Deck_{load} := (DL + LL) \cdot \left(\frac{y_d}{2}\right) \cdot \left(\frac{L_d}{2}\right)$

$Deck_{load} = 1.115 \cdot kip$ Load on Roof Deck being transferred to clip angle

$Shear_{14ga} := 588lbf$ Capacity of screws connecting 12gage clip angle and 14gage rim track

$purlin := 6.31plf$ weight of 12gage C10 purlin - 1000S350-97

$$Tot_{screws\_14ga} := \frac{Deck_{load} + purlin \cdot \frac{L_d}{2}}{Shear_{14ga}} = 2.032$$

Check transfer of roof deck load through clip angle and clip angle transfer via 2 screws to rim track.
2 screws OK

$$Vert_{load} := Deck_{load} + purlin \cdot \frac{L_d}{2} = 1.195 \cdot kip$$

Vertical load including deck load and weight of purlin

Locate stud directly under purlin

Stud cross section area: $A_{st} := 1.032 \cdot in^2$ $E_s := 29000 \cdot ksi$ $L_s := 18 \cdot in$ $r_x := 2.459 \cdot in$

$$C_c := \sqrt{\frac{2 \cdot \pi \cdot E_s}{F_y}} = 60.368 \qquad K := 1 \qquad \frac{K \cdot L_s}{r_x} = 7.32$$

$$F_a := \frac{\left[1 - \frac{\left(\frac{K \cdot L_s}{r_x}\right)^2}{2 \cdot C_c^2}\right] \cdot F_y}{\frac{5}{3} + \frac{3 \cdot \frac{K \cdot L_s}{r_x}}{8 \cdot C_c} - \frac{\left(\frac{K \cdot L_s}{r_x}\right)^3}{8 \cdot C_c^3}} = 28.992 \cdot ksi$$

check steel stud for weight of deck load + purlin load + steel top track load

$$\frac{\left(Vert_{load} + 2.06plf \cdot \frac{y_d}{2}\right)}{A_{st}} = 1.166 \cdot ksi$$

Less than F.a
OK

** no need to check bottom track; it's in compression resting on top of masonry wall

WIND LOADS - Buildings of All Heights - Enclosed Buildings (per IBC 2012 in accordance with ASCE 7-10)

Building Conditions

Reference:G:\WHI_ENG\Projects\Structural\MATHCAD\Units.xmcd

$Height\_of\_Building := 8.67ft$ — See ASCE 7 section 26.2 definitions

$Roof\_slope := \frac{2}{12}$ $\theta = 9.46 \cdot deg$ — From architectural drawings. - Gable Roof

$RiskCategory := "II"$ — From IBC 2012, table 1604.5 (pg. 281)

$V := 110$ - wind speed (mph) — From ASCE 7 - 10, figure 26.5-1B (pgs. 248a and 248b)

$Exposure := C$ — From ASCE 7 - 10, section 26.7.3 (pg. 251)

$G := .85$ - gust factor — From ASCE 7-10, section 26.9 (pg. 254)

$GC_{pi} := 0.18$ - internal pressure coef. — From ASCE 7-10, section 26.10 (pg. 255). table 26.11-1 (pg. 258)

Plan dimensions: $x := 25.33 \cdot ft$ $y := 17.0 \cdot ft$

Wind Loading Coefficients

$K_z := 0.85$ - velocity pressure exposure coef. — From ASCE 7- 10, section 27.3.1 (pg. 260), table 27.3-1 (pg. 261)

$K_1 := 0$ $K_2 := 0$ $K_3 := 0$ — From ASCE 7-10, section 26.8 (pg. 251), figure 26.8-1 (pg. 252-253)

$K_{zt} := (1 + K_1 \cdot K_2 \cdot K_3)^2$ - topograghic factor $K_{zt} = 1$

$K_d := 0.85$ - wind directionality factor — From ASCE 7-10, section 26.6 (pg. 246). table 26.6-1 (pg. 250)

$G := 0.85$ -gust factor — From ASCE 7-10, section 26.9 (pg. 254)

Velocity Pressure

$q_z := .00256 \cdot K_z \cdot K_{zt} \cdot K_d \cdot V^2$

$q_z = 22.38 \cdot psf$ — Equation 29.3-1 from ASCE 7-10, section 29.3.2 (pg. 307)

Main Wind Force Resisiting System: wind at 0 degrees and 180 degrees

Case A: $B := x$ $L := y$ $\frac{L}{B} = 0.67$ $\frac{h}{L} = 0.51$ $Area := x \cdot y = 430.61ft^2$ $R_f := 0.88$

$C_{PW} := 0.8$ $C_{PL} := -0.5$ From ASCE 7 - 10 figure 27.4-1 (pg. 264) $C_{PR1} := -0.9$ $C_{PR2} := -0.5$

$qA\_windward\_factored := q_z \cdot G \cdot C_{PW}$ — Equation 27.4-3 From ASCE 7 - 10 section 27.4.3 (pg. 262) — $qA\_windward\_factored = 15.22 \cdot psf$

$qA\_leeward\_factored := q_z \cdot G \cdot C_{PL}$ — $qA\_leeward\_factored = -9.51 \cdot psf$

$qA := qA\_windward\_factored - qA\_leeward\_factored = 24.73 \cdot psf$ — $qA = 24.73 \cdot psf$

$qA_{r1} := q_z \cdot G \cdot C_{PR1} - q_z \cdot GC_{pi}$ — $qA_{r1} = -21.15 \cdot psf$ over h/2

$qA_{r2} := q_z \cdot G \cdot C_{PR2} - q_z \cdot GC_{pi}$ — $qA_{r2} = -13.54 \cdot psf$ over >h/2

$qA\_windward\_unfactored := 0.6 \cdot qA\_windward\_factored$ — $qA\_windward\_unfactored = 9.13 \cdot psf$

$qA\_leeward\_unfactored := 0.6 \cdot qA\_leeward\_factored$ — $qA\_leeward\_unfactored = -5.71 \cdot psf$

$qAunf := qA\_windward\_unfactored - qA\_leeward\_unfactored = 14.84 \cdot psf$ — $qAunf = 14.84 \cdot psf$

$qA_{r1unf} := (q_z \cdot G \cdot C_{PR1} - q_z \cdot GC_{pi}) \cdot 0.6$ — $qA_{r1unf} = -12.69 \cdot psf$ over h/2

$qA_{r2unf} := (q_z \cdot G \cdot C_{PR2} - q_z \cdot GC_{pi}) \cdot 0.6$ — $qA_{r2unf} = -8.12 \cdot psf$ over >h/2

Main Wind Force Resisiting System: wind at 90 degrees

$\theta_B := 0 \cdot deg$

Case B:

$B := y$ $L := x$ $\frac{L}{B} = 1.49$ $\frac{h}{L} = 0.34$ $Area := x \cdot y = 430.61 ft^2$ $Rf := 0.88$

$C_{PW} := 0.8$ $C_{PL} := -0.4$ From ASCE 7 - 10 figure 27.4-1 (pg. 264) $C_{PR1} := -0.9$ $C_{PR2} := -0.5$ $C_{PR3} := -0.3$

$q_{B\_windward\_factored} := q_z \cdot G \cdot C_{PW}$ Equation 27.4-3 From ASCE 7 - 10 section 27.4.3 (pg. 262) $q_{B\_windward\_factored} = 15.22 \cdot psf$

$q_{B\_leeward\_factored} := q_z \cdot G \cdot C_{PL}$ $q_{B\_leeward\_factored} = -7.61 \cdot psf$

$q_B := q_{B\_windward\_factored} - q_{B\_leeward\_factored} = 22.83 \cdot psf$ $q_B = 22.83 \cdot psf$

$q_{Br1} := q_z \cdot G \cdot C_{PR1} - q_z \cdot GC_{pi}$ $q_{Br1} = -21.15 \cdot psf$ over h

$q_{Br2} := q_z \cdot G \cdot C_{PR2} - q_z \cdot GC_{pi}$ $q_{Br2} = -13.54 \cdot psf$ over h to 2h

$q_{Br3} := q_z \cdot G \cdot C_{PR3} - q_z \cdot GC_{pi}$ $q_{Br3} = -9.74 \cdot psf$ over > 2h

$q_{B\_windward\_unfactored} := 0.6 \cdot q_{B\_windward\_factored}$ $q_{B\_windward\_unfactored} = 9.13 \cdot psf$

$q_{B\_leeward\_unfactored} := 0.6 \cdot q_{B\_leeward\_factored}$ $q_{B\_leeward\_unfactored} = -4.57 \cdot psf$

$q_{Bunf} := q_{B\_windward\_unfactored} - q_{B\_leeward\_unfactored} = 13.7 \cdot psf$ $q_{Bunf} = 13.7 \cdot psf$

$q_{Br1unf} := (q_z \cdot G \cdot C_{PR1} - q_z \cdot GC_{pi}) \cdot 0.6$ $q_{Br1unf} = -12.69 \cdot psf$ over h

$q_{Br2unf} := (q_z \cdot G \cdot C_{PR2} - q_z \cdot GC_{pi}) \cdot 0.6$ $q_{Br2unf} = -8.12 \cdot psf$ over h to 2h

$q_{Br3unf} := (q_z \cdot G \cdot C_{PR3} - q_z \cdot GC_{pi}) \cdot 0.6$ $q_{Br3unf} = -5.84 \cdot psf$ over > 2h

USGS Design Maps Summary Report

User–Specified Input

Report Title PG&E Topock
Wed August 26, 2015 15:28:17 UTC

Building Code Reference Document 2012 International Building Code
(which utilizes USGS hazard data available in 2008)

Site Coordinates 34.7147°N, 114.494°W

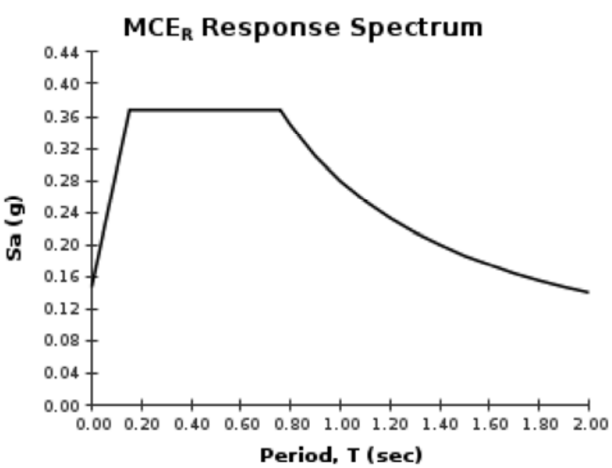
Site Soil Classification Site Class D – "Stiff Soil"

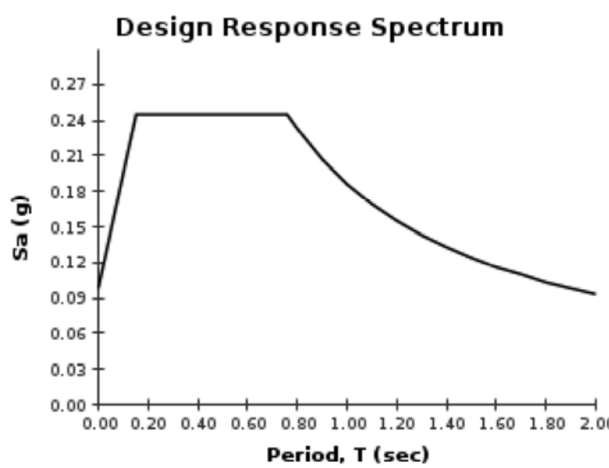
Risk Category I/II/III

USGS–Provided Output

S_S =	0.230 g	S_{MS} =	0.368 g	S_{DS} =	0.245 g
S_1 =	0.121 g	S_{M1} =	0.279 g	S_{D1} =	0.186 g

For information on how the SS and S1 values above have been calculated from probabilistic (risk-targeted) and deterministic ground motions in the direction of maximum horizontal response, please return to the application and select the "2009 NEHRP" building code reference document.





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3.2.7 HIT-HY 70 Hybrid for Masonry Construction

Table 4 - HIT-HY 70 allowable tension and shear values for threaded rods based on steel strength[1, 2, 3]

Nominal anchor diameter	Tension, lb (kN)					Shear, lb (kN)				
	ASTM A36	ASTM A307	ASTM A193 B7	ISO 898 Class 5.8	ASTM F593 CW 304/316	ASTM A36	ASTM A307	ASTM A193 B7	ISO 898 Class 5.8	ASTM F593 CW 304/316
1/4	940 (4.2)	972 (4.3)	2,025 (9.0)	1,175 (5.2)	1,620 (7.2)	485 (2.2)	500 (2.2)	1,040 (4.6)	605 (2.7)	835 (3.7)
5/16	1,470 (6.5)	1,520 (6.8)	3,160 (14.1)	1,835 (8.2)	2,530 (11.3)	756 (3.4)	780 (3.5)	1,630 (7.3)	945 (4.2)	1,300 (5.8)
3/8	2,115 (9.4)	2,185 (9.7)	4,555 (20.3)	2,640 (11.7)	3,645 (16.2)	1,090 (4.8)	1,125 (5.0)	2,345 (10.4)	1,360 (6.1)	1,875 (8.3)
1/2	3,755 (16.7)	3,885 (17.3)	8,100 (36.0)	4,700 (20.9)	6,480 (28.8)	1,935 (8.6)	2,000 (8.9)	4,170 (18.6)	2,420 (10.8)	3,335 (14.8)
5/8	5,870 (26.1)	6,075 (27.0)	12,655 (56.3)	7,340 (32.7)	10,125 (45.0)	3,025 (13.5)	3,130 (13.9)	6,520 (29.0)	3,780 (16.8)	5,215 (23.2)
3/4	8,455 (37.6)	8,750 (38.9)	18,225 (81.1)	10,570 (47.0)	14,580 (64.9)	4,355 (19.4)	4,506 (20.0)	9,388 (41.8)	5,445 (24.2)	7,510 (33.4)

1 Allowable load used in the design must be the lesser of bond values and tabulated steel values.

2 The allowable tension and shear values for threaded rods to resist short term loads, such as wind or seismic, must be calculated in accordance with the appropriate IBC Sections.

3 Allowable steel loads are based on tension and shear stresses equal to $0.33 \times F_u$ and $0.17 \times F_u$, respectively.

Table 5 - HIT-HY 70 allowable adhesive bond loads for threaded rods and reinforcing bars in the top of grout-filled concrete masonry walls[1, 2, 3, 4, 5, 6]

Nominal anchor diameter or rebar size	Effective embedment in. (mm)	Edge distance in. (mm)[7, 8]	Minimum end distance in. (mm)	Tension lb (kN)	Shear load, lb (kN) [9]	
					Load parallel to edge of masonry wall	Load perpendicular to edge of masonry wall
1/2	4-1/2 (114)	1-3/4 (44.5)	8 (203)	1,165 (5.2)	815 (3.6)	345 (1.5)
		4 (101.6)		1,625 (7.2)	1,445 (6.4)	505 (2.3)
5/8	5-5/8 (143)	1-3/4 (44.5)		1,165 (5.2)	1,190 (5.3)	385 (1.7)
		4 (101.6)		1,590 (7.1)	1,825 (8.1)	655 (2.9)
No. 4	4-1/2 (114)	1-3/4		865 (4.0)	630 (2.8)	245 (1.1)
No. 5	5-5/8 (143)			980 (4.4)	755 (3.4)	295 (1.3)

1 All values are for anchors installed in fully grouted concrete masonry with minimum masonry prism strength of 1,500 psi. Concrete masonry units shall be lightweight, medium-weight or heavy-weight conforming to ASTM C90. Allowable loads are calculated using a safety factor of 5.

2 When using the basic load combinations in accordance with IBC Section 1605.3.1 or the alternative basic load combinations in IBC Section 1605.3.2. Tabulated allowable loads must not be increased for seismic or wind loading.

3 One anchor shall be permitted to be installed in each concrete block.

4 Anchors are not permitted to be installed in a head joint, flange or web of the concrete masonry unit.

5 Allowable loads must be the lesser of the adjusted masonry or bond tabulated values and the steel values given in table 4.

6 Tabulated allowable loads shall be adjusted for increased base material temperatures in accordance with figure 12.

7 For combined loading: $(T_{applied} / T_{allowable}) + (V_{applied} / V_{allowable}) \le 1$

8 The tabulated edge distance is measured from the anchor centerline to the edge of the concrete block. See figure 2.

9 Linear interpolation of load values between the two tabulated edge distances is permitted.

Figure 1 - HIT-HY 70 specifications for HAS threaded rod in grout-filled masonry walls

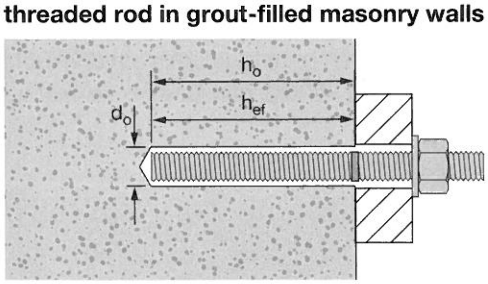
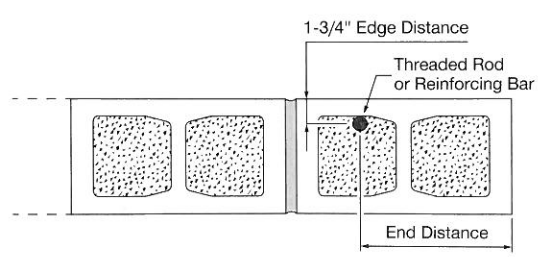


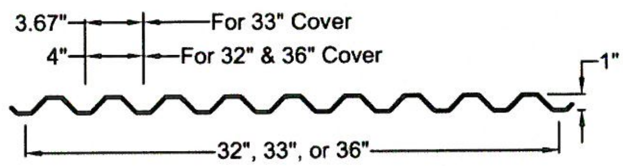
Figure 2 — Edge and end distances for threaded rods and reinforcing bars installed in the top of grout-filled CMU



1.0 E

Maximum Sheet Length 42'-0
Extra Charge for Lengths Under 6'-0

ROOF



Type E deck provides a very economical roof deck for use on shorter spans. 1" or more rigid insulation should be used with Type E deck. Installation of rigid insulation should be with mechanical fasteners.

This deck also lends itself for use as a building siding.

SECTION PROPERTIES

Deck type	Design thickness in.	W psf	Section Properties				V_a lbs/ft	F_y ksi
			I_p	S_p	I_n	S_n		
			in^4/ft	in^3/ft	in^4/ft	in^3/ft		
E26	0.0179	1.06	0.040	0.067	0.042	0.071	2216	60
E24	0.0239	1.38	0.057	0.098	0.059	0.103	3867	60
E22	0.0295	1.67	0.073	0.130	0.073	0.134	4754	60
E20	0.0358	2.01	0.088	0.167	0.088	0.165	5744	60

VERTICAL LOADS FOR TYPE 1.0E

No. of Spans	Deck Type	Max. SDI Const. Span	Allowable Total (PSF) / Load Causing Deflection of L/240 or 1 inch (PSF)										
			Span (ft.-in.) ctr to ctr of supports										
			2-6	3-0	3-6	4-0	4-6	5-0	5-6	6-0	6-6	7-0	7-6
1	E26	2'-10	257 / 168	178 / 97	131 / 61	100 / 41	79 / 29	64 / 21	53 / 16	45 / 12	38 / 10	33 / 8	29 / 6
	E24	3'-5	376 / 239	261 / 138	192 / 87	147 / 58	116 / 41	94 / 30	78 / 22	65 / 17	56 / 14	48 / 11	42 / 9
	E22	3'-10	498 / 306	346 / 177	254 / 112	195 / 75	154 / 53	125 / 38	103 / 29	86 / 22	74 / 17	64 / 14	55 / 11
	E20	4'-2	640 / 369	444 / 214	327 / 135	250 / 90	198 / 63	160 / 46	132 / 35	111 / 27	95 / 21	82 / 17	71 / 14
2	E26	3'-4	267 / 414	187 / 240	138 / 151	106 / 101	84 / 71	68 / 52	56 / 39	47 / 30	40 / 24	35 / 19	30 / 15
	E24	4'-0	390 / 586	272 / 339	200 / 214	153 / 143	121 / 101	98 / 73	81 / 55	68 / 42	58 / 33	50 / 27	44 / 22
	E22	4'-6	506 / 738	353 / 427	260 / 269	199 / 180	158 / 127	128 / 92	106 / 69	89 / 53	76 / 42	65 / 34	57 / 27
	E20	5'-0	623 / 889	435 / 515	320 / 324	246 / 217	194 / 152	158 / 111	130 / 84	109 / 64	93 / 51	81 / 41	70 / 33
3	E26	3'-4	330 / 325	232 / 188	171 / 118	132 / 79	104 / 56	84 / 41	70 / 30	59 / 23	50 / 18	43 / 15	38 / 12
	E24	4'-0	485 / 459	338 / 266	249 / 167	191 / 112	151 / 79	123 / 57	102 / 43	85 / 33	73 / 26	63 / 21	55 / 17
	E22	4'-6	629 / 578	440 / 334	324 / 211	249 / 141	197 / 99	160 / 72	132 / 54	111 / 42	95 / 33	82 / 26	71 / 21
	E20	5'-0	774 / 697	541 / 403	399 / 254	306 / 170	242 / 119	197 / 87	163 / 65	137 / 50	117 / 40	101 / 32	88 / 26

Notes: 1. Minimum exterior bearing length required is 1.50 inches. Minimum interior bearing length required is 3.00 inches. If these minimum lengths are not provided, web crippling must be checked.

Marino\WARE® Product Submittal Data

PRODUCT NAME: **1000S350-97**

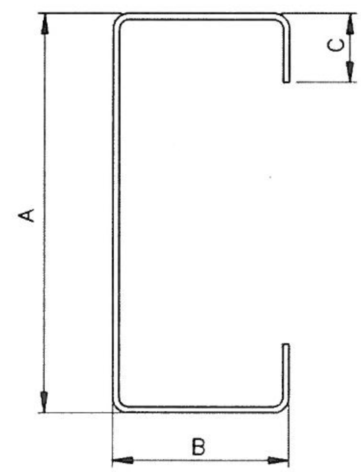
05.40.00 Cold-Formed Metal Framing

MARINO\WARE PART # 100SW12

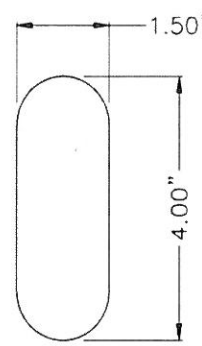
PROPERTIES:

A. Web (in)	10"	**Yield Strength Fy (KSI)**	50
B. Flange (in)	3-1/2"	**Tensile Strength Fu (KSI)**	65
C. Lip (in)	1"	**Design Thickness (in)**	0.1017
Mils	97	**Minimum Thickness (in)**	0.0966
Available Finish	G60, G90	**Gauge**	12

STRUCTURAL STUD



Punchout



SECTION PROPERTIES

GROSS SECTION PROPERTIES

Cross Sectional Area: **A** (in^2)	1.855
Weight of Member: (lb/ft)	6.31
Moment of Inertia: **Ix** (in^4)	28.148
Section Modulus: **Sx** (in^3)	5.630
Radius of Gyration: **Rx** (in)	3.895
Gross Moment of Inertia: **Iy** (in^4)	2.992
Gross Radius of Gyration: **Ry** (in)	1.270

EFFECTIVE SECTION PROPERTIES

Moment of Inertia-Deflection: **Ixe** (in^4)	28.15
Section Modulus: **Sxe** (in^3)	5.12
Allowable Bending Moment: **Ma** (in-k)	153.25
Allowable strong axis shear away from punch: **Vag** (lb)	9864
Allowable strong axis shear at punch: **Vanet** (lb)	7177

TORSIONAL SECTION PROPERTIES

St. Venant Torsional Constant: **Jx1000** (in^4)	6.397
Torsional Warping Constant: **Cw** (in^6)	62.280
Shear Center to Centroid on Principal X-axis: **Xo** (in)	-2.492
Shear Center to Mid-Plane of the Web: **m** (in)	1.538
Radius of Gyration on the Centroid Principal axis: **Ro** (in)	4.795
Torsional Flexural Constant: **β** $[1-(xo/Ro)^2]$	0.730

CODES & STANDARDS

- AISI North American Specification 2001 with 2004 Supplement
- Framing meets ASTM A 1003, A 653, & C 955

GREEN INFO LEED® v3

Available LEED® points in the following categories:

- MR Credit 2 - Construction Waste Management (1-2 points)
- MR Credit 4 - Recycled Content (1-2 points)
- MR Credit 5 - Regional Materials (1-2 points)

- Total Recycled Content: 34.9%
- Post Consumer Content: 24.3%
- Pre Consumer (Post Industrial) Content: 9.4%

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Marino\WARE® Product Submittal Data

PRODUCT NAME: **600S350-68**

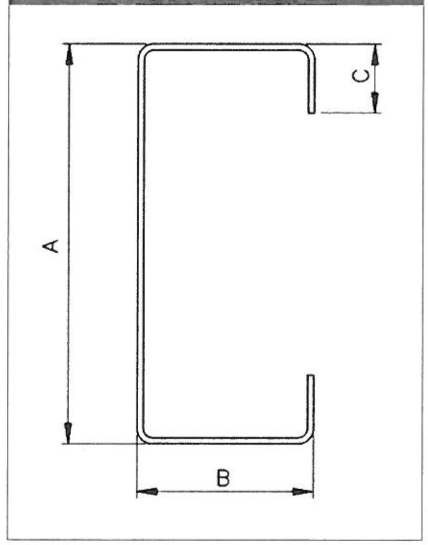
MARINO\WARE PART # 600SW14

05.40.00 Cold-Formed Metal Framing

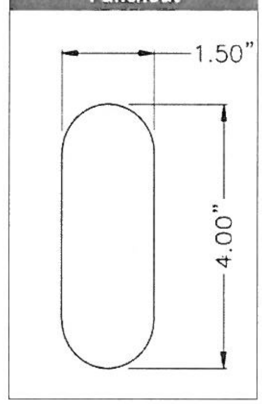
PROPERTIES:

A. Web (in)	6"	**Yield Strength Fy (KSI)**	50
B. Flange (in)	3-1/2"	**Tensile Strength Fu (KSI)**	65
C. Lip (in)	1"	**Design Thickness (in)**	0.713"
Mils	68	**Minimum Thickness (in)**	0.677"
Available Finish	G60, G90	**Gauge**	14

STRUCTURAL STUD



Punchout



SECTION PROPERTIES

GROSS SECTION PROPERTIES

Cross Sectional Area: **A** (in^2)	1.032
Weight of Member: (lb/ft)	3.51
Moment of Inertia: **Ix** (in^4)	6.237
Section Modulus: **Sx** (in^3)	2.079
Radius of Gyration: **Rx** (in)	2.459
Gross Moment of Inertia: **Iy** (in^4)	1.841
Gross Radius of Gyration: **Ry** (in)	1.336

EFFECTIVE SECTION PROPERTIES

Moment of Inertia-Deflection: **Ixe** (in^4)	6.17
Section Modulus: **Sxe** (in^3)	1.77
Allowable Bending Moment: **Ma** (in-k)	53.01
Allowable strong axis shear away from punch: **Vag** (lb)	5350
Allowable strong axis shear at punch: **Vanet** (lb)	2879

TORSIONAL SECTION PROPERTIES

St. Venant Torsional Constant: **Jx1000** (in^4)	1.748
Torsional Warping Constant: **Cw** (in^6)	15.968
Shear Center to Centroid on Principal X-axis: **Xo** (in)	-3.018
Shear Center to Mid-Plane of the Web: **m** (in)	1.777
Radius of Gyration on the Centroid Principal axis: **Ro** (in)	4.115
Torsional Flexural Constant: **β** $1-(xo/Ro)^2$	0.462

CODES & STANDARDS

- AISI North American Specification 2001 with 2004 Supplement
- Framing meets ASTM A 1003, A 653, & C 955

GREEN INFO LEED® v3

Available LEED® points in the following categories:

- MR Credit 2 - Construction Waste Management (1-2 points)
- MR Credit 4 - Recycled Content (1-2 points)
- MR Credit 5 - Regional Materials (1-2 points)

- Total Recycled Content: 34.9%
- Post Consumer Content: 24.3%
- Pre Consumer (Post Industrial) Content: 9.4%

MARINO WARE
www.marinoware.com

For more information, please contact Marino\WARE Technical Services at 866-545-1545.

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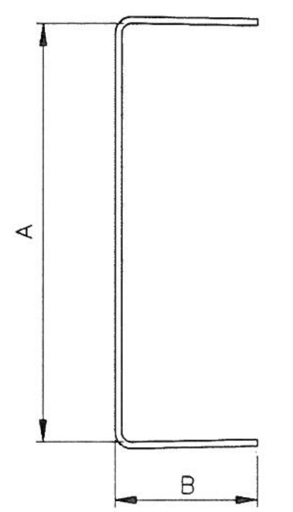
Marino\WARE® Product Submittal Data

PRODUCT NAME: **600T125-68**

MARINO\WARE PART # 600ST14

05.40.00 Cold-Formed Metal Framing

STRUCTURAL TRACK



PROPERTIES:

A. Web (in)	6"	**Yield Strength Fy (KSI)**	50
B. Flange (in)	1-1/4"	**Tensile Strength Fu (KSI)**	65
Mils	68	**Design Thickness (in)**	0.0713
Available Finish	G60, G90	**Minimum Thickness (in)**	0.0677
		Gauge	14

SECTION PROPERTIES

GROSS SECTION PROPERTIES

Cross Sectional Area: **A** (in^2)	0.605
Weight of Member: (lb/ft)	2.06
Moment of Inertia: **Ix** (in^4)	2.969
Section Modulus: **Sx** (in^3)	0.950
Radius of Gyration: **Rx** (in)	2.215
Gross Moment of Inertia: **Iy** (in^4)	0.067
Gross Radius of Gyration: **Ry** (in)	0.332

EFFECTIVE SECTION PROPERTIES

Moment of Inertia-Deflection: **Ix** (in^4)	2.934
Section Modulus: **Sx** (in^3)	0.858
Allowable Bending Moment: **Ma** (in-k)	25.690
Allowable strong axis shear away from punch: **Vag** (lb)	5350

TORSIONAL SECTION PROPERTIES

St. Venant Torsional Constant: **Jx1000** (in^4)	1.025
Torsional Warping Constant: **Cw** (in^6)	0.483
Shear Center to Centroid on Principal X-axis: **Xo** (in)	-0.503
Shear Center to Mid-Plane of the Web: **m** (in)	0.329
Radius of Gyration on the Centroid Principal axis: **Ro** (in)	2.296
Torsional Flexural Constant: **β** $[1-(xo/Ro)^2]$	0.952

CODES & STANDARDS

- AISI North American Specification 2001 with 2004 Supplement
- Framing meets ASTM A 1003, A 653, & C 955
- Galvanized steel sheet meets ASTM A 924

GREEN INFO LEED® v3

Available LEED® points in the following categories:

- MR Credit 2 - Construction Waste Management (1-2 points)
- MR Credit 4 - Recycled Content (1-2 points)
- MR Credit 5 - Regional Materials (1-2 points)

- Total Recycled Content: 34.9%
- Post Consumer Content: 24.3%
- Pre Consumer (Post Industrial) Content: 9.4%

MARINO WARE

www.marinoware.com

For more information, please contact Marino\WARE Technical Services at 866-545-1545.

This technical information reflects the most current information available and supersedes any and all publications, effective 12/1/2010

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Fastening Options

Connections can be made using a variety of fastening options. It is critical to specify the proper fastener to ensure the proper performance of the connections in light-gauge (cold-formed) steel construction. The most common and widely used connection methods are screw connections, powder-actuated fastener connections and weld connections. Each type of connection method has various advantages and disadvantages. Therefore, we provide data for the most common types so you can choose your preferred connection method.

SCREW CONNECTIONS

Self-drilling screws—These high-strength fasteners are used if the connection is multiple thicknesses of 33mil steel or thicker. One of the more common self-drilling screws is a #10-16 x 5/8 HWH SD (#10 diameter shaft, 16 threads per inch, 5/8 length, hex washer head self-drilling screw).

AISI CALCULATED ALLOWABLE LOADS FOR SCREW CONNECTION

Material thickness (mils)	Design thickness (in)	Material Strength		#8-18 HWH Screw Dia. = 0.160		#10-16 HWH Screw Dia. = 0.190		#12-14 HWH Screw Dia. = 0.210		1/4"-14 HWH Screw Dia. = 0.240	
		Fy (ksi)	Fu (ksi)	Shear (lbs)	Tension (lbs)	Shear (lbs)	Tension (lbs)	Shear (lbs)	Tension (lbs)	Shear (lbs)	Tension (lbs)
33	0.0346	33	45	162	71	177	84	186	93	199	106
43	0.0451	33	45	241	92	263	109	277	121	296	138
54	0.0566	33	45	333	115	370	137	389	152	416	173
	0.0566	50	65	333	167	467	198	562	219	600	250
68	0.0713	33	45	—	—	467	173	550	191	588	218
	0.0713	50	65	—	—	467	249	667	276	849	315
97	0.1017	33	45	—	—	467	246	667	272	867	311
	0.1017	50	65	—	—	467	356	667	393	867	450
118	0.1242	33	45	—	—	—	—	667	333	867	380
	0.1242	50	65	—	—	—	—	667	480	867	549

AISI CALCULATED ALLOWABLE BEARING & PULLOVER FOR SCREWS

Material thickness (mils)	Design thickness (in)	Material Strength		#8-18 Screw Shank = 0.160 Head = 0.250		#10-16 Screw Shank = 0.190 Head = 0.375		#12-14 Screw Shank = 0.210 Head = 0.375		1/4"-14 Screw Shank = 0.240 Head = 0.500	
		Fy (ksi)	Fu (ksi)	Bearing (lbs)	Pullover (lbs)	Bearing (lbs)	Pullover (lbs)	Bearing (lbs)	Pullover (lbs)	Bearing (lbs)	Pullover (lbs)
33	0.0346	33	45	224	195	266	292	294	292	336	389
43	0.0451	33	45	292	254	347	381	384	381	438	507
54	0.0566	33	45	367	318	436	478	481	478	550	637
		50	65	530	460	629	690	695	690	795	920
68	0.0713	33	45	—	—	549	602	606	602	693	802
		50	65	—	—	792	869	876	869	1001	1159
97	0.1017	33	45	—	—	783	858	865	858	989	1144
		50	65	—	—	1130	1239	1249	1239	1428	1653
118	0.1242	33	45	—	—	—	—	1056	1048	1207	1397
		50	65	—	—	—	—	1526	1514	1744	2018

Notes:

1 All values were calculated using the 2001 AISI Specification w/2004 supplement.
2 Charts are based on Buildex TEK2 HWH screw capacities. All screws must meet minimum criteria outlined.
3 Shear strength for #8, #10, #12, and 1/4" screws must be greater than or equal to 1000 lbs, 1400 lbs, 2000 lbs and 2600 lbs respectively.
4 Tension strength for #8, #10, #12, and 1/4" screws must be greater than or equal to 1545 lbs, 1936 lbs, 2778 lbs and 4060 lbs respectively.
5 The minimum head diameter for #8 screws is 1/4". The minimum head diameter for #10 and #12 screws is 3/8". The minimum head diameter for 1/4" screws is 1/2".
6 Screw ultimate shear capacity is based on Buildex® DATA as a minimum.
7 Buildex is a registered trademark of Illinois Tool Works, Inc.

FastClip™ deflection screws—Many of the ClarkDietrich deflection clips include our proprietary FastClip fastener that has been specifically designed to provide friction-free deflection. These fasteners eliminate drag, binding or resistance that can often occur with common fasteners.

FastClip™ Deflection Screw	
Average Ultimate Shear	2400 lbs
NASPEC 2007 ASD Factor of Safety	3.0
Average Allowable Shear Load	800 lbs

Reference:G:\WHI_ENG\Projects\Structural\MATHCAD\Units.xmcd

$Allow_{bp} := 1500psf$ Allowable Bearing Pressure

Column Weight (Assume 5plf for Square D ServicePak)

$h_c := 2.42ft$ $w_c := 8 \cdot in$

$wt_c := 5plf \cdot h_c$ $wt_c = 12.1 \cdot lbf$

Wind: $q_{wa} := 18.57 \cdot psf$

Footing Properties

length $l_f := 2ft$ $c := \frac{l_f}{2}$

height $h_f := 0.5ft$

width $w_f := 2ft$ $I := \frac{w_f \cdot l_f^3}{12}$

area $A_f := l_f \cdot w_f$

$wt_f := \gamma_c \cdot (l_f \cdot h_f \cdot w_f)$ $wt_f = 0.3 \cdot kip$

Moment

$$M := q_{wa} \cdot w_c \cdot h_c \cdot \left(\frac{h_c}{2} + h_f\right) = 51.231 \cdot ft \cdot lbf$$

Vertical Design Force

$P := wt_c + wt_f$ $P = 0.312 \cdot kip$

$M_r := P \cdot l_f \cdot 0.5 = 312.1\ ft \cdot lbf$ $FS_{ot} := \frac{M_r}{M} = 6.092$ OK

Checking for full bearing

$e_{actual} := \frac{M}{P}$ $e_{actual} = 1.97 \cdot in$

$e_{max} := \frac{l_f}{6}$ $e_{max} = 4 \cdot in$

Setting e_actual and e_max equal to each other...

Given

$$\gamma_c \cdot w_f \cdot h_f \cdot l_f^2 + wt_c \cdot l_f - 6 \cdot M = 0$$

$l_{req} := Find(l_f)$

$l_{req} = 1.392\ ft$ This length would give us full bearing with qmin=0

$A_{req} := l_{req}^2$

$$Area_{bearing} := \begin{cases} \text{"ok"} & \text{if } A_f > A_{req} \\ \text{"use larger area"} & \text{otherwise} \end{cases}$$

$Area_{bearing} = \text{"ok"}$

Maximum and Minimum Bearing Pressures

$$q_{max} := \frac{P}{A_f} + \frac{M \cdot c}{I}$$

$$q_{max} = 0.116 \cdot ksf$$

$$q_{min} := \frac{P}{A_f} - \frac{M \cdot c}{I}$$

$$q_{min} = 0.04 \cdot ksf$$

$$Check := \begin{cases} \text{"ok"} & \text{if } \frac{M \cdot c}{I} \le \frac{P}{A_f} \\ \text{"not in full contact with soil"} & \text{if } \frac{M \cdot c}{I} > \frac{P}{A_f} \end{cases}$$

$$Check = \text{"ok"}$$

$$Check_{bp} := \begin{cases} \text{"ok"} & \text{if } q_{max} < Allow_{bp} \\ \text{"not okay"} & \text{otherwise} \end{cases}$$

$$Check_{bp} = \text{"ok"}$$

$$a := \frac{l_f}{2} - e_{actual}$$

$$L_{bearing} := 3a$$

$$L_{bearing} = 2.508\,ft$$

$$\frac{L_{bearing}}{l_f} = 125.378 \cdot \%$$

3 - #4 bars each way okay by inspection

Arcadis
Job No: RC00753.0028
Calc By: N. Ceme
Date: 06 Oct 15
Project: Pacific Gas & Electric - 100% Final Groundwater Remediation

Chkd By: L. Tabat
Date: 26 Oct 15
Subject: Wind Load on Service Pak

WIND LOADS - Wind Load on Free Standing Walls (per IBC 2012 in accordance with ASCE 7-10)

Building Conditions

Reference:G:\WHI_ENG\Projects\Structural\MATHCAD\Units.xmcd

Height_of_Building := 2.5ft		See ASCE 7 section 26.2 definitions
B_{wall} := 0.67·ft		Length of Wall
RiskCategory := "III"		From IBC 2012, table 1604.5 (pg. 281)
V := 110	- wind speed (mph)	From ASCE 7 - 10, figure 26.5-1B (pgs. 248a and 248b)
Exposure := C		From ASCE 7 - 10, section 26.7.3 (pg. 251)
G := .85	- gust factor	From ASCE 7 - 10, section 6.5.8.1 (pg. 254)

Wind Loading Coefficients

$K_z := 0.85$ - velocity pressure exposure coef. From ASCE 7- 10, section 29.3.1 (pg. 307), table 29.3-1 (pg. 310)

$K_1 := 0$ $K_2 := 0$ $K_3 := 0$ From ASCE 7-10, section 26.8 (pg. 251), figure 26.8-1 (pg. 252-253)

$K_{zt} := (1 + K_1 \cdot K_2 \cdot K_3)^2$ - topograghic factor $K_{zt} = 1$

$K_d := 0.85$ - wind directionality factor From ASCE 7-10, section 26.6 (pg. 246). table 26.6-1 (pg. 250)

Velocity Pressure

$q_z := .00256 \cdot K_z \cdot K_{zt} \cdot K_d \cdot V^2$

$q_z = 22.38 \cdot psf$ Equation 29.3-1 from ASCE 7-10, section 29.3.2 (pg. 307)

Force Coefficient:

$s := h$ $\frac{s}{h} = 1$ $\frac{B_{wall}}{s} = 0.27$ Case A

$C_f := 1.627$ Interpolation between 0.2 and 0.5 (B/s = 0.268) From ASCE 7 - 10, figure 29.4-1 (pg. 311)

$q_{factored\_wind\_wall} := q_z \cdot G \cdot C_f$ Equation 29.4-1 from ASCE 7 - 10 section 29.4 (pg. 308) $q_{factored\_wind\_wall} = 30.95 \cdot psf$

$q_{unfactored\_wind\_wall} := 0.6 \cdot q_{factored\_wind\_wall}$ $q_{unfactored\_wind\_wall} = 18.57 \cdot psf$

Reference:G:\WHI_ENG\Projects\Structural\MATHCAD\Units.xmcd

$Allow_{bp} := 1500psf$ Allowable Bearing Pressure

Column Weight (Assume P1000 @ 1.89plf)

$h_c := 2.5ft$ $z_c := 6 \cdot in$ $x_c := 8 \cdot in$

Conduits: $x_{cond} := 3 \cdot 1.5 \cdot in$

$wt_c := 1.89plf \cdot h_c$ $wt_c = 4.725 \cdot lbf$

Wind: $q_{wa} := 18.74 \cdot psf$

Footing Properties

length $l_f := 2ft$ $c := \frac{l_f}{2}$

height $h_f := 0.5ft$

width $w_f := 2ft$ $I := \frac{w_f \cdot l_f^3}{12}$

area $A_f := l_f \cdot w_f$

$wt_f := \gamma_c \cdot (l_f \cdot h_f \cdot w_f)$ $wt_f = 0.3 \cdot kip$

Moment

$$M := q_{wa} \cdot z_c \cdot x_c \cdot \left(h_c - \frac{z_c}{2}\right) + q_{wa} \cdot (h_c - z_c) \cdot x_{cond} \cdot \frac{(h_c - z_c)}{2}$$ $M = 337.32 \cdot lbf \cdot in$

$$V := q_{wa} \cdot z_c \cdot x_c + q_{wa} \cdot (h_c - z_c) \cdot x_{cond}$$ $V = 20.302\,lbf$

Vertical Design Force

$P := wt_c + wt_f$ $P = 0.305 \cdot kip$

Checking for full bearing

$e_{actual} := \frac{M}{P}$ $e_{actual} = 1.107 \cdot in$

$e_{max} := \frac{l_f}{6}$ $e_{max} = 4 \cdot in$

Setting e_actual and e_max equal to each other...

Given

$$\gamma_c \cdot w_f \cdot h_f \cdot l_f^2 + wt_c \cdot l_f - 6 \cdot M = 0$$

$l_{req} := Find(l_f)$

$l_{req} = 1.045\,ft$ This length would give us full bearing with qmin=0

$A_{req} := l_{req}^2$

$$Area_{bearing} := \begin{cases} \text{"ok"} & \text{if } A_f > A_{req} \\ \text{"use larger area"} & \text{otherwise} \end{cases}$$ $Area_{bearing} = \text{"ok"}$

Maximum and Minimum Bearing Pressures

$$q_{max} := \frac{P}{A_f} + \frac{M \cdot c}{I}$$

$q_{max} = 0.097 \cdot ksf$

$$q_{min} := \frac{P}{A_f} - \frac{M \cdot c}{I}$$

$q_{min} = 0.055 \cdot ksf$

$$Check := \begin{cases} \text{"ok"} & \text{if } \frac{M \cdot c}{I} \le \frac{P}{A_f} \\ \text{"not in full contact with soil"} & \text{if } \frac{M \cdot c}{I} > \frac{P}{A_f} \end{cases}$$

$Check = \text{"ok"}$

$$Check_{bp} := \begin{cases} \text{"ok"} & \text{if } q_{max} < Allow_{bp} \\ \text{"not okay"} & \text{otherwise} \end{cases}$$

$Check_{bp} = \text{"ok"}$

$$a := \frac{l_f}{2} - e_{actual}$$

$$L_{bearing} := 3a$$

$L_{bearing} = 2.723\,ft$

$\frac{L_{bearing}}{l_f} = 136.163 \cdot \%$

$$S_{reqd} := \frac{M}{33ksi \cdot 0.6}$$

$S_{reqd} = 0.017 \cdot in^3$

P1000 Sx = 0.202in^3 OK

P1000 Sy = 0.290in^3

Check Unistrut: $S_{us} := 0.202 \cdot in^3$ $F_y := 33 \cdot ksi$ $F_b := 0.6 \cdot F_y = 1.98 \times 10^4\ psi$

$$f_{bus} := \frac{M}{S_{us}} = 1.67 \times 10^3\ psi$$ OK

Check post base P2072A SQ

Post base section properties, U shape:

$x_b := 2.125 \cdot in$ $y_b := 0.25 \cdot in$ $x_s := 0.25 \cdot in$ $y_s := 1.625 \cdot in$

$CG_{bx} := 0.5 \cdot x_b$ $CG_{by} := 0.5 \cdot y_b$ $CG_{Lsx} := 0.5 \cdot x_s$ $CG_{Rsx} := x_b - 0.5 \cdot x_s$ $CG_{sy} := y_b + 0.5 \cdot y_s$

$$I_{bx} := \frac{x_b \cdot y_b^3}{12} = 2.767 \times 10^{-3} \cdot in^4 \qquad I_{sx} := \frac{x_s \cdot y_s^3}{12} = 0.089 \cdot in^4$$

$$I_{by} := \frac{y_b \cdot x_b^3}{12} = 0.2 \cdot in^4 \qquad I_{sy} := \frac{y_s \cdot x_s^3}{12} = 2.116 \times 10^{-3} \cdot in^4$$

$$A_b := x_b \cdot y_b = 0.531 \cdot in^2 \qquad A_s := x_s \cdot y_s = 0.406 \cdot in^2$$

$$NAy := \frac{A_b \cdot CG_{by} + 2 \cdot A_s \cdot CG_{sy}}{A_b + 2 \cdot A_s} = 0.692 \cdot in$$

$$NAx := \frac{A_b \cdot CG_{bx} + A_s \cdot CG_{Lsx} + A_s \cdot CG_{Rsx}}{A_b + 2 \cdot A_s} = 1.063 \cdot in$$

Calculate properties around X-axis:

$d_{by} := CG_{by} - NAy = -0.567 \cdot in$ $d_{sy} := CG_{sy} - NAy = 0.371 \cdot in$

$$I_x := I_{bx} + 2 \cdot I_{sx} + d_{by}^2 \cdot A_b + 2 \cdot d_{sy}^2 \cdot A_s = 0.464 \cdot in^4$$

$$S_{x1} := \frac{I_x}{y_b + y_s - NAy} = 0.392 \cdot in^3 \qquad S_{x2} := \frac{I_x}{NAy} = 0.67 \cdot in^3$$

Calculate properties around Y-axis:

$d_{bx} := CG_{bx} - NAx = 0 \cdot in$ $d_{Rsx} := CG_{Rsx} - NAx = 0.937 \cdot in$ $d_{Lsx} := CG_{Lsx} - NAx = -0.938 \cdot in$

$$I_y := I_{by} + 2 \cdot I_{sy} + d_{bx}^2 \cdot A_b + d_{Rsx}^2 \cdot A_s + d_{Lsx}^2 \cdot A_s = 0.918 \cdot in^4$$

$$S_{y1} := \frac{I_y}{x_b + x_s - NAx} = 0.7 \cdot in^3 \qquad S_{y2} := \frac{I_y}{NAx} = 0.864 \cdot in^3$$

$f_{bpb} := \frac{M}{S_{x1}} = 860.34\,psi$ OK

Hilti Profis input: $M_{anch} := 1.6 \cdot M = 539.712 \cdot in \cdot lbf$

$V_{anch} := 1.6 \cdot V = 32.483\,lbf$

See Profis output: 4 - HIT-RE 500-SD w/ 1/2" HAS

WIND LOADS - Wind Load on Free Standing Walls
(per IBC 2012 in accordance with ASCE 7-10)

Building Conditions

Reference:G:\WHI_ENG\Projects\Structural\MATHCAD\Units.xmcd

$Height\_of\_Building := 2.5ft$ — See ASCE 7 section 26.2 definitions

$B_{wall} := 0.67 \cdot ft$ — Length of Wall

$RiskCategory := "III"$ — From IBC 2012, table 1604.5 (pg. 281)

$V := 110$ - wind speed (mph) — From ASCE 7 - 10, figure 26.5-1B (pgs. 248a and 248b)

$Exposure := C$ — From ASCE 7 - 10, section 26.7.3 (pg. 251)

$G := .85$ - gust factor — From ASCE 7 - 10, section 6.5.8.1 (pg. 254)

Wind Loading Coefficients

$K_z := 0.85$ - velocity pressure exposure coef. — From ASCE 7- 10, section 29.3.1 (pg. 307), table 29.3-1 (pg. 310)

$K_1 := 0$ $K_2 := 0$ $K_3 := 0$ — From ASCE 7-10, section 26.8 (pg. 251), figure 26.8-1 (pg. 252-253)

$K_{zt} := (1 + K_1 \cdot K_2 \cdot K_3)^2$ - topograghic factor $K_{zt} = 1$

$K_d := 0.85$ - wind directionality factor — From ASCE 7-10, section 26.6 (pg. 246). table 26.6-1 (pg. 250)

Velocity Pressure

$q_z := .00256 \cdot K_z \cdot K_{zt} \cdot K_d \cdot V^2$

$q_z = 22.38 \cdot psf$ — Equation 29.3-1 from ASCE 7-10, section 29.3.2 (pg. 307)

Force Coefficient:

$s := h$ $\frac{s}{h} = 1$ $\frac{B_{wall}}{s} = 0.27$ Case A

$C_f := 1.627$ Interpolation between 0.2 and 0.5 (B/s = 0.268) — From ASCE 7 - 10, figure 29.4-1 (pg. 311)

$q_{factored\_wind\_wall} := q_z \cdot G \cdot C_f$ — Equation 29.4-1 from ASCE 7 - 10 section 29.4 (pg. 308) — $q_{factored\_wind\_wall} = 30.95 \cdot psf$

$q_{unfactored\_wind\_wall} := 0.6 \cdot q_{factored\_wind\_wall}$ — $q_{unfactored\_wind\_wall} = 18.57 \cdot psf$

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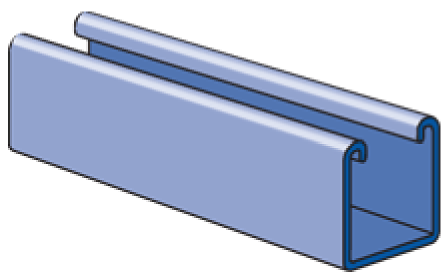
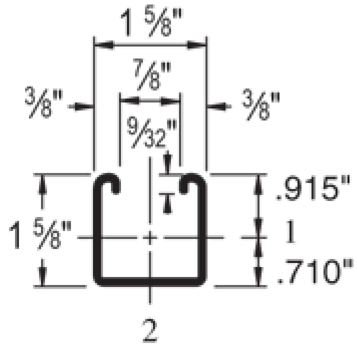
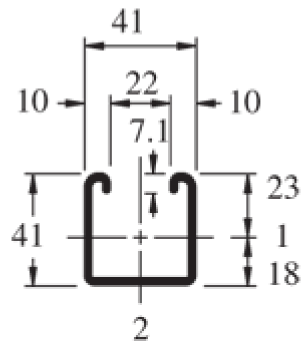
- p1000 - P1000 - 1-5/8" x 1-5/8", 12 Gage Channel, Solid



Channel Selection Chart
Related Channel Nuts
Additional Specifications

Part No.	Finish	Length	Weight
P1000	DF	20	201.40
P1000	DF	10	201.40
P1000	GR	20	189.00
P1000	GR	10	189.00
P1000	PG	10	189.00
P1000	PG	20	189.00
P1000	HG	20	201.40
P1000	HG	10	201.40
P1000	ZD	20	189.00
P1000	ZD	10	189.00
P1000	PL	20	189.00
P1000	PL	10	189.00
P1000	EA	20	73.30
P1000	EA	10	73.30
P1000	SS	10	189.00
P1000	SS	20	189.00
P1000	ST	20	189.00
P1000	ST	10	189.00





Elements of Section - P1000

Area of Section	0.555 in² (3.6 cm²)	
	Axis 1-1	Axis 2-2
Moment of Inertia (I)	0.185 in^4 (7.7 cm^4)	0.236 in^4 (9.8 cm^4)
Section Modulus (S)	0.202 in^3 (3.3 cm^3)	0.290 in^3 (4.8 cm^3)
Radius of Gyration (r)	0.577 in (1.5 cm)	0.651 in (1.7 cm)

Column Loading - P1000

Unbraced Height (in)	Allowable Load at Slot Face (lbs)	Max Column Load Applied at C.G.			
		K=0.65 (lbs)	K=0.80 (lbs)	K=1.0 (lbs)	K=1.2 (lbs)
24	3,550	10,740	9,890	8,770	7,740
36	3,190	8,910	7,740	6,390	5,310
48	2,770	7,260	6,010	4,690	3,800
60	2,380	5,910	4,690	3,630	2,960
72	2,080	4,840	3,800	2,960	2,400
84	1,860	4,040	3,200	2,480	1,980
96	1,670	3,480	2,750	2,110	1,660
108	1,510	3,050	2,400	1,810	*
120	1,380	2,700	2,110	*	*
144	1,150	2,180	1,660	*	*
*KL/r > 200					

Beam Loading - P1000

Span (in)	Max Allow. Uniform Load (lbs)	Defl at Uniform load (in)	Uniform Loading at Deflection			Lateral Bracing Reduct. Factor
			Span /180 (lbs)	Span /240 (lbs)	Span /360 (lbs)	
24	1,690	0.06	1,690	1,690	1,690	1.00
36	1,130	0.13	1,130	1,130	900	0.94
48	850	0.22	850	760	500	0.88
60	680	0.35	650	480	320	0.82
72	560	0.50	450	340	220	0.78
84	480	0.68	330	250	160	0.75
96	420	0.89	250	190	130	0.71
108	380	1.14	200	150	100	0.69
120	340	1.40	160	120	80	0.66
144	280	2.00	110	80	60	0.61
168	240	2.72	80	60	40	0.55
192	210	3.55	60	50	-	0.51
216	190	4.58	50	40	-	0.47
240	170	5.62	40	-	-	0.44

Notes:

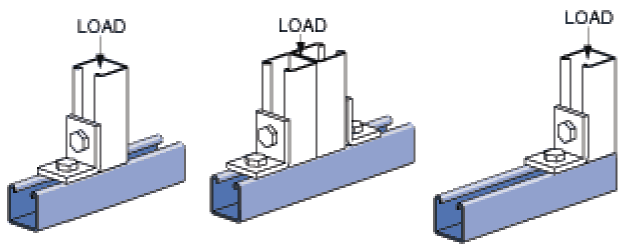
- Above loads include the weight of the member.
  This weight must be deducted to arrive at the net allowable load the beam will support.

- Long span beams should be supported so as to prevent rotation and twist.

- Allowable uniformly distributed loads are listed for various simple spans, that is, a beam on two supports. If load is concentrated at the center of the span, multiply load from the table by 0.5 and corresponding deflection by 0.8.

- The lateral bracing factor should be multiplied by the load to determine the load retained based on the distance between lateral braces.

Bearing Load on Channel:



Max Load	Max Load	Max Load
5,000 Lbs	8,000 Lbs	3,500 Lbs
2,268 Kg	3,629 Kg	1,588 Kg

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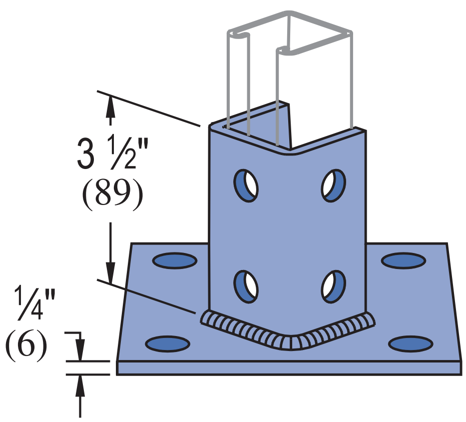
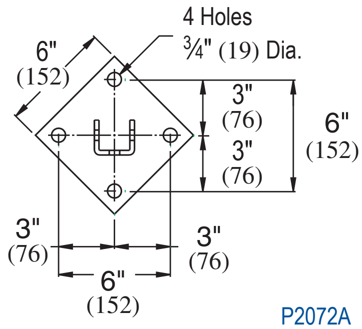
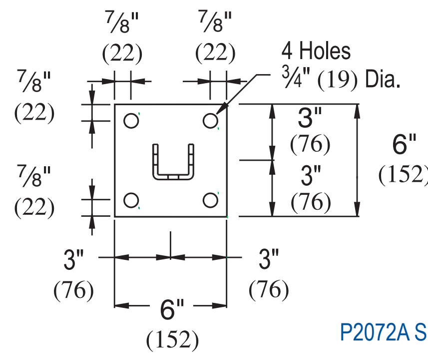
P2072A, P2072A SQ

Wt/100 pcs: 373 Lbs (169.2 kg)





P2072A



P2072A SQ

Standard Dimensions for 1⅝" (41mm) width series channel fittings *(Unless Otherwise Shown on Drawing)*
Hole Diameter: 9⁄16" (14mm); Hole Spacing - From End: 13⁄16" (21mm); Hole Spacing - On Center: 1⅞" (48mm); Width: 1⅝"(41mm); Thickness: ¼" (6mm)
Note : When used for mechanical supports, load capacities of brackets and fittings should be in compliance with the American Standard Code for Pressure Piping.

MATERIAL

Fittings, unless noted, are made from hot-rolled, pickled and oiled steel plates, strip or coil, and conform to ASTM specifications A575, A576, A635, or A36. The fitting steel also meets the physical requirements of ASTM A1011 SS GR 33. The pickling of the steel produces a smooth surface free from scale.

Many fittings are also available in stainless steel, aluminum and fiberglass. Consult factory for ordering information.

FINISHES

Fittings are available in:

- Perma-Green III (GR),
- Electro-galvanized (EG), conforming to ASTM B633 Type III SC1;
- Hot-dipped galvanized (HG), conforming to ASTM A123 or A153 and
- Plain (PL).

Project: ______________________________

Architect / Engineer: ______________________________

Date: ______________ **Phone:** ______________

Contractor: ______________________________

Address: ______________________________

____

Notes 1: ______________________________

____

Notes 2: ______________________________

____

Approval Stamp:

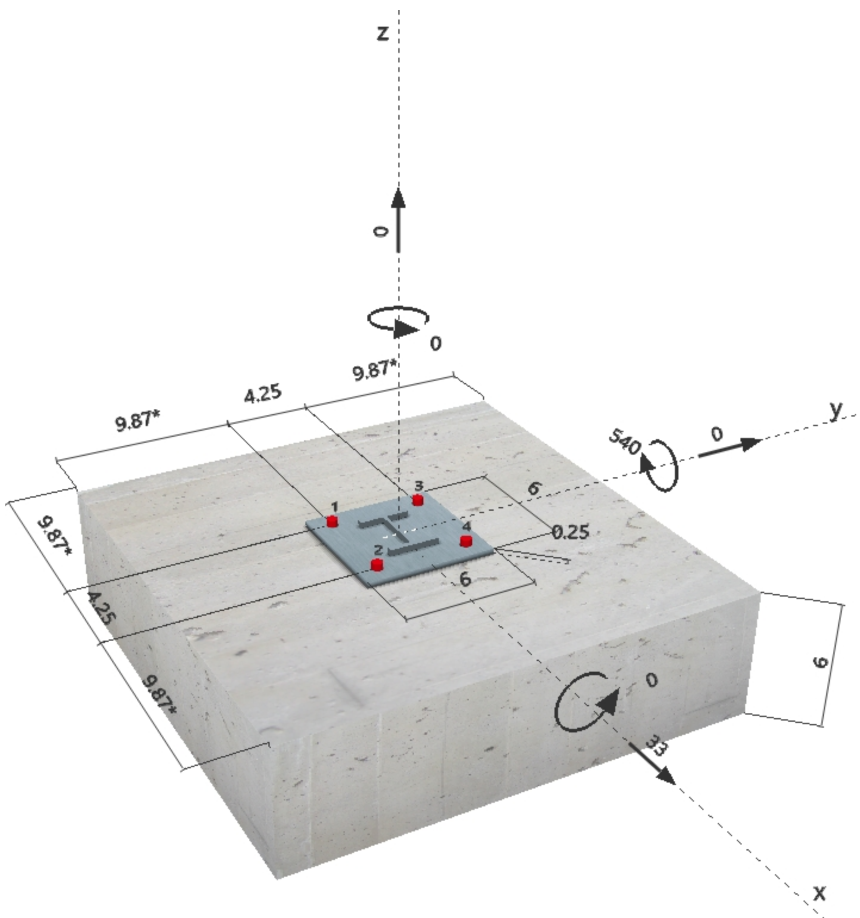
Company:	Arcadis U.S.	Page:	1
Specifier:	Larry Tabat	Project:	PG&E Topock
Address:		Sub-Project I Pos. No.:	RC000753.0028
Phone I Fax:	|	Date:	11/5/2015
E-Mail:			

Specifier's comments: Unistrut post base anchors

1 Input data

Anchor type and diameter:	**HIT-RE 500-SD + HAS 1/2**
Effective embedment depth:	$h_{ef,opti}$ = 2.750 in. ($h_{ef,limit}$ = 4.750 in.)
Material:	5.8
Evaluation Service Report:	ESR-2322
Issued I Valid:	4/1/2015 | 4/1/2016
Proof:	Design method ACI 318-08 / Chem
Stand-off installation:	e_b = 0.000 in. (no stand-off); t = 0.250 in.
Anchor plate:	l_x x l_y x t = 6.000 in. x 6.000 in. x 0.250 in.; (Recommended plate thickness: not calculated
Profile:	S shape (AISC); (L x W x T x FT) = 3.000 in. x 2.330 in. x 0.170 in. x 0.260 in.
Base material:	cracked concrete, 4000, f_c' = 4000 psi; h = 6.000 in., Temp. short/long: 32/32 °F
Installation:	hammer drilled hole, Installation condition: Dry
Reinforcement:	tension: condition B, shear: condition B; no supplemental splitting reinforcement present edge reinforcement: none or < No. 4 bar
Seismic loads (cat. C, D, E, or F)	no

Geometry [in.] & Loading [lb, in.lb]



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Company:	Arcadis U.S.	Page:	2
Specifier:	Larry Tabat	Project:	PG&E Topock
Address:		Sub-Project I Pos. No.:	RC000753.0028
Phone I Fax:	|	Date:	11/5/2015
E-Mail:			

2 Proof I Utilization (Governing Cases)

		Design values [lb]		Utilization	
Loading	**Proof**	**Load**	**Capacity**	**β_N / β_V [%]**	**Status**
Tension	Bond Strength	117	2938	4 / -	OK
Shear	Steel Strength	8	3705	- / 1	OK

Loading	β_N	β_V	ζ	Utilization $\beta_{N,V}$ [%]	Status
Combined tension and shear loads	0.040	0.007	5/3	1	OK

3 Warnings

- Please consider all details and hints/warnings given in the detailed report!

Fastening meets the design criteria!

4 Remarks; Your Cooperation Duties

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ARCADIS Design & Consultancy for natural and built assets
Project: Pacific Gas & Electric - 100 % Final Groundwater Remediation
Subject: Double Unistrut Posts

Reference:G:\WHI_ENG\Projects\Structural\MATHCAD\Units.xmcd

Assumptions:

$b := 12in$ Diameter of round post

$d_a := 2.17 \cdot ft$ Assumed depth

$q_{wa} := 18.41 \cdot psf$ Wind Load

$P_1 := q_{wa} \cdot 1.5ft \cdot 1.5ft$

$h_1 := 37in + \frac{18in}{2} = 3.833\,ft$

$P_2 := 5\left[q_{wa} \cdot 1.625in \cdot (37in - 1.625in)\right]$

$h_2 := \frac{37 \cdot in}{2} = 1.542\,ft$

$P_3 := q_{wa} \cdot 1.5ft \cdot 1.625in$

$h_3 := h_2$

$P_{tot} := P_1 + P_2 + P_3 = 81.908\,lbf$

$P := \frac{P_{tot}}{2} = 40.954\,lbf$ Lateral load applied, divided over two piers

$q_p := 150 \cdot pcf$ Allowable lateral soil-bearing pressure

$S_1 := \frac{d_a}{3} \cdot q_p = 108.5 \cdot psf$

$h := \frac{\left[P_1 \cdot h_1 + \left(P_2 + P_3\right) \cdot h_2\right]}{P_{tot}} = 2.701\,ft$ Distance from ground surface to point of application (Average location of the highest 2 forces)

$A := \frac{2.34P}{S_1 \cdot b}$

$d_{min} := 0.5A \cdot \left[1 + \left(1 + \frac{4.36h}{A}\right)^{\frac{1}{2}}\right]$ Calculated embedment depth (12ft maximum) $d_{min} = 2.113\,ft$

Equation 18A-1 ref. 2013 CBC

$d_{embed} := \min\left(d_{min}, 12ft\right)$ $d_{embed} = 2.113\,ft$

use: $d := 2.17ft$

Concrete reinforcement:

Equivalent rectangular section: $A_1 := \pi \cdot b^2 \cdot \frac{1}{4}$ $\quad b_w := \frac{A_1}{b} = 9.425 \cdot in$

$r_1 := \left(\frac{b}{2} - 3.75 \cdot in\right) \cdot \sin(45 \cdot deg) = 1.591 \cdot in$ $\quad d_1 := \frac{b}{2} + r_1 = 7.591 \cdot in$ $\quad$ based on 2 of 4 bars

working stress: $a := 1.76$

$M := P \cdot \left(\frac{2 \cdot d}{3} + h\right) = 0.17 \cdot ft \cdot k$ $\quad A_s := \frac{0.173}{a \cdot 7.591} = 0.013$ sq in

$A_{smin1} := \min\left(\frac{3 \cdot \sqrt{4000}}{60000} \cdot \frac{b_w}{in} \cdot \frac{d_1}{in}, A_s \cdot 1.333\right) = 0.017$ sq in $\quad$ use 4-#4 bars

Minimum design criteria	$b = 12 \cdot in$, $d = 2.17 ft$
USE:	As= 4 - #4 bars

WIND LOADS - Wind Load on Free Standing Walls (per IBC 2012 in accordance with ASCE 7-10)

Building Conditions

Reference:G:\WHI_ENG\Projects\Structural\MATHCAD\Units.xmcd

$Height\_of\_Building := 4.583ft$ — See ASCE 7 section 26.2 definitions

$B_{wall} := 1.5 \cdot ft$ — Length of Wall

$RiskCategory := "III"$ — From IBC 2012, table 1604.5 (pg. 281)

$V := 110$ - wind speed (mph) — From ASCE 7 - 10, figure 26.5-1B (pgs. 248a and 248b)

$Exposure := C$ — From ASCE 7 - 10, section 26.7.3 (pg. 251)

$G := .85$ - gust factor — From ASCE 7 - 10, section 6.5.8.1 (pg. 254)

Wind Loading Coefficients

$K_z := 0.85$ - velocity pressure exposure coef. — From ASCE 7- 10, section 29.3.1 (pg. 307), table 29.3-1 (pg. 310)

$K_1 := 0$ $K_2 := 0$ $K_3 := 0$ — From ASCE 7-10, section 26.8 (pg. 251), figure 26.8-1 (pg. 252-253)

$K_{zt} := (1 + K_1 \cdot K_2 \cdot K_3)^2$ - topograghic factor $K_{zt} = 1$

$K_d := 0.85$ - wind directionality factor — From ASCE 7-10, section 26.6 (pg. 246). table 26.6-1 (pg. 250)

Velocity Pressure

$q_z := .00256 \cdot K_z \cdot K_{zt} \cdot K_d \cdot V^2$

$q_z = 22.38 \cdot psf$ — Equation 29.3-1 from ASCE 7-10, section 29.3.2 (pg. 307)

Force Coefficient:

$s := h$ $\frac{s}{h} = 1$ $\frac{B_{wall}}{s} = 0.33$ Case A

$C_f := 1.613$ Interpolation between 0.2 and 0.5 (B/s = 0.31) — From ASCE 7 - 10, figure 29.4-1 (pg. 311)

$q_{factored\_wind\_wall} := q_z \cdot G \cdot C_f$ — Equation 29.4-1 from ASCE 7 - 10 section 29.4 (pg. 308) — $q_{factored\_wind\_wall} = 30.68 \cdot psf$

$q_{unfactored\_wind\_wall} := 0.6 \cdot q_{factored\_wind\_wall}$ — $q_{unfactored\_wind\_wall} = 18.41 \cdot psf$

Reference:G:\WHI_ENG\Projects\Structural\MATHCAD\Units.xmcd

Assumptions:

$b := 24in$ Diameter of round post

$d_a := 5.33 \cdot ft$ Assumed depth

$P := 1000lbf$ Lateral load applied

$q_p := 150 \cdot pcf$ Allowable lateral soil-bearing pressure

$S_1 := \frac{d_a}{3} \cdot q_p = 266.5 \cdot psf$

$h := 12in$ Distance from ground surface to point of application

$A := \frac{2.34P}{S_1 \cdot b}$

$d_{min} := 0.5A \cdot \left[1 + \left(1 + \frac{4.36h}{A}\right)^{\frac{1}{2}}\right]$ Calculated embedment depth (12ft maximum) $d_{min} = 5.294\ ft$

Equation 18A-1 ref. 2013 CBC

$d_{embed} := \min(d_{min}, 12ft)$ $d_{embed} = 5.294\ ft$

use: $d := 5.33ft$

Equivalent rectangular section: $A_1 := \pi \cdot b^2 \cdot \frac{1}{4}$ $b_w := \frac{A_1}{b} = 18.85 \cdot in$

$r_1 := \left(\frac{b}{2} - 3.75 \cdot in\right) \cdot \sin(60 \cdot deg) = 7.145 \cdot in$ $d_1 := \frac{b}{2} + r_1 = 19.145 \cdot in$ based on 2 of 6 bars

working stress: $a := 1.76$

$M := P \cdot \left(\frac{2 \cdot d}{3} + h\right) = 4.553 \cdot ft \cdot k$ $A_s := \frac{4.553}{a \cdot 19.145} = 0.135$ sq in

$A_{smin1} := \min\left(\frac{3 \cdot \sqrt{4000}}{60000} \cdot 18.85 \cdot 19.145, A_s \cdot 1.333\right) = 0.18$ sq in use 6-#4 bars

Minimum design criteria	$b = 24 \cdot in$, $d = 5.33\ ft$
USE:	b= 24in, d= 5'-4" As= 6 - #4 bars

Reference:G:\WHI_ENG\Projects\Structural\MATHCAD\Units.xmcd

Task: Design of Slab On Grade For Uniform Loading On Aisle Width

Reference:
1. "Designing Floor Slabs On Grade", Second Edition.PCA
2. ""Design Of Slab On Grade", ACI 360-97

Assume:

$f'_c := 4000 \cdot psi$

$f_y := 60000 \cdot psi$

$f_s := 0.4 \cdot f_y$ $\qquad f_s = 24000 \cdot psi$

$\gamma_c := 150 \cdot pcf$

$k_{soil} := 100 \cdot pci$

$F := 1.5$ — Friction factor for granular base see reference 2 pg 21

$L := 50 \cdot ft$ — distance in feet between joints (the distance between the free ends of the slab that can move due to shrinkage contraction or thermal expansion)

$b := 12 \cdot in$

$P_{equip} := 64kip + 8 \cdot kips$ — equipment load — H20 Loading - Standard HS trucks

$Area_{equip} := 28ft \cdot 6ft$ — equipment area — H20 Loading - Standard HS trucks

$w_{LL} := 600 \cdot psf$

$w := \max\left(\frac{P_{equip}}{Area_{equip}}, w_{LL}\right)$ $\qquad w = 600 \cdot psf$

$FS := 1.7$ — factor of safety from reference 1

$MOR := 9 \cdot \sqrt{f'_c \cdot psi}$ — Modulus of Rupture, Ref 2, Table 2 $\qquad MOR = 569.21 \cdot psi$

$Conc_{allow} := \frac{MOR}{FS}$ $\qquad Conc_{allow} = 334.829 \cdot psi$

TRY

$t := 7 \cdot in$	thickness of slab	
$w_{DL} := t \cdot \gamma_c$	slab Dead Load	$w_{DL} = 87.5 \cdot psf$
$w_{tot} := w_{DL} + w$	total load on slab	$w_{tot} = 687.5 \cdot psf$

See chart A.5 in reference 1

$w_{allow} := 895 \cdot psf$	total allowable load See Ref 1 Table 14	"OK" if $w_{tot} \le w_{allow}$ = "OK" "No Good" otherwise
$A_{smin} := \max\left(\frac{F \cdot L \cdot w_{DL}}{2 \cdot f_s} \cdot b, .0018 \cdot t \cdot b\right)$	See reference 2 pg 21	$A_{smin} = 0.151 \cdot in^2$

For better containment crack control: **Use #5@12" at center of slab**

Slab thickness in.	Subgrade k* pci	Allowable load, psf **			
		Concrete flexural strength, psi			
		550	600	650	700
5	50	535	585	635	685
	100	760	830	900	965
	200	1,075	1,175	1,270	1,370
6	50	585	640	695	750
	100	830	905	980	1,055
	200	1,175	1,280	1,390	1,495
8	50	680	740	800	865
	100	960	1,045	1,135	1,220
	200	1,355	1,480	1,603	1,725
10	50	760	830	895	965
	100	1,070	1,170	1,265	1,365
	200	1,515	1,655	1,790	1,930
12	50	830	905	980	1,055
	100	1,175	1,280	1,390	1,495
	200	1,660	1,810	1,965	2,115
14	50	895	980	1,060	1,140
	100	1,270	1,385	1,500	1,615
	200	1,795	1,960	2,120	2,285

* *k* of subgrade; disregard increase in *k* due to subbase.

** For allowable stress equal to 1/2 flexural strength.
Based on aisle and load widths giving maximum stress.

Table 14 *Allowable distributed load on slabs with unjointed aisles and variable layout, from* References 6 and 14.

Commentary:
The use of this concrete allows a much wider spacing of contraction joints than is appropriate for standard portland cement concrete. The designer is cautioned against spacing joints too far apart. Joints (construction joints in this case) spaced at approximately 50 to 60 feet each way are considered good, although greater spacings have been successfully used. The joint spacing selected must depend on whether or not hairline cracks are to be permitted. Critical to the prevention of cracking are any possible restraints to slab motion, such as posts, pits, etc.

6.5 — Using shrinkage-compensating concrete for slabs with distributed uniform loading on both sides of an aisle

The use of a shrinkage-compensating concrete, produced with either Type K cement or an additive, is a change in material rather than loading or design assumptions. The concrete behaves differently, but the thickness selections are done using the same methods as with normal portland cement concrete.

No example is given for thickness determination. Given the problem, the design for thickness is the same as previous sections. The use of this technique allows a wider joint spacing, therefore, fewer lineal feet of joint per job. It is also a crack control technique. However, shrinkage-compensating concrete demands the use of reinforcing steel, properly sized and properly placed. The best reference is ACI 223 (*Reference 13*) which gives procedures for determining the expansion and shrinkage strains and for selecting the proper percentages of steel. Since steel is mandatory, it is also feasible to consider the use of structurally active reinforcement as discussed in Section 1.5.1 and illustrated in Section 6.7.

Final (100%) Design Submittal for the Final Groundwater Remedy
PG&E Topock Compressor Station
Needles, California

TEG Load Calculations

11/18/2015

Prepared for:

Pacific Gas and Electric Company

Reviewed by:

Dave Oberle, P.E.
Principal Electrical Engineer
Arcadis, U.S., Inc.

Prepared by:

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Electrical Engineer
Arcadis, U.S., Inc.

ARCADIS Design & Consultancy for natural and built assets

PROJECT: TOPOCK COMPRESSOR STATION
SUBJECT: TEG LOAD CALCULATIONS
CLIENT: PACIFIC GAS AND ELECTRIC COMPANY, SAN FRANCISCO, CALIFORNIA

CALCULATIONS

TEG LOAD LIST

Load Tag	QTY	Load (W)	Sub	Power Factor	Load VA
PSPRO-AC-8, 200W	1	200	200	0.95	210.5263158
POND LIGHT 1&2, 120W	2	120	240	1	240
POND LIGHT 3&4, 120W	2	120	240	1	240
BUILDING LIGHT	1	150	150	1	150
FLOOD LIGHT 120W POND 1&2	2	120	240	1	240
FLOOD LIGHT 120W POND 3&4	2	120	240	1	240
VALVE ACTUATORS POND 1,2 ,3 &4	4	48	192	0.8	240
ROSEMOUNT 3490	N/A	N/A	N/A	N/A	10
ROSEMOUNT 3101	N/A	N/A	N/A	N/A	10
SCADA	N/A	N/A	N/A	N/A	N/A
TOTAL					***1580 VA***

TEG POWER CURVE

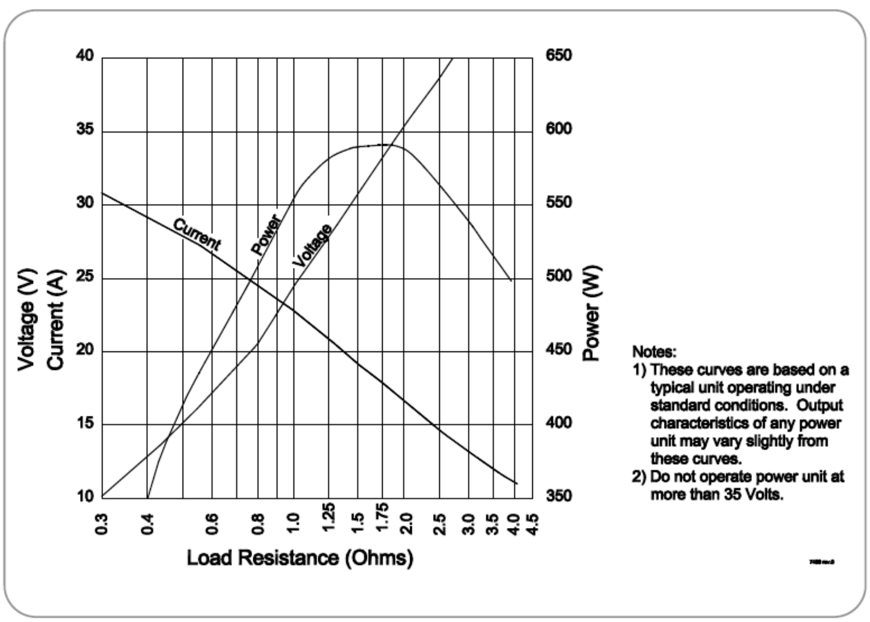


Figure 3 Gross Power Unit Electrical Output Characteristics at 20°C, Beginning of Life (without Power Conditioner)

Assume 525 *Watts at* 24 *V for site conditions*

TEG QUANTITY

$Maximum\ coincident\ demand = 1580\ VA$

$Transformer\ Efficiency = 0.85$

$Power\ Factor = 1$

$P_{(W)} = S_{(VA)} \times PF = 1580\ VA \times 1 = 1580\ W$

$$\frac{1580W}{0.85} = 1858\ W \leftarrow minimum\ capacity\ generator\ for\ loads$$

$$Minimum\ Number\ of\ TEG's = \frac{1858\ W}{525\ W} = 3.54 \approx 4\ TEG's\ Required$$

Attachment C
Geotechnical Summary (*on CD-ROM only*)

- Geotechnical Data Summary and Proposed Supplemental Geotechnical Investigation
- Selected Boring Logs from RFI/RI Report Volume 2 (CH2M HILL 2009)
- *Geotechnical Investigation Report, Topock Compressor Station, Water Treatment Plant* (CH2M HILL 2004)
- *Geotechnical Investigation, Topock AOC 4 Remediation – Pre-Work Plan Data Collection Activities, PG&E Compressor Station, Needles, California* (CH2M HILL 2009)

Geotechnical Data Summary and Proposed Supplemental Geotechnical Investigation

Geotechnical Data Summary and Proposed Supplemental Geotechnical Investigation

The purpose of this geotechnical summary is to provide information on existing site geology and geotechnical data in support of the groundwater remedy design and to propose areas where supplemental geotechnical investigation is needed to verify design parameters. Coordination with the Soil RCRA Facility Investigation/Remedial Investigation (RFI/RI) investigation program was conducted in planning the supplemental geotechnical investigation to minimize the number of required boreholes, thereby minimizing ground disturbance.

C.1 Summary of Existing Site Geologic and Geotechnical Data

In 2004 and 2009, CH2M HILL conducted geotechnical investigations in and around the compressor station and Area of Concern (AOC) 4, respectively. Results were presented in the following reports and are summarized below:

- *Geotechnical Investigation Report, Topock Compressor Station, Water Treatment Plant*. Prepared by CH2M HILL in September 2004. (Full report presented in PDF format as part of this Attachment to Appendix C of the 60% Basis of Design Report on the Appendix C CD-ROM).
- *Geotechnical Investigation, Topock AOC 4 Remediation – Pre-Work Plan Data Collection Activities, PG&E Compressor Station, Needles, California*. Prepared by CH2M HILL in October 2009. (Full report presented in PDF format as part of this Attachment to Appendix C on the Appendix C CD-ROM).

In addition, geologic information for the MW-20 Bench and hydrogeologic cross sections throughout the site are also summarized in the sections below. Original results were reported in the following reports:

- *Work Plan for Installation of Extraction Well TW-3D, Interim Measure No. 3 Groundwater Extraction System, PG&E Topock Compressor Station, Needles, California.* Prepared by CH2M HILL in October 2005.
- *RCRA Facility Investigation/Remedial Investigation Report, PG&E Topock Compressor Station, Needles, California, Volume 2 – Hydrogeologic Characterization and Results of Groundwater and Surface Water Investigation.* Prepared by CH2M HILL in February 2009. A selection of relevant borings logs from this report is included following this geotechnical data summary on the Appendix C CD-ROM.

C.1.1 Compressor Station

The 2004 geotechnical investigation found that in the vicinity of monitoring wells MW-13 and MW-14 the area consists of alternating layers of gravelly sand and sandy gravel down to an approximate elevation of 435 feet above mean sea level (msl). In the vicinity of MW-37D gravelly sand with clay and sandy clay layers starts at an elevation of approximately 465 feet msl underlying the sandy gravel. The difference in material in this boring can be attributed to the fact that it was located in a wash that transports the finer material from higher elevations.

Soil borings B-01, B02, B-02A, and B-03 were also advanced during this investigation. Exhibit C.1-1 presents a summary of the generalized subsurface profile and design strength parameters. Complete details of the soil borings can be found in the 2004 *Geotechnical Investigation Report*, which is included in PDF format as part of this Attachment to Appendix C on the Appendix C CD-ROM. Generally, medium dense to very dense, silty sands and poorly graded silty sands underlie the proposed treatment plant site. Blow counts in the dry, silty sands were generally in the range of 20 to greater than 50. Therefore, liquefaction potential of the site soils is estimated to be low, especially where the groundwater is greater than 50 feet below ground surface (bgs).

In addition, the following conclusions were made as a result of the 2004 geotechnical investigation:

- Expansion/Collapse – Based on the medium dense to very dense granular material encountered at the project site, expansion and collapse potential is regarded as low.

- Settlement – Based on the medium dense to very dense granular material encountered at the project site (above and below the proposed/ existing footing elevation), and the relatively deep groundwater table (>45 feet), consolidation settlement is not considered an issue. Secondary compression settlement has been determined to be negligible.

EXHIBIT C.1-1
Generalized Subsurface Soil Profile and Design Strength Parameters
Groundwater Remedy Basis of Design Report/Intermediate (60%) Design
PG&E Topock Compressor Station, Needles, California

Geologic Unit	Approximate Elevation of Layer (± feet)	Soil Type [1]	Average Corrected SPT N-Values [2] (blows per foot)	Total Unit Weight (lbs/ft^3)	Friction Angle (degree)
Boring B-01					
Alluvium	508-498	SMg	20	120	32
Alluvium	498-493	SMg	>50	120	35
Alluvium	493-474	SW-SM	>50	120	35
Alluvium	<474	SMg	>50	120	35
Boring B-02					
Alluvium	505-495	SMg	46	120	32
Alluvium	<495	SMg	>50	120	35
Boring B-02A					
Alluvium	505-495	SMg	63	120	32
Alluvium	<495	SMg	>50	120	35
Boring B-03					
Alluvium	508-498	SMg	44	120	32
Alluvium	498-488	SMg	>50	120	35
Alluvium	<488	SP-SM	>50	120	35

Notes:
[1] Unified Soil Classification System per ASTM standard D2487 and D2488.
[2] SPT = standard penetration test described in ASTM Standard D1586.
Source: *Geotechnical Investigation Report, Topock Compressor Station, Water Treatment Plant* (CH2M HILL 2004)

- Corrosion Conditions – Comparison between the laboratory test results and the Caltrans corrosion criteria indicates that the onsite soils are considered to be corrosive to concrete structures. The Caltrans corrosion criteria should not be applied to piping and other metal structures. Concrete in contact with onsite soil shall be batched using Type V cement in accordance with the 2001 California Building Code (CBC). Adequate concrete cover over reinforcing steel should be provided in accordance with good construction practices and design standards. Exhibit C.1-2 summarizes the results of the laboratory corrosion tests.
- Solubility – The solubility results are low at this site, so it is not expected to be an issue. Exhibit C.1-3 summarizes the results of the solubility tests.
- Seismicity – The Chemehuevi Graben Fault, approximately 18.8 kilometers from the project site, is the controlling fault at the project site. The Chemehuevi Graben Fault is a normal style fault with a maximum credible earthquake (MCE) moment magnitude (Mw) of 6.0. The fault is classified as Seismic Source Type C, the project site lies in Seismic Zone 3, and the soil profile is classified as type SD as defined in the 2001 CBC.

EXHIBIT C.1-2
Summary of Laboratory Corrosion Test
Groundwater Remedy Basis of Design Report/Intermediate (60%) Design
PG&E Topock Compressor Station, Needles, California

Boring	Sample Depth (feet)	Soil Type[1]	Minimum Resistivity (ohm-cm)	pH	Sulfate Content (ppm)	Chloride Content (ppm)
B-01	6.5-8.0	SM	370	8.63	2,888	1,025
B-02	6.5-8.0	SM	725	8.67	3,988	350

Notes:
[1] Unified Soil Classification System per ASTM standard D2487 and D2488.
Source: *Geotechnical Investigation Report, Topock Compressor Station, Water Treatment Plant* (CH2M HILL 2004)

EXHIBIT C.1-3
Summary of Solubility Tests
Groundwater Remedy Basis of Design Report/Intermediate (60%) Design
PG&E Topock Compressor Station, Needles, California

Boring	Sample Depth (feet)	Soil Type	Solubility (%)
B-01	6.5-8.0	SM	0.79
B-03	5.0-6.5	SM	0.33

Note:
[1] Unified Soil Classification System per ASTM standard D2487 and D2488.
Source: *Geotechnical Investigation Report, Topock Compressor Station, Water Treatment Plant* (CH2M HILL 2004)

Using the attenuation curves of Sadigh et al. (see Blake 1998), probabilistic analyses indicate that a horizontal peak ground acceleration (HPGA) of 0.07g may be used for a 10 percent probability of exceedance in 50 years. Deterministic analyses indicate a peak ground acceleration (PGA) of 0.20g at the project site.

Recommendations that were discussed in 2004 geotechnical investigation include:

- Shallow foundations are recommended for support of the water treatment plant. The depth of foundation support should be down to a minimum of 2 feet bgs.
- The slab and footings should be set on a minimum 6-inch-thick layer of granular base leveling course. The granular material should consist of well-graded sand and gravel with a maximum particle size of 3 inches and no more than 6 percent passing the No. 200 sieve. The granular material should be placed in 6-inch lifts and compacted to 95 percent of maximum dry density per American Society for Testing and Materials (ASTM) D1557.
- The native soil under the granular base course should be well compacted down to a depth of 12 inches to a minimum of 95 percent of maximum dry density per ASTM D1557 to provide a firm, unyielding surface. If the native soil under the granular course cannot be compacted to a minimum of 95 percent of maximum dry density per ASTM D1557, it should be removed to a maximum depth of 1 foot and replaced with competent granular backfill compacted in 6-inch lifts.
- The foundation design should be based on an evaluation of the allowable bearing capacity, settlement, and sliding coefficient of friction.
- Bearing capacity – Based on the calculations, it was determined that the subgrade at or near the bottom of the proposed footings will have an allowable bearing capacity of 2,000 pounds per square foot.

- Siding coefficient of friction – An ultimate sliding coefficient of friction equal to 0.45 may be used for foundation design.
- Cut and fill slopes – Cut slopes in the native soil are recommended to be 2H:1V or flatter. In fill areas, the native soil should be placed in 6-inch lifts and compacted to 95 percent of maximum dry density per ASTM D1557.

C.1.2 AOC 4

During the 2009 geotechnical investigation, four geotechnical borings were drilled in the areas on top of the ravine slopes in the AOC 4 area. The scope of the geotechnical investigation did not include evaluation of fill along the slope face and at the bottom of the slope. The four borings were drilled until the augers refused on possible rock or other obstructions. Exhibit C.1-4 presents a summary of field exploration details. Complete results of the 2009 investigation can be found in the 2009 *Geotechnical Investigation, Topock AOC 4 Remediation – Pre-Work Plan Data Collection Activities* report, which is included as part of this Attachment to Appendix C on the Appendix C CD-ROM.

EXHIBIT C.1-4
Summary of Field Exploration Details
Groundwater Remedy Basis of Design Report/Intermediate (60%) Design
PG&E Topock Compressor Station, Needles, California

Exploration Number	Approximate Location (NAD 83 Lat./Long,)	Approximate Ground Surface Elevation (feet)	Type of Boring	Depth to Auger Refusal (feet)	Groundwater Depth (feet)
AOC4-GEO1	34°42’47” N; 114° 29’37” W	611.0	Hollow-stem auger	38.5	NE
AOC4-GEO2	34°42’47” N; 114°29’38” W	611.0	Hollow-stem auger	56	NE
AOC4-GEO3	34°42’46” N; 114°29’37” W	612.0	Hollow-stem auger	26	NE
AOC4-GEO4	34°42’46” N; 114°29’36” W	612.0	Hollow-stem auger	8.5	NE

Notes:
NE = Not Encountered
Source: *Geotechnical Investigation, Topock AOC 4 Remediation – Pre-Work Plan Data Collection Activities, PG&E Compressor Station, Needles, California* (CH2M HILL 2009b)

Based on the soil borings, the subsurface materials in the vicinity of AOC 4 generally consist of gray to grayish brown, dry, medium dense to very dense, silty sand and silty gravel. The gravel sizes ranged from 0.5 to 3 inches. The uncorrected standard penetration test (SPT) N-value in this zone ranges from 17 for 12 inches of penetration to 50 for 6 inches of penetration.

Below the fill layer and alluvial sediments, weathered rock materials were encountered in some of the borings to the explored maximum depths overlying relatively unweathered metadiorite bedrock. The weathered rock generally consists of dense to very dense gravel and sand with silt. Gravel sizes varied from less than an inch up to 5 inches. In some areas broken cobbles or fragments of bedrock were present in the recovered samples. The uncorrected SPT N-values within the native soil zone were above 50. Detailed boring logs are presented in the 2009 *Geotechnical Investigation, Topock AOC 4 Remediation – Pre-Work Plan Data Collection Activities* report that is included as part of this Attachment.

Results and conclusions of the 2009 geotechnical investigation include:

- The depth of debris fill materials encountered in the borings extends approximately 5 feet bgs on the nearly level area of AOC 4 and contains silty sand and gravel mixed with debris including some trash, roots and peaty materials. This depth corresponds to elevations of 606 feet and 607 feet above mean sea level on the west and east sides of the AOC 4 area, respectively, above the ravines.
- The debris fill is underlain by possible weakly cemented alluvium and weathered metadiorite bedrock. These materials consist of dense to very dense silty sand (SM) to silty gravels (GM). The gravel sizes ranges from 0.5 to 3 inches.
- Boring refusal, indicating bedrock or obstructions, was encountered at depths varying from 56 to 5 feet bgs. Boring AOC4-GEO2, located on the west edge of the existing slope, encountered refusal at EL 556 feet or about 56 feet bgs. Boring AOC4-GEO4, located on the east side of the existing slope, encountered refusal at EL 607 feet or at about 5 feet bgs. With respect to the exposed bedrock observed near the investigation site, boring refusal is interpreted as the surface of relatively unweathered bedrock.
- Based on the results of the slope stability analyses, a 35-foot-tall slope with a 1H: 1V slope ratio is expected to be globally stable during construction and remediation activities. A factor of safety (FOS) for slope failure of 1.2 was computed for this condition. An FOS of 1.1 or greater is normally considered adequate for temporary slopes during construction activities.
- It is recommended that temporary slopes be maintained no steeper than 1H: 1V and not higher than 35 feet. Shorter, steeper slopes may be achievable and should be evaluated if proposed.
- The surficial stability of a localized side slope should be considered during the grading and other construction activities. Localized instabilities, if left unchecked, could lead to larger stability issues.

C.1.3 MW-20 Bench Geology

In the vicinity of the MW-20 Bench, the current active interim measure (IM) extraction well TW-2D is screened from 115 feet to 150 feet bgs, in the lower portion of the Alluvial Aquifer above Miocene conglomerate bedrock. During initial pumping tests, TW-2D was pumped at sustained rates of 90 to 100 gallons per minute (gpm). The specific capacity of TW-2D has increased by a factor of two since installation and is currently 8 gpm per foot of drawdown.

Well TW-2D is screened in sandy gravel alluvial deposits that appear to be more conductive than the formations encountered at similar elevations in monitoring wells MW-20 to the south or MW-31 to the north. Although the saturated alluvium above bedrock is thicker to the north of TW-2D, the alluvial deposits at the two monitoring well locations generally had higher clay content and may be less productive than the formation at the TW-2D/TW-2S well pair.

Well TW-2S is screened as a water table extraction well, with the bottom of the screen at 95 feet bgs and the top of the screen at 45 feet bgs. The static water level in both TW-2S and TW-2D is roughly 45 feet bgs under non-pumping conditions. The screened intervals of TW-2S and TW-2D are separated, with TW-2S screened above 95 feet and TW-2D screened below 115 feet. The reason for drilling separate shallow TW-2S and deep TW-2D wells was that an aquitard appeared to be present at the intervening depth in the MW-20 wells, and Consultative Technical Workgroup members expressed concern that a single extraction well should not be screened across the aquitard. However, this aquitard does not appear to be present in the northern portion of the MW-20 bench at the MW-31 location.

A fine-grained unit that forms a local aquitard was encountered at a depth between 100 and 110 feet bgs in TW-2D. Flowing sands were encountered within the fine-grained horizon during drilling at well MW-20. The TW-2 wells were drilled using mud rotary methods, which did not allow for identification of flowing sands.

C.1.4 Hydrogeologic Cross Sections

In the 2009 RFI/RI hydrogeologic characterization report a series of cross sections were prepared to illustrate the site hydrogeology, hydrostratigraphy, bedrock structure, and aquifer distribution and geometry. The hydrogeologic features shown on several of the cross sections which are pertinent to the 60% design are summarized below. A complete discussion of the cross section and site hydrogeology can be found in Volume 2 of the 2009 RFI/RI report.

Hydrogeologic Cross Section A-A' (Figure 5-2 of the 2009 RFI/RI) extends northward from the bedrock outcrop of the Chemehuevi Mountains, along the upper part of Bat Cave Wash, and farther north to the Colorado River floodplain. Wells shown include the former injection well PGE-8 (SWMU 2) as well as the well clusters in the upland area (MW-24), IM extraction area (TW-2, TW-3, MW-20), and the floodplain (MW-34, MW-36, MW-39). Also shown on this cross section are the southward pinch-out of the saturated Alluvial Aquifer, the Alluvial Aquifer hydrostratigraphic units, and the inferred depiction of bedrock contacts and the projected trace of the regional Chemehuevi detachment fault.

Hydrogeologic Cross Section B-B' (Figure 5-3 of the 2009 RFI/RI) extends along the axis of Bat Cave Wash and illustrates the progressive south-to-north thickening of the saturated Alluvial Aquifer. The Alluvial Aquifer consists of the older alluvial fan deposits of the Tertiary Alluvium and Basal Alluvium.

Hydrogeologic Cross Section E-E' (Figure 5-6 of the 2009 RFI/RI) extends from the IM-3 injection area eastward to the Colorado River. Key features shown include the generalized Miocene bedrock structure and the inferred distribution and depositional contacts of the alluvial fan deposits (Toa0, Toa) and the younger fluvial sediments of the Colorado River (Qr1, Qr2, Qr3). As shown on this cross section, the injection interval at the injection well field (wells IW-2 and IW-3) span the mid-depth and deep portions of the Alluvial Aquifer.

Hydrogeologic Cross Section F-F' (Figure 5-7 of the 2009 RFI/RI) extends eastward from the MW-20 bench across the floodplain to the MW-34 monitoring well cluster adjacent to the Colorado River. Features shown include the screen depths of the two active IM extraction wells (TW-3D and PE-1) and the distribution and depositional contacts of the alluvial fan deposits (Toa0, Toa) and the younger fluvial sediments of the Colorado River (Qr1, Qr2, Qr3).

C.2 Proposed Areas for Supplemental Geotechnical Investigation to support Remedy Design

Collection of additional geotechnical samples to support remedy design was coordinated with the Soil RFI/RI investigation program; as a result, no new boreholes will be required just for geotechnical data collection, thereby minimizing disturbance. Geotechnical samples will be collected from proposed soil sample locations SD-19 and SD-20 near the Compressor Station and Bat Cave Wash; and AOC11-3 on the Transwestern Bench (see Exhibit C.2-1). The supplemental geotechnical data will be evaluated to verify design assumptions associated with the new pipe bridge that crosses Bat Cave Wash and the new Central Maintenance Facility at the Transwestern Bench.

As PG&E continues to engage in discussions with transportation agencies, counties, and other property owners/land managers to obtain institutional controls, access agreements, and permits, additional geotechnical data may be required to meet specific requirements of agencies and/or property owners/land managers. This attachment will be updated as needed to reflect changes in requirements.

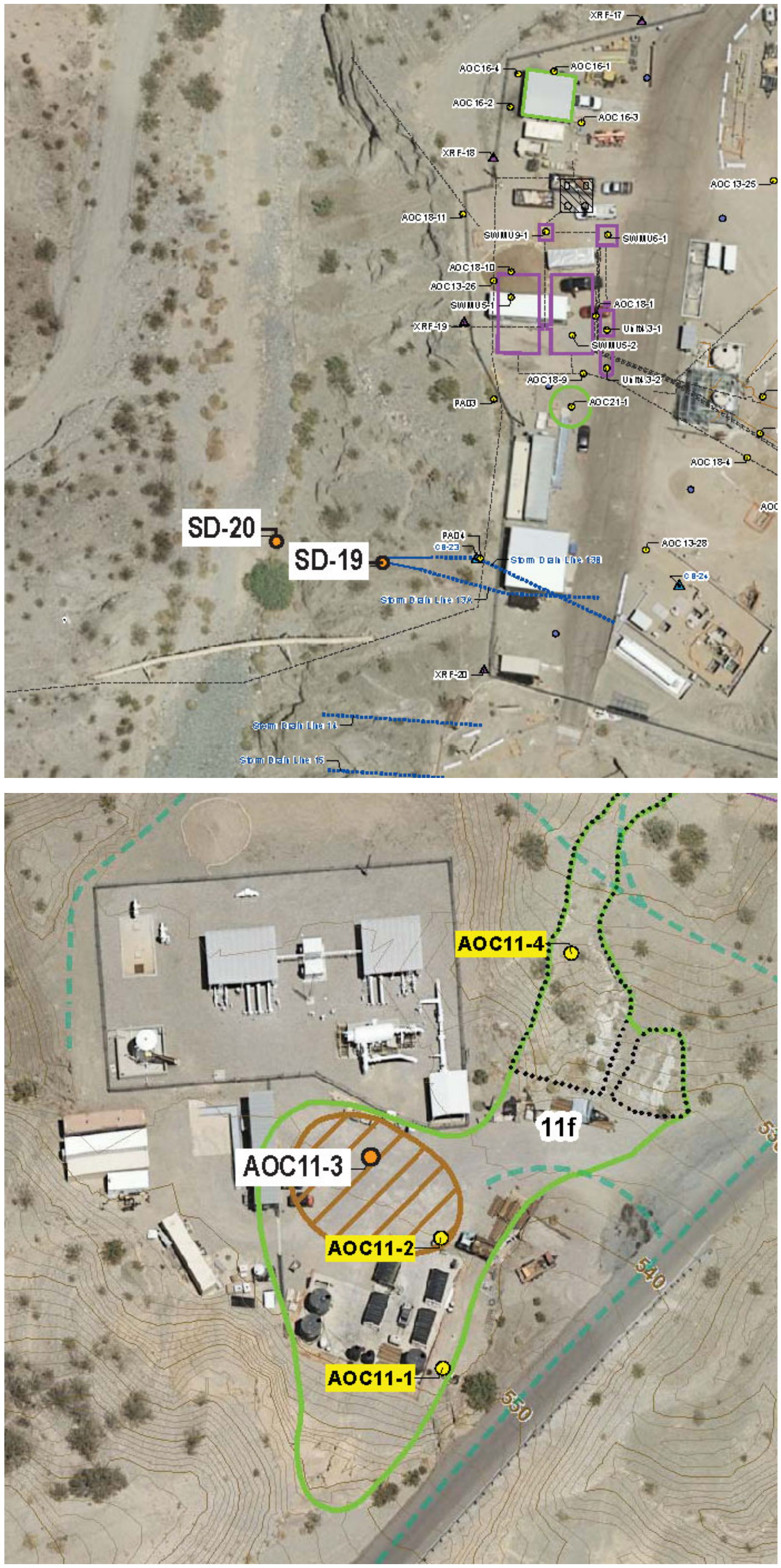


EXHIBIT C.2-1

Geotechnical Sampling Locations in Bat Wash Cave and the Transwestern Bench

Groundwater Remedy Basis of Design Report/Intermediate (60%) Design
PG&E Topock Compressor Station, Needles, California

Source: Soil RFI/RI Work Plan (CH2M HILL 2012)

C.3 References

Blake, T.F. 1998. *FRISKSP, A Computer Program for the Probabilistic Estimation of Seismic Hazard Using Faults as Earthquake Sources*. User's Manual.

CH2M HILL. 2004. *Geotechnical Investigation Report, Topock Compressor Station, Water Treatment Plant.* September.

_______. 2005. *Work Plan for Installation of Extraction Well TW-3D, Interim Measures No. 3 Groundwater Extraction System, PG&E Topock Compressor Station, Needles, California.* October.

_______.2009a. *RCRA Facility Investigation/Remedial Investigation Report, PG&E Topock Compressor Station, Needles, California, Volume 2 – Hydrogeologic Characterization and Results of Groundwater and Surface Water Investigation.* February.

_______. 2009b. *Geotechnical Investigation, Topock AOC 4 Remediation – Pre-Work Plan Data Collection Activities, PG&E Compressor Station, Needles, California.* October.

_______.2012. *Soil RCRA Facility Investigation/Remedial Investigation Work Plan, PG&E Compressor Station, Needles, California.* September 5.

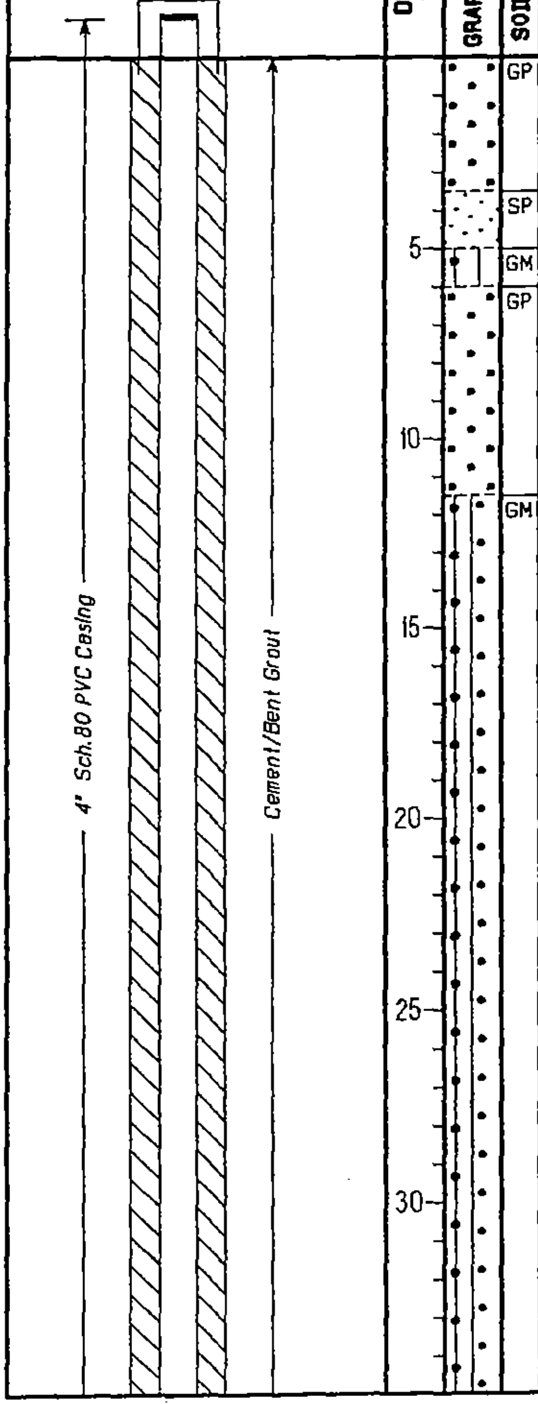
International Code Council and the California Building Standards Commission. 2001. *2001 California Building Code*. California Code of Regulations Title 24, Part 2.

Selected Boring Logs from RFI/RI Report Volume 2 (CH2M HILL 2009)

ALISTO ENGINEERING GROUP WALNUT CREEK, CALIFORNIA	LOG OF WELL MW-9	Page 1 of 3

SEE SITE PLAN	ALISTO PROJECT NO: *10-320-06* DATE DRILLED: *07/01/97*
	CLIENT: *Pacific Gas and Electric Co.*
	LOCATION: *Topock Compressor Station*
	DRILLING METHOD: *Resonant Sonic, Continuous Coring*
	DRILLING COMPANY: *Boart Longyear* CASING ELEVATION: *536.18*
	LOGGED BY: *Dan Salaices* *APPROVED BY:* *Dan Salaices*

WELL DIAGRAM | DEPTH feet | GRAPHIC LOG

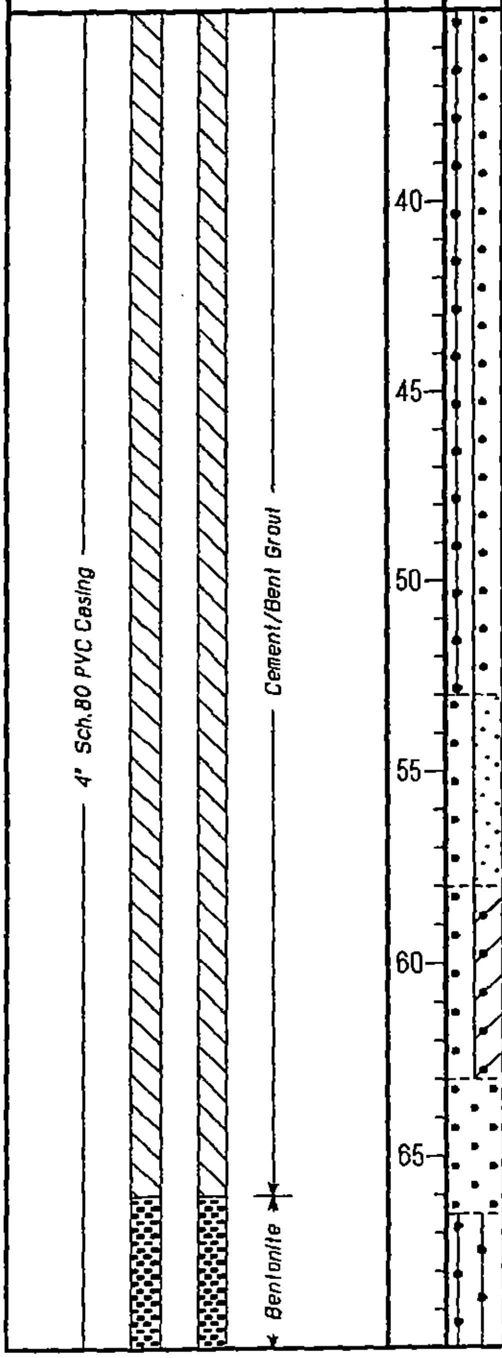


SOIL CLASS	GEOLOGIC DESCRIPTION
GP	sandy GRAVEL: Pale yellowish brown, to light gray; 85% gravel, 4–40 mm, subangular; 15% sand, mostly fine; dry.
SP	SAND: Moderate yellowish brown; fine grained, dry, fill ?
GM	silty GRAVEL: moderate brown to dark yellowish brown; 70% gravel, 4–30 mm, subangular.
GP	sandy GRAVEL: Pale yellowish brown, to light gray; 85% gravel, 4–40 mm, subangular; 15% sand, mostly fine; dry. 6.5' sandy GRAVEL: Light olive gray; 80% gravel, 4–30 mm, subangular; 40% sand, fine to coarse. 7.5' color change to yellowish gray; 80% gravel, 4–40 mm, subangular; 20% sand, mostly fine and coarse, dry.
GM	sandy silty GRAVEL: Pale yellowish brown; 70% gravel, 4–30 mm, subangular, occasional cobble fragment; 15% sand, fine and coarse grained; 15% fines; dry. Same: color change to moderate brown, moist.

ALISTO ENGINEERING GROUP WALNUT CREEK, CALIFORNIA	LOG OF WELL MW-9	Page 2 of 3

SEE SITE PLAN	ALISTO PROJECT NO: *10-320-08* DATE DRILLED: *07/01/97*
	CLIENT: *Pacific Gas and Electric Co.*
	LOCATION: *Topock Compressor Station*
	DRILLING METHOD: *Resonant Sonic, Continuous Coring*
	DRILLING COMPANY: *Boart Longyear* CASING ELEVATION: *536.18*
	LOGGED BY: *Dan Salaices* APPROVED BY: *Dan Salaices*

WELL DIAGRAM | **DEPTH feet** | **GRAPHIC LOG**



SOIL CLASS	GEOLOGIC DESCRIPTION
GM	Same: 80% gravel; 20% sand, fine to coarse grained; 20% fines; dry.
GP/SP	gravelly SAND/sandy GRAVEL: moderate yellowish brown; appears to be 50% gravel, 4-30mm; 50% sand, fine to coarse grained; moist.
GP/GC	sandy clayey GRAVEL: moderate yellowish brown; 70% gravel, 4-30 mm, subangular; 20% sand, fine to coarse grained; 10% fines; damp.
GP	sandy GRAVEL: moderate yellowish brown; 70 % gravel, 4-30 mm, subangular and somewhat fractured; 30% sand, fine to coarse grained; damp.
GM	sandy silty GRAVEL: Moderate yellowish brown; 70% gravel, 4-50 mm, subangular and somewhat fractured; 15% sand, fine to coarse; 15% fines; moist.

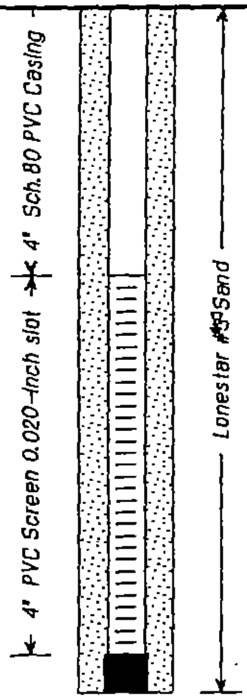
ALISTO ENGINEERING GROUP
WALNUT CREEK, CALIFORNIA

LOG OF WELL MW-9

ALISTO PROJECT NO: *10-320-06*	DATE DRILLED: *07/01/97*
CLIENT: *Pacific Gas and Electric Co.*	
LOCATION: *Topock Compressor Station*	
DRILLING METHOD: *Resonant Sonic, Continuous Coring*	
DRILLING COMPANY: *Boart Longyear*	CASING ELEVATION: *536.18*
LOGGED BY: *Dan Salaices*	APPROVED BY: *Dan Salaices*

SEE SITE PLAN

WELL DIAGRAM



GRAPHIC LOG

DEPTH feet	SOIL CLASS	GEOLOGIC DESCRIPTION
75	GM	
	GP GM	sandy silty GRAVEL: moderate brown; 70% gravel, 4–30 mm, subangular; 20% sand, fine to coarse grained; 10% fines; very moist.
80	GC	clayey GRAVEL: dark yellowish brown; 80% gravel, 4–30 mm, occasional cobble fragments; 20% sand, fine grained; 20% fines; wet.
85	GM	RED FANGLOMERATE sandy silty GRAVEL: (GM although rock at 88.5) moderate reddish brown, wet to 88.5, dry at 88.5.
90		refusal at 89 feet. Total depth of borehole is 89 feet.
95		
100		

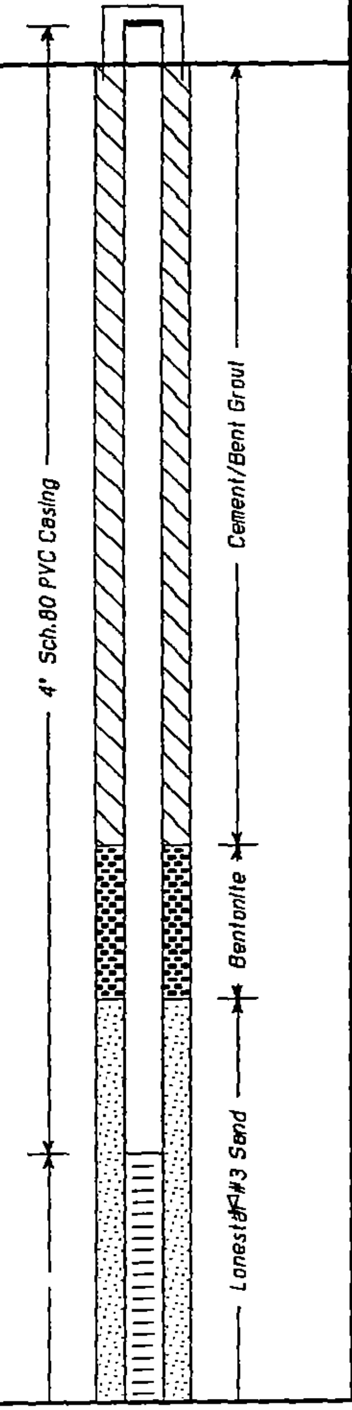
ALISTO ENGINEERING GROUP
WALNUT CREEK, CALIFORNIA

LOG OF WELL MW-13

ALISTO PROJECT NO: *10-320-08*	DATE DRILLED: *07/09/97*
CLIENT: *Pacific Gas and Electric Co.*	
LOCATION: *Topock Compressor Station*	
DRILLING METHOD: *Resonant Sonic, Continuous Coring*	
DRILLING COMPANY: *Boart Longyear*	CASING ELEVATION: *488.19*
LOGGED BY: *Ted Moise/Dan Birch*	APPROVED BY: *Dan Salaices*

SEE SITE PLAN

WELL DIAGRAM



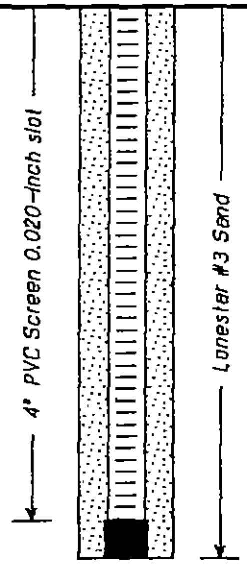
DEPTH feet	SOIL CLASS	GEOLOGIC DESCRIPTION
0	SP	gravelly SAND: yellowish gray; 50% sand, fine to coarse grained; 45% gravel, 4–50 mm, subangular, occasional cobbles; minor fines; dry.
5		color change to light olive gray
12	GP	sandy GRAVEL: light gray; 60% gravel, 4–75 mm, subangular; 40% sand, fine to medium grained; dry.
18		at 18 feet, 150 mm cobble.
19.5		at 19.5 feet, color change to pale yellowish brown; 70% gravel; 30% sand, fine to medium grained. Possibly older alluvium.
26.5		at 26.5 feet, 60% gravel, 40% sand.
30		Wet at 30 feet.
34.5	SP	gravelly SAND: pale brown; 60% sand, fine to coarse grained;

LOG OF WELL MW-13

SEE SITE PLAN

ALISTO PROJECT NO: *10-320-06*	DATE DRILLED: *07/09/97*
CLIENT: *Pacific Gas and Electric Co.*	
LOCATION: *Topock Compressor Station*	
DRILLING METHOD: *Resonant Sonic, Continuous Coring*	
DRILLING COMPANY: *Boart Longyear*	CASING ELEVATION: *488.19*
LOGGED BY: *Ted Moise/Dan Birch*	*APPROVED BY:* *Dan Salaices*

WELL DIAGRAM



DEPTH feet	GRAPHIC LOG	SOIL CLASS	GEOLOGIC DESCRIPTION
		SP	35% gravel, 4–40 mm, subangular; wet.
40			At 40 feet, color change to pale red; 70% sand, fine to coarse grained; 30% gravel, 4–25 mm, subangular.
			At 43 feet, color change to light brownish gray, cobble to 100 mm.
45			
50			Total depth of borehole is 48.5 feet.
55			
60			
65			

ALISTO ENGINEERING GROUP
WALNUT CREEK, CALIFORNIA

LOG OF WELL MW-14

SEE SITE PLAN

ALISTO PROJECT NO: *10-320-06* DATE DRILLED: *07/14-15/97*

CLIENT: *Pacific Gas and Electric Co.*

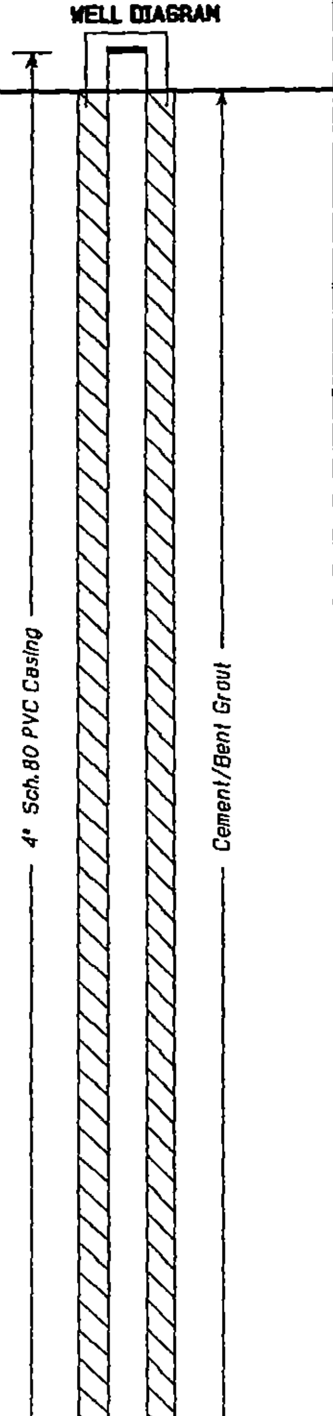
LOCATION: *Topock Compressor Station*

DRILLING METHOD: *Resonant Sonic, Continuous Coring*

DRILLING COMPANY: *Boart Longyear* CASING ELEVATION: *570.54*

LOGGED BY: *Ted Moise/Ken Simas* APPROVED BY: *Dan Salaices*

WELL DIAGRAM



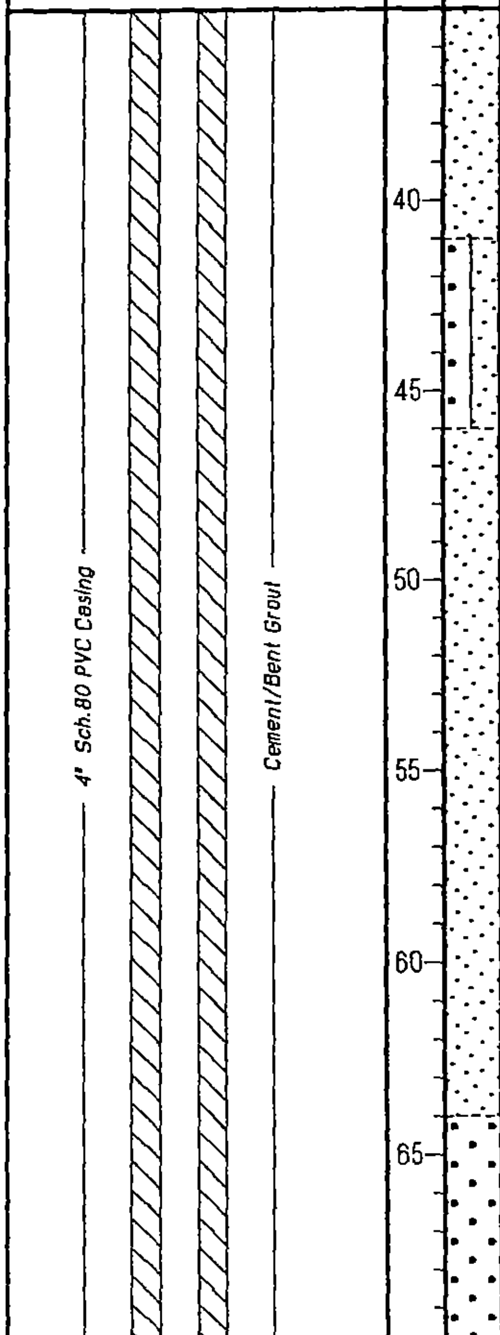
DEPTH feet	SOIL CLASS	GEOLOGIC DESCRIPTION
0–4	GP	sandy GRAVEL: grayish orange pink; 70% gravel, 4-75 mm, rounded to subangular; 30% sand, fine to coarse grained; dry.
4	SP	gravelly SAND: pale yellowish brown; 80% sand, fine to coarse grained; 20% gravel, 4-50 mm, subangular; dry.
8		At 8 feet, 60% sand, fine to coarse grained; 40% gravel, 4-70 mm, subangular.
14	GP	sandy GRAVEL: pale yellowish brown; 60% gravel, 4-35 mm; subangular; 40% sand, fine to coarse grained, dry.
16.5	SP	gravelly SAND: pale yellowish brown; 90% sand, fine to coarse grained; 10% gravel, 4-20 mm, subangular, dry.
20		At 20 feet, 55% sand, fine to coarse grained; 45% gravel, 4-50 mm.
22		At 22 feet, color change to light gray; 60% sand, fine to coarse grained; 40% gravel, 4-50 mm, angular to subrounded.
25		At 25 feet, color change to light olive gray; 40% gravel, 4-25 mm, subangular.
30		At 30 feet, color change to pale yellowish brown; 75% sand, fine to coarse grained; 25% gravel, 4-80 mm, subangular; dry.

ALISTO ENGINEERING GROUP
WALNUT CREEK, CALIFORNIA

LOG OF WELL MW-14

SEE SITE PLAN

ALISTO PROJECT NO: *10-320-06*	DATE DRILLED: *07/14-15/97*
CLIENT: *Pacific Gas and Electric Co.*	
LOCATION: *Topock Compressor Station*	
DRILLING METHOD: *Resonant Sonic, Continuous Coring*	
DRILLING COMPANY: *Boart Longyear*	CASING ELEVATION: *570.54*
LOGGED BY: *Ted Moise/Ken Simas*	APPROVED BY: *Dan Salaices*



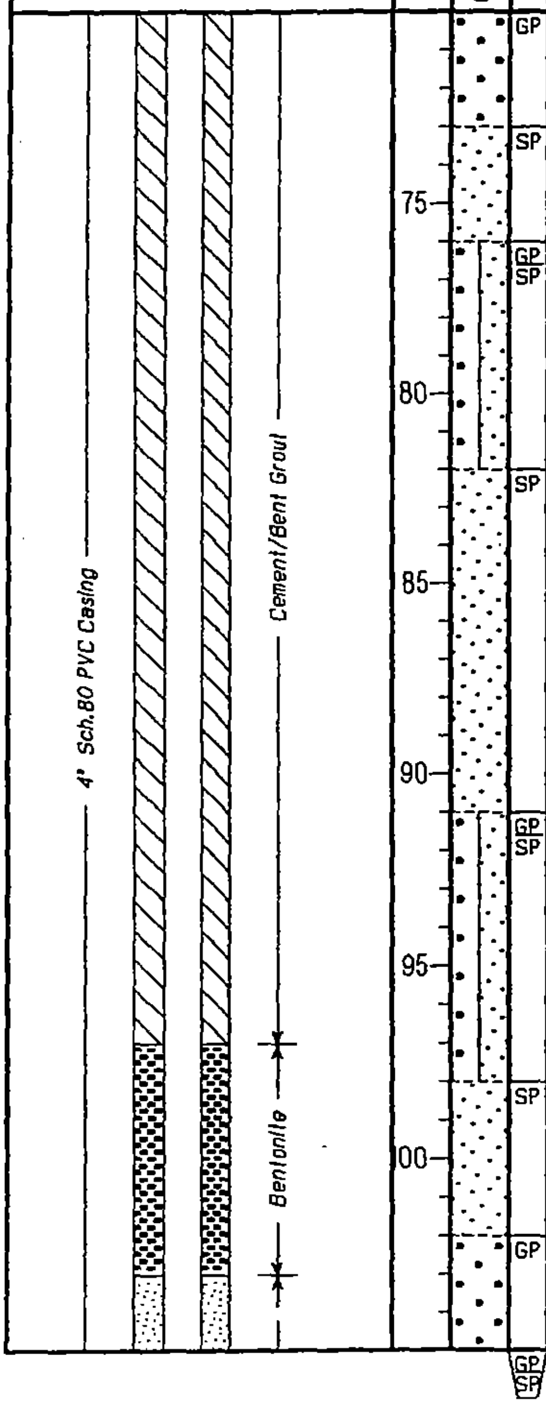
WELL DIAGRAM	DEPTH feet	SOIL CLASS	GEOLOGIC DESCRIPTION
		SP	At 36 feet, gravel, 4-40 mm, subangular. At 38 feet, color change to light olive gray; 60% sand, fine to coarse grained; 40% gravel, 4-75 mm, subrounded to subangular; dry.
	40	GP/SP	sandy GRAVEL/gravelly SAND: Pale yellowish brown; 50% sand, fine to coarse grained; 50% gravel, 4-75 mm, subangular to subrounded; dry.
	45	SP	gravelly SAND: Pale yellowish brown; 70% sand, fine to coarse grained; 30% gravel, 4-75 mm, subangular. At 50 feet, 60% sand, fine to coarse grained; 40% gravel, 4-85 mm, subrounded to subangular; dry. At 54 feet; color change to light gray, 55% sand, fine to coarse grained; 40% gravel, 4-35 mm, subangular to subrounded; 5% fines; dry. At 57 feet, 65% sand, fine to coarse grained; 30% gravel, subangular to subrounded, 4-75 mm; 5% fines.
	65	GP	sandy GRAVEL: light gray; 60% gravel, subangular to subrounded, 4-75 mm; 40% sand, fine to coarse grained.

ALISTO ENGINEERING GROUP
WALNUT CREEK, CALIFORNIA

LOG OF WELL MW-14

SEE SITE PLAN

ALISTO PROJECT NO: *10-320-06* DATE DRILLED: *07/14-15/97*
CLIENT: *Pacific Gas and Electric Co.*
LOCATION: *Topock Compressor Station*
DRILLING METHOD: *Resonant Sonic, Continuous Coring*
DRILLING COMPANY: *Boart Longyear* CASING ELEVATION: *570.54*
LOGGED BY: *Ted Moise/Ken Simas* APPROVED BY: *Dan Salaices*



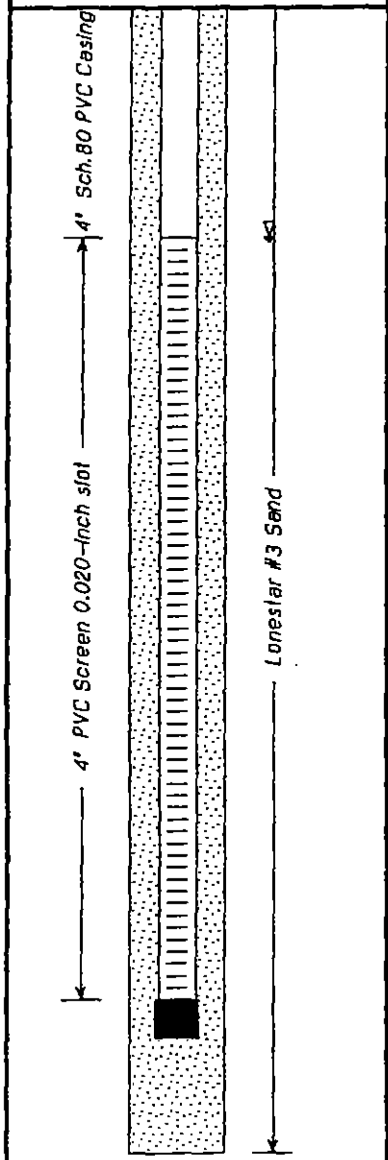
GEOLOGIC DESCRIPTION

SOIL CLASS	GEOLOGIC DESCRIPTION
GP	Same
SP	gravelly SAND: pale yellowish brown; 80% sand, fine to coarse grained; 40% gravel, 4-50 mm, subangular.
GP/SP	sandy GRAVEL/gravelly SAND: light olive brown; 50% sand, fine to coarse grained; 50% gravel, 4-50 mm, subangular. At 79.5 feet, 1.5 foot long boulder core, 8-inches wide. Rock flour is light gray.
SP	gravelly SAND: light olive gray; 80% sand, fine to coarse grained; 40% gravel, 4-50 mm, subangular.
GP/SP	sandy GRAVEL/gravelly SAND: light olive gray, 50% sand, fine to coarse grained; 50% gravel, 4-50 mm, subangular.
SP	gravelly SAND: light gray; 80% sand, fine to coarse grained; 20% gravel, 4-50 mm, subangular.
GP	sandy GRAVEL: light gray; 75% gravel, 4-50 mm, subangular to subrounded; 25% sand, fine to coarse grained, dry.

ALISTO ENGINEERING GROUP WALNUT CREEK, CALIFORNIA	LOG OF WELL MW-14	*Page 4 of 4*

SEE SITE PLAN	
	ALISTO PROJECT NO: *10-320-08* DATE DRILLED: *07/14-15/97*
	CLIENT: *Pacific Gas and Electric Co.*
	LOCATION: *Topock Compressor Station*
	DRILLING METHOD: *Resonant Sonic, Continuous Coring*
	DRILLING COMPANY: *Boart Longyear* CASING ELEVATION: *570.54*
	LOGGED BY: *Ted Moise/Ken Simas* APPROVED BY: *Dan Salaices*

WELL DIAGRAM



DEPTH feet	SOIL CLASS	GEOLOGIC DESCRIPTION
	GP SP	sandy GRAVEL/gravelly SAND: moderate brown; 50% gravel, 4-75 mm, subrounded to subangular; 50% sand, fine to coarse grained; damp.
	SP	gravelly SAND: light olive brown; 60% sand, fine to coarse grained; 40% gravel, subangular, 4-40 mm; moist to wet.
110	GP	sandy GRAVEL: light olive gray; 60% gravel, subangular to subrounded, 4-75 mm; 40% sand, fine to coarse grained; wet at 111 feet.
115		At 116 feet, color change to light brown; gravel 4-75 mm. At 117.5 feet, 140 mm cobble, light gray rock flour.
120	SP	gravelly SAND: pale yellowish brown; 65% sand, fine to coarse grained, 30% gravel, subangular, 4-75 mm; 5% fines; wet.
125	GP GM	sandy silty GRAVEL: pale yellowish brown; 55% gravel, subangular, 4-50 mm, occasional cobble to 80 mm; 35% sand, fine to coarse grained; 10% fines; wet.
130	SP	gravelly SAND: pale yellowish brown; 60% sand, fine to coarse grained; 35% gravel, subangular, 4-20 mm; 5% fines; wet.
	SM	gravelly silty SAND: pale yellowish brown; 60% sand, fine to coarse grained; 20% gravel, subangular, 4-30 mm; 20% fines; wet.
135	SP	gravelly SAND: light olive gray; 65% sand, fine to coarse grained; 30% gravel, subangular, 4-25 mm; 5% fines; wet.
		Total depth of the boring is 135 feet.

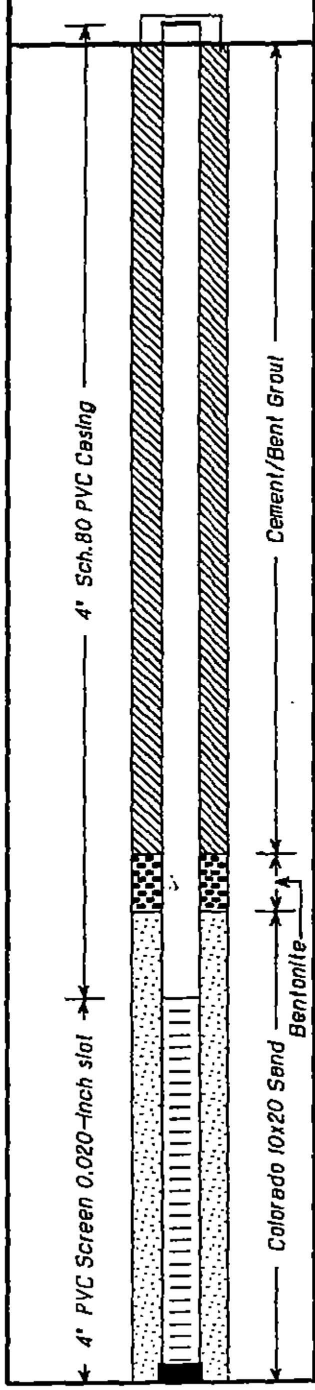
ALISTO ENGINEERING GROUP
WALNUT CREEK, CALIFORNIA

LOG OF BORING MW-20/70

SEE SITE PLAN

ALISTO PROJECT NO: *10-320-08*	DATE DRILLED: *03/24-25/98*
CLIENT: *Pacific Gas and Electric Co.*	
LOCATION: *Topock Compressor Station*	
DRILLING METHOD: *AP-1000 Dual Tube Percussion*	
DRILLING COMPANY: *THF Drilling*	CASING ELEVATION:
LOGGED BY: *Dan Salaices*	APPROVED BY: *Dan Salaices*

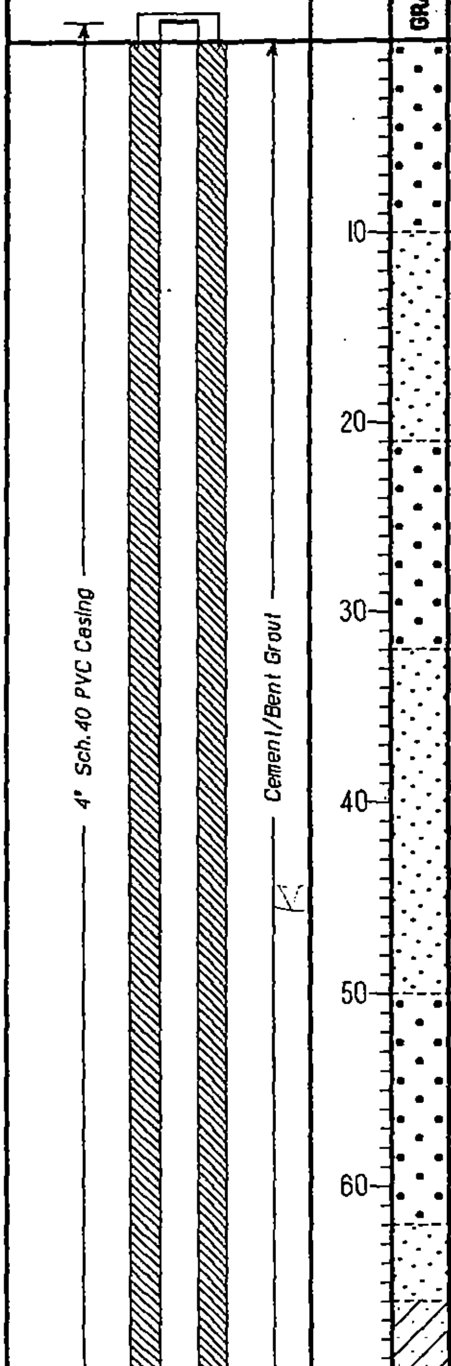
BORING DIAGRAM



DEPTH feet	SOIL CLASS	GEOLOGIC DESCRIPTION
0	GP	sandy GRAVEL: moderate yellowish-brown; ~80-70% gravel, subrounded, to 80 mm; ~30-40% sand.
10	SP	SAND: pale yellowish-brown; very fine- to fine-grained; ~5% gravel.
21	GP	sandy GRAVEL: light brownish-gray; cobble at 21-24 feet. Changes at 24 feet of color to moderate yellowish-brown; ~80-70% gravel, subrounded, to 80 mm.
32	SP	gravelly SAND: light gray; ~80% sand, very fine- to fine-grained; ~10% gravel, subrounded, to 50 mm. gravelly SAND continued.
45		SAND: reddish brown; fine- to very fine-grained; ~5% fines; damp.
50	GP	sandy GRAVEL: reddish-brown; ~55% gravel, subrounded, to 80 mm; ~45% sand. Appears wet at 80 feet.

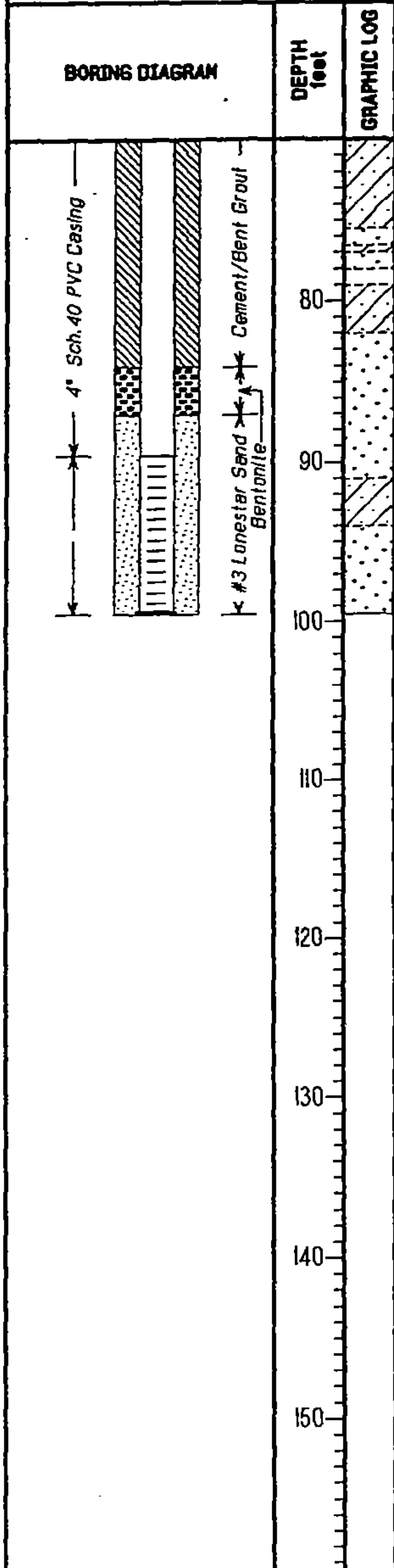
ALISTO ENGINEERING GROUP WALNUT CREEK, CALIFORNIA	# LOG OF BORING MW-20/100	Page 1 of 2

SEE SITE PLAN	ALISTO PROJECT NO: *10-320-09* DATE DRILLED: *04/28-29/99*
	CLIENT: *Pacific Gas and Electric Co.*
	LOCATION: *Topock Compressor Station*
	DRILLING METHOD: *Roto Sonic, Continuous Coring*
	DRILLING COMPANY: *Boart Longyear* CASING ELEVATION:
	LOGGED BY: *Chris Reinheimer* APPROVED BY: *Dan Hidalgo*



BORING DIAGRAM	DEPTH feet	GRAPHIC LOG	SOIL CLASS	GEOLOGIC DESCRIPTION
			GP	sandy GRAVEL: moderate yellowish-brown; ~60-70% gravel, subrounded, ~80 mm; ~30-40% sand.
	10		SP	SAND: pale yellowish-brown; very fine- to fine-grained; ~5% gravel.
	20		GP	sandy GRAVEL: light brownish-gray; cobble at 21 to 24 feet. At 24 feet color change to moderate yellowish-brown; ~60-70% gravel, subrounded, ~80 mm.
	30		SP	gravelly SAND: light gray; ~80% sand, very fine- to fine-grained; ~10% gravel, subrounded, ~50 mm. gravelly SAND continued.
	40			SAND: reddish-brown; very fine- to fine-grained; ~5% fines; damp.
	50		GP	sandy GRAVEL: reddish-brown; ~55% gravel, subrounded, ~80 mm; ~45% sand.
	60		SP	gravelly SAND: brown to reddish-brown; 70% sand, fine- to coarse-grained; gravel, subrounded to subangular, 4 to 10 mm; wet.
			SC	gravelly clayey SAND: reddish-brown; 70% sand, fine- to coarse-grained; gravel, 4 to 8 mm; ~15% fines, plastic; wet.

LOG OF BORING MW-20/100

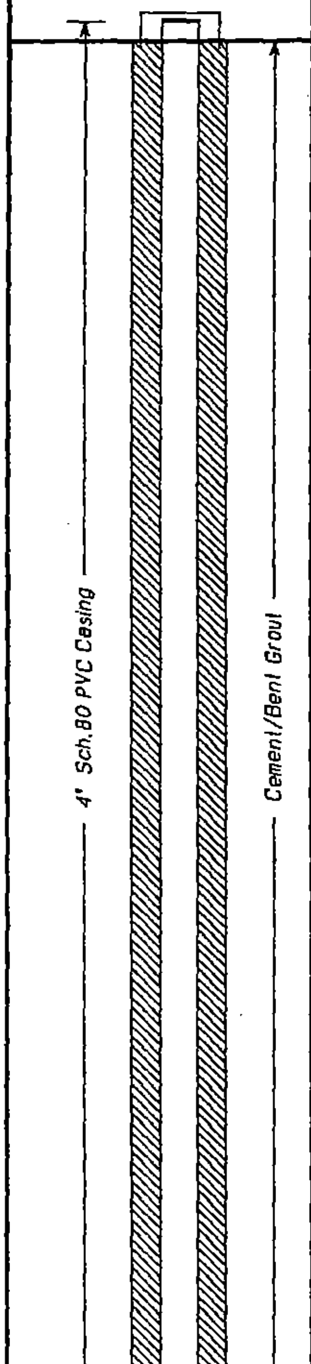


SOIL CLASS	GEOLOGIC DESCRIPTION
SC	gravelly clayey SAND continued.
SP	SAND: reddish-brown; fine- to coarse-grained; minor gravel, fine-grained; wet.
SC	gravelly clayey SAND: reddish-brown; 70% sand, fine- to coarse-grained; gravel, 4 to 8 mm; ~15% fines, plastic; wet.
SP	SAND: reddish-brown; fine- to coarse-grained; minor gravel, fine-grained; wet.
SC	gravelly clayey SAND: reddish-brown; 70% sand, fine- to coarse-grained; gravel, 4 to 8 mm; ~15% fines, plastic; wet.
SP	gravelly SAND: reddish-brown; 85% sand, very fine- to coarse-grained; gravel; wet.
SC	gravelly clayey SAND: reddish-brown; 70% sand, fine- to coarse-grained; gravel, 4 to 8 mm; ~15% fines, plastic; wet.
SP	gravelly SAND: reddish-brown; ~85% sand, very fine- to coarse-grained; gravel, ~4 to 20 mm; wet.
	At 98 feet color change to moderate yellowish-brown; 80% sand, medium- to coarse-grained.
	At 98 feet color change to brown; 85% sand, very fine- to coarse-grained.
	Total depth of borehole at 99.5 feet.

ALISTO ENGINEERING GROUP WALNUT CREEK, CALIFORNIA	LOG OF BORING MW-20/130	Page 1 of 2

SEE SITE PLAN	
	ALISTO PROJECT NO: *10-320-09* DATE DRILLED: *04/25-27/99*
	CLIENT: *Pacific Gas and Electric Co.*
	LOCATION: *Topock Compressor Station*
	DRILLING METHOD: *Roto Sonic, Continuous Coring*
	DRILLING COMPANY: *Boart Longyear* CASING ELEVATION:
	LOGGED BY: *Dan Hidalgo & Chris Reinheimer* APPROVED BY: *Dan Hidalgo*

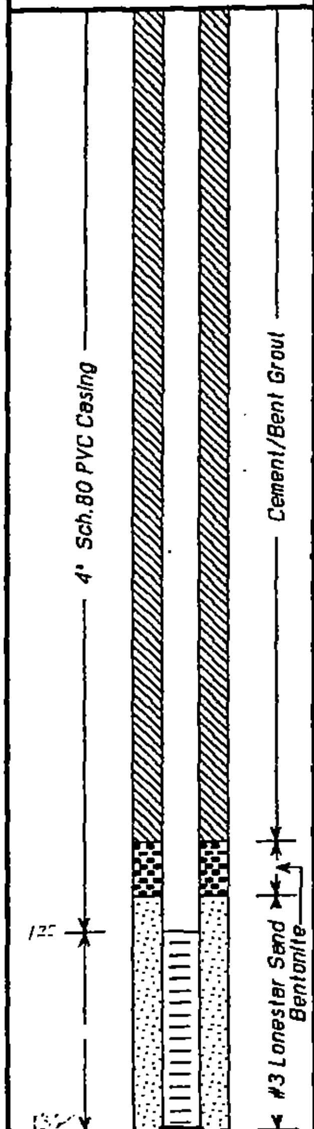
BORING DIAGRAM



DEPTH feet	SOIL CLASS	GEOLOGIC DESCRIPTION
	GP	sandy GRAVEL: moderate yellowish-brown; ~60-70% gravel, subrounded, ~90 mm; ~30-40% sand.
10	SP	SAND: pale yellowish-brown; very fine- to fine-grained; ~5% gravel.
20	GP	sandy GRAVEL: light brownish-gray; cobbles at 21 to 24 feet. At 24 feet color change to moderate yellowish-brown; ~60-70% gravel, subrounded, ~90 mm.
30	SP	gravelly SAND: light gray; ~90% sand, very fine- to fine-grained; ~10% gravel, subrounded, ~50 mm. gravelly SAND continued.
40		SAND: reddish-brown; very fine- to fine-grained; ~5% fines; damp.
50	GP	sandy GRAVEL: reddish-brown; ~55% gravel, subrounded, ~90 mm; ~45% sand.
60	SP	gravelly SAND: brown to reddish-brown; 70% sand, fine- to coarse-grained; gravel, subrounded to subangular, 4 to 10 mm; wet.
	SC	gravelly clayey SAND: reddish-brown; 70% sand, fine- to coarse-grained; gravel, 4 to 8 mm; ~15% fines, plastic; wet.

LOG OF BORING MW-20/130

BORING DIAGRAM



SOIL CLASS	GEOLOGIC DESCRIPTION
SC	gravelly clayey SAND continued.
SP	SAND: reddish-brown; fine- to coarse-grained; minor gravel, fine-grained; wet.
SC	gravelly clayey SAND: reddish-brown; 70% sand, fine- to coarse-grained; gravel, 4 to 6 mm; ~15% fines, plastic; wet.
SP	SAND: reddish-brown; fine- to coarse-grained; minor gravel, fine-grained; wet.
SC	No recovery.
SP	gravelly clayey SAND: reddish-brown; 70% sand, fine- to coarse-grained; gravel, 4 to 6 mm; ~15% fines, plastic; wet.
	gravelly SAND: reddish-brown; 85% sand, very fine- to coarse-grained; gravel, ~4 to 20 mm; wet.
SC	gravelly clayey SAND: reddish-brown; 70% sand, fine- to coarse-grained; gravel, 4 to 6 mm; ~15% fines, plastic; wet.
SP	gravelly SAND: reddish-brown; ~85% sand, very fine- to coarse-grained; gravel, ~4 to 20 mm; wet.
	At 98 feet color change to moderate yellowish-brown; 80% sand, medium- to coarse-grained.
ML	At 98 feet color change to brown; 85% sand, very fine- to coarse-grained.
	gravelly sandy SILT: medium reddish-brown with less than 2% greenish-gray stain; ~80% fines, non-plastic; ~20% gravel to 2", coarse-grained; moist to wet.
	gravelly sandy SILT continued.
SP	silty SAND: medium reddish-brown; ~80% sand, medium- to coarse-grained; ~10% gravel; ~10% fines, non-plastic; wet.
	At 114 feet change to ~30% gravel.
ML	gravelly sandy SILT: medium reddish-brown with less than 2% greenish-gray stain; ~80% fines, non-plastic; ~20% gravel to 2", coarse-grained; moist to wet.
SC	clayey SAND: medium-orange; 60% sand, medium- to coarse-grained; ~30% fines, medium plasticity; ~10% gravel to 2"; wet to saturated.
GM	silty GRAVEL: medium reddish-brown; ~70% gravel to 3"; ~30% fines, non-slight plasticity; moist.
	At 129.5 feet changes to ~80% gravel to 3"; ~15% fines, non plastic; angular clast to 2"; damp.
	RED FANGLOMERATE cemented dry, drill refusal at 132 feet.
	Total depth of borehole at 132 feet.

PROJECT NUMBER: 326128.01.07.AR

BORING NUMBER: MW-41

SOIL BORING LOG

PROJECT NAME: IM-3 Hydrogeologic Investigation, PG&E Topock	**HOLE DEPTH (ft):** 320.0	**DRILLING CONTRACTOR:** WDC Exploration & Wells, Montclair, CA	
SURFACE ELEVATION: 476.9 ft. MSL	**NORTHING (CCS NAD 27 Z 5):** 2,103,536.66	**EASTING (CCS NAD 27 Z 5):** 7,614,578.85	**DATE STARTED:** 10/22/2004 **DATE COMPLETED:** 11/05/2004
DRILLING METHOD: Rotosonic	**WATER LEVEL (ft):** ---	**DRILLING EQUIPMENT:** Gefco SS-15K-HL	
LOCATION: Bat Cave Wash, Parcel No. 650-151-06		**LOGGED BY:** T. McDonald	

DEPTH BGS (feet)	SAMPLE: INTERVAL	SAMPLE: TYPE/NUMBER	SAMPLE: RECOVERY (ft)	USCS CODE	SOIL DESCRIPTION: SOIL NAME, USCS SYMBOL, COLOR, PERCENT COMPOSITION, GRADING, GRAIN SHAPE, MINERALOGY, DENSITY/CONSISTENCY, STRUCTURE, MOISTURE.	COMMENTS: DRILLING OBSERVATIONS AND OPERATIONS, DAILY START AND END TIMES , DRILL RATE, REFUSALS, SAMPLING AND TESTING NOTES.
0–20				SW	**WELL GRADED SAND WITH GRAVEL (SW)** - 45% rnd to ang gravel/cobbles up to 0.75", 40% f-m sand, 10% coarse sand, 5% silty clay.	0 to 20 ft not collected in core barrel during conductor casing set. Description is from homogenized cuttings
20–31	20–31	CC1	11	SW		Box 1 - 20 to 23 ft Box 2: 23 to 27 ft Box 3: 27 to 31 ft
29–31				GW-GM	**WELL GRADED GRAVEL WITH SILT AND SAND (GW-GM)** - 65% f-c gravel avg 2.5" up to 3", 20% c sand, 10% silt/clay, 5% f-m sand, sand and gravel ang to subang, metamorphic, 50% of gravels are highly weathered, moist, abrupt lower boundary.	
31–35	31–35			SC	**SILTY SAND WITH GRAVEL (SC)** - olive brn (2.5Y 4/3), 30% c sand, 25-30% silt, 20% m sand, 10% f gravel (0.2" to 0.75"), 10% f sand, sand and gravel ang to subang, metamorphic, moist.	Box 4: 31 to 34 ft Appears to be fining upward from to 31 to __ ft bgs Box 5: 34 to 38 ft

CH2MHILL

SHEET 2 of 10	PROJECT NUMBER: 326128.01.07.AR	BORING NUMBER: MW-41

SOIL BORING LOG

PROJECT NAME: IM-3 Hydrogeologic Investigation, PG&E Topock		**HOLE DEPTH (ft):** 320.0	**DRILLING CONTRACTOR:** WDC Exploration & Wells, Montclair, CA
SURFACE ELEVATION: 476.9 ft. MSL	**NORTHING (CCS NAD 27 Z 5):** 2,103,536.66	**EASTING (CCS NAD 27 Z 5):** 7,614,578.85	**DATE STARTED:** 10/22/2004 **DATE COMPLETED:** 11/05/2004
DRILLING METHOD: Rotosonic		**WATER LEVEL (ft):** ---	**DRILLING EQUIPMENT:** Gefco SS-15K-HL
LOCATION: Bat Cave Wash, Parcel No. 650-151-06			**LOGGED BY:** T. McDonald

DEPTH BGS (feet)	SAMPLE INTERVAL	SAMPLE TYPE/NUMBER	SAMPLE RECOVERY (ft)	USCS CODE	SOIL DESCRIPTION: SOIL NAME, USCS SYMBOL, COLOR, PERCENT COMPOSITION, GRADING, GRAIN SHAPE, MINERALOGY, DENSITY/CONSISTENCY, STRUCTURE, MOISTURE.	COMMENTS: DRILLING OBSERVATIONS AND OPERATIONS, DAILY START AND END TIMES, DRILL RATE, REFUSALS, SAMPLING AND TESTING NOTES.
		CC2	8.5	SW-SC	**WELL GRADED SAND WITH SILT AND GRAVEL (SW-SC)** - olive brn (2.5Y 4/3), 40% f sand, 30% m sand, 10-15% silt, 10% c sand, 5-10% f gravel, sand and gravel ang to subang, metamorphic, moist, abrupt lower boundary.	
				SW	**WELL GRADED SAND WITH GRAVEL (SW)** - brn (7.5YR 4/4), 50% m sand, 20% f sand, 15% c sand, 10% f gravel coarsening with depth, 5% silt, moderate caliche development, sand and gravel ang to subang, metamorphic, moist.	Box 6: 38 to 42 ft
40						
				SW-SM	**SAND WITH SILT AND GRAVEL (SW-SM)** - brn (10YR 4/4), 40% m sand, 25% c sand, 10-15% f gravel, 10-15% silt, 10% f sand well graded, sand and gravel ang to subang, metamorphic.	Box 7: 42 to 46 ft
					- lt to moderate caliche	Appears to encounter water table at 45 to 46 ft bgs
45		CC3	9.5			
				SW	**WELL GRADED SAND WITH GRAVEL (SW)** - dark grayish brn to brn (10YR 4/2-4/3), 60% m sand, 15% f sand, 15% f-m gravel, 10% f sand, ang to subang, metamorphic, wet.	Box 8: 46 to 50 ft
					- 20% f gravel	
50					- 5% gravel, 15% silt	Box 9: 50 to 54 ft
					- 30% f gravel, 25% vf sand, 15% silt, 15% f sand, 5% m sand, 10% c sand	Box 10: 54 to 58 ft
55		CC4	10			
					- brn (10YR 4/3), 40% c sand , 15% f sand, 15% m sand, 15% f gravel, 10% c gravel, 5% silt, ang to subang, metamorphic, wet	Box 11: 58 to 62 ft
60						
						Box 12: 62 to 66 ft Collect grain size sample at 62 to 64 ft, ID: MW-41D-63
65		CC5	10	SW	- 5% silt, 10% f sand, 10% m sand, 60% c sand, 5-10% f gravel	Collect grain size sample at 65 to 66 ft, ID: MW-41D-66
						Box 13: 66 to 70 ft
					- increasing silt content, 10% silt at 70 ft bgs, 15% silt at 71 ft bgs	Collect groundwater grab sample, ID: MW-41D-70
70						

SHEET 3 of 10	**PROJECT NUMBER:** 326128.01.07.AR	**BORING NUMBER:** MW-41

SOIL BORING LOG

PROJECT NAME: IM-3 Hydrogeologic Investigation, PG&E Topock		**HOLE DEPTH (ft):** 320.0	**DRILLING CONTRACTOR:** WDC Exploration & Wells, Montclair, CA	
SURFACE ELEVATION: 476.9 ft. MSL	**NORTHING (CCS NAD 27 Z 5):** 2,103,536.66	**EASTING (CCS NAD 27 Z 5):** 7,614,578.85	**DATE STARTED:** 10/22/2004	**DATE COMPLETED:** 11/05/2004
DRILLING METHOD: Rotosonic		**WATER LEVEL (ft):** ---	**DRILLING EQUIPMENT:** Gefco SS-15K-HL	
LOCATION: Bat Cave Wash, Parcel No. 650-151-06			**LOGGED BY:** T. McDonald	

DEPTH BGS (feet)	SAMPLE INTERVAL	SAMPLE TYPE/NUMBER	SAMPLE RECOVERY (ft)	USCS CODE	SOIL DESCRIPTION: SOIL NAME, USCS SYMBOL, COLOR, PERCENT COMPOSITION, GRADING, GRAIN SHAPE, MINERALOGY, DENSITY/CONSISTENCY, STRUCTURE, MOISTURE.	COMMENTS: DRILLING OBSERVATIONS AND OPERATIONS, DAILY START AND END TIMES , DRILL RATE, REFUSALS, SAMPLING AND TESTING NOTES.
70–75					**WELL GRADED SAND WITH GRAVEL (SW)** - dark grayish brn to brn (10YR 4/2-4/3), 60% m sand, 15% f sand, 15% f-m gravel, 10% f sand, ang to subang, metamorphic, wet.	Box 14: 70 to 74 ft Box 15: 74 to 78 ft Box 16: 78 to 82 ft
75		CC6	9.5			
75–80					- 10-15% silt	Stop drilling at 80 ft bgs on 10/22/04, continue drilling on 10/23/04
80					- 5-10% silt	
80–85						Box 17: 82 to 86 ft
85		CC7	10	ML	**SANDY SILT WITH GRAVEL (ML)** - greenish gray (GLEY1 5/5GY), 50% silt, 20% vf sand, 10% f sand, 10% m sand, 10% f gravel, sand and gravel ang to subang, metamorphic, silty plastic, silty sticky to not sticky, moist to wet. Abrupt lower boundary (< 2 cm).	Box 18: 86 to 90 ft
85–90				SW	**WELL GRADED SAND WITH GRAVEL (SW)** - brn (7.5YR 4/4), 40% f sand, 20% m sand, 20% c sand, 10% silt, 10% f gravel, sand and gravel ang to subang, metamorphic, moist, distinct layers of 15-20% silt < 2 cm thick.	
90				SM	**SILTY SAND WITH GRAVEL (SM)** - brn (10YR 5/3-4/3), 35% f sand, 20% silt, 15% f gravel 0.2" to 1", 10% vf sand, 10% m sand, 10% c sand, sand and gravel dominantly ang to subang, v few subrnd, metamorphic and v few conglomerate, moist.	Box 19: 90 to 94 ft Collect grain size sample at 93 ft, ID: MW-41D-93 Box 20: 94 to 98 ft
95		CC8	10		- silt caliche	
95–100				SW-SM	**SAND WITH SILT AND GRAVEL (SW-SM)** - brn (7.5YR 4/3), 30% m sand, 20% f sand, 20% c sand, 20% f-m gravel, 10% silt, sand and gravel ang to subang, metamorphic, moist to wet, silt caliche.	Box 21: 98 to 102 ft Drilled 100 to 110 ft but dropped core during retrieval and recovered on next run
100–105		CC9	5		- 15% silt, 5% f-m gravel	Box 22: 102 to 106 ft
105						

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SHEET 4 of 10	**PROJECT NUMBER:** 326128.01.07.AR	**BORING NUMBER:** MW-41

SOIL BORING LOG

PROJECT NAME: IM-3 Hydrogeologic Investigation, PG&E Topock		**HOLE DEPTH (ft):** 320.0	**DRILLING CONTRACTOR:** WDC Exploration & Wells, Montclair, CA
SURFACE ELEVATION: 476.9 ft. MSL	**NORTHING (CCS NAD 27 Z 5):** 2,103,536.66	**EASTING (CCS NAD 27 Z 5):** 7,614,578.85	**DATE STARTED:** 10/22/2004 / **DATE COMPLETED:** 11/05/2004
DRILLING METHOD: Rotosonic		**WATER LEVEL (ft):** ---	**DRILLING EQUIPMENT:** Gefco SS-15K-HL
LOCATION: Bat Cave Wash, Parcel No. 650-151-06			**LOGGED BY:** T. McDonald

DEPTH BGS (feet)	SAMPLE INTERVAL	SAMPLE TYPE/NUMBER	SAMPLE RECOVERY (ft)	USCS CODE	SOIL DESCRIPTION: SOIL NAME, USCS SYMBOL, COLOR, PERCENT COMPOSITION, GRADING, GRAIN SHAPE, MINERALOGY, DENSITY/CONSISTENCY, STRUCTURE, MOISTURE.	COMMENTS: DRILLING OBSERVATIONS AND OPERATIONS, DAILY START AND END TIMES , DRILL RATE, REFUSALS, SAMPLING AND TESTING NOTES.
				SW	**WELL GRADED SAND WITH GRAVEL (SW)** - brn (7.5YR 4/4), 30% m sand, 30% c sand, 20% f sand, 15% f-m gravel, 5% silt, sand and gravel ang to subang, metamorphic, moist. Moderate caliche development, silty cemented throughout. Distinct 1/8" silt layers are dark gray (5Y4/1), 90% silt, 10% vf sand.	Box 23: 106 to 110 ft
				SW	**WELL GRADED SAND (SW)** - brn (10YR 4/3), 30% f sand, 30% m sand, 15% silt, 15% c sand, 10% f gravel, ang to subang, metamorphic, wet.	
110		CC10	14	SW	**WELL GRADED SAND WITH GRAVEL (SW)** - brn (10YR 4/3 at top, 7.5YR 4/3 at bottom), 30% m sand, 30% c sand, 25% f-c gravel, 10% f sand, 5% silt, sand ang to subang and fining downwards, gravel ang to subrnd, metamorphic, wet.	Box 24: 110 to 114 ft
115						Box 25: 114 to 118 ft
					- 20% silt	Box 26: 118 to 122 ft
120		CC11	10	MH	**SILT WITH GRAVEL (MH)** - dark brn (2.5Y 4/3 or 4/4), 65% silt, 30% f-m ang to subang gravel up to 2.75", 5% clay, 5% c sand, metamorphic, med-high elasticity, sticky, plastic, dry, caliche on gravels, abrupt lower boundary.	Box 27: 122 to 126 ft Collect grain size sample at 122 to 124 ft, ID: MW-14D-123
125					- interbedded sand with gravels, brn (7.5YR 4/3), 30% c sand, 20% f gravel, 20% m sand, 20% f gravel, 10% silt, well graded	Box 28: 126 to 130 ft
130		CC12	10	SW	**SILTY SAND (SW)** - dark greenish gray (Y2 4/10G), 30% vf sand, 30% f sand, 20% silt, 10% m-c sand, 10% ang to subang gravel, metamorphic, moist. Moderate caliche development. Mottled brn (7.5YR 4/4) over 10% of surface, mottling increases to 50% of surface at bottom 3".	Box 29: 130 to 134 ft
					- 80% silt, 10% f sand, 10% c sand	Box 30: 134 to 138 ft
135					**WELL GRADED SAND WITH GRAVEL (SW)** - 40% m sand, 25% f-c gravel (1/5" to 1"), 20% c sand, 10% f sand, 5% silt, ang to subang, metamorphic, wet.	Collect grain size sample at 136.5 to 137.5 ft, ID: MW-14D-137 Box 31: 138 to 142 ft
					- 10% silt, slit horizontal fabric in gravels	Collect groundwater sample at 139 ft
140						

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SHEET 5 of 10	**PROJECT NUMBER:** 326128.01.07.AR	**BORING NUMBER:** MW-41

SOIL BORING LOG

PROJECT NAME: IM-3 Hydrogeologic Investigation, PG&E Topock		**HOLE DEPTH (ft):** 320.0	**DRILLING CONTRACTOR:** WDC Exploration & Wells, Montclair, CA	
SURFACE ELEVATION: 476.9 ft. MSL	**NORTHING (CCS NAD 27 Z 5):** 2,103,536.66	**EASTING (CCS NAD 27 Z 5):** 7,614,578.85	**DATE STARTED:** 10/22/2004	**DATE COMPLETED:** 11/05/2004
DRILLING METHOD: Rotosonic		**WATER LEVEL (ft):** ---	**DRILLING EQUIPMENT:** Gefco SS-15K-HL	
LOCATION: Bat Cave Wash, Parcel No. 650-151-06			**LOGGED BY:** T. McDonald	

DEPTH BGS (feet)	SAMPLE INTERVAL	SAMPLE TYPE/ NUMBER	SAMPLE RECOVERY (ft)	USCS CODE	SOIL DESCRIPTION: SOIL NAME, USCS SYMBOL, COLOR, PERCENT COMPOSITION, GRADING, GRAIN SHAPE, MINERALOGY, DENSITY/CONSISTENCY, STRUCTURE, MOISTURE.	COMMENTS: DRILLING OBSERVATIONS AND OPERATIONS, DAILY START AND END TIMES, DRILL RATE, REFUSALS, SAMPLING AND TESTING NOTES.
					WELL GRADED SAND WITH GRAVEL (SW) - 40% m sand, 25% f-c gravel (1/5" to 1"), 20% c sand, 10% f sand, 5% silt, ang to subang, metamorphic, wet.	bgs, ID: MW-41D-139 Appears to be reworked due to drilling
					- dark grayish brn (10YR 4/2), 40% f sand, 20% f-c gravel 1/5" up to 3", 10% m sand, 5-10% silt, moist. Mottling in blocks of brn (7.5YR 4/3)	Box 32: 142 to 146 ft
145						
					- 35% m sand, 25% c sand, 25% f sand, 15% gravel, 5-10% silt, well graded, caliche development throughout and increased cementation with depth	Box 33: 146 to 150 ft
150		CC13	15	SW		Box 34: 150 to 154 ft
155						Box 35: 154 to 158 ft
						Reworking at 140 to 176 indicated by lack of fabric, no silt layers around gravels, color, and blocks of mottled brown
160					- brn (10YR 4/3 to 7.5YR 4/3), 5% silt, 10% f sand, 40% m sand, 35% c sand, 10% f gravel, well graded, sand and gravel ang to subang - metamorphic. Gravels less than 2 cm	
165		CC14	10			
					WELL GRADED SAND WITH SILT (SW-SM) - brn (7.5YR 4/2 to 4/3), 35% m sand, 30% f sand, 15% c sand, 10-15% silt, 5-10% f-c gravel (0.2" avg, up to 2"), ang to subang with v few subang gravel, moist to wet.	
170						
				SW-SM		Collect grain size sample at 172.5 to 173.5 ft, ID: MW-41D-173
175						

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PROJECT NUMBER: 326128.01.07.AR

BORING NUMBER: MW-41

SOIL BORING LOG

PROJECT NAME: IM-3 Hydrogeologic Investigation, PG&E Topock		**HOLE DEPTH (ft):** 320.0	**DRILLING CONTRACTOR:** WDC Exploration & Wells, Montclair, CA	
SURFACE ELEVATION: 476.9 ft. MSL	**NORTHING (CCS NAD 27 Z 5):** 2,103,536.66	**EASTING (CCS NAD 27 Z 5):** 7,614,578.85	**DATE STARTED:** 10/22/2004	**DATE COMPLETED:** 11/05/2004
DRILLING METHOD: Rotosonic		**WATER LEVEL (ft):** ---	**DRILLING EQUIPMENT:** Gefco SS-15K-HL	
LOCATION: Bat Cave Wash, Parcel No. 650-151-06			**LOGGED BY:** T. McDonald	

DEPTH BGS (feet)	SAMPLE INTERVAL	SAMPLE TYPE/NUMBER	SAMPLE RECOVERY (ft)	USCS CODE	SOIL DESCRIPTION: SOIL NAME, USCS SYMBOL, COLOR, PERCENT COMPOSITION, GRADING, GRAIN SHAPE, MINERALOGY, DENSITY/CONSISTENCY, STRUCTURE, MOISTURE.	COMMENTS: DRILLING OBSERVATIONS AND OPERATIONS, DAILY START AND END TIMES , DRILL RATE, REFUSALS, SAMPLING AND TESTING NOTES.
		CC15	10		**WELL GRADED SAND WITH SILT (SW-SM)** - brn (7.5YR 4/2 to 4/3), 35% m sand, 30% f sand, 15% c sand, 10-15% silt, 5-10% f-c gravel (0.2" avg, up to 2"), ang to subang with v few subang gravel, moist to wet. - < 5% red mottling (2.5YR 4/6), < 5% silt, 20% f sand, 50% m sand, 20% c sand, 5% gravel	
180				SW	**WELL GRADED SAND WITH GRAVEL (SW)** - brn (10YR 5/3), 50% m sand, 20% c sand, 20% f sand, 5% silt, 5% gravel avg 0.5", ang to subang, metamorphic, wet.	
				SP	**POORLY GRADED SAND (SP)** - grayish brn (10YR 5/2), 85% m sand, 10% f sand, < 5% silt, ang to subang, metamorphic, wet.	
185				SW	**WELL GRADED SAND WITH GRAVEL (SW)** - brn (10YR 5/3), 50% m sand, 20% f sand, 20% c sand, 5% silt, 5% gravel avg 0.5", ang to subang, metamorphic, wet.	
190		CC16	18	SM	**SILTY SAND WITH GRAVEL (SM)** - brn (7.5YR 4/3) with 15% dark greenish gray (GLEY1 4/10Y) and 10% red (10R 4/6) mottling, 25% m sand, 25% c sand, 20% silt, 15% f sand, 15% gravel 0.5" - 2.5", ang to subang with v few subrnd, metamorphic. Silty caliche development, faint fabric with aligned gravels.	
195						
200				SW-SM	**WELL GRADED SAND WITH SILT AND GRAVEL (SW-SM)** - brn (7.5YR 4/3) with 10% dark greenish gray (GLEY1 4/10Y) mottling, 30% m sand, 25% c sand, 20% f sand, 15% gravel from 0.5" - 2.5", 10% silt, sand and gravel ang to subang, metamorphic, silt caliche development, abrupt lower boundary.	
205						
210						

CH2MHILL

SHEET 7 of 10	**PROJECT NUMBER:** 326128.01.07.AR	**BORING NUMBER:** MW-41

SOIL BORING LOG

PROJECT NAME: IM-3 Hydrogeologic Investigation, PG&E Topock		**HOLE DEPTH (ft):** 320.0	**DRILLING CONTRACTOR:** WDC Exploration & Wells, Montclair, CA	
SURFACE ELEVATION: 476.9 ft. MSL	**NORTHING (CCS NAD 27 Z 5):** 2,103,536.66	**EASTING (CCS NAD 27 Z 5):** 7,614,578.85	**DATE STARTED:** 10/22/2004	**DATE COMPLETED:** 11/05/2004
DRILLING METHOD: Rotosonic		**WATER LEVEL (ft):** ---	**DRILLING EQUIPMENT:** Gefco SS-15K-HL	
LOCATION: Bat Cave Wash, Parcel No. 650-151-06			**LOGGED BY:** T. McDonald	

DEPTH BGS (feet)	SAMPLE INTERVAL	SAMPLE TYPE/ NUMBER	SAMPLE RECOVERY (ft)	USCS CODE	SOIL DESCRIPTION: SOIL NAME, USCS SYMBOL, COLOR, PERCENT COMPOSITION, GRADING, GRAIN SHAPE, MINERALOGY, DENSITY/CONSISTENCY, STRUCTURE, MOISTURE.	COMMENTS: DRILLING OBSERVATIONS AND OPERATIONS, DAILY START AND END TIMES , DRILL RATE, REFUSALS, SAMPLING AND TESTING NOTES.
		CC17	18	GW-GM	**WELL GRADED GRAVEL WITH SILT AND SAND (GW-GM)** - brn (7.5YR 4/2), 50% gravel up to 2" , 20% m sand, 20% c sand, 5% silt, 5% f sand, sand and gravel ang to subang, metamorphic.	Appears to be coarsening upward sequence 210 to 213 ft bgs
215				SW-SM	**WELL GRADED SAND WITH SILT AND GRAVEL (SW-SM)** - brn (7.5YR 4/3) with 10% dark greenish gray (GLEY1 4/10Y) mottling, 30% m sand, 25% c sand, 20% f sand, 15% gravel from 0.5" to 2", 10% silt, ang to subang, metamorphic with lt caliche development.	
				SW	**WELL GRADED SAND WITH SILT AND GRAVEL (SW)** - brn (7.5YR 4/3), 40% m sand, 30% f sand, 20% c sand, 5% silt, 5% gravel, sand and gravel ang to subang, metamorphic, wet, moderate to strong caliche development, silt fabric with horizontally aligned gravels and c sand.	
220				SP	**POORLY GRADED SAND (SP)** - dark grayish brn (2.5Y 4/2), 50% m sand, 50% c sand, subang, metamorphic, wet.	Core from 220 to 233 appears to be washed out from drilling process
225					**WELL GRADED SAND (SW)** - brn (7.5YR 5/3), 40% m sand, 30% c sand, 15% f sand, 10% gravel, 5% silt, sand and gravel ang to subang, metamorphic, wet, silt cementation. - 10% silt - reddish brn (5YR 4/3), 45% m sand, 5-10% silt, 10% f sand, 5-10% gravel .5 to 8 cm, moderate caliche development	
230		CC18	17			
235					- 60-70% m sand, 20% c sand, 5% silt, 5% gravel 0.5 - 2 cm - 45% m sand, 30% c sand, 5-10% silt, 10% f sand, 5-10% gravel 0.5 to 8 cm	
240					- 30% m sand, 30% c sand, 10-15% silt, 15% f sand, 10-15% gravel, some caliche, wet	
245						

CH2MHILL

PROJECT NUMBER:	BORING NUMBER:
326128.01.07.AR	MW-41

SOIL BORING LOG

PROJECT NAME: IM-3 Hydrogeologic Investigation, PG&E Topock		HOLE DEPTH (ft): 320.0	DRILLING CONTRACTOR: WDC Exploration & Wells, Montclair, CA	
SURFACE ELEVATION: 476.9 ft. MSL	NORTHING (CCS NAD 27 Z 5): 2,103,536.66	EASTING (CCS NAD 27 Z 5): 7,614,578.85	DATE STARTED: 10/22/2004	DATE COMPLETED: 11/05/2004
DRILLING METHOD: Rotosonic		WATER LEVEL (ft): ---	DRILLING EQUIPMENT: Gefco SS-15K-HL	
LOCATION: Bat Cave Wash, Parcel No. 650-151-06			LOGGED BY: T. McDonald	

DEPTH BGS (feet)	SAMPLE INTERVAL	SAMPLE TYPE/ NUMBER	SAMPLE RECOVERY (ft)	USCS CODE	SOIL DESCRIPTION: SOIL NAME, USCS SYMBOL, COLOR, PERCENT COMPOSITION, GRADING, GRAIN SHAPE, MINERALOGY, DENSITY/CONSISTENCY, STRUCTURE, MOISTURE.	COMMENTS: DRILLING OBSERVATIONS AND OPERATIONS, DAILY START AND END TIMES , DRILL RATE, REFUSALS, SAMPLING AND TESTING NOTES.
		CC19	10		**WELL GRADED SAND (SW)** - brn (7.5YR 5/3), 40% m sand, 30% c sand, 15% f sand, 10% gravel, 5% silt, sand and gravel ang to subang, metamorphic, wet, silt cementation.	
					- reddish brn (5YR 4/4), 5% red (10R 4/8), 5% grayish green (GLEY1 4/5G) mottled, 60-70% m sand, 10-15% silt, 15% f sand, 5% gravel, some caliche, silty consolidated	
250				SW	- 40% f sand, 40% m sand, 10% c sand, 5% silt, 5% f gravel, very few c gravel of 4 to 5 cm, silty indurated, slit fabric with horizontal gravel, strongest at base	
255		CC20	9		- brn (10YR 5/3) matrix, 60% yellowish red (5YR 4/6), 20% v dark greenish gray GLEY2 3/5BG mottling, 30% f sand, 20% vf sand, 20% m sand, 15-20% silt, 5% c sand, 5% c gravel, few thin layers of 25-30% silt, abrupt lower boundary	
					- reddish brn (5YR 4/4), 40% f sand, 35% c sand, 10% m sand, 10% f gravel up to 2 cm, 5% silt, gravel ang to subang, c sand ang to subround, metamorphic, wet, slit clay films on gravels	
260						
265		CC21	9		- red (2.5YR 4/4 to 4/6), 5-10% silt/clay, 30% f sand, 30% c sand, 20% m sand, 15% gravel, increased induration, v few weak clay films around gravels - strong caliche	
					- 2 to 6 cm gravels from 267 to 268 ft bgs	
270					- brn (5YR 4/4), 50% c sand, 25% f gravel up to 0.5", 10% f sand, 10% m sand, 5% clay/silt	
275		CC22	5		- v few spots of dk greenish gray (GLEY2 4/5BG) mottling, 40% f sand, 20% m sand, 20% c sand, 10% silt, 10% f gravel, well graded, silty indurated, moderate caliche, strongest in top 6 inches	
					SILTY SAND WITH GRAVEL (SM) - dark reddish brn (2.5YR 3/3), 30% f sand, 25% silt, 20% c sand, 15% gravel, 10% m sand, subang, little metamorphic, wet, silty indurated, weathered.	
280						

PROJECT NUMBER:	BORING NUMBER:
326128.01.07.AR	MW-41

SOIL BORING LOG

PROJECT NAME: IM-3 Hydrogeologic Investigation, PG&E Topock	**HOLE DEPTH (ft):** 320.0	**DRILLING CONTRACTOR:** WDC Exploration & Wells, Montclair, CA	
SURFACE ELEVATION: 476.9 ft. MSL / **NORTHING (CCS NAD 27 Z 5):** 2,103,536.66	**EASTING (CCS NAD 27 Z 5):** 7,614,578.85	**DATE STARTED:** 10/22/2004	**DATE COMPLETED:** 11/05/2004
DRILLING METHOD: Rotosonic	**WATER LEVEL (ft):** ---	**DRILLING EQUIPMENT:** Gefco SS-15K-HL	
LOCATION: Bat Cave Wash, Parcel No. 650-151-06		**LOGGED BY:** T. McDonald	

DEPTH BGS (feet)	SAMPLE INTERVAL	SAMPLE TYPE/NUMBER	SAMPLE RECOVERY (ft)	USCS CODE	SOIL DESCRIPTION: SOIL NAME, USCS SYMBOL, COLOR, PERCENT COMPOSITION, GRADING, GRAIN SHAPE, MINERALOGY, DENSITY/CONSISTENCY, STRUCTURE, MOISTURE.	COMMENTS: DRILLING OBSERVATIONS AND OPERATIONS, DAILY START AND END TIMES , DRILL RATE, REFUSALS, SAMPLING AND TESTING NOTES.
285	X	CC23	5	SM	**SILTY SAND WITH GRAVEL (SM)** - dark reddish brn (2.5YR 3/3), 30% f sand, 25% silt, 20% c sand, 15% gravel, 10% m sand, subang, little metamorphic, wet, silty indurated, weathered.	
290	X	CC24	15	SW	**WELL GRADED SAND (SW)** - grayish brn (10YR 5/2), 40% m sand, 25% c sand, 15% f sand, 10% fines, 10% gravel to 0.5", sand and gravel ang to subang, some metamorphic, wet, silty indurated, trace caliche.	
295				SM	**SILTY SAND (SM)** - grayish brn (10YR 5/2), 30% m sand, 25% fines, 25% gravel, 20% c sand, 10% f sand, ang to subang, some metamorphic, wet, moderately indurated.	
300				SW	**SAND (SW)** - dark red (2.5YR 3/6) with brn (7.5YR4/3 clay layer, 30% m sand, 25% gravel up to 1.5", 20% c sand, 15% fines, 10% f sand, weathered bedrock, moderately indurated, wet.	Angled bedding plane seen at 301' (photo)
	X	CC25	15	BR	**CONGLOMERATE (BR)** - dark reddish brn (2.5YR 3/3), 30% m sand, 30% c sand, 20% f sand, 10% fines, 10% gravel up to 1.5", ang to subang, dry, strongly indurated.	
305				BR	**CONGLOMERATE (BR)** - reddish brn (2.5YR 4/4), 30% m sand, 30% c sand, 20% f sand, 10% fines, 10% gravel, gravel subrnd, dry.	
310				BR	**CONGLOMERATE (BR)** - reddish brn (2.5YR 4/3), 30% f sand, 20% fines, 20% c sand, 20% subang gravel up to 1", 10% m sand, wet.	
315					**CONGLOMERATE (BR)** - dark reddish brn (2.5YR 3/3), 30% m sand, 30% subang gravel to 1.5", 20% f sand, 10% fines, 10% c sand, dry, silty indurated, weathered.	

PROJECT NUMBER: 326128.01.07.AR

BORING NUMBER: MW-41

SOIL BORING LOG

PROJECT NAME: IM-3 Hydrogeologic Investigation, PG&E Topock		**HOLE DEPTH (ft):** 320.0	**DRILLING CONTRACTOR:** WDC Exploration & Wells, Montclair, CA
SURFACE ELEVATION: 476.9 ft. MSL	**NORTHING (CCS NAD 27 Z 5):** 2,103,536.66	**EASTING (CCS NAD 27 Z 5):** 7,614,578.85	**DATE STARTED:** 10/22/2004 **DATE COMPLETED:** 11/05/2004
DRILLING METHOD: Rotosonic		**WATER LEVEL (ft):** ---	**DRILLING EQUIPMENT:** Gefco SS-15K-HL
LOCATION: Bat Cave Wash, Parcel No. 650-151-06			**LOGGED BY:** T. McDonald

DEPTH BGS (feet)	SAMPLE INTERVAL	SAMPLE TYPE/NUMBER	SAMPLE RECOVERY (ft)	USCS CODE	SOIL DESCRIPTION: SOIL NAME, USCS SYMBOL, COLOR, PERCENT COMPOSITION, GRADING, GRAIN SHAPE, MINERALOGY, DENSITY/CONSISTENCY, STRUCTURE, MOISTURE.	COMMENTS: DRILLING OBSERVATIONS AND OPERATIONS, DAILY START AND END TIMES , DRILL RATE, REFUSALS, SAMPLING AND TESTING NOTES.
320	X	CC26	5	BR	**CONGLOMERATE (BR)** - dark reddish brn (2.5YR 3/3), 30% m sand, 30% subang gravel to 1.5", 20% f sand, 10% fines, 10% c sand, dry, silty indurated, weathered. - silty more indurated, moist	Well Completion: TD = 311.5' bgs; Screen Interval = 271 to 291 ft bgs; Filter Pack = 299 - 261 ft bgs; Stick-up Approx = 2.6 ft; Sump = 291 to 311 bgs

Boring Terminated at 320 ft

ABBREVIATIONS

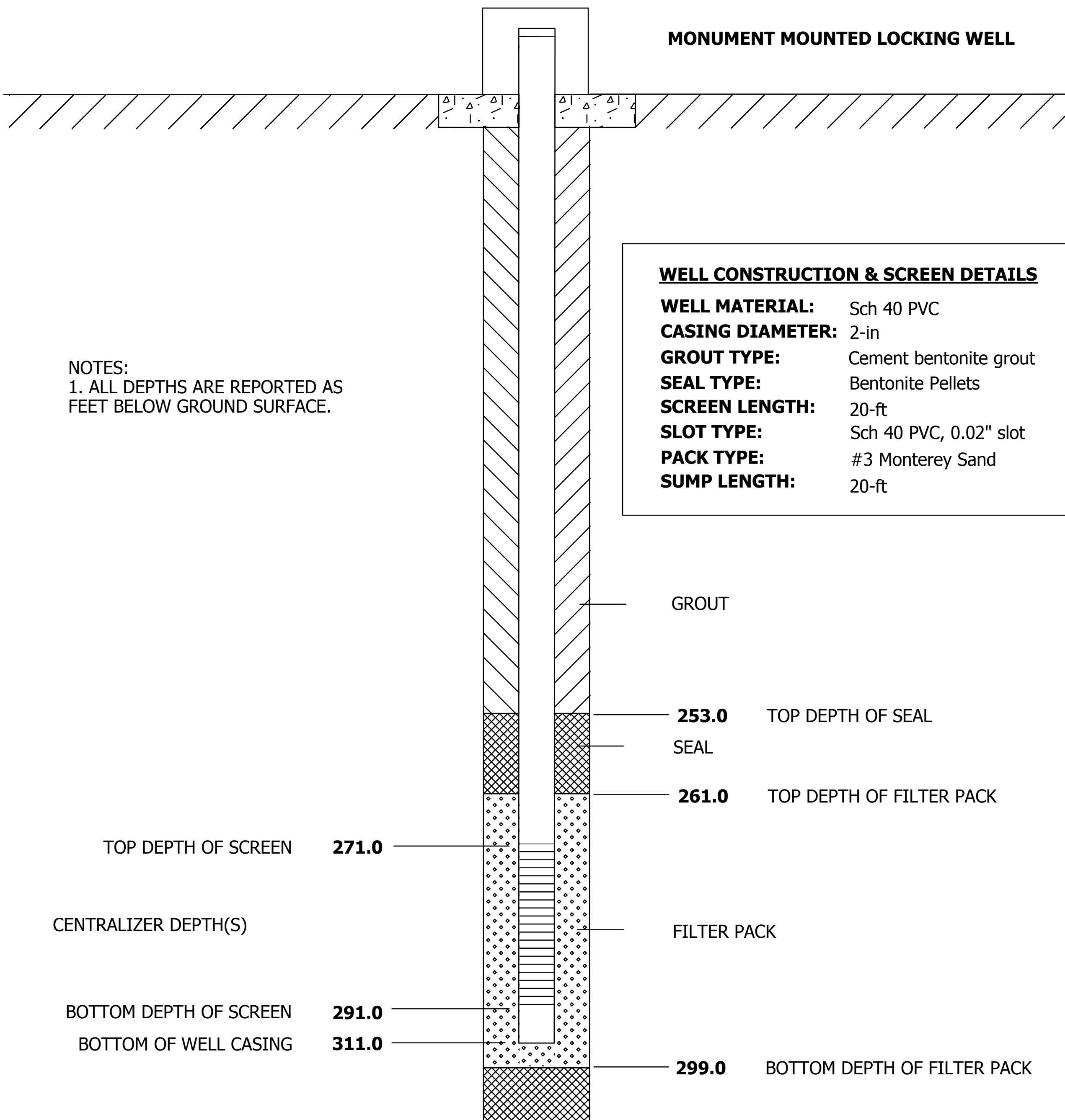
cc = continuous core run
brn = brown
lt = light
dk = dark
vf = very fine-grained
f = fine-grained
m = medium-grained
c = coarse-grained
vc = very coarse-grained
ang = angular
subang = subangular
subrnd = subrounded
rnd = rounded
br = bedrock formation
ss = sandstone
conglom = conglomerate
comptd = compacted
qtz = quartz

WELL COMPLETION DIAGRAM

PROJECT NO: 326128.01.07.AR	**PROJECT:** IM-3 Hydrogeologic Investigation, PG&E Topock	**WELL NO:** **MW-41D**

LOCATION: Bat Cave Wash, Parcel No. 650-151-06

DRILLING CONTRACTOR: WDC Exploration & Wells, Montclair, CA	**DRILLING START DATE:** 10/22/2004
DRILLING METHOD: Rotosonic	**DRILLING END DATE:** 11/05/2004
LOGGER: T. McDonald	**WELL COMPLETION DATE:** 11/05/2004
TOP OF WELL CASING (NGVD 29): 479.42	**NORTHING COORDINATE (CCS DAND 27, ZONE 5):** 2103536.66
GROUND SURFACE ELEVATION (NGVD 29): 476.88	**EASTING COORDINATE (CCS NAD 27 ZONE 5):** 7614578.85



WELL CONSTRUCTION & SCREEN DETAILS

WELL MATERIAL:	Sch 40 PVC
CASING DIAMETER:	2-in
GROUT TYPE:	Cement bentonite grout
SEAL TYPE:	Bentonite Pellets
SCREEN LENGTH:	20-ft
SLOT TYPE:	Sch 40 PVC, 0.02" slot
PACK TYPE:	#3 Monterey Sand
SUMP LENGTH:	20-ft

NOTES:
1. ALL DEPTHS ARE REPORTED AS FEET BELOW GROUND SURFACE.

WELL DIAGRAM IS NOT TO SCALE

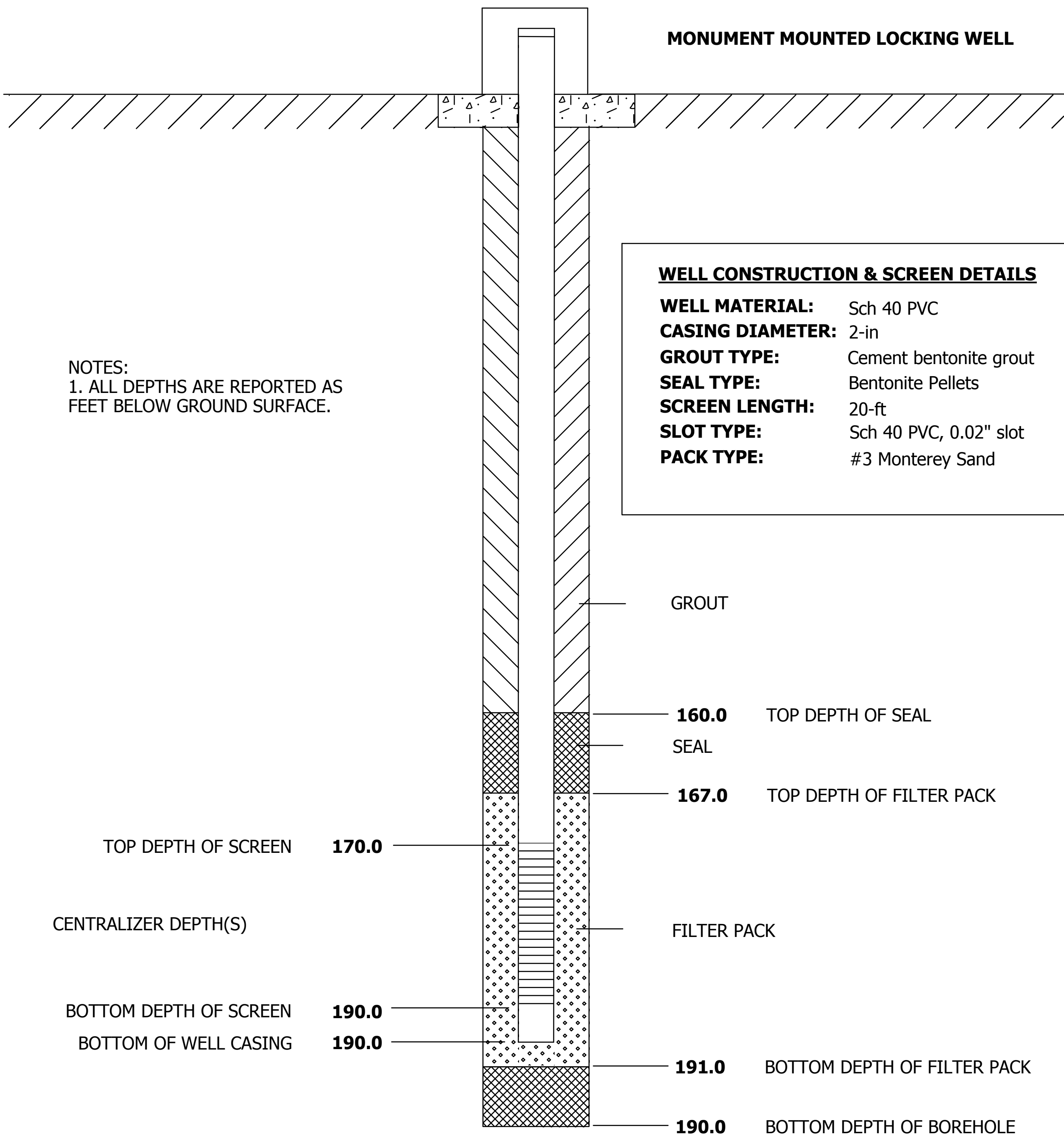
CH2MHILL

WELL COMPLETION DIAGRAM

PROJECT NO: 326128.01.07.AR	**PROJECT:** IM-3 Hydrogeologic Investigation, PG&E Topock	**WELL NO:** **MW-41M**

LOCATION: Bat Cave Wash, Parcel No. 650-151-06

DRILLING CONTRACTOR: WDC Exploration & Wells, Montclair, CA	**DRILLING START DATE:** 11/01/2004
DRILLING METHOD: Rotosonic	**DRILLING END DATE:** 11/01/2004
LOGGER: T. McDonald	**WELL COMPLETION DATE:** 11/07/2004
TOP OF WELL CASING (NGVD 29): 479.84	**NORTHING COORDINATE (CCS DAND 27, ZONE 5):** 2103527.41
GROUND SURFACE ELEVATION (NGVD 29): 477.06	**EASTING COORDINATE (CCS NAD 27 ZONE 5):** 7614583.19



WELL CONSTRUCTION & SCREEN DETAILS

WELL MATERIAL:	Sch 40 PVC
CASING DIAMETER:	2-in
GROUT TYPE:	Cement bentonite grout
SEAL TYPE:	Bentonite Pellets
SCREEN LENGTH:	20-ft
SLOT TYPE:	Sch 40 PVC, 0.02" slot
PACK TYPE:	#3 Monterey Sand

NOTES:
1. ALL DEPTHS ARE REPORTED AS FEET BELOW GROUND SURFACE.

WELL DIAGRAM IS NOT TO SCALE

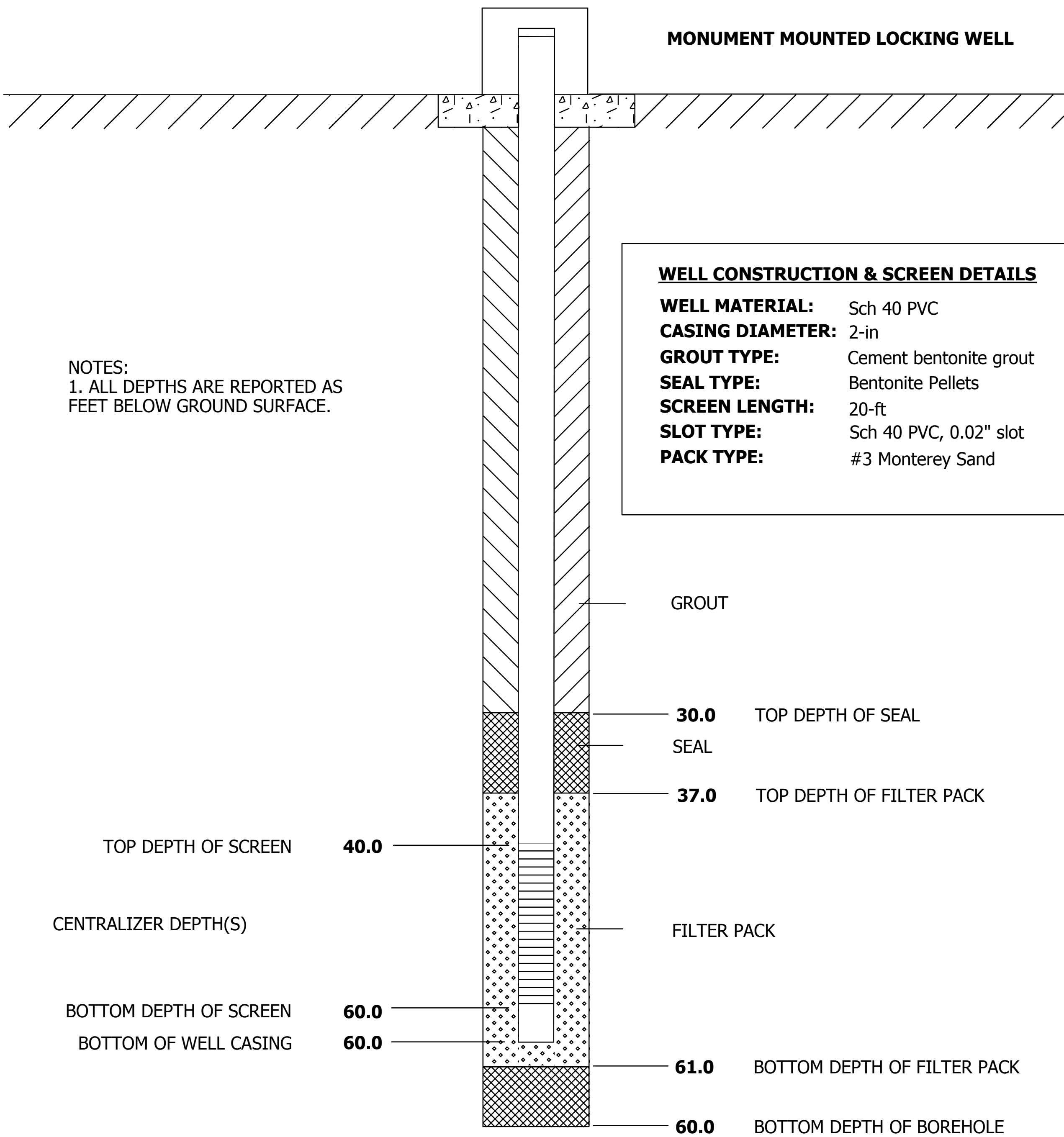
CH2MHILL

WELL COMPLETION DIAGRAM

PROJECT NO: 326128.01.07.AR	**PROJECT:** IM-3 Hydrogeologic Investigation, PG&E Topock	**WELL NO:** **MW-41S**

LOCATION: Bat Cave Wash, Parcel No. 650-151-06

DRILLING CONTRACTOR: WDC Exploration & Wells, Montclair, CA	**DRILLING START DATE:** 11/01/2004
DRILLING METHOD: Rotosonic	**DRILLING END DATE:** 11/01/2004
LOGGER: T. McDonald	**WELL COMPLETION DATE:** 11/08/2004
TOP OF WELL CASING (NGVD 29): 480.07	**NORTHING COORDINATE (CCS DAND 27, ZONE 5):** 2103518.07
GROUND SURFACE ELEVATION (NGVD 29): 477.41	**EASTING COORDINATE (CCS NAD 27 ZONE 5):** 7614588.78



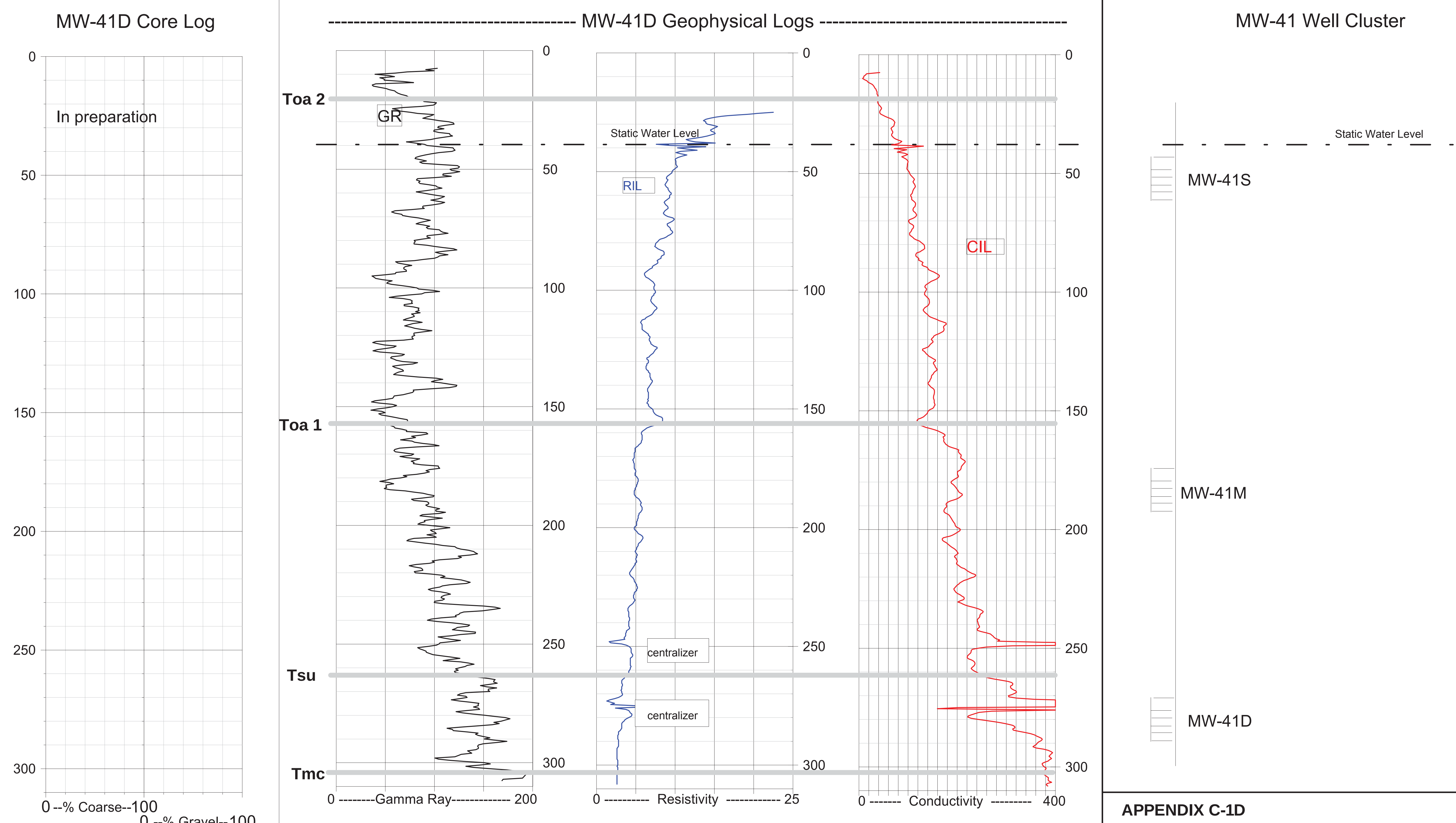
WELL CONSTRUCTION & SCREEN DETAILS

WELL MATERIAL:	Sch 40 PVC
CASING DIAMETER:	2-in
GROUT TYPE:	Cement bentonite grout
SEAL TYPE:	Bentonite Pellets
SCREEN LENGTH:	20-ft
SLOT TYPE:	Sch 40 PVC, 0.02" slot
PACK TYPE:	#3 Monterey Sand

NOTES:
1. ALL DEPTHS ARE REPORTED AS FEET BELOW GROUND SURFACE.

WELL DIAGRAM IS NOT TO SCALE

CH2MHILL



Plots show percentages of coarse sediment (> No. 200 sieve) and gravel-size fragments logged in MW-41D core.

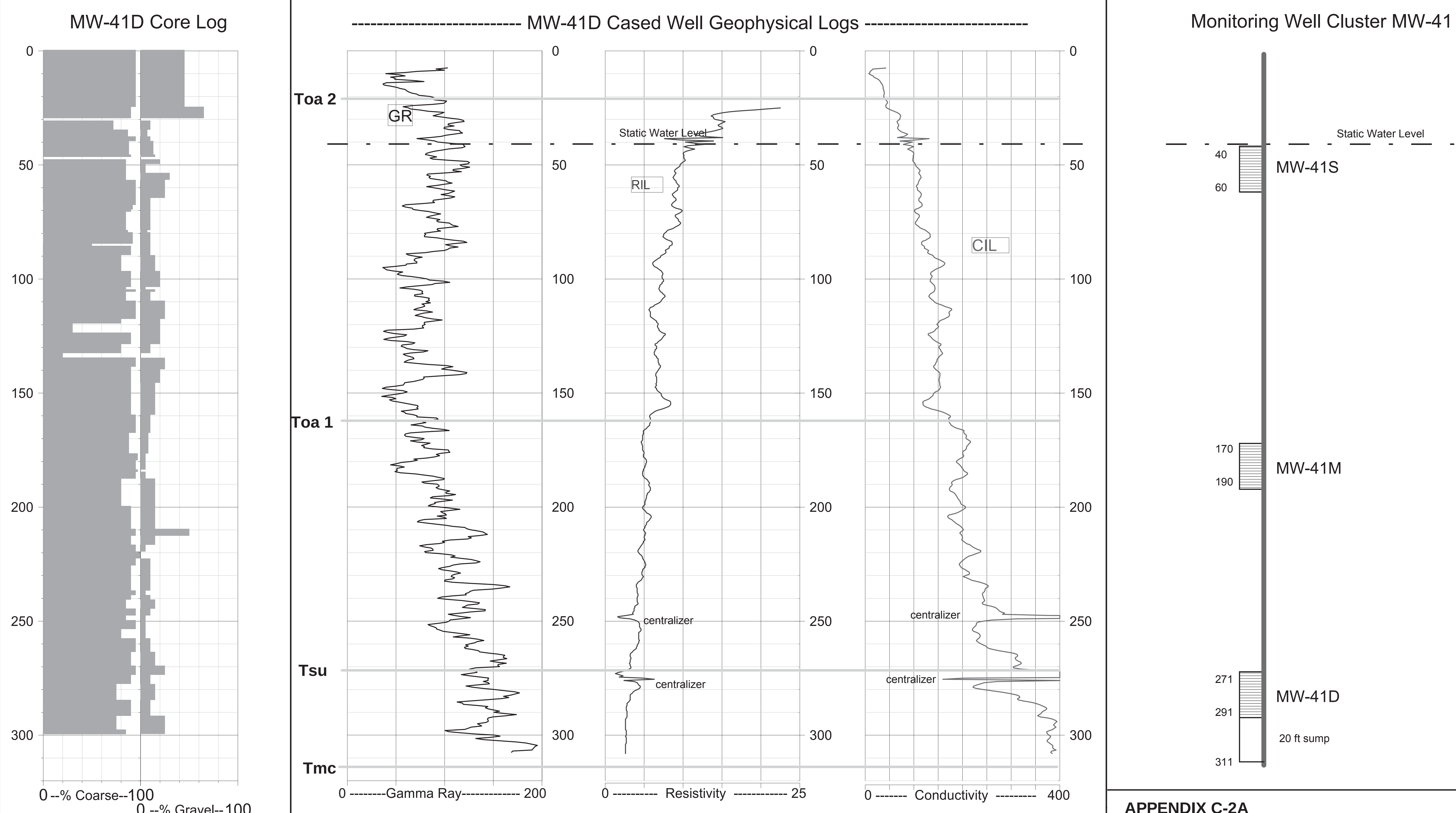
Cased Well Geophysical Log November 5, 2004

Log Units: Gamma Ray (API units), Induction Resistivity (ohm/m), Induction Conductivity (µS/cm)

APPENDIX C-1D
SUMMARY OF HYDROGEOLOGIC LOGGING FOR MW-41 WELL CLUSTER

RCRA FACILITY INVESTIGATION/
REMEDIAL INVESTIGATION REPORT (VOLUME 2)
PG&E TOPOCK COMPRESSOR STATION
NEEDLES, CALIFORNIA

CH2MHILL



Plots show percentages of coarse sediment (> No. 200 sieve) and gravel-size fragments logged in MW-41D core.

Cased Well Geophysical Log November 5, 2004

Log Units: Gamma Ray (API units), Induction Resistivity (ohm/m), Induction Conductivity (µS/cm)

APPENDIX C-2A
SUMMARY OF HYDROGEOLOGIC LOGGING FOR MW-41 WELL CLUSTER

RCRA FACILITY INVESTIGATION/
REMEDIAL INVESTIGATION REPORT (VOLUME 2)
PG&E TOPOCK COMPRESSOR STATION
NEEDLES, CALIFORNIA

CH2MHILL

ES102007005BAO_Appendix_C_figures.indd_022708_lho

PROJECT NUMBER:	BORING NUMBER:
315024.IM.02	TW-2

SOIL BORING LOG

PROJECT NAME: PG&E Topock IM Investigation (Phase 1 2004)		HOLE DEPTH (ft): 180.0	DRILLING CONTRACTOR: WDC Exploration and Wells, Montclair, CA	
SURFACE ELEVATION: 497.0 ft. MSL	NORTHING (CCS NAD 27 Z 5): 2,102,633.34	EASTING (CCS NAD 27 Z 5): 7,615,861.57	DATE AND TIME STARTED: 03/30/2004	DATE AND TIME COMPLETED: 04/01/2004
DRILLING METHOD: Mud Rotary		WATER LEVEL (ft): ---	DRILLING EQUIPMENT: Speedstar 30K Rig with 94-mm Punch Core	
LOCATION: MW-20 Bench			LOGGED BY: J. Sarabia	

DEPTH BGS (feet)	SAMPLE INTERVAL	SAMPLE TYPE/ NUMBER	SAMPLE RECOVERY (ft)	USCS CODE	SOIL DESCRIPTION: SOIL NAME, USCS SYMBOL, COLOR, PERCENT COMPOSITION, GRADING, GRAIN SHAPE, MINERALOGY, DENSITY/CONSISTENCY, STRUCTURE, MOISTURE.	COMMENTS: DRILLING OBSERVATIONS AND OPERATIONS, DAILY START AND END TIMES, DRILL RATE, REFUSALS, SAMPLING AND TESTING NOTES.
					No core	AM activities: rig-up, set conductor casing to 17' bgs with air rotary. P.M. activities: set up mud circulation system, drill direct 17'-40' bgs. 15:30 begin first core run
5						
10						
15						
20						
25						
30						
35						

CH2MHILL

PROJECT NUMBER:	BORING NUMBER:
315024.IM.02	TW-2

SOIL BORING LOG

PROJECT NAME: PG&E Topock IM Investigation (Phase 1 2004)		**HOLE DEPTH (ft):** 180.0	**DRILLING CONTRACTOR:** WDC Exploration and Wells, Montclair, CA
SURFACE ELEVATION: 497.0 ft. MSL	**NORTHING (CCS NAD 27 Z 5):** 2,102,633.34	**EASTING (CCS NAD 27 Z 5):** 7,615,861.57	**DATE AND TIME STARTED:** 03/30/2004 / **DATE AND TIME COMPLETED:** 04/01/2004
DRILLING METHOD: Mud Rotary		**WATER LEVEL (ft):** ---	**DRILLING EQUIPMENT:** Speedstar 30K Rig with 94-mm Punch Core
LOCATION: MW-20 Bench			**LOGGED BY:** J. Sarabia

DEPTH BGS (feet)	SAMPLE INTERVAL	SAMPLE TYPE/NUMBER	SAMPLE RECOVERY (ft)	USCS CODE	SOIL DESCRIPTION (SOIL NAME, USCS SYMBOL, COLOR, PERCENT COMPOSITION, GRADING, GRAIN SHAPE, MINERALOGY, DENSITY/CONSISTENCY, STRUCTURE, MOISTURE.)	COMMENTS (DRILLING OBSERVATIONS AND OPERATIONS, DAILY START AND END TIMES , DRILL RATE, REFUSALS, SAMPLING AND TESTING NOTES.)
					No core	
40		CC124	0.75	SW	**WELL GRADED SAND WITH GRAVEL (SW)** - brn 10YR4/3, well graded sand, c silt, f gravel up to 3/4, subang to ang.	
		CC125	0.5	ML	**SILT WITH GRAVEL (ML)** - brn 10YR4/3, sand fraction nearly absent.	very slow coring very slow - rig maxed out
		CC126	3.5	SW	**WELL GRADED SAND WITH GRAVEL (SW)** - brn 10YR4/3, 80% well graded c silt to f gravel, m gravel up to 2, ang.	hard coring
45		CC127	0.5			very hard coring
		CC128	2			
		CC129	0.5	SM	**SILTY SAND WITH GRAVEL (SM)** - brn 10YR4/3, well graded c silt to 0.75 gravel, subang to ang, slight plasticity.	
50		CC130	2.25			
		CC131	0.75		**WELL GRADED SAND WITH GRAVEL (SW)** - brn 10YR4/3, c silt, gravel up to 1, subang to subrnd.	
		CC132	3.5			moderate to hard coring, core is less dense/consolidated-remains intact after extraction from core barrel
55		CC133	0.5			
		CC134	1.5			very hard coring
		CC135	0			very hard coring, obstruction at 57' - will try to drill through with bit drill ahead to try to get through obstruction
		CC136	1.5			attempt to core- no recovery
60					- 1/8 to 1 ang gravel, subrnd cobbles to 2.5	hard coring cannot core, will drill ahead and attempt to core at 62' bgs attempted to core at 62'bgs - too many rocks, will drill to 65' bgs
65						attempted to core at 65'bgs - too many rocks, will drill ahead to 67' bgs and attempt to core attempted to core at 67'bgs - too many rocks, will drill ahead to 70' bgs and attempt to core
70						

CH2MHILL

PROJECT NUMBER:	BORING NUMBER:
315024.IM.02	TW-2

SOIL BORING LOG

PROJECT NAME:	HOLE DEPTH (ft):	DRILLING CONTRACTOR:	
PG&E Topock IM Investigation (Phase 1 2004)	180.0	WDC Exploration and Wells, Montclair, CA	
SURFACE ELEVATION: 497.0 ft. MSL / **NORTHING (CCS NAD 27 Z 5):** 2,102,633.34	**EASTING (CCS NAD 27 Z 5):** 7,615,861.57	**DATE AND TIME STARTED:** 03/30/2004	**DATE AND TIME COMPLETED:** 04/01/2004
DRILLING METHOD: Mud Rotary	**WATER LEVEL (ft):** ---	**DRILLING EQUIPMENT:** Speedstar 30K Rig with 94-mm Punch Core	
LOCATION: MW-20 Bench		**LOGGED BY:** J. Sarabia	

DEPTH BGS (feet)	SAMPLE INTERVAL	SAMPLE TYPE/ NUMBER	SAMPLE RECOVERY (ft)	USCS CODE	SOIL DESCRIPTION: SOIL NAME, USCS SYMBOL, COLOR, PERCENT COMPOSITION, GRADING, GRAIN SHAPE, MINERALOGY, DENSITY/CONSISTENCY, STRUCTURE, MOISTURE.	COMMENTS: DRILLING OBSERVATIONS AND OPERATIONS, DAILY START AND END TIMES , DRILL RATE, REFUSALS, SAMPLING AND TESTING NOTES.
				SW	**WELL GRADED SAND WITH GRAVEL (SW)** - brn 10YR4/3, c silt, gravel up to 1, subang to subrnd.	attempted to core at 70'bgs - refusal, will drill ahead
						rig chatter significant in this zone, becomes progressively harder to drill with depth, and impossible to core (possible basal conglomerate)
75						
80						at ~79.5 bgs, rig chatter subsides (possible lith, contact), will attempt to core at 80'bgs attempted to core at 80' bgs, could not advance the core barrel - will continue to attempt to get core.
85						attempted to core - could not advance core, will drill forward and attempt to core when lithology changes or 90' bgs (which ever comes first)
90					**SILTY SAND WITH GRAVEL (SM)** - brn 10YR4/3, silt.	core barrel cannot be advanced (too many rocks/ cobbles. Will continue to drill direct with tricone bit and attempt to core every 3-5 feet.
95						continued strong rig chatter. Still unable to advance core barrel
100				GM		
105						

CH2MHILL

PROJECT NUMBER:	BORING NUMBER:
315024.IM.02	TW-2

SOIL BORING LOG

PROJECT NAME: PG&E Topock IM Investigation (Phase 1 2004)		HOLE DEPTH (ft): 180.0	DRILLING CONTRACTOR: WDC Exploration and Wells, Montclair, CA	
SURFACE ELEVATION: 497.0 ft. MSL	NORTHING (CCS NAD 27 Z 5): 2,102,633.34	EASTING (CCS NAD 27 Z 5): 7,615,861.57	DATE AND TIME STARTED: 03/30/2004	DATE AND TIME COMPLETED: 04/01/2004
DRILLING METHOD: Mud Rotary		WATER LEVEL (ft): ---	DRILLING EQUIPMENT: Speedstar 30K Rig with 94-mm Punch Core	
LOCATION: MW-20 Bench			LOGGED BY: J. Sarabia	

DEPTH BGS (feet)	SAMPLE INTERVAL	SAMPLE TYPE/NUMBER	SAMPLE RECOVERY (ft)	USCS CODE	SOIL DESCRIPTION SOIL NAME, USCS SYMBOL, COLOR, PERCENT COMPOSITION, GRADING, GRAIN SHAPE, MINERALOGY, DENSITY/CONSISTENCY, STRUCTURE, MOISTURE.	COMMENTS DRILLING OBSERVATIONS AND OPERATIONS, DAILY START AND END TIMES , DRILL RATE, REFUSALS, SAMPLING AND TESTING NOTES.
					SILTY SAND WITH GRAVEL (SM) - brn 10YR4/3, silt.	
110		CC137	2.75		**WELL GRADED SAND WITH GRAVEL (SW)** - reddish brn 2.5YR4/4, well graded c silt, gravel up to 2, subang to ang, massive.	lithology still causing rig chatter, but will attempt core run. partial core recovery; core color implies geologic contact
115		CC138	1.75	SW		poor core recovery, punch coring bit has been chewed up due to cobbles/rocks. Well put on another bit. Very hard coring
120		CC139	1			
		CC140	1.75			hard to very hard coring
		CC141	2			very hard coring
125		CC142	0.5		**SILTY SAND (SM)** - reddish brn 2.5YR4/4, increasing silts and clays, ang gravel clasts, variable mineralogy, massive.	very hard coring
		CC143	4			hard coring - good core recovery and competence (less very large stones/cobbles, more cohesion in lithology)
130		CC144	2.5	SM		alternating moderate to hard coring stones/cobbles stuck on both ends of returned core preventing better recovery
135		CC145	2			moderate to easy coring
		CC146	2			
140						moderate coring difficulty

CH2MHILL

SHEET 5 of 6	**PROJECT NUMBER:** 315024.IM.02	**BORING NUMBER:** TW-2

SOIL BORING LOG

PROJECT NAME: PG&E Topock IM Investigation (Phase 1 2004)		**HOLE DEPTH (ft):** 180.0	**DRILLING CONTRACTOR:** WDC Exploration and Wells, Montclair, CA
SURFACE ELEVATION: 497.0 ft. MSL	**NORTHING (CCS NAD 27 Z 5):** 2,102,633.34	**EASTING (CCS NAD 27 Z 5):** 7,615,861.57	**DATE AND TIME STARTED:** 03/30/2004 — **DATE AND TIME COMPLETED:** 04/01/2004
DRILLING METHOD: Mud Rotary		**WATER LEVEL (ft):** ---	**DRILLING EQUIPMENT:** Speedstar 30K Rig with 94-mm Punch Core
LOCATION: MW-20 Bench			**LOGGED BY:** J. Sarabia

DEPTH BGS (feet)	SAMPLE INTERVAL	SAMPLE TYPE/NUMBER	SAMPLE RECOVERY (ft)	USCS CODE	SOIL DESCRIPTION (SOIL NAME, USCS SYMBOL, COLOR, PERCENT COMPOSITION, GRADING, GRAIN SHAPE, MINERALOGY, DENSITY/CONSISTENCY, STRUCTURE, MOISTURE.)	COMMENTS (DRILLING OBSERVATIONS AND OPERATIONS, DAILY START AND END TIMES , DRILL RATE, REFUSALS, SAMPLING AND TESTING NOTES.)
	X	CC147	3	SC	**CLAYEY GRAVEL WITH SAND (SC)** - dk reddish brn 2.5YR3/4, well graded vf sand to 0.125, 20% gravel up to 2.	
	X	CC148	3			very easy coring
145	X	CC149	3			very hard coring
	X	CC150	2			very hard coring, probable geologic contact at 150' very dense/tough material
150	X	CC151	0.5	SM	**SILTY SAND WITH GRAVEL (SC)** - dk reddish brn 2.5YR3/4, well graded vf sand, 20% gravel 0.125 up to 2.	extremely hard coring
	X	CC152	1.5		- dark red, geologic contact, dense, lithified, stiff, rock-like	extremely hard coring, will drill 2.5'
						drill ahead due to difficult or impossible coring
155	X	CC153	2			extremely hard coring
						extremely hard core refusal
	X	CC154	0.4			drill ahead due to core refusal, will attempt to core again at 162' bgs
160						very slow drill with abundant rig chatter
	X	CC155	0.3			extremely hard core refusal at 6
						drill ahead due to core refusal, will attempt to core again at 167' bgs
165						lots of rig chatter, very slow drilling
	X	CC156	0.5			extremely hard core, refusal at 6
						drill ahead due to core refusal
170						extremely slow drilling, abundant rig chatter, will attempt core run at 172'
	X	CC157	0.25			attempted core run, refusal at 3, will drill ahead
175						

CH2MHILL

SHEET 6 of 6	**PROJECT NUMBER:** 315024.IM.02	**BORING NUMBER:** TW-2

SOIL BORING LOG

PROJECT NAME: PG&E Topock IM Investigation (Phase 1 2004)		**HOLE DEPTH (ft):** 180.0	**DRILLING CONTRACTOR:** WDC Exploration and Wells, Montclair, CA
SURFACE ELEVATION: 497.0 ft. MSL	**NORTHING (CCS NAD 27 Z 5):** 2,102,633.34	**EASTING (CCS NAD 27 Z 5):** 7,615,861.57	**DATE AND TIME STARTED:** 03/30/2004 — **DATE AND TIME COMPLETED:** 04/01/2004
DRILLING METHOD: Mud Rotary		**WATER LEVEL (ft):** ---	**DRILLING EQUIPMENT:** Speedstar 30K Rig with 94-mm Punch Core
LOCATION: MW-20 Bench			**LOGGED BY:** J. Sarabia

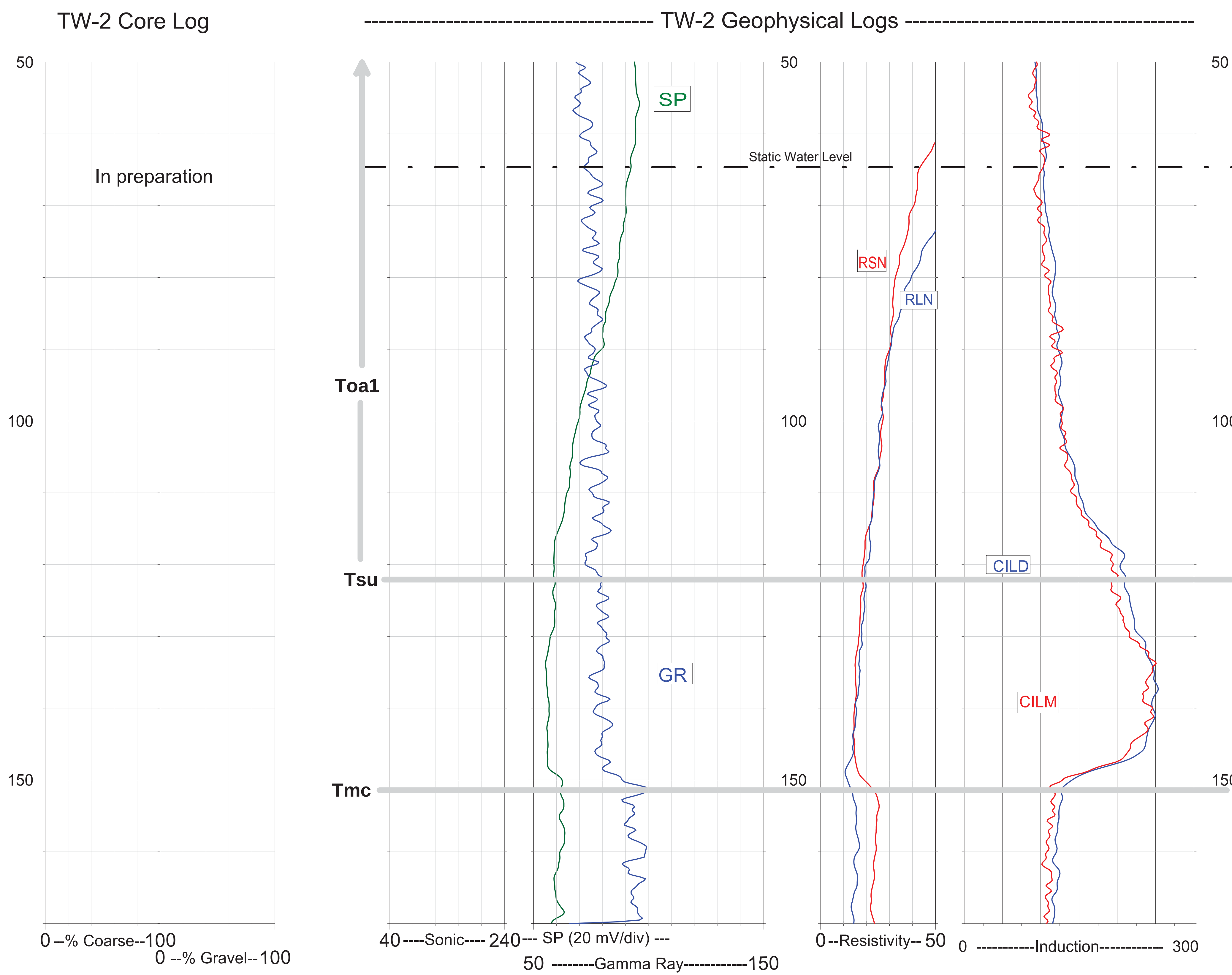
DEPTH BGS (feet)	SAMPLE INTERVAL	SAMPLE TYPE/ NUMBER	SAMPLE RECOVERY (ft)	USCS CODE	SOIL DESCRIPTION: SOIL NAME, USCS SYMBOL, COLOR, PERCENT COMPOSITION, GRADING, GRAIN SHAPE, MINERALOGY, DENSITY/CONSISTENCY, STRUCTURE, MOISTURE.	COMMENTS: DRILLING OBSERVATIONS AND OPERATIONS, DAILY START AND END TIMES , DRILL RATE, REFUSALS, SAMPLING AND TESTING NOTES.
					SILTY SAND WITH GRAVEL (SC) - reddish brn, 2.5YR3/4, well graded vf sand, 20% gravel 0.125 up to 2. [illegible] increasing silts and clays, ang gravel clasts, variable mineralogy, massive.	extremely hard drilling to 180' bgs
180						

Boring Terminated at 180 ft

ABBREVIATIONS

cc = continuous core run
brn = brown
lt = light
dk = dark
vf = very fine-grained
f = fine-grained
m = medium-grained
c = coarse-grained
vc = very coarse-grained
ang = angular
subang = subangular
subrnd = subrounded
rnd = rounded
br = bedrock formation
ss = sandstone
conglom = conglomerate
comptd = compacted
qtz = quartz

CH2MHILL



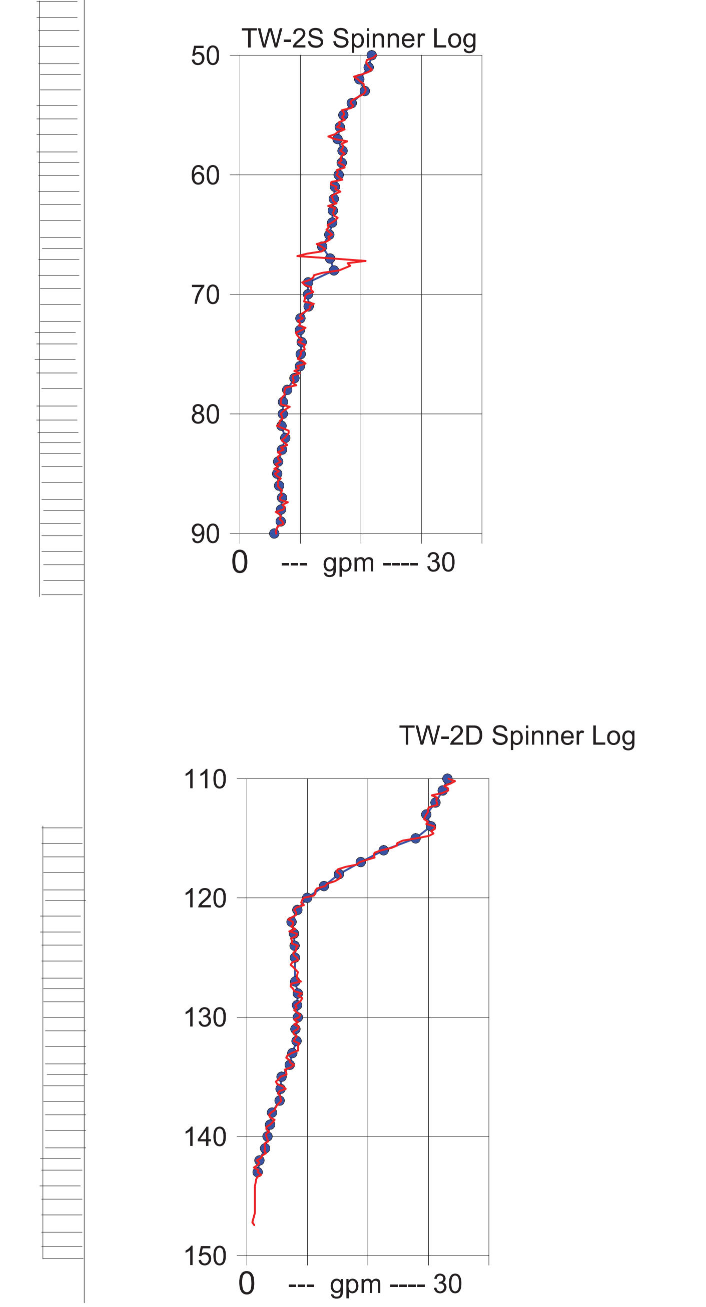
Plot shows percentages of coarse sediment (> No. 200 sieve) and gravel-size fragments logged in OW corehole adjacent to IW location. Core log depths adjusted to match ground surface datum for IW logs.

Cased Well Geophysical Log April 1, 2004

Log Units:
Sonic (μsecs/ft), SP (mV/div.), Gamma Ray (API units), Resistivity (RLN = 64" Normal (ohm/m), RSN = 16" Normal (ohm/m)), Induction (μS/m)

Well TW-2 Production Spinner Log

Log Date: May 10, 2004

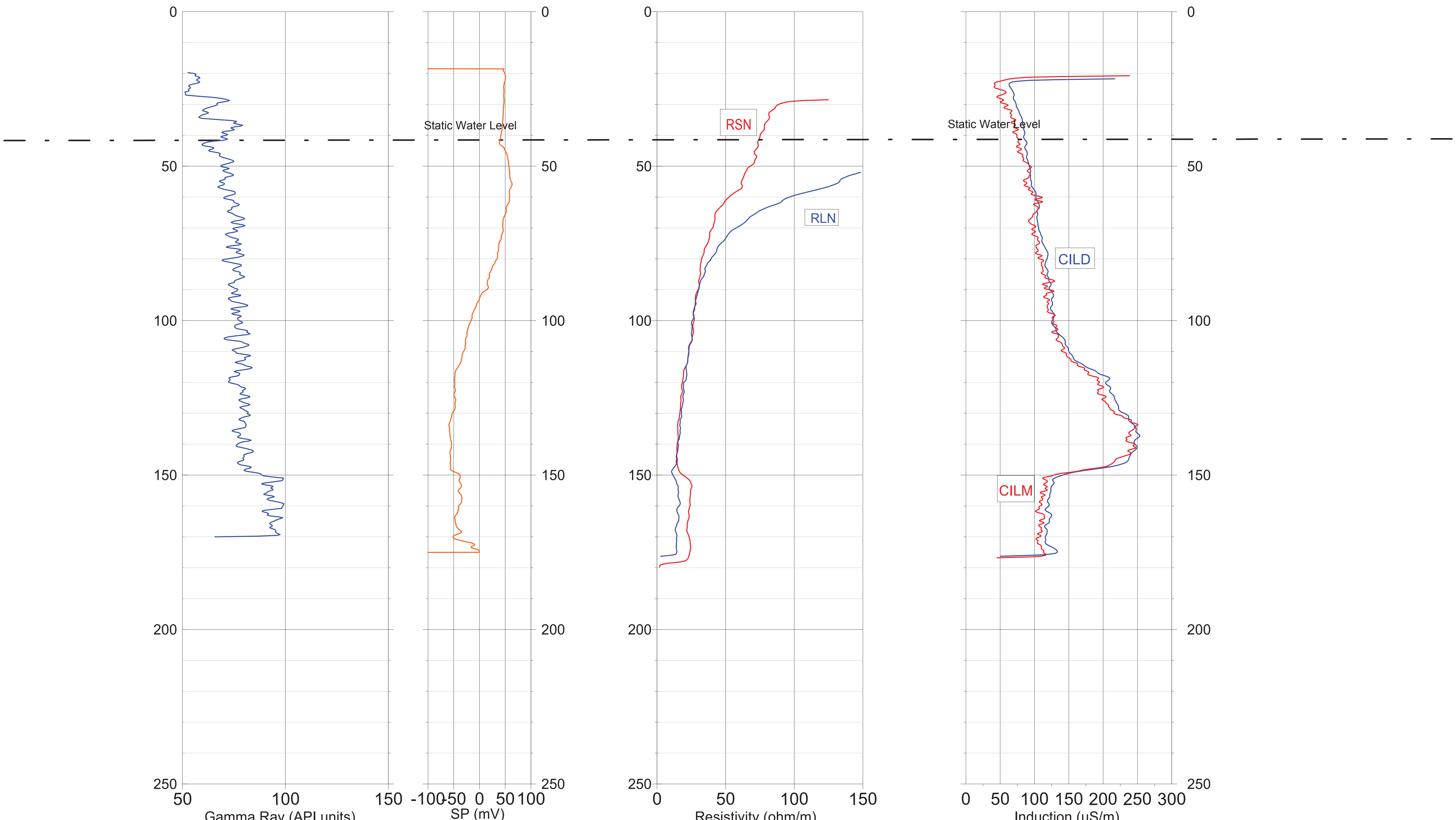


Spinner Logs Represent a combination of data from two Spinner tests. One in TW-2S and one in TW-2D

TW-2S (screen 42-93 ft bgs) pumped at 18 pgm, pump at about 50 feet bgs
TW-2D (screen 113-148 ft bgs) pumped at 33 gpm, pump at about 80 ft bgs

APPENDIX C-1I
SUMMARY OF HYDROGEOLOGIC LOGGING AND TESTING FOR WELL TW-2
RCRA FACILITY INVESTIGATION/
REMEDIAL INVESTIGATION REPORT (VOLUME 2)
PG&E TOPOCK COMPRESSOR STATION
NEEDLES, CALIFORNIA

CH2MHILL



APPENDIX C-1J
TW-2 GEOPHYSICAL LOGS
RCRA FACILITY INVESTIGATION/
REMEDIAL INVESTIGATION REPORT (VOLUME 2)
PG&E TOPOCK COMPRESSOR STATION
NEEDLES, CALIFORNIA

CH2MHILL

PROJECT NUMBER:	BORING NUMBER:
326128.01.19.EW	*TW-3D*

SOIL BORING LOG

PROJECT NAME:		HOLE DEPTH (ft):	DRILLING CONTRACTOR:	
PG&E Topock Interim Measures Extraction Well		157.0	Prosonic Corp., Phoenix, AZ	
SURFACE ELEVATION: 497.0 ft. MSL	**NORTHING (CCS NAD 83):** Approx. 2,102,627.34	**EASTING (CCS NAD 83):** Approx. 7,615,874.57	**DATE STARTED:** 10/20/2005 09:00	**DATE COMPLETED:** 10/24/2005 14:15
DRILLING METHOD: Rotosonic		**DRILLING EQUIPMENT:** Standard Rotosonic Rig		
LOCATION: MW-20 bench, approx. 13 ft. west and 6 ft. south of TW-2D		**LOGGED BY:** J. Piper		

DEPTH BGS (feet)	SAMPLE: INTERVAL	SAMPLE: RECOVERY (ft)	SAMPLE: PID (PPM)	SAMPLE: SOIL SAMPLE	USCS CODE	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY
						- start coring at 9:00 AM 10/20/05
						Note: TW-3D pilot boring (7") diameter) continuously cored using sonic core barrel system. No analytical sampling conducted during drilling.
5					SW	**GRAVELLY SAND WITH SILT (SW)** - dk yellowish brn (10YR4/2 to 5/4), 65% poorly sorted f-m sand, 30% rnd quartz, limestone, and vesicular basaltic gravel up to 15 cm (minor portion reworked? subang mm clasts), 5% silt, moist.
						- dry
10					SP	**POORLY GRADED SAND (SP)** - dk yellowish orange (10YR7/4 to 6/6), 95% well sorted f sand, 5% gravel up to 1 cm, loose, moist
15					SW	**GRAVELLY SAND (SW)** - dk yellowish brn (10YR4/2), 55% sand, 40% rnd qtz, limestone, and jasper gravel up to 4-5 cm, 5% fines
						- 60% sand, no fines (coarsening downwards), rounded chert and limestone clasts up to 12 cm
20						
25					GW	**WELL GRADED SANDY GRAVEL (GW)** - 10YR4/2, 60% rnd (fluvial) gravel up to 15 cm (diverse rock types), 40% sand
30					SW/GW	**GRAVELLY SILTY SAND (SW/GW)** - med brn (5YR4/4), 50% sand, 40% subang mm gravel with weathered rinds, 10% fines, weakly cemented
35						

CH2MHILL

PROJECT NUMBER:	BORING NUMBER:
326128.01.19.EW	*TW-3D*

SOIL BORING LOG

PROJECT NAME: PG&E Topock Interim Measures Extraction Well		HOLE DEPTH (ft): 157.0	DRILLING CONTRACTOR: Prosonic Corp., Phoenix, AZ	
SURFACE ELEVATION: 497.0 ft. MSL	NORTHING (CCS NAD 83): Approx. 2,102,627.34	EASTING (CCS NAD 83): Approx. 7,615,874.57	DATE STARTED: 10/20/2005 09:00	DATE COMPLETED: 10/24/2005 14:15
DRILLING METHOD: Rotosonic		DRILLING EQUIPMENT: Standard Rotosonic Rig		
LOCATION: MW-20 bench, approx. 13 ft. west and 6 ft. south of TW-2D		LOGGED BY: J. Piper		

DEPTH BGS (feet)	SAMPLE: INTERVAL	SAMPLE: RECOVERY (ft)	SAMPLE: PID (PPM)	SAMPLE: SOIL SAMPLE	USCS CODE	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY
					SW/GW	**GRAVELLY SILTY SAND (SW/GW)** - med brn (5YR4/4), 50% sand, 40% subang mm gravel with weathered rinds, 10% fines, weakly cemented
40					SW/SM	**GRAVELLY SILTY SAND (SW/SM)** - med brn (5YR4/4), 45% sand, 40% gravel up to 5 cm, 15% fines, slightly cohesive - weakly cemented, dry to moist
45					SM/GM	**SILTY GRAVEL WITH SAND (SM/GM)** - 45% gravel up to 9 cm, 40% sand, 20% fines
50					SM	- saturated conditions encountered at 47 ft. **GRAVELLY SILTY SAND (SM)** - med brn (5YR4/4), 55% sand, 30% fines, 15% gravel up to 3 cm, slightly plastic
55						- 55% sand, 25% gravel up to 5 cm, 20% fines, coarsening downwards
60					SW	**GRAVELLY SAND (SW)** - 5YR4/4-3/4, 55% poorly sorted sand, 40% subang weathered mm gravel up to 15 cm, 5% fines - increasing sand and less fines, gravel up to 4 cm
65					SM	**GRAVELLY SILTY SAND (SM)** - 45% sand, 30% gravel up to 7 cm, 25% clayey fines
					SW	**SAND WITH GRAVEL AND SILT (SW)** - 60% poorly sorted f-c sand, 25% mm gravel, 15% fines
70					GW	**SANDY GRAVEL (GW)** - 5YR5/2 - 10YR6/2, 70% fluvial (and some reworked? mm) gravel up to 8 cm, 27% sand, 3% fines

PROJECT NUMBER:	BORING NUMBER:
326128.01.19.EW	*TW-3D*

SOIL BORING LOG

PROJECT NAME:		HOLE DEPTH (ft):	DRILLING CONTRACTOR:	
PG&E Topock Interim Measures Extraction Well		157.0	Prosonic Corp., Phoenix, AZ	
SURFACE ELEVATION: 497.0 ft. MSL	**NORTHING (CCS NAD 83):** Approx. 2,102,627.34	**EASTING (CCS NAD 83):** Approx. 7,615,874.57	**DATE STARTED:** 10/20/2005 09:00	**DATE COMPLETED:** 10/24/2005 14:15
DRILLING METHOD: Rotosonic		**DRILLING EQUIPMENT:** Standard Rotosonic Rig		
LOCATION: MW-20 bench, approx. 13 ft. west and 6 ft. south of TW-2D		**LOGGED BY:** J. Piper		

DEPTH BGS (feet)	SAMPLE: INTERVAL	SAMPLE: RECOVERY (ft)	SAMPLE: PID (PPM)	SAMPLE: SOIL SAMPLE	USCS CODE	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY
75					GW	**SANDY GRAVEL (GW)** - 5YR5/2 - 10YR6/2, 70% fluvial (and some reworked? mm) gravel up to 8 cm, 27% sand, 3% fines - 65% ang to subang mm gravel up to 3 cm, 35% sand - 5YR4/4, 65% gravel up to 3 cm, 25% sand, 10% fines - end of drilling on 10/20/05
80					SW	**SAND (SW)** - 60% sand, 30% gravel up to 9 cm, 10% fines, gradational contact (grades finer) - start of drilling at 8:45 10/21/05
85					SM	**GRAVELLY SAND WITH SILT AND CLAY (SM)** - 55% sand, 25% gravel up to 5 cm, 20% fines
					SW	**SAND (SW)** - 55% m-c sand, 25% gravel up to 13 cm, 20% fines (clay increasing with depth), becoming slightly plastic - 50% sand, 35% gravel, 15% fines
90					GW	**SANDY GRAVEL (GW)** - 65% gravel up to 3 cm, 35% sand, 5% fines
95					GM/SM	**SILTY SAND AND GRAVEL (GM/SM)** - 5YR4/4, 40% sand, 40% mm gravel up to 13 cm, 20% fines
					SW	**GRAVELLY SAND (SW)** - 52% well sorted m-c sand, 45% f gravel up to 2 cm, 3% fines - 62% gravel up to 15 cm, 35% sand, 3% fines
100					GW	**GRAVEL WITH SAND (GW)** - 50% sand, 45% gravel up to 4 cm (90% of gravel is subang mm clasts, 10% is reworked? subrnd mm clasts), 5% fines
105						

SHEET 4 of 5	PROJECT NUMBER: 326128.01.19.EW	BORING NUMBER: TW-3D

SOIL BORING LOG

PROJECT NAME: PG&E Topock Interim Measures Extraction Well		HOLE DEPTH (ft): 157.0	DRILLING CONTRACTOR: Prosonic Corp., Phoenix, AZ	
SURFACE ELEVATION: 497.0 ft. MSL	NORTHING (CCS NAD 83): Approx. 2,102,627.34	EASTING (CCS NAD 83): Approx. 7,615,874.57	DATE STARTED: 10/20/2005 09:00	DATE COMPLETED: 10/24/2005 14:15
DRILLING METHOD: Rotosonic		DRILLING EQUIPMENT: Standard Rotosonic Rig		
LOCATION: MW-20 bench, approx. 13 ft. west and 6 ft. south of TW-2D		LOGGED BY: J. Piper		

DEPTH BGS (feet)	SAMPLE: INTERVAL	SAMPLE: RECOVERY (ft)	SAMPLE: PID (PPM)	SAMPLE: SOIL SAMPLE	USCS CODE	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY
					GW	**GRAVEL WITH SAND (GW)** - 50% sand, 45% gravel up to 4 cm (90% of gravel is subang mm clasts, 10% is reworked? subrnd mm clasts), 5% fines - 57% gravel up to 4 cm, 40% sand, 3% fines - 50% sand, 40% gravel, 10% fines
110					SW/SM	**GRAVELLY SILTY SAND (SW/SM)** - 5YR3/4, 55% sand, 25% gravel up to 3 cm, 20% fines
115					SM	**SILTY SAND (SM)** - 65% sand, 25% fines (clayey), 10% gravel, slightly plastic - clayey - clayey
120					SW	**GRAVELLY SAND (SW)** - 60% gravel up to 4 cm, 25% well sorted m-c sand, 15% fines
125						
130					GW	**GRAVEL WITH SAND AND SILT (GW)** - 50% sand, 40% gravel up to 15 cm, 10% fines
					SM	**SILTY SAND (SM)** - 55% sand, 25% gravel (mm cobble), 20% fines
					SW	**SAND WITH GRAVEL AND SILT (SW)** - 5YR4/4, 60% sand, 25% gravel up to 4 cm, 15% silty fines - maximum clast size decreasing
135					SM	**GRAVELLY SILTY SAND (SM)** - 50% sand, 40% gravel up to 3 cm, 10% fines
					SW	**GRAVELLY SAND (SW)** - 45% sand, 40% gravel up to 3 cm, 15% fines
140						

PROJECT NUMBER:	BORING NUMBER:
326128.01.19.EW	***TW-3D***

SOIL BORING LOG

PROJECT NAME:	HOLE DEPTH (ft):	DRILLING CONTRACTOR:	
PG&E Topock Interim Measures Extraction Well	157.0	Prosonic Corp., Phoenix, AZ	

SURFACE ELEVATION:	NORTHING (CCS NAD 83):	EASTING (CCS NAD 83):	DATE STARTED:	DATE COMPLETED:
497.0 ft. MSL	Approx. 2,102,627.34	Approx. 7,615,874.57	10/20/2005 09:00	10/24/2005 14:15

DRILLING METHOD:	DRILLING EQUIPMENT:
Rotosonic	Standard Rotosonic Rig

LOCATION:	LOGGED BY:
MW-20 bench, approx. 13 ft. west and 6 ft. south of TW-2D	J. Piper

DEPTH BGS (feet)	SAMPLE: INTERVAL	SAMPLE: RECOVERY (ft)	SAMPLE: PID (PPM)	SAMPLE: SOIL SAMPLE	USCS CODE	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY
					GW	**SANDY GRAVEL (GW)** - 50% gravel up to 12 cm, 45% sand, 5% fines, grading finer downwards
145					SM	**GRAVEL WITH SAND AND SILT (SM)** - 60% gravel up to 15 cm, 35% sand, 5% fines - becoming stiff - transition to weathered bedrock - stronger white CO3 cemented zones, mm clasts very weathered
150						- 45% sand, 45% gravel up to 12 cm, 10% fines, weathered bedrock with (mm clasts), stiff, competent, moist - drilling becomes harder below 150 ft.
155					BR	**BEDROCK (BR)** - consolidated Miocene conglomerate, 45% gravel up to 15 cm, 40% sand, 15% fines, competent, dry, dark reddish brown - shattered, moist - shattered, dry bedrock - End of boring 16:30 10/21/05 - Enlarged borehole to 10.7" for installing extraction well TW-3D. See TW-3D installation report.

Total Depth = 157 ft bgs

ABBREVIATIONS

brn = brown
lt = light
dk = dark
vf = very fine-grained
f = fine-grained
m = medium-grained
c = coarse-grained
ang = angular
subang = subangular
subrnd = subrounded
rnd = rounded
mm = metamorphic

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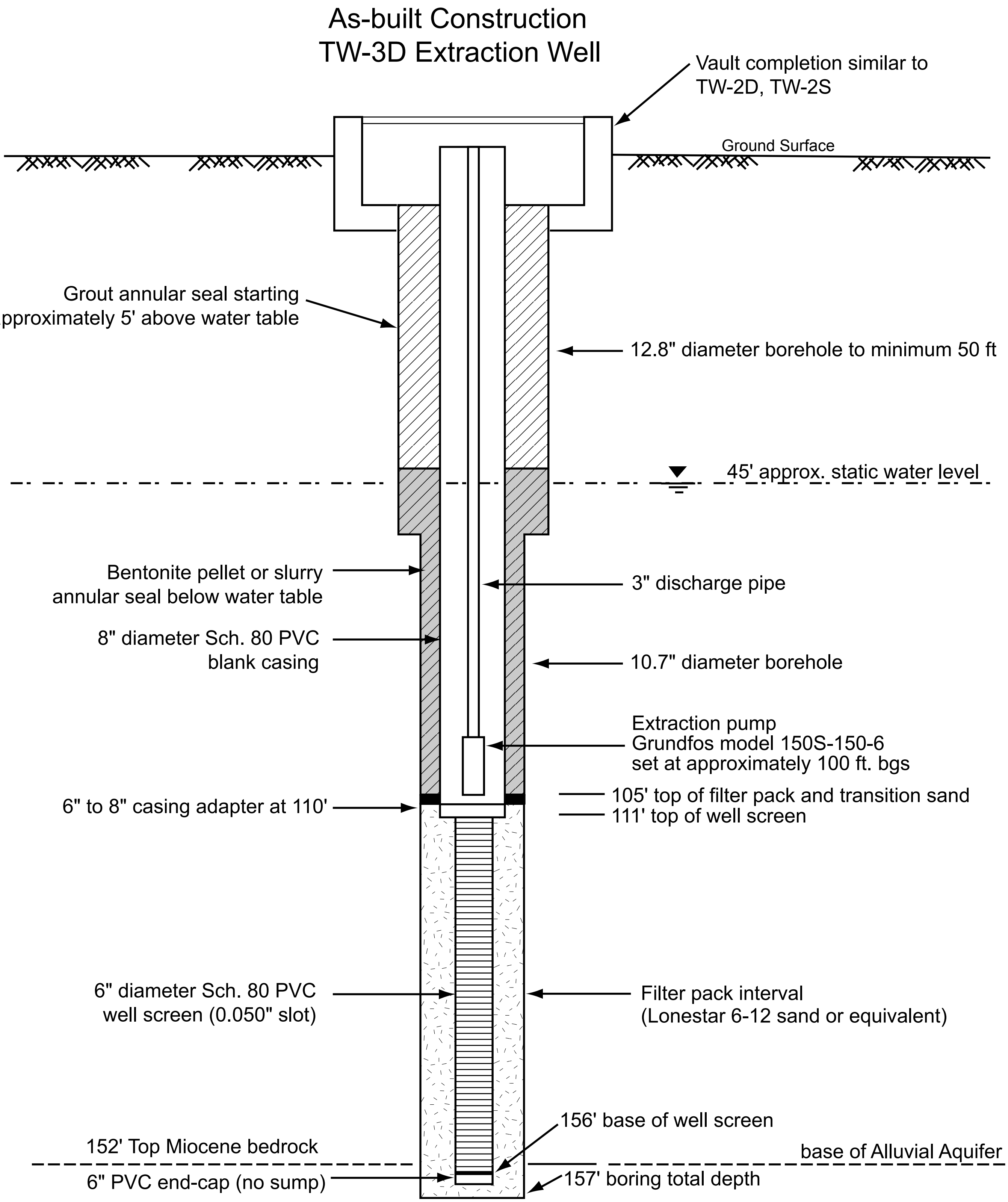

DIAGRAM NOT TO SCALE

Well screen selection reviewed with DTSC 10/21/05

Well TW-3D installed 10/26-27/05

FIGURE 3
WELL CONSTRUCTION DIAGRAM
TW-3D EXTRACTION WELL
IM NO. 3 GROUNDWATER EXTRACTION SYSTEM
PG&E TOPOCK COMPRESSOR STATION

CH2MHILL

LOG OF BORING XMW-9

ALISTO ENGINEERING GROUP
WALNUT CREEK, CALIFORNIA

SEE SITE PLAN

ALISTO PROJECT NO: *10-320-06* DATE DRILLED: *06/25/97*

CLIENT: *Pacific Gas and Electric Company*

LOCATION: *Topock Compressor Station, Needles, CA*

DRILLING METHOD: *Resonant Sonic, Continuous Core*

DRILLING COMPANY: *Boart Longyear* CASING ELEVATION:

LOGGED BY: *Dan Salaices/ Dan Birch* *APPROVED BY: Dan Salaices*

BORING DIAGRAM: GROUT (full depth shown)

DEPTH feet	SOIL CLASS	GEOLOGIC DESCRIPTION
	GP	GRAVEL: pinkish gray, yellowish gray, light medium gray; 4–70 mm, subangular. At 2 feet, sandy GRAVEL: light medium gray; 80% gravel, 4–8 mm; 40% sand, fine to coarse grained. At 3 feet, GRAVEL: pinkish yellow, light medium gray; 80% gravel, 4–70 mm; 40% cobbles, fractured.
	SP	ALLUVIUM/OLDER ALLUVIUM CONTACT AT 4 FEET. gravelly SAND: dark yellowish brown; 70% sand, fine to medium grained; 30% gravel, subangular to angular, various grays and browns.
10	GP/GC	sandy clayey GRAVEL: mottled olive gray to dark yellowish brown; 80–70% gravel, 4–40 mm, subangular to angular; 15–20% sand, fine to coarse grained; 10–25% fines; slightly moist.
20	SP	gravelly SAND: dark yellowish brown; 70% sand, fine grained, minor coarse grained; 30% gravel, light medium gray, subangular, 4–20 mm; occasional fractured cobbles.
30, 40	GP/GC	sandy clayey GRAVEL: mottled light olive gray to dark yellowish brown; 80% gravel, 4–20 mm, subangular, 0–15% cobble fragments; 20–30% sand, fine to coarse grained; 5–15% fines; slightly moist; slight to low plasticity. At 42 feet, 70–85% gravel.
50	GP	sandy GRAVEL: light olive brown; 80% gravel, 4–30 mm, subangular, fractured cobbles; 20% sand, fine grained with minor coarse grained; slightly moist.
	GP/GM	sandy silty GRAVEL: mottled dark yellowish brown to olive gray; 80% gravel, 4–30 mm, subangular and fractured; 10% sand, fine grained; 10% fines, moist.
60	CL	sandy CLAY: moderate brown; 40% sand, very fine; occasional fine gravel; low plasticity; moist.
	GP	Fractured cobbles.
	GM	sandy silty GRAVEL: light olive gray to moderate brown; 80% gravel, 4–50 mm, subangular to fractured; 10% sand, fine grained; 10% fines; moist.
	GP	RED FANGLOMERATE GRAVEL: moderate reddish brown; 80% gravel, 4–50 mm, appears crushed by drill bits, very angular; less than 10% sand/fines; dry. At 89 feet, color change to pale red.

LOG OF BORING XMW-9

BORING DIAGRAM	DEPTH feet	GRAPHIC LOG	SOIL CLASS	GEOLOGIC DESCRIPTION
GROUT			GP	At 73 feet, color change to dark yellowish brown; material is very crushed and powdered; rock fragments are up to 100 mm and olive gray with dark reddish brown mineral coating on fractures.
				CHEMEHUEVI FORMATION: olive gray; very hard; old fracture surfaces with dark reddish brown mineral coating.
	80			Total depth of boring is 77.5 feet.
	90			
	100			
	110			
	120			
	130			
	140			
	150			

Geotechnical Investigation Report, Topock Compressor Station, Water Treatment Plant

(CH2M HILL 2004)

Geotechnical Investigation Report
Topock Compressor Station
Water Treatment Plant

Prepared for

Pacific Gas & Electric Company

September 2004

CH2MHILL

9193 South Jamaica Street
Englewood, Colorado
80112

The following individuals have participated in the preparation and/or have completed quality review of this geotechnical report for the *Geotechnical Investigation Report, Topock Compressor Station Water Treatment Plant.*

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Primary Preparer

Curt Basnett, G.E.
Senior Reviewer

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Exp. 12/31/05
GEOTECHNICAL
STATE OF CALIFORNIA

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Appendixes

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1.0 Introduction

1.1 Project Description

This report describes the results of a geotechnical investigation regarding construction of a new water treatment plant (WTP) for remediating contaminated groundwater at Pacific Gas and Electric Company's (PG&E's) Topock compressor station. The Topock site is located in eastern San Bernardino County, approximately 15 miles to the southeast of Needles, California. Figure 1 shows the Topock site and the location of WTP, while Figure 2 shows a detailed layout of the WTP and soil borings drilled during this investigation. The main purpose of this investigation was to provide site-specific data regarding geotechnical properties for foundation design and excavation in the existing ground, and to develop appropriate geotechnical design recommendations.

The water treatment plant is situated on Metropolitan Water District of Southern California (MWD) property and permission was required from MWD, as well as the Bureau of Land Management (BLM), to conduct the geotechnical investigation.

1.2 Objectives and Scope

The primary objective of CH2M HILL's geotechnical services was to provide appropriate geotechnical information for the foundation design of the water treatment plant. The geotechnical design criteria and recommendations described here were developed based on evaluation of available subsurface information, field exploration, laboratory testing, and engineering analyses.

The scope of work for this study includes the following tasks:

Task 1. Compile and Review Existing Information

This task involved compilation and review of available geologic and geotechnical information in the vicinity of the WTP. The following information was reviewed:

- Area geologic data
- Area monitoring well installation logs

Task 2. Field Exploration

This task included drilling four (4) soil borings within the treatment plant footprint. This task also included planning the field investigation, arranging for a drilling subcontractor, obtaining the necessary utility clearances for the work, and coordinating with the various parties involved.

Task 3. Laboratory Testing

A laboratory testing program was conducted on selected soil samples as required to determine pertinent engineering properties and to aid in soil classification.

Task 4. Engineering Evaluation

Engineering evaluations were carried out to aid in the development of geotechnical design and construction recommendations for the WTP.

Task 5. Geotechnical Report Preparation

This geotechnical report was prepared to document the methods and results of the field and laboratory investigations, and to provide geotechnical design criteria for various project facilities.

1.3 Limitations

This report has been prepared according to generally accepted principles and practices of geotechnical engineering applicable at the time of the work. No other warranty, express or implied, is made. This report is for the exclusive use of PG&E and CH2M HILL for specific application to the Topock water treatment plant project.

The analyses and recommendations contained in this report are based on the results of field exploration, laboratory testing, and engineering evaluation. The soil explorations indicate subsurface conditions only at specific locations and times, and only to the depths penetrated. They do not necessarily reflect strata variations that may exist between or outside such locations. If variations in subsurface conditions from those described are noted during construction, the recommendations in this report must be reevaluated.

If any significant changes in the nature, design, or location of the facilities are planned, the conclusions and recommendations contained in this report should not be considered valid unless the changes are reviewed and the conclusions of this report are modified or verified in writing by CH2M HILL. CH2M HILL is not responsible for any claims, damages, or liability associated with interpretation of subsurface data or reuse of the subsurface data or engineering analyses without the express written authorization of CH2M HILL.

We recommend that CH2M HILL be provided the opportunity to review the project plans and specifications to confirm that the intent of the geotechnical recommendations provided in this report has been appropriately incorporated.

2.0 Technical Data

2.1 Field Exploration

The geotechnical field exploration program conducted at the Topock water treatment plant site included site reconnaissance and drilling soil borings. The reconnaissance was performed to locate onsite utilities and to identify locations of soil borings.

2.1.1 Current Investigation

CH2M HILL conducted a field exploration at the project site on August 13, 2004. Four borings were advanced to depths ranging from 11.5 to 36.5 feet below existing ground surface. Approximate boring locations are shown on Figure 2. Locations were determined by measuring from existing site reference features.

Boring locations were selected to provide site-specific information below the proposed structure. Before drilling began, utility locates were requested so boring locations would avoid underground utility lines.

Kleinfelder, Inc. of Las Vegas, Nevada mobilized a truck-mounted B-61 drill rig to the site. Soil borings were advanced using 6-inch outside diameter hollow stem auger techniques.

Soil samples were obtained in borings by driving 1.4-inch ID split spoon samplers. The 1.4-inch ID sampler was driven by a 140-pound autohammer with a 30-inch drop in accordance with standard penetration test (SPT) procedures described in ASTM Standard D1586. Recovered soil samples obtained with the split spoon samplers were sealed in double plastic bags with locking tops to preserve the natural moisture content. Soil samples were typically obtained at 5-foot intervals throughout each boring. One sample was also obtained using a modified California sampler, but this method was abandoned due to the difficulty in obtaining a full sample in the sample liner.

Bulk samples were also obtained from each boring by taking a grab sample directly from the auger stem.

A CH2M HILL geotechnical engineer supervised drilling and sampling operations, and also logged soil borings and obtained representative soil samples. The soils encountered during drilling were visually classified in the field according to the Unified Soil Classification System (USCS). Table 2-1 provides a summary of the depth of the soil borings. Logs of the soil borings drilled during this study are included in Appendix A. A key sheet explaining terms used on the logs is also included in Appendix A.

All borings were terminated above the groundwater table; therefore, no groundwater levels were recorded. At the completion of drilling, all borings were backfilled with drill cuttings back to ground surface.

Table 2-1
Soil Boring Summary
Topock Water Treatment Plant

Soil Boring	Approximate Ground Surface Elevation (ft msl)	Depth Explored (ft bgs)
B-01	508	36.5
B-02	505	11.5
B-02A	505	15.0
B-03	508	31.5

2.1.2 Previous Investigations

Several monitoring wells have been installed throughout the Topock site to characterize and monitor the groundwater. The new water treatment plant is located north of the compressor station and Interstate 40, and west of Bat Cave Wash (see Figure 1). The closest monitoring well to the WTP site is approximately 400 feet away to the southeast (MW-13). The discussion of existing subsurface information will focus on three wells that have been installed near the WTP site (MW-13, MW-14, and MW-37D). These boring logs are included in Appendix B.

The logs for MW-13 and MW-14 indicate that the area consists of alternating layers of gravelly sand and sandy gravel down to an approximate elevation of 435 feet above mean sea level (msl). The log for MW-37D revealed gravelly sand with clay and sandy clay layers starting at an elevation of approximately 465 feet msl underlying the sandy gravel. The difference in material in this boring can be attributed to the fact that it was located in a wash that transports the finer material from higher elevations.

Groundwater elevations encountered during drilling range from 455 to 459.5 feet msl.

2.2 Laboratory Testing Program

Laboratory tests to determine pertinent geotechnical index and engineering properties on selected soil samples were performed by Kleinfelder, Inc. of Las Vegas, Nevada. Tests were conducted to confirm field classifications and provide additional data needed for geotechnical engineering analyses. Laboratory tests were conducted in accordance with American Society for Testing and Materials (ASTM) standards as follows:

- Moisture Content (ASTM D2216)
- Grain-size Analyses (ASTM D422 and D1140)
- Corrosion Potential (pH, resistivity, sulfates, chlorides)
- R-value (ASTM D2844)
- Solubility (AWWA test methods)

Laboratory test results are presented in Appendix C.

3.0 Interpretation

3.1 Regional and Local Geology

The Topock site is located in the Mojave Desert area southeast of Needles, CA and west of the Colorado River. The surficial soils consist of nonmarine sedimentary rocks and alluvial deposits of the Cenozoic period (California Geologic Survey, 2002). Volcanic rocks may also be present.

Logs from current borings and installation of monitoring wells indicate that the surficial soils consist of silty sands, sandy gravels and gravelly sands at depths of over 50 feet below ground surface. There is also evidence of sandy clay layers.

3.2 Site Conditions

The interpretation of site and subsurface conditions presented here has been developed from the soil borings, laboratory testing, and review of previous investigations.

3.2.1 Surface

The topography of the site is relatively flat with an elevation ranging between 505 and 510 feet above mean sea level (msl). Historic Route 66 runs north of the site. Bat Cave Wash runs east of the site into the Colorado River.

3.2.2 Subsurface

3.2.2.1 Soil Classification

In the preparation of this report, soil has been classified using the USCS per ASTM Standards D2487 and D2488. The relative consistency of the soil, used in the soil description, relies on the standard penetration test (SPT) blow count (N) that was obtained during the subsurface investigation.

3.2.2.2 General

A total of four borings (B-01 to B-03) were drilled across the site ranging in depth from 11.5 to 36.5 feet. Boring B-01 was drilled down to a depth of 36.5 feet near the southeast corner of the WTP footprint. Boring B-02 was located near the northwest corner of the WTP site and hit refusal at 11.5 feet. The drill rig was moved approximately 12 feet west where boring B-02A was drilled and the auger hit refusal at 15 feet. The driller stated that boulders were probably the cause of refusal in both borings. Boring B-03 was drilled at the center of the WTP site down to 31.5 feet. The soils encountered can be grouped into two general categories. These categories are silty sand with gravel, and poorly graded sand with silt and gravel. Not all soil categories are present at each location drilled. Discussions of individual soil categories, including locations encountered, are presented below.

3.2.2.3 Silty Sand with Gravel

The entire site appears to be underlain by a layer of silty sand with gravel ranging from 11.5 to 31.5 feet thick as identified in the borings. The consistency of the material ranged from medium dense to very dense, according to SPT blow counts. The sand was fine to coarse grained and the amount of gravel was estimated to range from 10 to 30 percent of the sample. The percentage of gravel increased with depth and the gravel sizes ranged from 1/8 to 2 inches.

The driller noted the presence of cobbles and boulders. In the deeper holes, there was no sample recovery after 15 feet, most likely due to the presence of cobbles obstructing the sampling tip. Boring B-02 and B-02A probably encountered large boulders at depths of 11.5 and 15 feet, respectively, causing auger refusal.

3.2.2.4 Poorly Graded Sand with Silt and Gravel

A 1.5 feet thick layer of poorly graded sand with silt and gravel was identified below the silty sand with gravel layer in Boring B-03 at a depth of 20 feet. The consistency of the material was very dense containing approximately 40 to 50 percent gravels ranging in size from 1/8 to 1/2 inch.

3.2.3 Engineering Parameters

Current and previous investigations and laboratory test results were used to develop the engineering properties of the subsurface materials. In addition to laboratory tests, SPT blow counts from various test borings were used to estimate equivalent friction angles for granular soils based on established correlations in the literature (Federal Highway Administration [FHWA], 1996).

The generalized soil profiles and material properties used for engineering analyses are presented in Table 3-1.

TABLE 3-1
Generalized Subsurface Soil Profile and Design Strength Parameters
Topock Water Treatment Plant

Geologic Unit	Approx. Elevation of Layer[1] (± feet)	Soil Type	Average Corrected[2] SPT N-Values (blows per foot)	Total Unit Weight [lbs/ft^3]	Friction Angle (degree)
		Boring B-01			
Alluvium	508 – 498	SMg	20	120	32
Alluvium	498 – 493	SMg	>50	120	35
Alluvium	493 – 474	SW-SM	>50	120	35
Alluvium	<474	SMg	>50	120	35
		Boring B-02			
Alluvium	505 – 495	SMg	46	120	32
Alluvium	<495	SMg	>50	120	35

TABLE 3-1
Generalized Subsurface Soil Profile and Design Strength Parameters
Topock Water Treatment Plant

Geologic Unit	Approx. Elevation of Layer[1] (± feet)	Soil Type	Average Corrected[2] SPT N-Values (blows per foot)	Total Unit Weight [lbs/ft^3]	Friction Angle (degree)
		Boring B-02A			
Alluvium	505 – 495	SMg	63	120	32
Alluvium	<495	SMg	>50	120	35
		Boring B-03			
Alluvium	508 – 498	SMg	44	120	32
Alluvium	498 – 488	SMg	>50	120	35
Alluvium	<488	SP-SM	>50	120	35

Notes:
1. Bottom of footing elevation for the proposed slab on grade at the treatment plant is approximately 2 feet below grade.
2. SPT blow counts corrected for overburden and efficiency.
3. Groundwater table was not encountered during current investigation.

3.3 Groundwater

The groundwater table was not encountered during the current investigation. The deepest boring (Boring B-01) was terminated at a depth of 36.5 feet below ground surface, or approximately elevation 471.5 feet msl. There was no surface flow in washes at the time the borings were performed. The groundwater table may fluctuate due to seasonal variation, nearby construction, irrigation, vegetation, and other man-made influences. Groundwater elevations in the monitoring wells nearby ranged from 455 to 459.5 feet msl.

3.4 Liquefaction

The term liquefaction, as used herein, describes a phenomenon in which a cohesionless saturated soil loses strength during an earthquake and acquires a degree of mobility sufficient to permit movements ranging from settlement to lateral spreading. The factors known to influence liquefaction potential include grain size, relative density, groundwater conditions, effective confining pressures, and intensity and duration of ground shaking. Saturated, loose and medium dense, near-surface cohesionless soils exhibit the highest liquefaction potential, while dry, dense cohesionless soils, and cohesive soils exhibit low to negligible liquefaction potential.

Generally, medium dense to very dense, silty sands and poorly graded silty sands underlie the proposed treatment plant site. Blow counts in the dry, silty sands were generally in the range of 20 to greater than 50. Therefore, liquefaction potential of the site soils is estimated to be low, especially where the groundwater is greater than 50 feet bgs.

3.5 Expansion/Collapse

Based on the medium dense to very dense granular material encountered at the project site, expansion and collapse potential is regarded as low.

3.6 Settlement

Primary consolidation settlement occurs when a load is applied to saturated compressible materials, causing an increase in pore water pressure (in excess of the static groundwater conditions) that results in a reduction in volume due to the expulsion of water from the pores of the soil (Fang, 1991). Based on the medium dense to very dense granular material encountered at the project site (above and below the proposed/existing footing elevation), and the relatively deep groundwater table (>45 feet), consolidation settlement is not considered an issue.

Secondary compression settlement is not a result of a reduction in volume due to the expulsion of water from the pores of the soil. It is the result of compression of bonds between individual particles after excess hydrostatic pressure is zero (Fang, 1991). Secondary compression settlement has been determined to be negligible.

3.7 Corrosion Conditions

Two samples collected at the site were tested for minimum soil resistivity, soil pH, water soluble sulfate content, and chloride content. The results of those laboratory tests are presented in Appendix C. Caltrans Bridge Memo to Designers 3-1 (Caltrans, 1998), regarding deep foundations, defines a corrosive environment as being a site where the soil has electrochemical resistivity of less than 1,000 ohm-centimeters (ohm-cm), a sulfate content greater than 2,000 parts per million (ppm), or chloride content of greater than 500 ppm. Comparison between the laboratory test results and the Caltrans corrosion criteria indicates that the onsite soils are considered to be corrosive to concrete structures. The results of the laboratory corrosion testing are summarized in Table 3-1. The Caltrans corrosion criteria should not be applied to piping and other metal structures. A corrosion engineer should review the test results and make recommendations for any metal structures.

Concrete in contact with onsite soil shall be batched using Type V cement in accordance with the 2001 California Building Code (CBC, 2001). Adequate concrete cover over reinforcing steel should be provided in accordance with good construction practices and design standards.

TABLE 3-2
Summary of Laboratory Corrosion Tests
Topock Water Treatment Plant

Boring	Sample Depth (ft)	Soil Type	Minimum Resistivity (ohm-cm)	pH	Sulfate Content (ppm)	Chloride Content (ppm)
B-01	6.5 – 8.0	SM	370	8.63	2,888	1,025
B-02	6.5 – 8.0	SM	725	8.67	3,988	350

3.8 Solubility

Due to the highly corrosive nature of the granular soil at the site, two soil samples were tested for solubility. Solubility refers to the potential for soluble particles to be present (i.e. salts, gypsum) that appear to be sand/gravel, but will dissolve when wet and cause excessive settlement. The results are shown in Table 3-3 and included in Appendix C.

TABLE 3-3
Summary of Solubility Tests
Topock Water Treatment Plant

Boring	Sample Depth (ft)	Soil Type	Solubility (%)
B-01	6.5 – 8.0	SM	0.79
B-03	5.0 – 6.5	SM	0.33

Local practice dictates that solubility results greater than 1.0 % require remedial efforts. Remedial efforts include mixing non-soluble soil with the soluble soil or pre-wetting the soluble soil. The solubility results are low at this site, so it is not expected to be an issue.

3.9 Seismicity

The proposed site is located in a seismically active region. The nearest faults that are considered capable of producing strong ground shaking are the Chemehuevi Graben Fault, Pahrump-Stateline Fault, and the Pisgah-Bullion Fault. The Chemehuevi Graben Fault, approximately 18.8 kilometers from the project site, is the controlling fault at the project site. The Chemehuevi Graben Fault is a normal style fault with a maximum credible earthquake (MCE) moment magnitude (M_w) of 6.0. The fault is classified as Seismic Source Type C, the project site lies in Seismic Zone 3, and the soil profile is classified as type S_D as defined in the California Building Code (CBC, 2001).

There are no Alquist-Priolo Fault-Rupture Hazard Zones in proximity to the project site, and no active faults are known to transect the proposed site. Therefore, the possibility of primary surface rupture or deformation at the site is considered low.

Site-specific probabilistic and deterministic analyses of ground motion were performed for active faults within the region using the computer programs EQFAULT and FRISKSP published by Thomas Blake (1998). The deterministic ground-motion analysis requires information regarding the fault geometry, maximum credible earthquake (MCE) magnitude of the fault, and a regional attenuation equation, which relates the relevant seismic parameters to the magnitude source and the source-site distance. Fault geometry was based on the CGS fault database for the State of California. Using the attenuation curves of Sadigh et al. (see Blake, 1998), probabilistic analyses indicate that a horizontal peak ground acceleration (HPGA) of 0.07g may be used for a 10 percent probability of exceedance in 50 years. Deterministic analyses indicate a peak ground acceleration (PGA) of 0.20g at the project site.

In order to verify the deterministic analysis, the results were compared to the California Seismic Hazard Map (Caltrans, 1996). Using this map, the peak bedrock acceleration at the site was estimated to be 0.20g. Additionally, the attenuation equation by Sadigh (Sadigh et al., 1997), which accounts for fault style and proximity, also estimated a peak bedrock acceleration of 0.20g based on distance to fault and fault MCE data from the Caltrans Seismic Hazard Map.

3.10 Frost Depth

According to a figure in NAVFAC DM 7.01-42 (1986), the depth of extreme frost penetration in the Needles, CA area is approximately 8 to 10 inches. Structures should be founded below this depth to mitigate frost heave potential.

4.0 Discussions and Recommendations

4.1 General

The soils at the Topock water treatment plant site consist primarily of alluvial deposits of silty sand with gravel and some poorly graded sand with silt and gravel. Groundwater was not encountered in any of the borings.

4.2 Water Treatment Plant

4.2.1 Facility Description

The water treatment plant consists of a prefabricated metal building with dimensions of approximately 50 feet by 140 feet built on a 6-inch concrete slab. The slab has a thickened edge that acts as a footing embedded approximately 2 feet below ground surface with a width of 2 feet. Tanks, compressors, and reactors will be installed inside the building and will sit on individual concrete footings also embedded 2 feet below ground surface with widths between 2 and 8.5 feet. There is also one area that will be excavated down to 12 feet bgs to accommodate a drain sump.

The existing ground will be leveled to build the WTP. One side will be cut and the other filled to make a level pad with a net fill of approximately 72 cubic yards. An access road with a ditch will surround the treatment plant facility. Site access will come from historic Route 66 at the north end of the site.

4.2.2 Recommendations

Shallow foundations are recommended for support of the water treatment plant. The depth of foundation support should be down to a minimum of 2 feet bgs.

The slab and footings should be set on a minimum 6-inch thick layer of granular base leveling course. The granular material should consist of well-graded sand and gravel with a maximum particle size of 3 inches and no more than 6 percent passing the No. 200 sieve. The granular material should be placed in 6-inch lifts and compacted to 95 percent of maximum dry density per ASTM D1557.

The native soil under the granular base course should be well compacted down to a depth of 12-inches to a minimum of 95 percent of maximum dry density per ASTM D1557 to provide a firm, unyielding surface. If the native soil under the granular course cannot be compacted to a minimum of 95 percent of maximum dry density per ASTM D1557, it should be removed to a maximum depth of 1 foot and replaced with competent granular backfill compacted in 6-inch lifts.

The foundation design should be based on an evaluation of the allowable bearing capacity, settlement, and sliding coefficient of friction.

4.2.2.1 Bearing Capacity

The allowable bearing capacity was determined, using soil parameters determined based on SPT blow counts and laboratory test results, for the soil at the proposed bottom of footing elevation. Calculations were based on methods proposed by Meyerhoff (1965), Bowles (1977), and Peck et al. (1974). All three methods are based on SPT blow counts in sandy soils, and all take into account an allowable settlement. For the purpose of design, an allowable settlement of 1 inch was used in the calculations. Based on the calculations, it was determined that the subgrade at or near the bottom of the proposed footings will have an allowable bearing capacity of 2,000 psf.

4.2.2.2 Sliding Coefficient of Friction

An ultimate sliding coefficient of friction equal to 0.45 may be used for foundation design. The recommended sliding coefficient of friction was estimated for mass concrete on silty medium to coarse sand through the use of a correlation table given in NAVFAC DM 7.2-63 (1986).

4.2.2.3 Cut and Fill Slopes

Cut slopes in the native soil are recommended to be 2H:1V or flatter. The native soil was classified as medium dense to very dense in the borings. In fill areas, the native soil should be placed in 6-inch lifts and compacted to 95 percent of maximum dry density per ASTM D1557.

Excavation of the overburden can be accomplished using conventional heavy earth-moving equipment. According to the boring logs, boulders and cobbles may be encountered in the excavation for the drain sump. The contractor should be aware of this possibility and be suitably prepared. All excavations should conform to OSHA, state, and local standards. Using OSHA criteria (CCH, 2000), the overburden soil would be classified as Type B.

5.0 Construction Considerations

5.1 Trenching and Temporary Excavations

The design of all temporary excavations (either braced or sloped) and work safety should be the responsibility of the contractor. Temporary excavations should be designed in accordance with the Occupational Safety and Health Administration's (OSHA) most recent revised standard for excavations. Adequate provisions should be made to protect the slopes from raveling and sloughing during construction. The design of the excavation wall support system is the responsibility of the contractor. The contractor should develop their own means and methods, based on experience and availability of materials, for constructing the required elements. Performance of the temporary construction must conform to the requirements stated in the contract documents. The analysis of the stability of the excavation and design of appropriate sheeting or shoring may require the contractor to hire a qualified professional engineer. Existing structures near the excavations shall be monitored during the excavation to detect any movement due to the excavations.

Soil types may mandate different types/styles of bracing or excavation support. However, regardless of soil type, excavation depth and configuration drive the requirement to brace or not to brace.

If groundwater is encountered in an excavation, instability may be created as a result of upward seepage of water into the cut if the water level inside the cut is lowered below the groundwater table. The design of the dewatering systems should consider these factors. It shall be the contractor's responsibility to install an appropriate dewatering system to achieve a proper working base for the subgrade of the excavation.

Temporary excavation bracing should be designed to protect adjacent traffic, utilities, and construction personnel. Suitable factors of safety should be used in the contractor's sheeting and bracing design.

During excavation, all equipment should be stored at a distance from the edge of the excavation equal to at least the depth of the excavation, so as not to produce a surcharge load, which could affect the stability of the slope. Temporary stockpiles of excavated materials should be stored well away from any settlement-sensitive utilities and pipelines.

5.2 Pipeline Design

It is our understanding that PVC or HDPE pipe will be used in the buried pipelines. The performance of the pipe is highly dependent on the support provided by the soils around it. Flexible pipe, such as PVC, normally is designed to transmit the load of the backfill over the pipe to the soil at the sides of the pipe. As the vertical load increases on the pipe, the vertical diameter of the pipe decreases and the horizontal diameter increases due to deformation of the pipe (i.e., the pipe becomes more elliptical). The increase in horizontal diameter is resisted by the soil at the sides of the pipe. The side soil must support the load without the pipe deflecting beyond acceptable limits. Thus, adequate soil support at the sides of the pipe is essential for the structural integrity of the pipe.

Along with depth of fill, unit weight of fill, and compaction of fill, the modulus of soil reaction, E', of the soil surrounding the trench is a parameter in flexible pipe design, because it controls the lateral support provided by the soil and, therefore, the deformation of the pipe. For the soils found along the project, an E' value of 1,000 pounds per square inch (psi) is recommended for pipe design. For the purposes of design, a total unit weight of 120 pounds per cubic foot (pcf) may be used for the fill above the pipeline.

5.2.1 Pipe Zone Backfill

The pipe zone backfill material placed surrounding the pipe from 6 inches below the invert to 1 foot above the top of pipe should be composed of sand, gravel, or crushed rock, that is reasonably well graded from coarse to fine with a maximum particle size of ½-inch, and free from excessive clay, organic material, and other deleterious substances.

Pipe zone backfill should be placed and spread in layers, not to exceed 6 inches loose thickness and compacted to at least 90 percent of the maximum dry density as determined by ASTM D1557, within 2 percent of the optimum moisture content. Compaction of the pipe zone backfill should be increased to 95 percent relative compaction (RC) in areas that are sensitive to surficial settlement. The contractor should be responsible for verifying that the pipe strength is adequate to withstand the weight and energy delivered by a compactor during the pipe backfill operation.

Although unanticipated, areas where weaker soil (e.g., soft clay or loose sand) is encountered during construction of the pipeline should be overexcavated a minimum depth of 1 foot below the proposed trench bottom and replaced with granular fill in 6-inch lifts compacted to 95 percent of the maximum dry density as determined by ASTM D1557.

5.2.2 Trench Backfill

Backfill material around structures and more than 1 foot above the top of the pipe (above the pipe zone backfill) may consist of excavated onsite soil. However, all topsoil, organic material, rubbish, debris, rock, and broken concrete larger than 2 inches in diameter and other unsuitable material should be removed prior to use as backfill. Rocks greater than 6 inches in any dimension should not be permitted in backfill placed within 1 foot of pavement subgrade.

Backfill should be placed and spread in layers, not to exceed 8 inches loose thickness and compacted to at least 90 percent of the maximum dry density as determined by ASTM D1557. Moisture conditions of backfill soils shall be at or above the optimum moisture content. Increased compaction is advised where greater sensitivity to surficial settlements may exist, so long as it does not damage or cause excessive deflections of the pipe.

5.3 Roadways

It is our understanding that the roadway around the WTP will consist of graded aggregate base course. No asphalt or Portland cement concrete pavement will be laid.

5.4 Fill Placement and Compaction

Native on-site materials may be considered for use as backfill if they have an expansion index (EI) less than 50, and contain less than 8 percent fines as determined in accordance with ASTM D4829 and D422, respectively. If native materials are considered, they should be tested for verification. The granular base course material shall be imported. The geotechnical engineer should approve the imported material prior to placement.

All fill soil should be placed in thin, loose lifts; moisture-conditioned, as necessary, to near optimum moisture content; and compacted to a minimum 95 percent relative compaction beneath structures as determined by ASTM D1557.

5.5 Site Drainage

Drainage is an important key to successful performance of any foundation or pavement scheme. Good surface drainage should be established prior to construction and maintained afterward to prevent water from ponding within or adjacent to the structures, or pavement areas. During and after construction, positive drainage should be provided to direct surface water away from structures and all excavations towards suitable, non-erosive drainage devices. Final grading should slope away from structures.

5.6 Geotechnical Observation

A geotechnical engineer or a technician under the supervision of a geotechnical engineer should observe the preparations for footing subgrades and backfill. Variations in soil and geologic conditions are possible and may be encountered during construction. To permit correlation between the exploration data and the actual conditions encountered during construction, a qualified geotechnical engineer should perform onsite reviews during construction.

5.7 Review of Construction Plans and Specifications

The geotechnical recommendations in this report are based on preliminary construction plans. The geotechnical designer should review construction plans and specifications to verify that the geotechnical recommendations have been incorporated into the design. If the nature, design, or location of the proposed facilities vary from those used to develop the recommendations provided in this report, then the recommendations should be re-evaluated.

6.0 References

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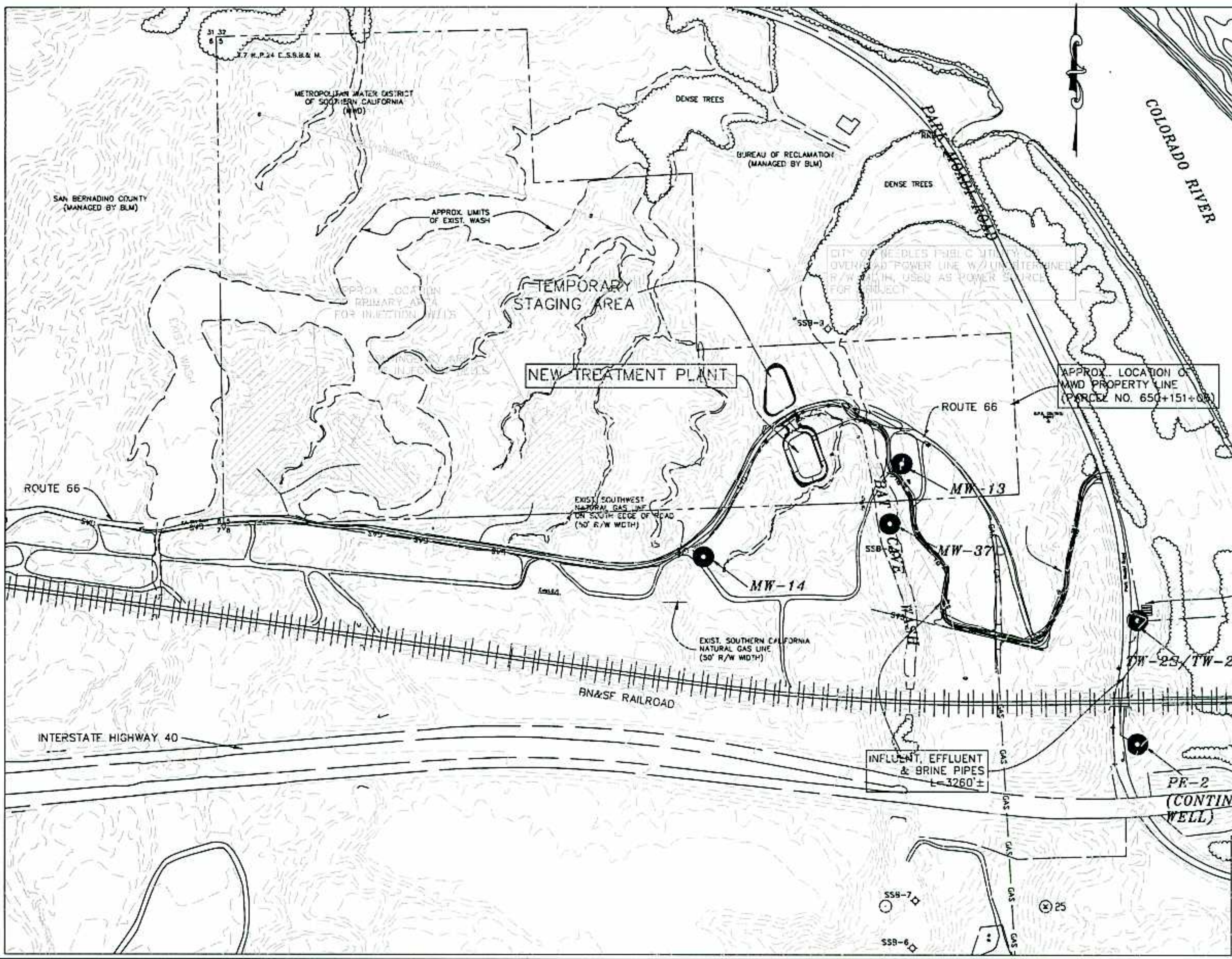


FIGURE 1
PROJECT SITE PLAN
PG & E TOPOCK WATER TREATMENT PLANT

TOPOCKDEOSKI DGN
SEPT 10, 2004

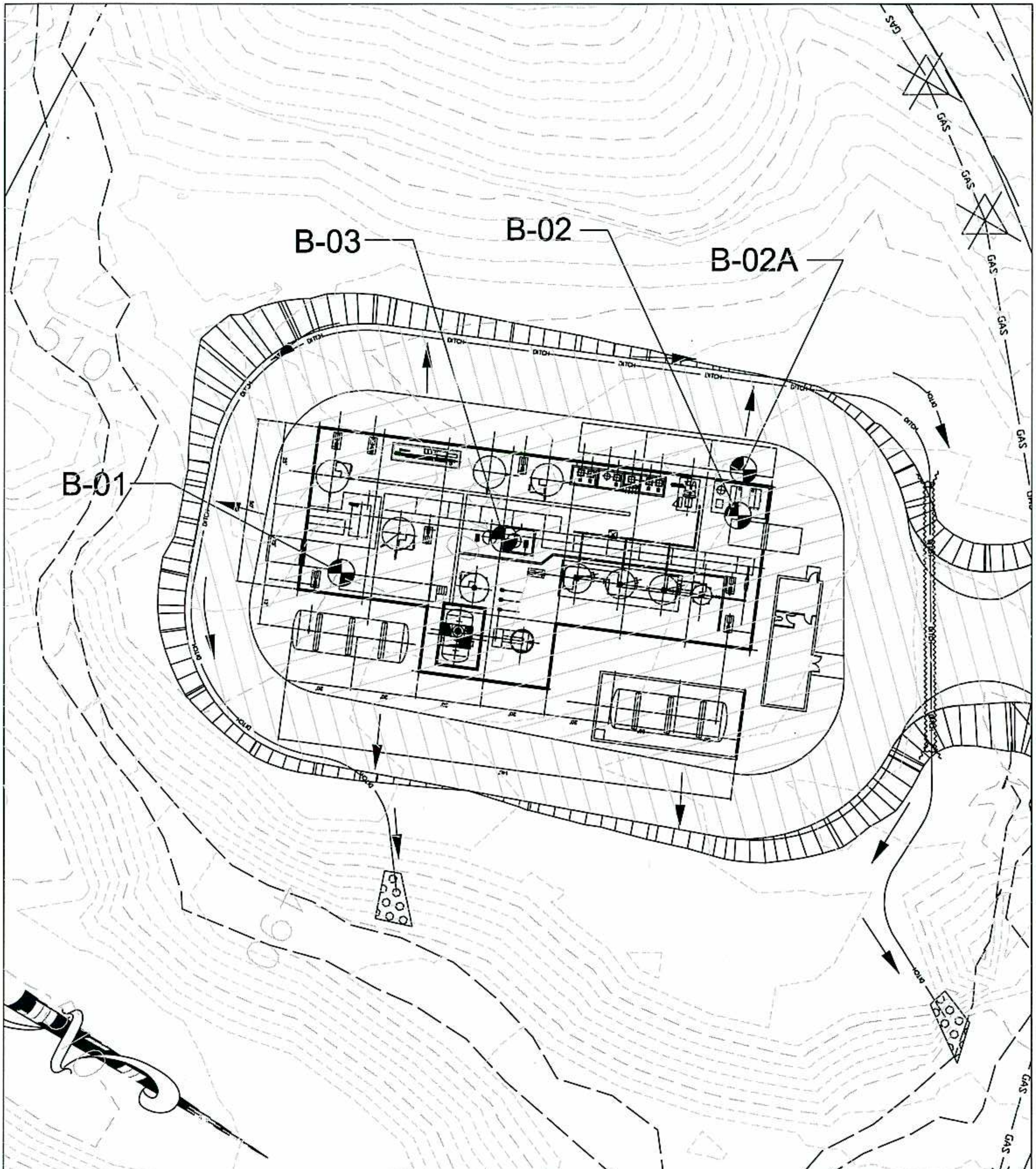
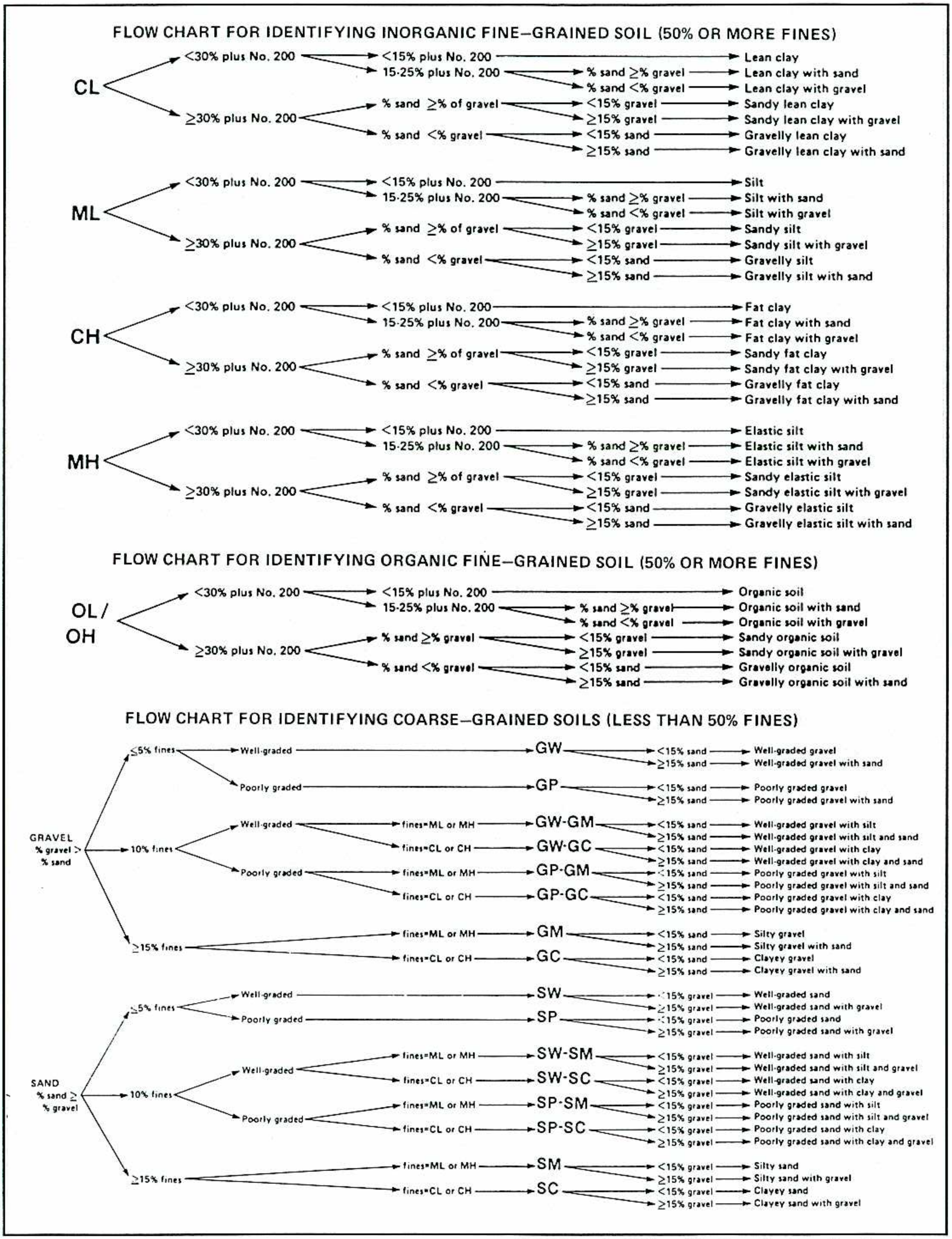


FIGURE 2
BORING LOCATIONS
PG & E TOPOCK WATER TREATMENT PLANT

TOPOCKGEOSK2.DGN
08/23/04

APPENDIX A

Soil Boring Logs



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Soil Classification System Used on Logs (From ASTM D2488, Based on Unified Soil Classification System)

TERMS USED ON LOGS

Criteria for Describing Moisture Condition

Description	Criteria
Dry	Absence of moisture, dusty, dry to the touch
Moist	Damp, but no visible water
Wet	Visible free water, usually soil is below water table

Relative Density of Coarse-Grained Soil

Blows/ Foot*	Description	Approximate Relative Density (%)	Field Test
0-4	Very loose	0-20	Easily penetrated with 1/2-inch steel rod pushed by hand
5-10	Loose	20-40	Easily penetrated with 1/2-inch steel rod pushed by hand
11-30	Medium	40-70	Easily penetrated with 1/2-inch steel rod driven with 5-pound hammer
31-50	Dense	70-90	Penetrated a foot with 1/2-inch steel rod driven with 5-pound hammer
50	Very Dense	90-100	Penetrated only a few inches with 1/2-inch steel rod driven with 5-pound hammer

Consistency of Fine-Grained Soil

Blows/ Foot*	Consistency	Pocket Penetrometer (TSF)	Torvane (TSF)	Field Test
<2	Very soft	<0.25	<0.12	Easily penetrated several inches by fist
2-4	Soft	0.25-0.50	<0.12-0.25	Easily penetrated several inches by thumb
5-8	Firm	0.50-1.0	0.25-0.5	Can be penetrated several inches by thumb with moderate effort
9-15	Stiff	1.0-2.0	0.5-1.0	Readily indented by thumbnail, but penetrated only with great effort
16-30	Very stiff	2.0-4.0	1.0-2.0	Readily indented by thumbnail
30	Hard	>4.0	>2.0	Indented with difficulty by thumbnail

*The number of blows on a 2-inch OD, split-spoon sampler by a 140-pound hammer falling 30 inches required to drive the sampler a distance of 1 foot from 6 to 18 inches (Standard Penetration Test, ASTM D1586). Actual sampler/hammer characteristics and actual field blow counts are noted on the boring logs.

Source: Sowers, 1979.

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PROJECT NUMBER:	BORING NUMBER: SHEET 1 OF 1

BORING LOG EXPLANATION

PROJECT : LOCATION :

ELEVATION : DRILLING CONTRACTOR :

DRILLING METHOD AND EQUIPMENT :

WATER LEVELS : START : END : LOGGER :

DEPTH BELOW GROUND SURFACE (ft)	DEPTH BELOW GROUND SURFACE (m)	INTERVAL (ft)	RECOVERY (ft)	#TYPE	STANDARD PENETRATION TEST RESULTS 6"-6"-6" (N)	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, AND INSTRUMENTATION
		1.0					
			1.5			Sample Interval: Top/Bottom (ft. bgs) Amount of Sample Recovered (ft)	Comments Comments and observations regarding drilling or sampling made by the driller or field personnel.
		2.5					
	1	3.5					
				S-1		Sample Type - Sample Number	Test
5		5.0					
	2					(S) Standard split-spoon drive sampler, 2.0-inch (51-mm) outside diameter, 1.4-inch (35-mm) inside diameter (without liners)	Field and Laboratory tests include the following: WC Moisture Content (ASTM D-2216) UW Dry Unit Weight (ASTM D-2937) in pounds per cubic foot (pcf) or kilonewtons per cubic meter (kN/m3)
						(M) Modified split-spoon drive sampler, 2.5-inch (64-mm) outside diameter, 2.0-inch (51-mm) inside diameter (with liners)	SA Seive analysis (ASTM D-1140) See appropriate laboratory data sheets for gradation curve
10	3					(MC) Modified California split-spoon drive sampler, 3.0-inch (76-mm) outside diameter, 2.4-inch (64-mm) inside diameter (with liners)	p200 Percentage of soil particles passing the No.200 sieve (ASTM D-422)
	4					(ST) Thin-walled Shelby tube sampler, 3.0-inch (76-mm) outside diameter, 2.9-inch (74-mm) inside diameter (G) Grab sample collected from drill cuttings	HD Standard hydrometer analysis LL PL PI Atterberg Limits (ASTM D-4318) LL = Liquid Limit, PL = Plastic Limit, PI = Plasticity Index
15		15.0					
	5	16.5			3-5-6 (11)	Standard Penetration Test Results Number of blows required to advance driven sampler over three 6-inch (152-mm) increments. Number in parenthesis is the total number of blows required to advance the sampler 12-inch (305 mm) beyond the first 6-inch (152-mm) interval. Drive samplers advanced using a 140 lb (63.5 kg) Hammer with the 30-inch (762-mm) drop. The blow counts given have not been modified to account for field and/or depth conditions.	PP Unconfined Compressive Strength in tons per square foot (tsf) or kilopascals (kPa) measured using a pocket penetrometer device TV Unconfined Compressive Strength in tsf or kPa measured using a torvane device
20	6					General Notes	TX-UU Unconsolidated Undrained Triaxial Shear Strength in pounds per square foot (psf) or kPa as measured in the laboratory (ASTM D-2850). Confining pressure given in parenthesis
	7					1) Soil classifications are based on the Unified Soil Classification System. Classifications and descriptions made in the field have been modified based on the results of laboratory testing.	TX-CU Consolidated Undrained Triaxial Shear Strength in psf or kPa as measured in the laboratory (ASTM D-4767). Confining pressure given in parenthesis
25	8					2) Boring logs depict subsurface conditions only at the specific locations and times the boring was made. Logs do not necessarily reflect strata variations that may exist between boring locations.	CONSOL One-Dimensional Consolidation (ASTM D-2435) PERM Triaxial, Falling Head Permeability (ASTM D-5084)
30	9						OC Organic content (ASTM D-2974) CA Corrosion Analysis

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PROJECT NUMBER: 315994.PS.07.GE

BORING NUMBER: B-01 SHEET 1 OF 2

SOIL BORING LOG

PROJECT : PG&E Topock Compressor Station, Needles, CA

LOCATION : Proposed Water Treatment Plant - Southeast Corner

ELEVATION : Approximately 508 to 510 feet mean sea level

DRILLING CONTRACTOR : Kent Groover/Kilenfelder/Las Vegas, NV

DRILLING METHOD AND EQUIPMENT : Hollow Stem Auger, B-61 Mobile Truck-Mounted, 140-lbs 30-in Drop Hammer with Cathead/Rope, 6-in OD and 3 1/4-in ID Auger

WATER LEVELS : Not Encountered START : 08/13/2004 08:20 END : 08/13/2004 14:30 LOGGER : P.Srinavakul

DEPTH BELOW GROUND SURFACE (ft)	DEPTH BELOW GROUND SURFACE (m)	INTERVAL (ft)	RECOVERY (ft)	#TYPE	STANDARD PENETRATION TEST RESULTS 6"-6"-6" (N)	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, AND INSTRUMENTATION
							Driller notes easy to drill between 0 and 3.5 ft below ground surface (bgs)
	1						Driller notes dense soils and small gravels from 3.5 ft bgs.
5		5.0					
	2	6.5	0.9	S-1	3-8-12 (20)	SILTY SAND WITH GRAVEL (SM), light brown, dry, medium dense, fine grained, with subrounded gravels (1/8 to 1 inch diameter)	WC = 1%; 29.6% gravel; 42.4% sand; 28.0% fines
		8.0	Bulk	B-2	Bulk	SILTY SAND (SM), similar to above, with approximately less than 10% gravels	CA; PI = Non Plastic
10	3	10.0					
		11.5	0.7	MC-3	45-50/1" (>50)	SILTY SAND WITH GRAVEL (SM), similar to above, very dense, fine to medium grained, with approximately 30% subangular gravels (1/8 to 2 inches diameter)	Driller notes gravelly soils and some cobbles between 11.5 and 15 ft bgs
	4						
15		15.0					
	5	16.5	1.0	S-4	21-38-50/5" (>50)	WELL-GRADED SAND WITH SILT AND GRAVEL (SW-SM), brown and gray, dry, very dense, fine to coarse grained, with subangular gravels (1/8 to 1/2 inch diameter)	WC = 1%; 34.2% gravel; 57.0% sand; 8.8% fines
20	6	20.0					
		21.5	NR	MC-5	50/1" (>50)		No Recovery Driller notes small cobbles and rocks while driving sample MC-5
	7						
25		25.0					
	8	26.5	NR	S-6	50/1" (>50)		No Recovery Driller notes gravels and cobbles with occasional big cobbles
	9						
30							

CH2MHILL

PROJECT NUMBER: 315994.PS.07.GE	BORING NUMBER: B-01 SHEET 2 OF 2

SOIL BORING LOG

PROJECT : PG&E Topock Compressor Station, Needles, CA

LOCATION : Proposed Water Treatment Plant - Southeast Corner

ELEVATION : Approximately 508 to 510 feet mean sea level

DRILLING CONTRACTOR : Kent Groover/Klienfelder/Las Vegas, NV

DRILLING METHOD AND EQUIPMENT : Hollow Stem Auger, B-61 Mobile Truck-Mounted, 140-lbs 30-in Drop Hammer with Cathead/Rope, 6-in OD and 3 1/4-in ID Auger

WATER LEVELS : Not Encountered START : 08/13/2004 08:20 END : 08/13/2004 14:30 LOGGER : P.Srinavakul

DEPTH BELOW GROUND SURFACE (ft)	DEPTH BELOW GROUND SURFACE (m)	INTERVAL (ft)	RECOVERY (ft)	#TYPE	STANDARD PENETRATION TEST RESULTS 6"-6"-6" (N)	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, AND INSTRUMENTATION
		30.0 31.5	NR	S-7	50/5" (>50)		No Recovery Driller notes gravelly and rocky soils
	10						
		34.0 35.0	Bulk	B-8	Bulk	SILTY SAND WITH GRAVEL (SM), brown and dark brown, moist, fine to coarse grained, with approximately 20% subangular to subrounded gravels (1/8 to 1 inch diameter), more silty than above	
35	11	35.0 36.5	NR	S-9	50/3" (>50)		No Recovery
							Hole backfilled with drill cuttings 8/13/04 14:30
40	12					Bottom of Hole at 36.5 ft below ground surface 08/13/2004 10:00 Groundwater Not Encountered	
	13						
45	14						
50	15						
	16						
55	17						
60	18						

CH2MHILL

PROJECT NUMBER: 315994.PS.07.GE

BORING NUMBER: B-02 SHEET 1 OF 1

SOIL BORING LOG

PROJECT : PG&E Topock Compressor Station, Needles, CA

LOCATION : Proposed Water Treatment Plant - Northwest Corner

ELEVATION : Approximately 505 to 507 feet mean sea level

DRILLING CONTRACTOR : Kent Groover/Kleinfelder/Las Vegas, NV

DRILLING METHOD AND EQUIPMENT : Hollow Stem Auger, B-61 Mobile Truck-Mounted, 140-lbs 30-in Drop Hammer with Cathead/Rope, 6-in OD and 3 1/4-in ID Auger

WATER LEVELS : Not Encountered

START : 08/13/2004 10:10

END : 08/13/2004 11:10

LOGGER : P.Srinavakul

DEPTH BELOW GROUND SURFACE (ft)	DEPTH BELOW GROUND SURFACE (m)	INTERVAL (ft)	RECOVERY (ft)	#TYPE	STANDARD PENETRATION TEST RESULTS 6"-6"-6" (N)	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, AND INSTRUMENTATION
	1						
5		5.0					
	2	6.5	1.2	S-1	16-25-21 (46)	SILTY SAND WITH GRAVEL (SM), brown and gray, dry, dense, fine to medium grained, with lots of gravels at bottom 6 inches of sample, subangular and flat gravels (1/8 to 2 inches diameter)	WC = 1%; 35.6% gravel; 50.7% sand; 13.7% fines
		8.0	Bulk	B-2	Bulk	SILTY SAND WITH GRAVEL (SM), similar to above, with subangular gravels (up to 3 inches diameter)	CA; PI = Non Plastic; R-Value = 83 Driller notes big cobbles, drill chatter, between 8 and 10 ft bgs
10	3	10.0					
		11.5	NR	S-3	50/0" (>50)		No Recovery
	4						Auger refusal at 11.5 ft bgs Moved 12 ft to the west to drill B-02A Hole backfilled with drill cuttings 8/13/04 11:10
15	5					Bottom of Hole at 11.5 ft below ground surface (Auger Refusal) 08/13/2004 11:00 Groundwater Not Encountered	
20	6						
	7						
25	8						
30	9						

CH2MHILL

PROJECT NUMBER: **315994.PS.07.GE**

BORING NUMBER: **B-02A** SHEET 1 OF 1

SOIL BORING LOG

PROJECT : PG&E Topock Compressor Station, Needles, CA

LOCATION : Proposed Water Treatment Plant - Northwest Corner (12 ft west of B-02)

ELEVATION : Approximately 505 to 507 feet mean sea level

DRILLING CONTRACTOR : Kent Groover/Klienfelder/Las Vegas, NV

DRILLING METHOD AND EQUIPMENT : Hollow Stem Auger, B-61 Mobile Truck-Mounted, 140-lbs 30-in Drop Hammer with Cathead/Rope, 6-in OD and 3 1/4-in ID Auger

WATER LEVELS : Not Encountered

START : 08/13/2004 11:15

END : 08/13/2004 14:40

LOGGER : P.Srinavakul

DEPTH BELOW GROUND SURFACE (ft)	DEPTH BELOW GROUND SURFACE (m)	INTERVAL (ft)	RECOVERY (ft)	#TYPE	STANDARD PENETRATION TEST RESULTS 6"-6"-6" (N)	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, AND INSTRUMENTATION
							Light brown, dry, fine silty sand in cuttings between 1 and 5 ft bgs
	1						
5							Becoming gravelly sand at 5 ft bgs
	2						
							Driller notes big cobbles, drill chatter, at 8 ft bgs, then, easy to drill between 9 and 10 ft bgs
10	3	10.0					
		11.5	1.0	S-1	22-29-34 (63)	SILTY SAND WITH GRAVEL (SM), orange-brown with gray and dark gray, dry, very dense, fine to medium grained, with subangular to angular gravels (1/8 to 2 inches diameter)	WC = 1%; 37.3% gravel; 48.5% sand; 14.2% fines
	4						
15							Auger refusal at 15 ft bgs Hole backfilled with drill cuttings 8/13/04 14:40
	5						
						Bottom of Hole at 15 ft below ground surface (Auger Refusal) 08/13/2004 11:30 Groundwater Not Encountered	
20	6						
	7						
25							
	8						
	9						
30							

CH2MHILL

PROJECT NUMBER: 315994.PS.07.GE

BORING NUMBER: B-03

SOIL BORING LOG

PROJECT : PG&E Topock Compressor Station, Needles, CA

LOCATION : Proposed Water Treatment Plant - Middle

ELEVATION : Approximately 508 to 510 feet mean sea level

DRILLING CONTRACTOR : Kent Groover/Klienfelder/Las Vegas, NV

DRILLING METHOD AND EQUIPMENT : Hollow Stem Auger, B-61 Mobile Truck-Mounted, 140-lbs 30-in Drop Hammer with Cathead/Rope, 6-in OD and 3 1/4-in ID Auger

WATER LEVELS : Not Encountered

START : 08/13/2004 11:50

END : 08/13/2004 14:00

LOGGER : P.Srinavakul

DEPTH BELOW GROUND SURFACE (ft)	DEPTH BELOW GROUND SURFACE (m)	INTERVAL (ft)	RECOVERY (ft)	#TYPE	STANDARD PENETRATION TEST RESULTS 6"-6"-6" (N)	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, AND INSTRUMENTATION
							Fine silty sand, easy to drill, between 0 and 5 ft bgs
	1						
5		5.0					
	2	6.5	0.8	S-1	12-16-13 (29)	SILTY SAND WITH GRAVEL (SM), brown and gray, dry, medium dense, fine to coarse grained, with approximately 20% subangular to subrounded gravels (1/8 to 1 1/2 inches diameter)	Gravelly sand in cuttings between 5 and 10 ft bgs
10	3	10.0					
		11.5	0.9	S-2	19-27-31 (58)	SITLY SAND WITH GRAVEL (SM), similar to above, very dense	WC = 1%; 22.8% gravel; 64.0% sand; 13.2% fines
	4	13.0	Bulk	B-3	Bulk	SILTY SAND WITH GRAVEL (SM), similar to above, brown, with approximately 15% to 20% flat and subangular gravels (1/8 to 3 inches diameter)	
15		15.0					
	5	16.5	NR	S-4	50/0" (>50)		No Recovery Gravelly soils and large cobbles in cuttings between 16.5 and 20 ft bgs
20	6	20.0					
		21.5	0.3	S-5	30-50/5" (>50)	POORLY GRADED SAND WITH SILT (SP-SM), brown and light gray, dry, very dense, fine to coarse grained, with subangular and flat gravels (1/8 to 1/2 inch diameter)	WC = 4%; 13.9% gravel
	7						Driller notes gravelly soils with large cobbles between 21.5 and 25 ft bgs
25		25.0					
	8	26.5	NR	S-6	50/0" (>50)		No Recovery
	9						
30							

CH2MHILL

PROJECT NUMBER: 315994.PS.07.GE	BORING NUMBER: B-03	SHEET 2 OF 2

SOIL BORING LOG

PROJECT : PG&E Topock Compressor Station, Needles, CA   LOCATION : Proposed Water Treatment Plant - Middle

ELEVATION : Approximately 508 to 510 feet mean sea level   DRILLING CONTRACTOR : Kent Groover/Klienfelder/Las Vegas, NV

DRILLING METHOD AND EQUIPMENT : Hollow Stem Auger, B-61 Mobile Truck-Mounted, 140-lbs 30-in Drop Hammer with Cathead/Rope, 6-in OD and 3 1/4-in ID Auger

WATER LEVELS : Not Encountered   START : 08/13/2004 11:50   END : 08/13/2004 14:00   LOGGER : P.Srinavakul

DEPTH BELOW GROUND SURFACE (ft)	DEPTH BELOW GROUND SURFACE (m)	INTERVAL (ft)	RECOVERY (ft)	#TYPE	STANDARD PENETRATION TEST RESULTS 6"-6"-6" (N)	SOIL DESCRIPTION SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, AND INSTRUMENTATION
		30.0 31.5	NR	S-7	50/0" (>50)		No Recovery
	10						Hole backfilled with drill cuttings 8/13/04 14:00
35	11					Bottom of Hole at 31.5 ft below ground surface 08/13/2004 13:10 Groundwater Not Encountered	
40	12						
	13						
45	14						
	15						
50	16						
55	17						
	18						
60							

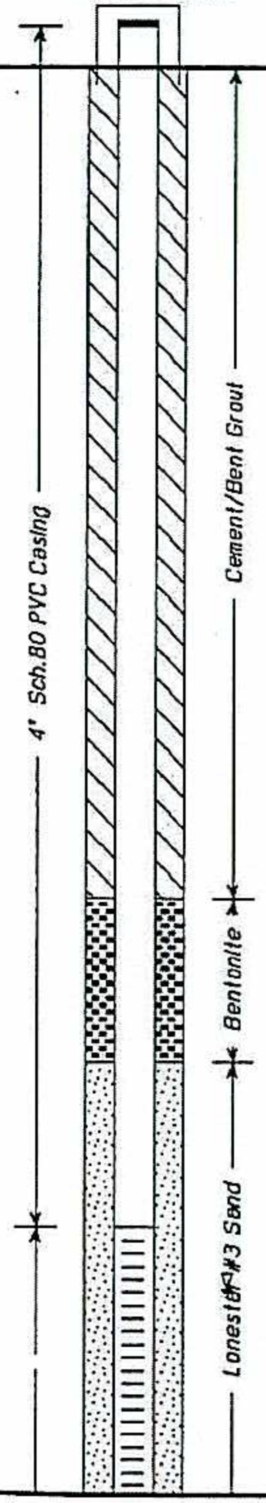
APPENDIX B

Existing Monitoring Well Logs

SEE SITE PLAN

ALISTO PROJECT NO: *10-320-08*	DATE DRILLED: *07/09/97*
CLIENT: *Pacific Gas and Electric Co.*	
LOCATION: *Topock Compressor Station*	
DRILLING METHOD: *Resonant Sonic, Continuous Coring*	
DRILLING COMPANY: *Boart Longyear*	CASING ELEVATION: *488.19*
LOGGED BY: *Ted Moise/Dan Birch*	APPROVED BY: *Dan Salaices*

WELL DIAGRAM



DEPTH feet	GRAPHIC LOG	SOIL CLASS	GEOLOGIC DESCRIPTION
0–12		SP	gravelly SAND: yellowish gray; 50% sand, fine to coarse grained; 45% gravel, 4-50 mm, subangular, occasional cobbles; minor fines; dry.
5			color change to light olive gray
12–34		GP	sandy GRAVEL: light gray; 60% gravel, 4-75 mm, subangular; 40% sand, fine to medium grained; dry.
			at 19 feet, 150 mm cobble.
			at 19.5 feet, color change to pale yellowish brown; 70% gravel; 30% sand, fine to medium grained. Possibly older alluvium.
			at 26.5 feet, 60% gravel, 40% sand.
30			Wet at 30 feet.
34		SP	gravelly SAND: pale brown; 60% sand, fine to coarse grained;

ALISTO ENGINEERING GROUP
WALNUT CREEK, CALIFORNIA

LOG OF WELL MW-13

SEE SITE PLAN

ALISTO PROJECT NO: *10-320-06* DATE DRILLED: *07/09/97*

CLIENT: *Pacific Gas and Electric Co.*

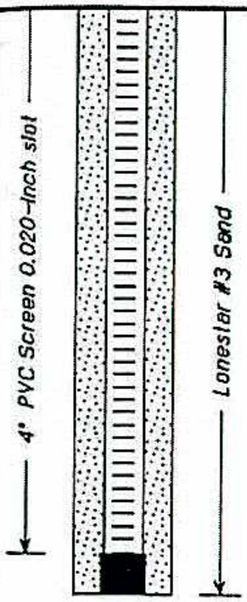
LOCATION: *Topock Compressor Station*

DRILLING METHOD: *Resonant Sonic, Continuous Coring*

DRILLING COMPANY: *Boart Longyear* CASING ELEVATION: *488.19*

LOGGED BY: *Ted Moise/Dan Birch* APPROVED BY: *Dan Salaices*

WELL DIAGRAM



DEPTH feet	SOIL CLASS	GEOLOGIC DESCRIPTION
	SP	35% gravel, 4-40 mm, subangular; wet.
40		At 40 feet, color change to pale red; 70% sand, fine to coarse grained; 30% gravel, 4-25 mm, subangular.
		At 43 feet, color change to light brownish gray, cobble to 100 mm.
45		
50		Total depth of borehole is 49.5 feet.
55		
60		
65		

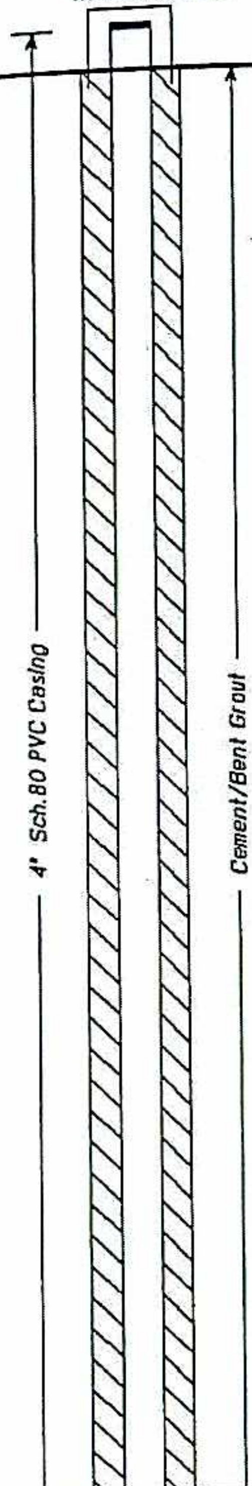
ALISTO ENGINEERING GROUP
WALNUT CREEK, CALIFORNIA

LOG OF WELL MW-14

ALISTO PROJECT NO: 10-320-06	DATE DRILLED: 07/14-15/97
CLIENT: Pacific Gas and Electric Co.	
LOCATION: Topock Compressor Station	
DRILLING METHOD: Resonant Sonic, Continuous Coring	
DRILLING COMPANY: Boart Longyear	CASING ELEVATION: 570.54
LOGGED BY: Ted Moise/Ken Simas	APPROVED BY: Dan Salaices

SEE SITE PLAN

WELL DIAGRAM



DEPTH feet	SOIL CLASS	GEOLOGIC DESCRIPTION
	GP	sandy GRAVEL: grayish orange pink; 70% gravel, 4-75 mm, rounded to subangular; 30% sand, fine to coarse grained; dry.
5	SP	gravelly SAND: pale yellowish brown; 80% sand, fine to coarse grained; 20% gravel, 4-50 mm, subangular; dry.
		At 8 feet, 80% sand, fine to coarse grained; 40% gravel, 4-70 mm, subangular.
10		
15	GP	sandy GRAVEL: pale yellowish brown; 80% gravel, 4-35 mm; subangular; 40% sand, fine to coarse grained, dry.
	SP	gravelly SAND: pale yellowish brown; 90% sand, fine to coarse grained; 10% gravel, 4-20 mm, subangular, dry.
20		At 20 feet, 55% sand, fine to coarse grained; 45% gravel, 4-50 mm.
		At 22 feet, color change to light gray; 80% sand, fine to coarse grained; 40% gravel, 4-50 mm, angular to subrounded.
25		At 25 feet, color change to light olive gray; 40% gravel, 4-25 mm, subangular.
30		At 30 feet, color change to pale yellowish brown; 75% sand, fine to coarse grained; 25% gravel, 4-80 mm, subangular; dry.

SEE SITE PLAN

ALISTO PROJECT NO: *10-320-06* DATE DRILLED: *07/14-15/97*

CLIENT: *Pacific Gas and Electric Co.*

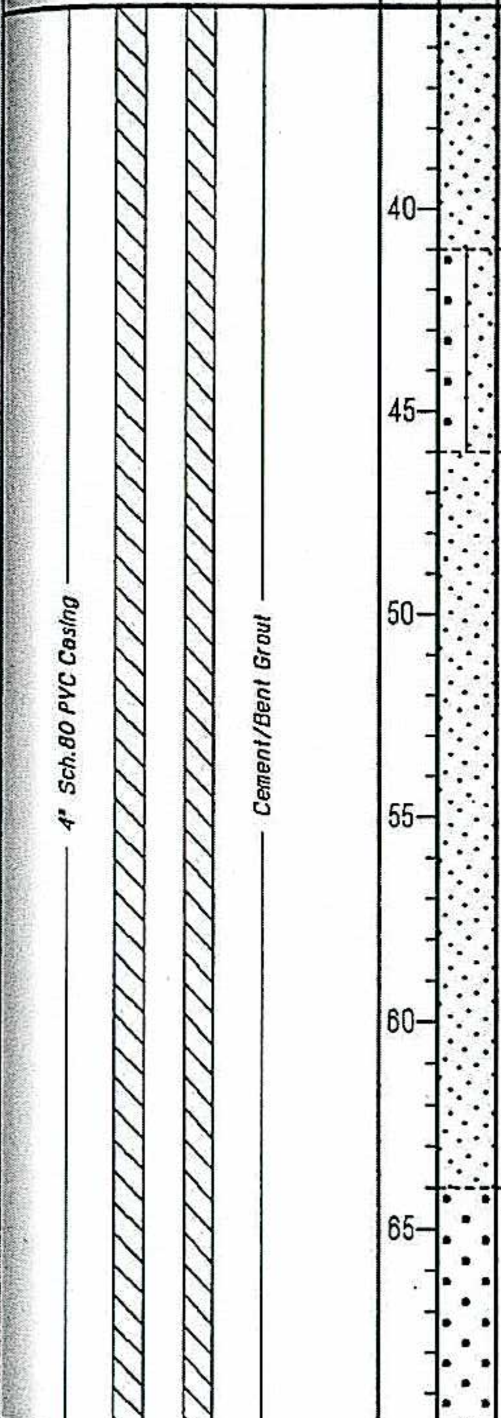
LOCATION: *Topock Compressor Station*

DRILLING METHOD: *Resonant Sonic, Continuous Coring*

DRILLING COMPANY: *Boart Longyear* CASING ELEVATION: *570.54*

LOGGED BY: *Ted Moise/Ken Simas* *APPROVED BY: Dan Salaices*

WELL DIAGRAM | **DEPTH feet** | **GRAPHIC LOG** | **SOIL CLASS** | **GEOLOGIC DESCRIPTION**



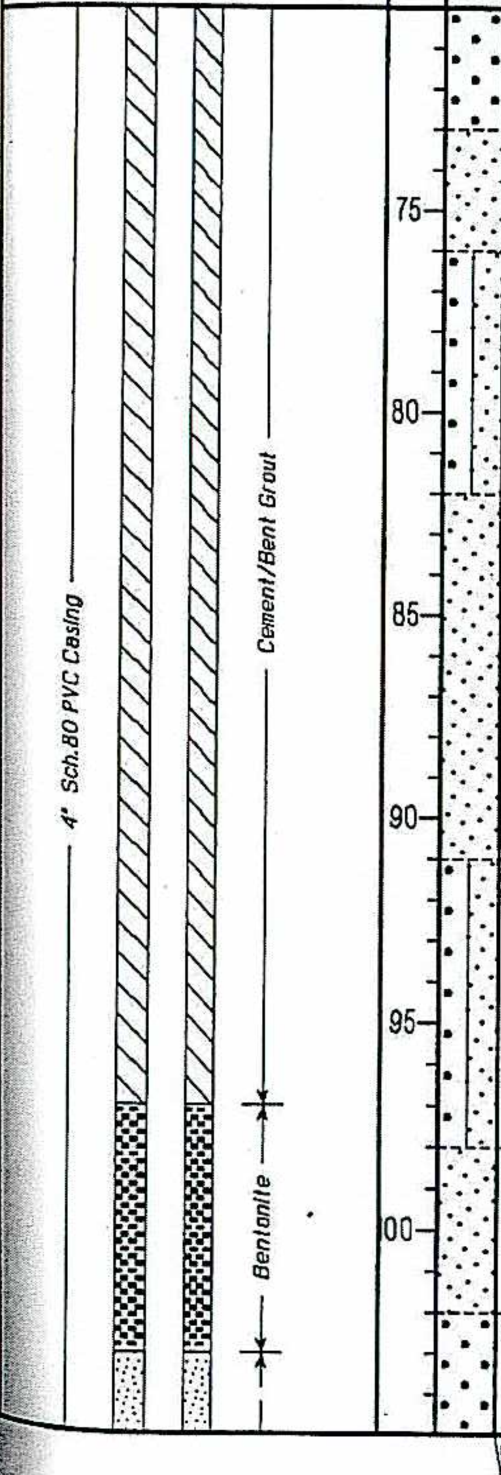
Soil Class	Geologic Description
SP	At 36 feet, gravel, 4-40 mm, subangular. At 38 feet, color change to light olive gray; 60% sand, fine to coarse grained; 40% gravel, 4-75 mm, subrounded to subangular; dry.
GP/SP	sandy GRAVEL/gravelly SAND: Pale yellowish brown; 50% sand, fine to coarse grained; 50% gravel, 4-75 mm, subangular to subrounded; dry.
SP	gravelly SAND: Pale yellowish brown; 70% sand, fine to coarse grained; 30% gravel, 4-75 mm, subangular. At 50 feet, 60% sand, fine to coarse grained; 40% gravel, 4-65 mm, subrounded to subangular; dry. At 54 feet; color change to light gray, 55% sand, fine to coarse grained; 40% gravel, 4-35 mm, subangular to subrounded; 5% fines; dry. At 57 feet, 65% sand, fine to coarse grained; 30% gravel, subangular to subrounded, 4-75 mm; 5% fines.
GP	sandy GRAVEL: light gray; 60% gravel, subangular to subrounded, 4-75 mm; 40% sand, fine to coarse grained.

ALISTO ENGINEERING GROUP WALNUT CREEK, CALIFORNIA	LOG OF WELL MW-14	Page 3 of 4

SEE SITE PLAN

ALISTO PROJECT NO: *10-320-08*	DATE DRILLED: *07/14-15/97*
CLIENT: *Pacific Gas and Electric Co.*	
LOCATION: *Topock Compressor Station*	
DRILLING METHOD: *Resonant Sonic, Continuous Coring*	
DRILLING COMPANY: *Boart Longyear*	CASING ELEVATION: *570.54*
LOGGED BY: *Ted Moise/Ken Simas*	APPROVED BY: *Dan Salalces*

WELL DIAGRAM



DEPTH feet	SOIL CLASS	GEOLOGIC DESCRIPTION
	GP	Same
75	SP	gravelly SAND: pale yellowish brown; 80% sand, fine to coarse grained; 40% gravel, 4-50 mm, subangular.
80	GP/SP	sandy GRAVEL/gravelly SAND: light olive brown; 50% sand, fine to coarse grained; 50% gravel, 4-50 mm, subangular. At 79.5 feet, 1.5 foot long boulder core, 8-inches wide. Rock flour is light gray.
85, 90	SP	gravelly SAND: light olive gray; 80% sand, fine to coarse grained; 40% gravel, 4-50 mm, subangular.
95	GP/SP	sandy GRAVEL/gravelly SAND: light olive gray, 50% sand, fine to coarse grained; 50% gravel, 4-50 mm, subangular.
00	SP	gravelly SAND: light gray; 80% sand, fine to coarse grained; 20% gravel, 4-50 mm, subangular.
	GP	sandy GRAVEL: light gray; 75% gravel, 4-50 mm, subangular to subrounded; 25% sand, fine to coarse grained, dry.
	GP/SP	

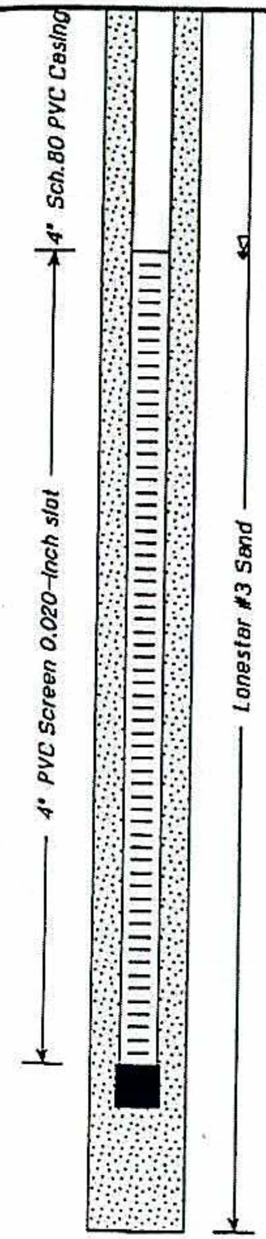
ALISTO ENGINEERING GROUP
WALNUT CREEK, CALIFORNIA

LOG OF WELL MW-14

SEE SITE PLAN

ALISTO PROJECT NO: *10-320-08*	DATE DRILLED: *07/14-15/97*
CLIENT: *Pacific Gas and Electric Co.*	
LOCATION: *Topock Compressor Station*	
DRILLING METHOD: *Resonant Sonic, Continuous Coring*	
DRILLING COMPANY: *Boart Longyear*	CASING ELEVATION: *570.54*
LOGGED BY: *Ted Moise/Ken Simas*	APPROVED BY: *Dan Salalces*

WELL DIAGRAM



DEPTH feet	SOIL CLASS	GEOLOGIC DESCRIPTION
	GP SP	sandy GRAVEL/gravelly SAND: moderate brown; 50% gravel, 4-75 mm, subrounded to subangular; 50% sand, fine to coarse grained; damp.
	SP	gravelly SAND: light olive brown; 80% sand, fine to coarse grained; 40% gravel, subangular, 4-40 mm; moist to wet.
110	GP	sandy GRAVEL: light olive gray; 80% gravel, subangular to subrounded, 4-75 mm; 40% sand, fine to coarse grained; wet at 111 feet.
115		At 118 feet, color change to light brown; gravel 4-75 mm. At 117.5 feet, 140 mm cobble, light gray rock flour.
120	SP	gravelly SAND: pale yellowish brown; 85% sand, fine to coarse grained, 30% gravel, subangular, 4-75 mm; 5% fines; wet.
125	GP GM	sandy silty GRAVEL: pale yellowish brown; 55% gravel, subangular, 4-50 mm, occasional cobble to 80 mm; 35% sand, fine to coarse grained; 10% fines; wet.
130	SP	gravelly SAND: pale yellowish brown; 80% sand, fine to coarse grained; 35% gravel, subangular, 4-20 mm; 5% fines; wet.
	SM	gravelly silty SAND: pale yellowish brown; 80% sand, fine to coarse grained; 20% gravel, subangular, 4-30 mm; 20% fines; wet.
135	SP	gravelly SAND: light olive gray; 85% sand, fine to coarse grained; 30% gravel, subangular, 4-25 mm; 5% fines; wet.
		Total depth of the boring is 135 feet.

CH2MHILL

PROJECT NUMBER	BORING NUMBER	SHEET
315024.JM.01	MW37D	1 OF 8

SOIL BORING LOG

PROJECT: PG&E Topock — LOCATION: Back Cave Wash North of I-40

ELEVATION: 482 — DRILLING CONTRACTOR: WDC Drilling & Exploration

DRILLING METHOD AND EQUIPMENT: Sonic

WATER LEVELS: 30.81' BTOC 4/23/04 — START: 4/13/04 1400 — FINISH: 4/21/04 — LOGGER: Stacy Cooper

DEPTH BELOW SURFACE (FT)	SAMPLE INTERVAL	SAMPLE NUMBER AND TYPE	SAMPLE RECOVERY (FT)	STANDARD PENETRATION TEST RESULTS 6"-6"-6" (N)	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION	Corebox
					0-8' Lost in setting conductor pipe.		
5							
						1500 - Driller's lost 8'-13' Dropped. Drilling is soft	
10			5/10'				
		①		13-14 GW-GC	Well Graded Sandy Gravel (GW-GC) Dark Gray (2.5Y 4/1), wet, high dry strength, no plasticity. 50% well-graded, angular to subangular gravel, 40% well-graded sand, subangular, 10% Fines. Becomes finer @16'.		
15						MW37D-15' (CrVI)	1
				SC	Gravelly Sand w/ Clay (SC) (2.5Y 5/2) Grayish Brown, Dry, Low Dry Strength 30% Gravel, well graded, subangular, 50% well-graded sand, subangular, 20% Fines no plasticity. Slightly moist layer @ 18 to 19' then the same as above.	1600	2
20			20/20'				3
		②		GW	22-23' Well-graded Gravel with Sand (GW) Dry, Gray (2.5Y 5/1), 70% Gravel, Cobbles to 3", course to fine, subrounded to subangular. 25% Sand, angular to subangular, course to medium, quartz, gneiss, feldspar, 5% Fines-Clay.		4
25				SC	23-25 Gravelly Sand with Clay (SC) (2.5Y 4/1) Dark Gray, moist, high dry strength, 30% Gravel, subangular, well-graded, course to fine. 50% Sand well graded, subangular, 20% fines, clay	26-28 - Becomes more Sandy, Besides that, same as above	5

REV 9/96 FORM D1586

CH2MHILL

PROJECT NUMBER	BORING NUMBER	SHEET	OF
315024.JM.01	MW-37D	2	8

SOIL BORING LOG

PROJECT PG&E Topock LOCATION Bat Cave Wash North of I-40

ELEVATION 482 DRILLING CONTRACTOR WDC Drilling & Exploration

DRILLING METHOD AND EQUIPMENT Sonic

WATER LEVELS START 4/13/04 1400 FINISH 4/21/04 LOGGER S. Cooper

DEPTH BELOW SURFACE (FT)	SAMPLE INTERVAL	SAMPLE NUMBER AND TYPE	SAMPLE RECOVERY (FT)	STANDARD PENETRATION TEST RESULTS 6"-6"-6" (N)	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
30						
		②	20'/20'	SC	Sandy Clay w/Gravel (SC) Dark Grayish Brown (10YR 4/2) 20% well-graded gravel, subrounded, moist Medium plasticity, high dry strength, 40% well graded, subangular sand, 40% clay fines.	6
35						7
40		③	10'/10'			8
45				SC	Clayey Sand w/Gravel (SC) Dark Gray (10YR 4/1), moist, High dry strength, Low plasticity, 30% round + subround, well-graded gravel, medium plasticity, 40% sand, 30% clay fines, (well-graded to round subround)	9
						10
50		④	10'/10'	SC	Sandy Clay with Gravel (SC) Dark Grayish Brown (10YR (4/2)), moist, high dry strength, medium plasticity, 30% well-graded gravel, subangular, 30% sand, well graded, subround to subangular, 40% clay fines.	MW-37D-50 Coll 0814
					Gravelly Sand with clay (SC) Color Change @ 55' 7.5YR (4/3) Brown more sand, 40% angular gravel well-graded 45% subangular to subround well-graded course to medium sand, 15% fines.	11
55						MW-37D-55 Coll 0816
					Becomes a little less consolidated @ 60'	12
		⑤		0737 4/14/04		

CH2MHILL

PROJECT NUMBER	BORING NUMBER	
315024.JM.01	MW-37D	SHEET 3 OF 8

SOIL BORING LOG

PROJECT PG&E Topock LOCATION Bat Cave wash North of I-40

ELEVATION 482 DRILLING CONTRACTOR WDC Drilling

DRILLING METHOD AND EQUIPMENT Sonic

WATER LEVELS START 4/13/04 FINISH 4/21/04 LOGGER S. Cooper

DEPTH BELOW SURFACE (FT)	SAMPLE INTERVAL	SAMPLE NUMBER AND TYPE	SAMPLE RECOVERY (FT)	STANDARD PENETRATION TEST RESULTS 6"-6"-6" (N)	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION	Core Box
60		5	10'/10'		a little less sandy, more clay to 62'	0845 Drilling is Hard MW-37D-60 CrGt 0930	13
					Becomes more Gravelly, unconsolidated		14
65				GW-GC	well-graded Sandy Gravel (GW-GC) Dark Brown (10YR 8/3) - moist, 60% well-graded, angular, subangular. Greiss, quartz, feldspar, 30% angular, subangular Sand, 10% Fines, no plasticity	MW-37D-65 CrGt 0935	
				SC	Same as 48'-60' Clayey Sand w/Gravel. moist. High dry strength.		15
70		6 1300	10'/10' 1300		70-72 slightly more clay, less Gravel. Still very sandy	MW-37D-70 CrGt 1030	16
75				GC	Sandy Gravel w/Clay (GC) (2.5Y 6/3) Light Yellowish Brown, Dry, Unconsolidated, medium plasticity 50% Gravel, cobbles to 3", Gneiss mostly, subangular, well-graded, 20% subangular well graded, coarse to medium sand. Fdsp, quartz, gneiss, 20% clay fines.	MW-37D-75 CrGt 1035	17
80		7 1345	15'/15'	CL	Sandy Lean Clay with Gravel (CL) (2.5Y 4/3) Olive Brown, moist, high plasticity High dry strength, 15% Subround, fine, to medium, well graded Gravel. 30% Sand, subround, well graded. 55% clay fines.	MW-37D-80 1405 CrGt	18
				GC	Sandy Gravel w/Clay (GC) (2.5Y 4/3) Olive Brown, Dry to moist, 50% subangular to subround gravel, well-graded - metamorphics, 30% well graded Sand, subangular to subround. 20% clay fines. Low plasticity. Unconsolidated low dry strength.		19
85						MW-37D-85 1410 CrGt	20
				SC	See next page		21

CH2MHILL

PROJECT NUMBER	BORING NUMBER	SHEET	OF
315024. IM.01	MW37D	4	8

SOIL BORING LOG

PROJECT PG & E Topock LOCATION Bat Cave wash
ELEVATION 482 DRILLING CONTRACTOR WDC Drilling & Exploration
DRILLING METHOD AND EQUIPMENT Sonic
WATER LEVELS ______ START 4/13/04 FINISH 4/21/04 LOGGER S. Cooper

DEPTH BELOW SURFACE (FT)	SAMPLE INTERVAL	SAMPLE NUMBER AND TYPE	SAMPLE RECOVERY (FT)	STANDARD PENETRATION TEST RESULTS 6"-6"-6" (N)	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
90				SC	Clayey Sand w/Gravel (SC) (10YR 4/3) Brown, moist, medium dry strength 25% subangular to subround well graded Gravel. 40% well-graded medium to fine Sand, subangular to sub round. 35% clay fines. Becomes a little sandier @ 93'. Also becomes wet.	MW-37D-90 1415; 21
95				CL	Lean clay w/ Sand (CL) (2.5Y 5/2) Grayish Brown, wet, medium plasticity low dry strength... mush. 10% Gravel, well graded, to 1", subangular, MM, 20% course to medium Sand. 70% clay fines. Becomes more Sandy & Gravelly with depth.	22; MW-37D-95 (crct) 1630 MM = metamorphic; 23
100		8 1500	15'/15'			MW-37D-100 1635 crct; 24
105				SC	Gravelly Sand w/Clay (SC) (7.5YR 4/2) Brown, has some reddish mottles & clasts. 40% fine gravel, subangular to angular, 40% course to medium Sand, well-graded, subangular Quartz, Gneiss, green minerals. 20% fines + clayey. Gravel & Sands has thin interlayers of clay.	Hard Drilling; MW-37D-105 1640 crct; 25
110		9 0800 4/15/04	10'/15'	SC	Gravelly Sand w/Clay (SC) Dark Grayish Brown (10YR 4/2), moist, 40% well-graded angular gravel, metamorphic, gneiss, 40% well-graded angular to subangular Sand. Same mineralogy as above. 20% clay fines. Gravel to 2". Unconsolidated at top of run.	MW-37D-110 0845 crct; 26; 27
115					116–118' – more Gravelly than @ top – a little more reddish in color. multicolored mineralogy with some red staining. Still moist, but a little drier.	MW-37D-115 0850 crct; 28; 29

(8.30) REV 9/96 FORM D1S

CH2MHILL

PROJECT NUMBER	BORING NUMBER	SHEET	OF
315024.JM.01	MW37D	5	8

SOIL BORING LOG

PROJECT: PG&E Topock
LOCATION: Bat Cave wash
ELEVATION: 482
DRILLING CONTRACTOR: WDC Drilling & Exploration
DRILLING METHOD AND EQUIPMENT: Sonic
WATER LEVELS:
START: 4/13/04
FINISH: 4/21/04
LOGGER: S. Cooper

DEPTH BELOW SURFACE (FT)	SAMPLE INTERVAL	SAMPLE NUMBER AND TYPE	RECOVERY (FT)	STANDARD PENETRATION TEST RESULTS 6"-6"-6" (N)	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION	Core box
120				SC	Clayey Sand w/Gravel (SC) Brown (10YR 4/3), wet, medium plasticity 20% angular to subangular gravel, to 3" well-graded, 60% well-graded, subangular sand, quartz, mm gneiss, green MM mineral, 20% clay fines.	MW-37D-120 1145 CrVI	29
			20'/20'				30
125					126'-128' - Same, but wetter.	MW-37D-125 1145 CrVI	
		10 1200 4/20/04			Same as above to 136'		31
130						MW-37D-130 1150 CrVI	32
135						MW-37D-135 1155 CrVI	33
				SC	Gravelly Sand w/clay (SC) (10YR 4/3) Brown, moist, low plasticity 25% well-graded, subangular gravel to 2", 60% sand, subangular, same mineralogy as above. 15% clay fines.		
140		11 1500	20'/20'	SW-SC	Gravelly Sand w/clay (SW-SC) Brown (10YR 4/3), wet, low plasticity, 40% well-graded, subangular gravel, 50% well-graded, angular to subangular sand, 10% clay fines. Becomes more clayey w/depth	Some heaving gravels @ 138' gneiss, green MM mineral, feldspar quartz MW-37D-140 CrVI 1445	34
145				CL	Sandy Lean Clay (CL) Brown (10YR 5/3), wet, medium plasticity, 10% well-graded, subangular gravel, 40% well-graded, subangular sand, 50% clay fines.	MW-37-145 CrVI 1450	35
							36

CH2MHILL

PROJECT NUMBER	BORING NUMBER	SHEET	OF
315024. IM.01	MW 37D	6	8

SOIL BORING LOG

PROJECT PG&E Topock LOCATION Bat Cave Wash

ELEVATION 482 DRILLING CONTRACTOR WDC Drilling & Exploration

DRILLING METHOD AND EQUIPMENT Sonic

WATER LEVELS ______ START 4/13/04 FINISH 4/21/04 LOGGER S. Cooper

150

DEPTH BELOW SURFACE (FT)	SAMPLE: INTERVAL	SAMPLE: NUMBER AND TYPE	SAMPLE: RECOVERY (FT)	STANDARD PENETRATION TEST RESULTS 6"-6"-6" (N)	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION	Core Box
150		(11) 1500	20'/20'	SC	Clayey Sand w/Gravel (SC) (10YR 4/2) dark Grayish Brown, wet, medium plasticity, 10% well-graded subangular gravel, 60% well-graded subangular sand, 30% clay fines. 150-156' - slightly drier → moist not wet	MW-37D-150 1455 crct	37
155						wet ↑ MW-37D-155 1500	
				GC	Sandy Gravel w/Clay (GC) Dark Grayish Brown (10YR 4/2), moist, Low plasticity, some reddish areas, 40% well-graded subangular, 40% well-graded angular to subangular sand, 20% clay fines. Reddish staining, multi-colored gravels, more consolidated than above.	Drilling got harder here Gravel, → Reworked red Fanglomerate	38
160				CL	Gravelly Lean Clay w/Sand (CL) (10YR 4/2) Dark Grayish Brown, moist, medium plasticity, 30% well-graded, subangular gravel, 20% well-graded, subangular sand, 50% clay fines. Green mineralogy,	MW-37D-160 1630 Fairly Hard drilling	39
165		(12) 1630	20'/20'			MW-37D-165 1635 crct	40
				SC	Gravelly Sand w/clay (SC) (10YR 4/2) Dark Grayish Brown, wet, medium plasticity, 25% well-graded, angular to subangular, gravel, 50% well-graded, subangular sand qtz, amphiboles, gneiss, 25% clay fines.		41
170					more clay w/depth to 174'	MW-37D-170 1640 crct	42
175				GC	Sandy Gravel w/Clay (GC) (10YR 4/3) Dark Grayish Brown, moist to dry, medium plasticity, 50% well-graded, subangular gravel, 30% well-graded, subangular sand, same mineralogy as above, 20% clay fines.	MW-37D-175 1645 crct	43
							44

CH2MHILL

PROJECT NUMBER	BORING NUMBER	SHEET	OF
315024.IN.01	MW37D	7	8

SOIL BORING LOG

O,P

PROJECT: PG&E Topock LOCATION: Bat Cave Wash

ELEVATION: 482 DRILLING CONTRACTOR: WDC Drilling & Exploration

DRILLING METHOD AND EQUIPMENT: Sonic

WATER LEVELS: ______ START: 4/13/04 FINISH: 4/21/04 LOGGER: S.Cooper

DEPTH BELOW SURFACE (FT)	SAMPLE INTERVAL	SAMPLE NUMBER AND TYPE	SAMPLE RECOVERY (FT)	STANDARD PENETRATION TEST RESULTS 6"-6"-6" (N)	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
180				SC	Clayey Sand w/ Gravel (SC) (7.5YR 4/3) Brown, moist, medium plasticity, 30% well-graded, subangular gravel, gneiss, 40% subangular, well-graded sand, quartz, gneiss, amphiboles, 30% clay fines, Reddish stains, matrix supported.	gravels to 3"
185		(13) 1830	20'/20'			
190					190-194 - more wet than above, slightly more sand & gravel than above, but the same otherwise.	
195					194-198' back to moist but same as 190 to 194' otherwise. (not quite as wet) Brown, but reddish tone throughout this run.	
200		(14) 1245	20'/20' 4/21/04	SC	Gravelly Sand w/ Clay (SC) (7.5YR 4/4) Brown, moist, low plasticity 25% well-graded, subangular to angular gravel, 60% well graded course to fine, subangular to angular sand, 15% clay fines. matrix supported. High dry strength	MW-37D-200' 1300 cr&t Fractures obliquely re-worked red fanglomerate
					204-208' Becomes more gravelly w/ depth. Cobbles to 3", still mostly sand.	MW-37D-205 cr&t 1305
					208-214 - Less gravel again - as above.	

Right margin: 44, 45, 46, 47, 48

CH2MHILL

PROJECT NUMBER	BORING NUMBER	SHEET	OF
315624.IM.01	MW37D	8	8

SOIL BORING LOG

PROJECT: PG&E Topock LOCATION: Bat Cave Wash

ELEVATION: 482 DRILLING CONTRACTOR: WDC Drilling & Exploration

DRILLING METHOD AND EQUIPMENT: Sonic

WATER LEVELS: START: 4/13/04 FINISH: 4/21/04 LOGGER:

DEPTH BELOW SURFACE (FT)	SAMPLE: INTERVAL	SAMPLE: NUMBER AND TYPE	SAMPLE: RECOVERY (FT)	STANDARD PENETRATION TEST RESULTS 6"-6"-6" (N)	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
210	X	(14) 1245	20'/20'	SC	214-218' more consolidated here - harder, still moist, high dry strength. More gravelly (30%). Whole run is Brown, but reddish tone.	MW-37D-210 1310 crct Still Fractures obliquely MW-37D-215 1315 crct
215						
220	X	(15) 1600	10'/10'	SC	Gravelly sand w/clay (SC) Brown (7.5 YR 4/3), moist, low plasticity Same as @ 198'. Looser than 214-218'. Gravels to 2". At 222', some bright red, brick red material color is (5YR 4/4) reddish brown. Material is same as above just redder in color. 226-228' A little more consolidated. otherwise, as above. EOB	226.' Digital photo of oblique Fracture in Red fanglomerate, photo #4. & #5.
225						
230					TD=228'	
235						

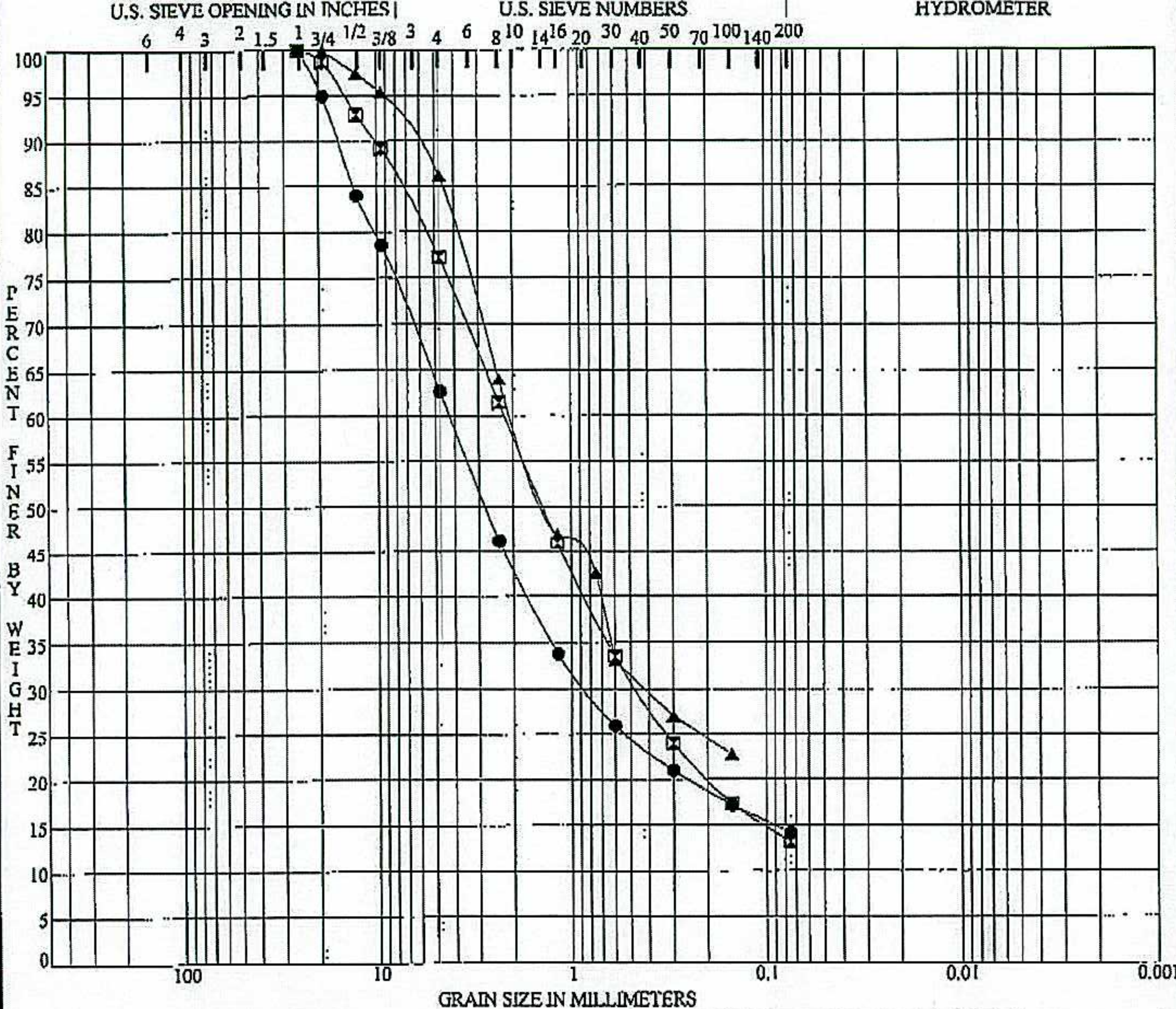
REV 9/96 FORM D1586

APPENDIX C

Laboratory Test Results

Moisture Test Results

Exploration Number	Sample Depth (ft.)	Moisture Content (%)
B-1	5	1%
B-1	15	1%
B-3	20	4%
B-2	5	1%
B-3	10	1%
B-2A	10	1%



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	Exploration No.	Depth(ft)	Classification	LL	PL	PI	Cc	Cu
●	B-2a	10.0	0					
⌧	B-3	10.0	0					
▲	B-3	20.0	0					

	Exploration No.	Depth(ft)	D100 (mm)	D60 (mm)	D30 (mm)	D10 (mm)	%Gravel	%Sand	%Silt	%Clay
●	B-2a	10.0	25.40	4.24	0.852		37.3	48.5	14.2	
⌧	B-3	10.0	25.40	2.21	0.466		22.8	64.0	13.2	
▲	B-3	20.0	19.00	2.01	0.422		13.9			

KLEINFELDER

GEOTECHNICAL AND ENVIRONMENTAL ENGINEERS
SOILS AND MATERIALS TESTING

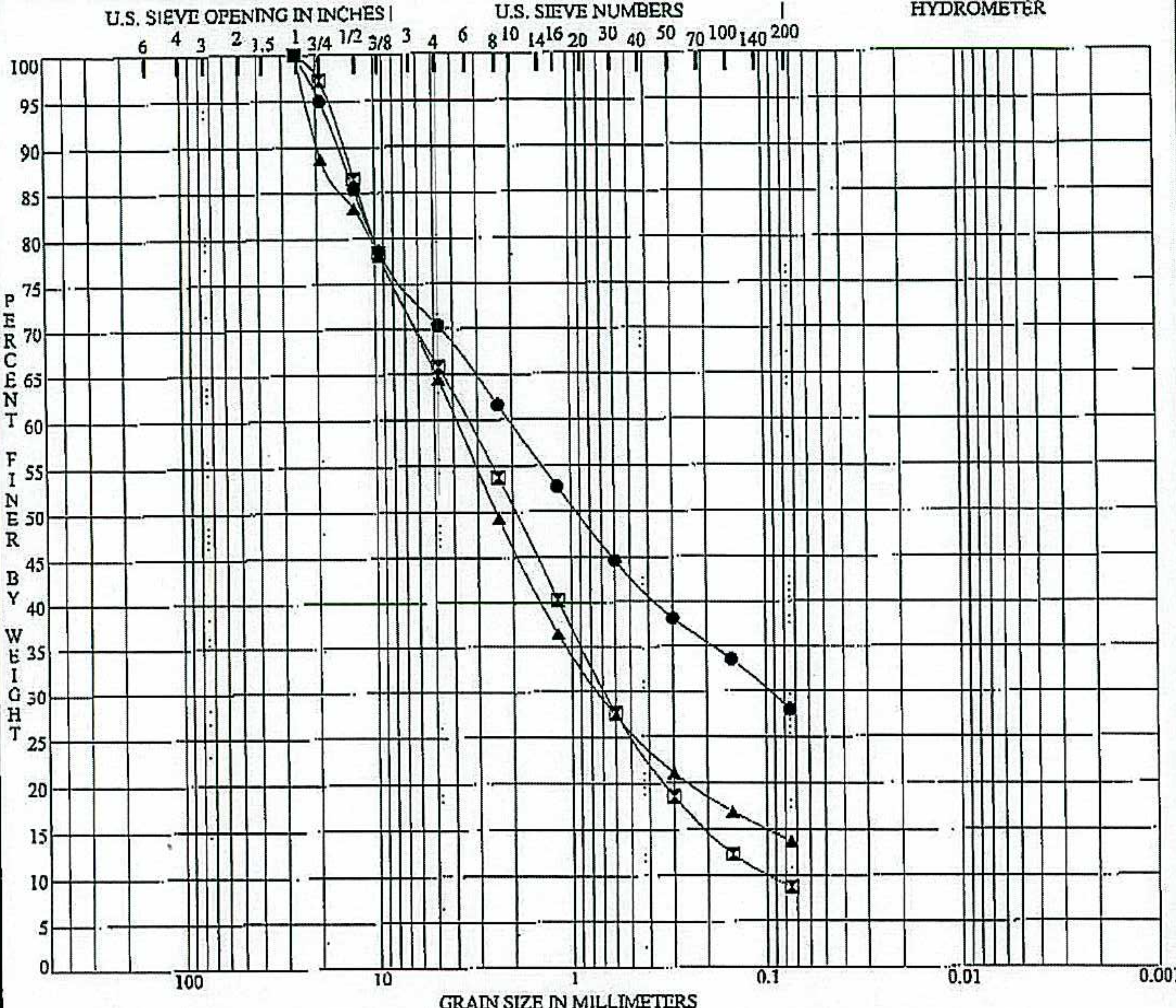
PROJECT NO. 48294

PROJECT: Needles Improvements

GRAIN SIZE ANALYSES

PLATE

B-2



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	Exploration No.	Depth(ft)	Classification	LL	PL	PI	Cc	Cu
●	B-1	5.0	0					
⊠	B-1	15.0	0				1.44	35.5
▲	B-2	5.0	0					

	Exploration No.	Depth(ft)	D100 (mm)	D60 (mm)	D30 (mm)	D10 (mm)	%Gravel	%Sand	%Silt	%Clay
●	B-1	5.0	25.40	2.08	0.096		29.6	42.4	28.0	
⊠	B-1	15.0	25.40	5.39	0.682	0.0953	34.2	57.0	8.8	
▲	B-2	5.0	25.40	3.87	0.732		35.6	50.7	13.7	

KLEINFELDER
GEOTECHNICAL AND ENVIRONMENTAL ENGINEERS
SOILS AND MATERIALS TESTING

PROJECT NO. 48294

PROJECT: Needles Improvements

GRAIN SIZE ANALYSES

PLATE B-1

Atlas Consultants, Inc.

6000 S. Eastern Avenue, Suite 10J • Las Vegas, Nevada 89119
(702) 383-1199 • Fax (702) 383-4983

member of
AMERICAN SOCIETY FOR
TESTING MATERIALS

LABORATORY NO: 12541(c)
SAMPLE: Soil
MARKED: 48294
SUBMITTED BY: Kleinfelder, Inc.

DATE: August 19, 2004
P.O.:
LAB ID: 27468
SOIL SIEVE = -10

REPORT OF DETERMINATION

BORING NUMBER	B-01	B-02				
SAMPLE NO.	27468-B2A	27468-B2B				
DEPTH (feet)	6.5-8.0	6.5-8.0				
pH VALUE	8.63	8.67				
RED-OX (mv)	+646	+668				
SULFATE (mg/Kg)	2,888	3,988				
SULFIDE (mg/Kg)	Nil	Nil				
TOTAL SALTS (mg/Kg)	7,890	6,574				
CHLORIDE (mg/Kg)	1,025	350				
RESISTIVITY (Ohm-cm)	370	725				

Respectfully submitted,

Robert L. Summers
Analytical Chemist

NOTES:

1. The soil:water extract ratio was 1:5, the results are in mg/Kg in the soil.
2. The standard methods used for the determinations are AWWA 4500 H pH Value, ASTM D 1498 Red-Ox, AWWA 4500-SO_4 E Turbidimetric, AWWA 4500-S D Methylene Blue, AWWA 2510 Electrical Conductivity, AWWA 4500-Cl B Argentometric and ASTM G 57.
3. Nil is less than 1.0 mg/Kg.

Job # => 48294
Project => PG & E TOPOCK
Client => CH2M HILL
Phase =>
Sample Location => Boring B-02, Sample B-2 @ 6.5 - 8.0

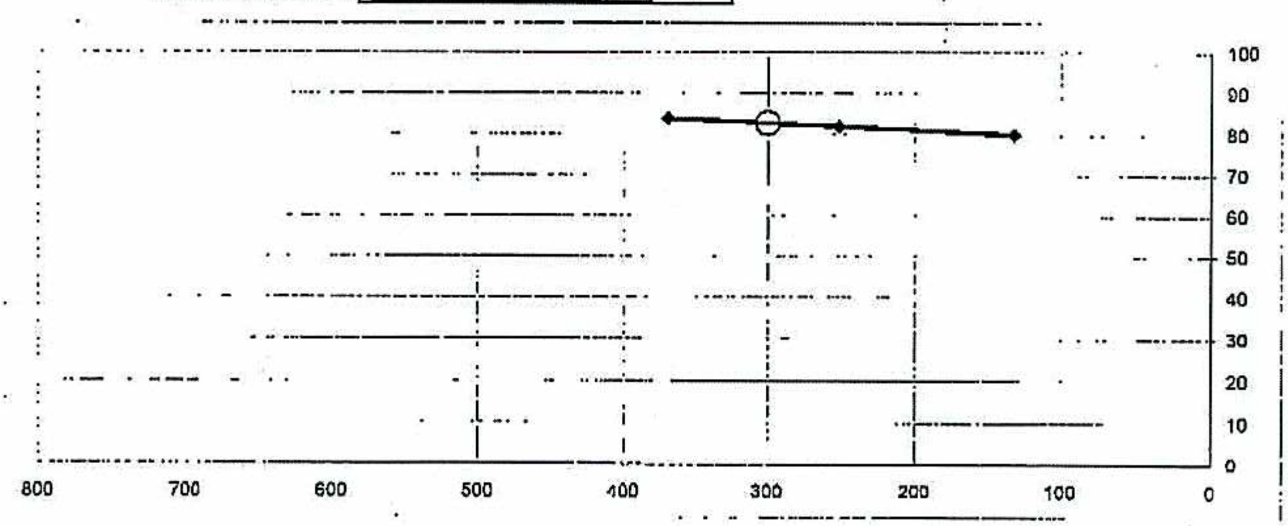
Lab Number => 27468
Date Sampled =>
Date Received => 23-Aug-04
Sampled By => Client
Tested By => J Wallis
Reviewed By => W Henshaw

Mold Label:	A	B	C
Moisture Content:	4.2%	5.0%	4.6%
Weight of Material used,gms:	1200.0	1200.0	1200.0
Water Added,gms:	50.0	60.0	55.0
Height of Specimen:	2.40	2.40	2.50
Weight of Specimen & mold:	3241.4	3293.8	3265.7
Weight of Mold,gms:	2098.4	2126.7	2110.3
Specimen Weight,gms:	1143	1167.1	1155.4
Exudation Pressure,lbs:	4636	1670	3150
Exudation Load Psi.:	369	133	251
Expansion Dial Reading:	0.0001	-0.0005	-0.0003
Stabilometer Reading @ 1000			
Stabilometer Reading @ 2000	16	27	21
Turns of Displacement:	4.05	2.94	3.63
Un-Corrected R-Value:	85	81	82
Correction from Chart:	-1	-1	
Corrected R-Value:	84	80	82
R-Value @ 300 psi. Exudation:			83
Dry Density PCF.:	138.6	140.5	134.0

Initial Moisture

Pan Number:	
Wet Wt of Sample + Pan:	2.0
Dry Wt of Sample + Pan:	2.0
Weight of Water:	
Weight of Pan:	1.0
Dry Weight of Sample:	1.0
Moisture content:	

Remarks and observations



Atlas Consultants, Inc.

6000 S. Eastern Avenue, Suite 10J • Las Vegas, Nevada 89119
(702) 383-1199 • Fax (702) 383-4983

member of
AMERICAN SOCIETY FOR TESTING MATERIALS

ACT LAB NO: 12594(e) **DATE:** September 13, 2004

PROJECT NO: 48294 **P.O.:**

ANALYZED BY: Robert L. Summers **LAB ID:** 26468

WATER SOLUBLE SALT ANALYSIS IN SOIL

1:5 (soil:water) Aqueous Extraction
AWWA 3500-Na D, AWWA 4500 E
AWWA 2540 C

SOIL SIEVE SIZE = -10 MESH

Sample No.	Location	Depth (feet)	Sodium (Percent)	Water Soluble Sulfate (SO_4) (Percent)	Total Available Water Soluble Sodium Sulfate (Na_2SO_4) (Percent)
	B-01-B-2	6.5-8.0	0.07	0.20	0.21
Solubility = 0.79%					
	B-03-S-1	5.0-6.5	0.04	0.03	0.04
Solubility = 0.33%					

Robert L. Summers

LABORATORY MANAGER

Notes: The results for each constituent denote the percentage of that analyte, at a 1:5 (soil:water) extraction ratio, which is present in the soil. Sodium was determined by flame photometry, sulfate turbidimetrically, and sodium sulfate by calculation.

Geotechnical Investigation, Topock AOC 4 Remediation – Pre-Work Plan Data Collection Activities, PG&E Compressor Station, Needles, California (CH2M HILL 2009)

Geotechnical Investigation, Topock AOC 4 Remediation – Pre-Work Plan Data Collection Activities, PG&E Compressor Station, Needles, California

PREPARED FOR:	Pacific Gas & Electric Company
PROJECT NO:	382653.FP.03.01
SUBMITTED BY:	CH2M HILL
PREPARED BY	Karthik Radhakrishnan, PE
REVIEWED BY:	Mike Cavaliere, PG Curt Basnett, GE
DATE:	October 9, 2009

Summary

This memorandum presents a summary of the geotechnical investigation conducted for the PG&E's Topock Compressor Station AOC 4 Pre-Work Plan data collection activities, including the field logs and laboratory test results. The purpose of this memorandum is to summarize the field investigation program, laboratory tests performed to evaluate the strength parameters of the subsurface materials, and present the findings from the stability analyses performed to assist with the planning of construction activities. This memorandum includes descriptions of the field investigation program and laboratory tests performed on collected samples including strength characteristics of the subsurface soils.

Four geotechnical borings were drilled in the areas on top of the ravine slopes in the AOC4 area. The scope of the geotechnical investigation did not include evaluation of fill along the slope face and at the bottom of the slope. The four borings were drilled until the augers refused on possible rock or other obstructions. Soil samples were obtained from the borings and tested for index properties, strength, and compaction characteristics. Profiles were developed based on the subsurface data and laboratory results. Slope stability analyses were also performed to evaluate the maximum slope ratio that can be maintained during construction activities, based on the estimated material strengths of the subsurface materials encountered.

Based on the subsurface exploration conducted, all the borings indicated fill material to depths of 5 feet below the existing ground surface. Based on results of the slope stability analyses, a 35 foot tall cut-slope with a 1 Horizontal (H): 1 Vertical (V) slope ratio is expected to be globally stable during construction and remediation activities. A factor of safety (FOS) for slope failure of over 1.2 was computed for this condition considering a surcharge of about 500 pounds per square foot (psf) on top of the slope. A factor of safety of 1.1 or greater is normally considered adequate for temporary slopes during construction activities.

Field Explorations

To characterize the subsurface conditions at the project site, a geotechnical field exploration was conducted at the truck-accessible locations in a nearly level area within the primary debris area of AOC4. The geotechnical field investigation included drilling four hollow stem auger (HSA) soil borings. Figure 1 shows the boring locations relative to the existing ravine, slopes, and the AOC4 area at the plant site. The figure also shows the existing grading at 1-foot contour intervals. Table 1 summarizes the field exploration.

Table 1 Summary of Field Exploration

Exploration Number	Approximate Location (NAD 83 Lat. /Lon.)	Approximate Ground Surface Elevation (feet)	Type of Boring	Depth to Auger Refusal (feet)	Groundwater Depth (feet)
AOC4-GEO1	34°42’47” N; 114°29’37” W	611.0	HSA	38.5	NE
AOC4-GEO2	34°42’47” N; 114°29’38” W	611.0	HSA	56	NE
AOC4-GEO3	34°42’46” N; 114°29’37” W	612.0	HSA	26	NE
AOC4-GEO4	34°42’46” N; 114°29’36” W	612.0	HSA	8.5	NE

NE – Not Encountered
NAD – North American Datum
Lat. – Latitude
Lon. – Longitude

Cascade Drilling, Inc., of La Habra, California, was contracted by CH2M HILL to drill the soil borings using a truck-mounted CME 85 drill rig equipped with an 8-inch-diameter HSA. The soil borings, B-1 and B-2, were drilled and sampled to the depth of 38.5 and 56 feet below ground surface (bgs), and borings B-3 and B-4 were drilled and sampled to the depth of 26 and 8.5 feet bgs. The borings were drilled until augers refused to advance either due to potential top of hard bedrock or due to hard cobbles. Groundwater was not encountered in the borings during drilling. A CH2M HILL geotechnical specialist specified the locations, depths, and sampling intervals of the borings, logged materials encountered, and observed the drilling and sampling operations.

Hand augering was performed for the first 5 feet in each of the boring to avoid possible underground utilities. Soil samples were collected at 5-foot intervals using the standard penetration test (SPT) and modified California ring (ring) samplers. The SPT and ring samplers were driven using a down-hole hydraulic hammer, 140-pound, free falling from a height of approximately 24 inches, for a total penetration of 18 inches into the ground. The blow counts were recorded for every 6 inches of penetration. The blow counts presented in parentheses on the boring logs are the blow counts for the last 12 inches of penetration and represent the field N-value.

Relatively intact soil samples were collected from the borings using the ring sampler. Sampling procedures generally followed SPT and split-barrel sampling of soils (American Society for Testing and Materials [ASTM] D1586). In addition, representative bulk samples were collected from the borings at shallow depths from the hand auger cuttings. Each soil sample collected was examined and classified in accordance with the Unified Soils Classification System (USCS) per ASTM D2488. Following drilling, sampling, and logging, the borings were grouted with a Sodium Bentonite slurry mix. The soil boring logs are included in Attachment A of this memorandum.

Laboratory Testing

A laboratory testing program was conducted using the soils collected during the surface sampling program, as discussed in the previous section. These samples were used to perform index testing, strength testing, and compaction testing.

Index, Strength, and Compaction Testing

Index testing was performed to properly classify the soil obtained from the field exploration program in accordance with the Unified Soil Classification System (USCS). Compaction characteristics were also determined including the maximum dry density and optimum moisture content of a surface sample. Direct-shear tests were performed to evaluate the strength characteristics of the fill and native soil materials. Confining pressures were used corresponding to the depth from which the sample is obtained.

The laboratory testing was conducted by Environmental Geotechnology Laboratories of Arcadia, California, under subcontract to CH2M HILL. Test assignment and coordination were provided by CH2M HILL. Laboratory testing included the following ASTM standard test methods:

- ASTM D422 – Test Method for Particle-Size Analysis of Soils (grain size and hydrometer analyses)
- ASTM D4318 – Standard Test Methods for Liquid Limit, Plastic Limit, and Plasticity Index of Soils
- ASTM D1557 – Test Method for Laboratory Compaction Characteristics of Soil Using Modified Effort
- ASTM D3080 – Test Method for Direct-Shear Test of Soils Under Consolidated Drained Conditions

Laboratory Test Results

The results of the laboratory testing programs are summarized in Tables 1 and 2 below. Laboratory testing is also summarized in Table B-1 provided in Attachment B. Detailed test results are presented in Attachment B.

The results of the index testing are presented in Table 2. Results of the index testing indicate that the grain size analyses for soil samples have predominantly granular components with fines content up to 32 percent. The results also indicate that all the tested samples had amounts of gravel ranging from 24 to 55 percent.

TABLE 2
Results of Index Testing

Boring Location	Sample Depth (ft)	% Gravel	% Sand	% Fines	LL (%)	PL (%)	PI (%)
AOC4-GEO1	1	-	-	-	17	16	1
	5	24	44	32			
	25	51	31	18			
	35	33	47	20			
AOC4-GEO2	15	37	41	22	19	18	1
	35	55	33	12			
	45	40	42	18			
AOC4-GEO3	1	44	35	21			
	15	33	38	29			
AOC4-GEO4	1	40	45	15			

ft = feet
LL = Liquid Limit
PL = Plastic Limit
PI = Plasticity Index

The results of strength testing are presented in Table 3. The in situ (field) moisture content of the native samples varied from 0.5 percent to 3.7 percent.

TABLE 3
Results of Direct Shear Strength Testing

Boring Location	Sample Depth (ft)	Sample Condition	Peak Strength		Ultimate Strength	
			Cohesion, C (psf)	Friction Angle, $\phi°$	Cohesion, C (psf)	Friction Angle, $\phi°$
AOC-GEO1	10	Relatively Intact	366	48	342	48
AOC-GEO2	20	Relatively Intact	6	40	0	40
	1	Remolded to 90% RC	185	36	86	34
	20	Relatively Intact	15	45	13	45
	30	Relatively Intact	301	44	307	44
AOC-GEO3	10	Remolded to 90% RC	534	31	112	33

psf = pound per square foot

RC = relative compaction

Subsurface Conditions

Based on the subsurface exploration conducted in AOC 4, the depth of debris fill materials is approximately 5 feet in the nearly level area and consists of silty sands and gravel mixed with debris, including some trash, roots, and peaty materials. These depths correspond to elevations of 606 feet and 607 feet, respectively, above mean sea level on the west and east side of the AOC4 area above the ravine. The debris and fill material is underlain by possible weakly cemented alluvium or weathered native materials. Boring AOC4-GEO2, located at the west edge of the existing slope above the ravine, encountered gravelly materials to approximately 35 feet bgs (El 577 feet). Based on the soil borings, the subsurface materials at the project site generally consist of gray to grayish brown, dry, medium dense to very dense, silty sand and silty gravel. The gravel sizes ranges from 0.5 to 3 inches. The uncorrected SPT N-values in this zone range from 17 for 12 inches of penetration to 50 for 6 inches of penetration.

Below the fill layer and alluvial sediments, weathered rock materials were encountered in some of the borings to the explored maximum depths overlying relatively unweathered metadiorite bedrock. The weathered rock generally consists of dense to very dense gravel and sand with silt. Gravel sizes varied from less than an inch up to 5 inches. In some areas broken cobbles or fragments of bedrock were present in the recovered samples. The uncorrected SPT N-values within the native soil zone were above 50. Detailed boring logs are presented in Attachment A.

Stability Analyses

Development of Stability Profiles

A critical cross section location was chosen passing through the existing slope at the point of maximum height. The section location is designated A-A′. CH2M HILL located the sections with respect to the existing grading plans, and the potential for overall impacts during slope excavations. As such, section A-A′ is located along the western side of the AOC 4 area running north-south across the slope as shown in Figure 1.

Cross sections to develop stability profile models used in the stability analyses were generated from the most recent topographic map provided. The cross sections were developed manually using the topographic map. Section modifications were completed to demarcate estimated fill, alluvium, and the bedrock. The existing ravine slopes in the AOC 4 area are approximately 1.5H: 1V. Steeper slopes of varying grades ranging from 1H: 1V to less than 0.75H: 1V were modeled to represent the potential temporary slopes that may be maintained during remediation and construction operations. The material types within the slopes and below the slope subsurface were stratified, and their boundaries were demarcated based on materials encountered in the borings.

Design Soil Parameters

The strength parameters used in the stability analyses are developed based on the geotechnical exploration and laboratory testing data. Shear strength parameters of 100 psf of cohesion (C) and a friction angle (ϕ) of 38 degrees were used for the fill and alluvial materials. For native materials consisting of very dense alluvium and weathered bedrock, a C of 100 psf and a ϕ of 40 degrees were used. The bedrock beneath the native soils is modeled using a C of 350 psf and a ϕ of 48 degrees.

Analyses Methodology

The slope stability analyses performed considers the overall (global) stability of slopes using circular and wedge-shaped failure planes. The slope stability analyses were performed using the Modified Bishop method for circular slip surfaces and Janbu Corrected method for wedge failures. The calculations were performed using the limit equilibrium computer program SLIDE v.5.0 (Rocscience, 2006). The method of slices estimates slope stability by assuming a failure surface and calculating the forces that would cause slope movement (driving forces) and the forces resisting slope movement (resisting forces) for the selected failure surface. The ratio of resisting forces to driving forces is known as the factor of safety. SLIDE 5.0 employs a searching routine to determine the failure surface with the minimum factor of safety. The critical slip surface for each major slope is shown on the analyses results.

Static slope stability analyses were conducted. A factor of safety of 1.1 or greater is normally considered adequate for temporary slopes during construction activities.

An equipment surcharge load of up to 500 psf is considered in the stability analyses to account for additional wheel loads on top of the slopes from vehicles and construction equipment. The following sections discuss the results and limitations of the analyses.

Stability Analyses Results

Cross section A-A′ was analyzed for slope stability assuming global circular and block failure surfaces considering a 1H: 1V slope. The maximum slope height used is 35 feet. The lowest FOS obtained is 1.2. The results show a 35 foot tall slope with a 1H: 1V slope ratio is expected to be globally stable during construction and remediation activities. A steeper slope with 0.75H: 1V was also analyzed for global stability. The lowest FOS obtained considering circular and block failure surfaces is slightly less than 1.1.

The surficial stability of a localized side slope should be considered during the grading and other construction activities. Localized instabilities, if left unchecked, could lead to larger stability issues.

Conclusions, Recommendations, and Discussion

Based on the results of the field explorations, laboratory testing results, and stability analyses, the following can be inferred:

- The depth of debris fill materials encountered in the borings extends approximately 5 feet bgs on the nearly level area of AOC 4 and contains silty sand and gravel mixed with debris including some trash, roots and peaty materials. These depths correspond to elevations of 606 feet and 607 feet above mean sea level, respectively, on the west and east side of the AOC 4 area above the ravines.

- The debris fill is underlain by possible weakly cemented alluvium and weathered metadiorite bedrock. These materials consist of dense to very dense silty sand (SM) to silty gravels (GM). The gravel sizes ranges from 0.5 to 3 inches.
- Boring refusal, indicating bedrock or obstructions, was encountered at depths varying from 56 to 5 feet bgs. Boring AOC4-GEO2, located on the west edge of the existing slope, encountered refusal at EL 556 feet or about 56 feet bgs. Boring AOC4-GEO4, located on the east side of the existing slope, encountered refusal at EL 607 feet or at about 5 feet bgs. With respect to the exposed bedrock observed near the investigation site, boring refusal is interpreted as the surface of relatively unweathered bedrock.
- Based on the results of the slope stability analyses, a 35 foot tall slope with a 1H: 1V slope ratio is expected to be globally stable during construction and remediation activities. A FOS for slope failure of 1.2 was computed for this condition. An FOS of 1.1 or greater is normally considered adequate for temporary slopes during construction activities.
- It is recommended that temporary slopes be maintained no steeper than 1H: 1V and not higher than 35 feet. Shorter, steeper slopes may be achievable and should be evaluated if proposed.
- The surficial stability of a localized side slope should be considered during the grading and other construction activities. Localized instabilities, if left unchecked, could lead to larger stability issues

The scope of the geotechnical investigation and subsequent analyses noted above did not include evaluation of fill along the slope face and at the bottom of the slope. The fill thickness and engineering properties are unknown in these areas. Because of this, stability of the fill along the slope was not conducted. In addition, a detailed geologic assessment of bedrock conditions, including mapping of fractures and bedding planes, was not part of this scope of work. The analyses conducted assumed a homogeneous subgrade consisting of dense to very dense alluvial type materials underlain by bedrock, which was encountered in the borings.

Additional assessments are recommended during the removal phase of the slope. This may include, but may not be limited to, conducting test pits along the slope face and bottom of slope to determine fill thicknesses and engineering properties. Once obtained, this data should be reviewed by the removal contractor to provide further direction on the contractor's means and methods for fill removal.

Limitations

This memorandum has been prepared for the use of the PG&E for specific application to the Topock AOC 4 – Pre-Work plan data collection activities. This memorandum was prepared in accordance with generally accepted geotechnical engineering practice; no warranty, expressed or implied, is made.

The conclusions and recommendations contained in this memorandum are based on information from the current field exploration, laboratory testing, and analyses performed. These results reflect subsurface conditions only at specific locations, times, and to the depths explored. They do not necessarily reflect strata variations that might exist between exploration locations. The nature and extent of any variations in subsurface conditions might not become evident until construction. If conditions encountered during construction differ from those described in this memorandum, recommendations made in this memorandum will need to be re-evaluated by CH2M HILL.

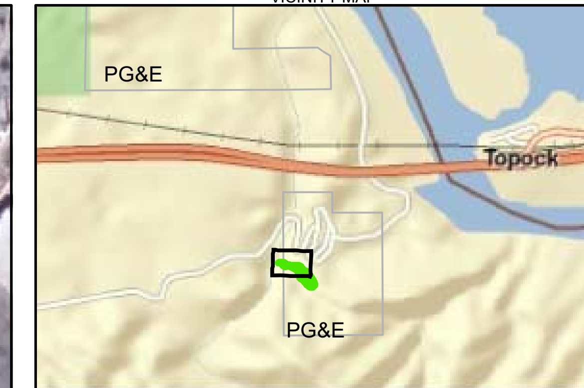
If any changes in the nature, design, or locations of the facilities are planned, the conclusions and recommendations contained in this memorandum should not be considered valid unless the changes are reviewed and the conclusions of this memorandum are modified or verified in writing by CH2M HILL.

References

Rocscience, Inc. 2006. SLIDE V5.04, *User's Guide 1989-2003*

Figures

VICINITY MAP



LEGEND

- AOC-4 Geotech Borings
- AOC 4 Boundary
- AOC4 Area 1 ft contour

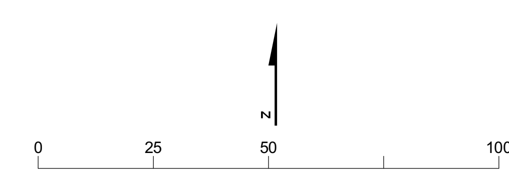


FIGURE 1
AOC 4 GEOTECHNICAL BORINGS GROUND SUFRACE ELEVATIONS
PG&E Topock Compressor Station
Needles, California

CH2MHILL

Attachments

Attachment A
Boring Logs

PROJECT NUMBER	BORING NUMBER:
382653.FP.03.01	AOC4-GE01 SHEET 1 OF 2

CH2MHILL

SOIL BORING LOG

PROJECT : PG & E TOPOCK SITE REMEDIATION LOCATION : Topock, CA

ELEVATION : 611.0 DRILLING CONTRACTOR : Cascade Drilling, Inc.

DRILLING METHOD AND EQUIPMENT : CME 85, HSA Downhole Hammer (140 lbs., 24 inch drop)

WATER LEVELS : --- START: 7/29/2009 END: 7/30/2009 LOGGER : KR

DEPTH BELOW GROUND SURFACE (ft)	INTERVAL (ft)	RECOVERY (ft)	#TYPE	STANDARD PENETRATION TEST RESULTS 6"-6"-6" (N)	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, AND INSTRUMENTATION
	0.0		B-1		SILTY SAND (SM), FILL, gray, dry, with fine to coarse gravel (1"-3"), trash, peat.	
5	5.0					
	5.0–6.5	1.1	S-2	18-24-38 (62)	-- dense, fine sand, low plastic silt, no trash, no peat.	
10	10.0					
	10.0–11.5	1.6	D-3	30-18-16 (34)	-- medium dense, medium to coarse gravel (1"-3"), low plastic silt.	
15	15.0					
	15.0–16.5	1.4	S-4	15-18-24 (42)	-- dense, grayish brown.	
20	20.0					
	20.0–21.5	1.0	D-5	38-27-37 (64)	-- gravel sizes from <0.5" to 2", coarse sand.	
25	25.0					
	25.0–26.5	0.2	S-6	39-50/6" (50/6")	SILTY GRAVEL (GM), gray, dry, very dense, with coarse sand, fine gravel, low plastic silt.	
30						

PROJECT NUMBER	BORING NUMBER:
382653.FP.03.01	AOC4-GE01 SHEET 2 OF 2

SOIL BORING LOG

PROJECT : PG & E TOPOCK SITE REMEDIATION LOCATION : Topock, CA

ELEVATION : 611.0 DRILLING CONTRACTOR : Cascade Drilling, Inc.

DRILLING METHOD AND EQUIPMENT : CME 85, HSA Downhole Hammer (140 lbs., 24 inch drop)

WATER LEVELS : --- START: 7/29/2009 END: 7/30/2009 LOGGER : KR

DEPTH BELOW GROUND SURFACE (ft)	INTERVAL (ft)	RECOVERY (ft)	#TYPE	STANDARD PENETRATION TEST RESULTS 6"-6"-6" (N)	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, AND INSTRUMENTATION
	30.0 31.5	0.6	D-7	50/6" (50/6")		
	32.0					
			B-8			
35	35.0					
	36.5	0.5	S-9	48-50/2" (50/2")	SILTY SAND (SM), gray, dry, very dense, with fine gravel, medium grained sand, low plastic silt. @36' - possible Bedrock, light gray, dry, weathered.	
40					Auger refusal @38.5'. Bottom of Hole @38.5'. No groundwater encountered. 7/30/09 8:00 AM	
45						
50						
55						
60						

PROJECT NUMBER	BORING NUMBER:
382653.FP.03.01	AOC4-GE02 SHEET 1 OF 2

SOIL BORING LOG

PROJECT : PG & E TOPOCK SITE REMEDIATION LOCATION : Topock, CA

ELEVATION : 611.0 DRILLING CONTRACTOR : Cascade Drilling, Inc.

DRILLING METHOD AND EQUIPMENT : CME 85, HSA Downhole Hammer (140 lbs., 24 inch drop)

WATER LEVELS : --- START: 7/30/2009 END: 7/30/2009 LOGGER : KR

DEPTH BELOW GROUND SURFACE (ft)	INTERVAL (ft)	RECOVERY (ft)	#TYPE	STANDARD PENETRATION TEST RESULTS 6"-6"-6" (N)	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, AND INSTRUMENTATION
	0.0				SILTY GRAVEL (GM), FILL, gray, moist, fine sand, low plastic silt, gravel sizes from <0.5" to 3", some waste debris.	Start @1:35 pm.
			B-1			
5	5.0					
	6.5	0.4	S-2	8-9-17 (26)	-- medium dense, no waste/debris.	
10	10.0					
	11.5	0.5	D-3	16-19-27 (46)		
15	15.0					
	16.5	0.6	S-4	18-19-24 (43)	SILTY SAND (SM), grayish-brown, with fine to medium gravel, fine sand, low plastic silt.	
20	20.0					
	21.5	1.0	D-5	19-27-31 (58)		
25	25.0					
	26.5	1.1	S-6	20-23-26 (49)	-- olive brown, dense.	
30						

PROJECT NUMBER	BORING NUMBER:
382653.FP.03.01	AOC4-GE02 SHEET 2 OF 2

CH2MHILL

SOIL BORING LOG

PROJECT : PG & E TOPOCK SITE REMEDIATION LOCATION : Topock, CA

ELEVATION : 611.0 DRILLING CONTRACTOR : Cascade Drilling, Inc.

DRILLING METHOD AND EQUIPMENT : CME 85, HSA Downhole Hammer (140 lbs., 24 inch drop)

WATER LEVELS : --- START: 7/30/2009 END: 7/30/2009 LOGGER : KR

DEPTH BELOW GROUND SURFACE (ft)	INTERVAL (ft)	RECOVERY (ft)	#TYPE	STANDARD PENETRATION TEST RESULTS 6"-6"-6" (N)	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, AND INSTRUMENTATION
	30.0 31.5	1.0	D-7	19-20-26 (46)	-- medium dense, turn into gray rock fragments/gravel @31'.	
35	35.0 36.5	0.8	S-8	20-24-27 (51)	POORLY GRADED GRAVEL WITH SILT AND SAND (GP-GM), olive-gray, dry, dense, gravel sizes (2" to 4"), fine sand, low plastic silt.	
40	40.0 41.5	1.0	D-9	50/6" (50/6")	-- very dense, broken rock fragments/cobble.	
45	45.0 46.5	0.8	S-10	27-50/6" (50/6")	SILTY SAND (SM), gray, dry, very dense, with fine to medium gravel, up to 1-5", coarse sand, low plastic silt.	
50	50.0 51.5	1.0	D-11	50/6" (50/6")		
55	55.0 56.5	0.7	S-12	39-50/2" (50/2")	Auger refusal @56'. Bottom of Hole @56'. No groundwater encountered. Backfilled with Bentonite grout. 7/30/09 3:45 PM	
60						

CH2MHILL

PROJECT NUMBER	BORING NUMBER:
382653.FP.03.01	AOC4-GE03 SHEET 1 OF 1

SOIL BORING LOG

PROJECT : PG & E TOPOCK SITE REMEDIATION LOCATION : Topock, CA

ELEVATION : 612.0 DRILLING CONTRACTOR : Cascade Drilling, Inc.

DRILLING METHOD AND EQUIPMENT : CME 85, HSA Downhole Hammer (140 lbs., 24 inch drop)

WATER LEVELS : --- START: 7/30/2009 END: 7/30/2009 LOGGER : KR

DEPTH BELOW GROUND SURFACE (ft)	INTERVAL (ft)	RECOVERY (ft)	#TYPE	STANDARD PENETRATION TEST RESULTS 6"-6"-6" (N)	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, AND INSTRUMENTATION
	0.0		B-1		SILTY SAND (SM), FILL, gray, dry, fine sand, with gravel size <0.2" to 4", low plastic silt, some debris.	
5	5.0 - 6.5	0.3	S-2	20-25-32 (57)	-- dense, no debris.	
10	10.0 - 11.5	0.3	D-3	12-15-17 (32)	-- medium dense.	
15	15.0 - 16.5	0.4	S-4	26-50/6" (50/6")	-- very dense.	
			B-5		SILTY GRAVEL (GM), gray to brown, dry, fine sand, low plastic silt, fine to medium gravel.	
20	20.0 - 21.5	0.5	D-6	16-21-19 (40)	-- medium dense.	
25	25.0 - 26.5	0.0	S-7	50/0" (50/0")	-- possible Bedrock or cobble.	
					Auger and spoon refusal @26'. Bottom of Hole @26'. No groundwater encountered. 7/30/09 12:00 PM	
30						

PROJECT NUMBER	BORING NUMBER:	
382653.FP.03.01	AOC4-GE04	SHEET 1 OF 1

SOIL BORING LOG

PROJECT : PG & E TOPOCK SITE REMEDIATION — LOCATION : Topock, CA

ELEVATION : 612.0 — DRILLING CONTRACTOR : Cascade Drilling, Inc.

DRILLING METHOD AND EQUIPMENT : CME 85, HSA Downhole Hammer (140 lbs., 24 inch drop)

WATER LEVELS : --- — START: 7/30/2009 — END: 7/30/2009 — LOGGER : KR

DEPTH BELOW GROUND SURFACE (ft)	INTERVAL (ft)	RECOVERY (ft)	#TYPE	STANDARD PENETRATION TEST RESULTS 6"-6"-6" (N)	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, AND INSTRUMENTATION
	0.0		B-1		SILTY SAND (SM), FILL, gray, dry, fine to coarse sand, with gravel size <0.2" to 2", some waste and debris.	Start @9:50 am.
5	5.0					
	6.5	0.3	S-2	50/3" (50/3")	-- gray, Bedrock (possible), soft, weathered, no waste or debris.	
					Bedrock @8.5'. Auger refusal @8.5'. Bottom of Hole @8.5'. No groundwater encountered. Backfilled with Bentonite grout. 7/30/09 11:00 AM	
10						
15						
20						
25						
30						

Attachment B
Laboratory Testing Results

TABLE B-1
SUMMARY OF LABORATORY TEST RESULTS - PG E TOPOCK SITE REMEDIATION

Boring	Sample	Sample Depth (ft)	USCS Classification	Field Dry Density (pcf)	Field Moisture Content (%)	Compaction Max. Dry Density (pcf)	Compaction Opt. Moisture Content (%)	Grain Size (GR:SD:FN)	Atterberg Limits Liquid Limit (%)	Atterberg Limits Plastic Limit (%)	Atterberg Limits Plasticity Index (%)	Direct Shear Undisturbed Peak C (psf)	Direct Shear Undisturbed Peak Phi (deg)	Direct Shear Undisturbed Ultimate C (psf)	Direct Shear Undisturbed Ultimate Phi (deg)	Direct Shear Remolded to 90% RC Peak C (psf)	Direct Shear Remolded to 90% RC Peak Phi (deg)	Direct Shear Remolded to 90% RC Ultimate C (psf)	Direct Shear Remolded to 90% RC Ultimate Phi (deg)
A0C4-GEO1	B1	1 - 5	SM		1.8				17	16	1								
	S2	5 - 6.5	SM		1.4			24:44:32											
	D3	10 - 11.5	SM									366	48	342	48				
	S4	15 - 16.5	SM		1.2														
	D5	20 - 21.5	SM									6	40	0	40				
	S6	25 - 26.5	GM		2.0			51:31:18											
	D7	30 - 31.5	GM		1.5														
	S9	35 - 36.5	SM		1.9			33:47:20											
A0C4-GEO2	B1	1 - 5	GM													185	36	86	34
	S2	5 - 6.5	GM		1.0														
	S4	15 - 16.5	SM		1.4			37:41:22	19	18	1								
	D5	20 - 21.5	SM									15	45	13	45				
	S6	25 - 26.5	SM		2.0														
	D7	30 - 31.5	SM									301	44	307	44				
	S8	35 - 36.5	GP-GM		0.5			55:33:12											
	D9	40 - 41.5	GP-GM	126.7	2.0														
	S10	45 - 46.5	SM		2.7			40:42:18											
	S12	55 - 56.5	SM		3.7														
A0C4-GEO3	B1	1 - 5	SM		1.2			44:35:21											
	S4	15 - 16.5	SM		1.6			33:38:29											
	B5	10 - 11.5	SM			141.0	5.5									534	31	112	33
	D6	20 - 21.5	GM	113.4	1.2														
A0C4-GEO4	B1	1 - 5	SM					40:45:15											

SUMMARY OF LABORATORY TEST RESULTS

PROJECT NAME: PG&E TOPOCK

PROJECT NO: 382653.FP.03.01

DATE: 8/19/2009

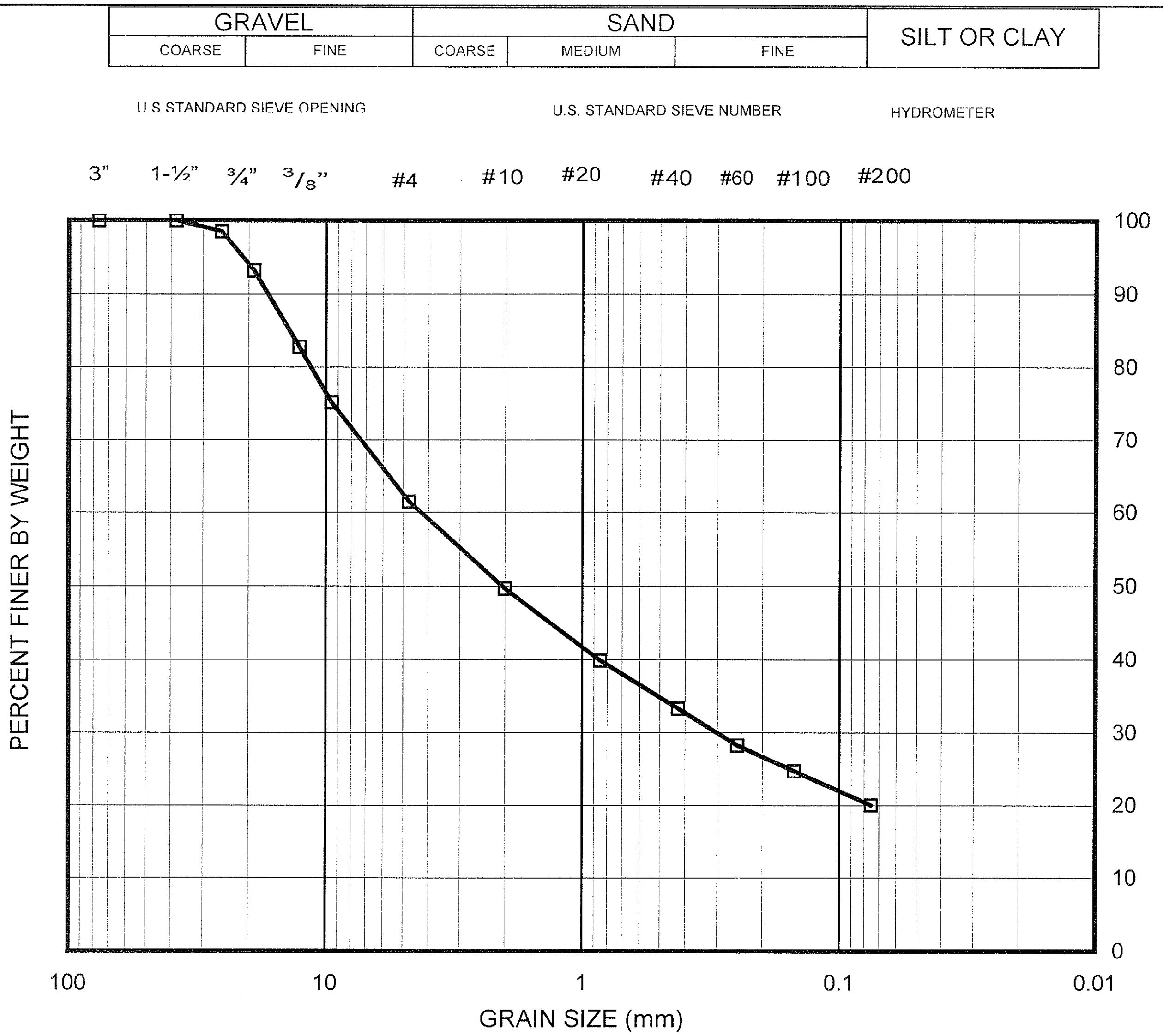
EGL JOB NO: 09-119-001

CLIENT: CH2M HILL

SUMMARIZED BY: RJ

BORING NO	SAMPLE NO	DEPTH (ft)	MOISTURE CONTENT ASTM D2216 (%)	DRY DENSITY ASTM D2937 (pcf)	ATTERBERG LIMITS ASTM D4318 *(LL,PL,PI)
N/A	AOC4-Geo1-B1	1-5	1.8		17,16,1
N/A	AOC4-Geo1-S2	5-6.5	1.4		
N/A	AOC4-Geo1-S4	15-16.5	1.2		
N/A	AOC4-Geo1-S6	25-26.5	0.7		
N/A	AOC4-Geo1-D7	30-31.5	1.5	disturbed	
N/A	AOC4-Geo1-S9	35-36.5	1.9		
N/A	AOC4-Geo2-S2	5-6.5	1.0		
N/A	AOC4-Geo2-S4	15-16.5	1.4		19,18,1
N/A	AOC4-Geo2-S6	25-26.5	2.0		
N/A	AOC4-Geo2-S8	35-36.5	0.5		
N/A	AOC4-Geo2-D9	40-41.5	2.0	126.7	
N/A	AOC4-Geo2-S10	45-46.5	2.7		
N/A	AOC4-Geo2-S12	55-56.5	3.7		
N/A	AOC4-Geo3-B1	1-5	1.2		
N/A	AOC4-Geo3-S4	15-16.5	1.6		
N/A	AOC4-Geo3-D6	20-21.5	1.2	113.4	

*LL,PL,PI = LIQUID LIMIT, PLASTIC LIMIT, PLASTICITY INDEX



SYMBOL	BORING NO	SAMPLE NO	DEPTH (FT)	SAMPLE TYPE	SOIL TYPE	LIQUID LIMIT	PLASTICITY INDEX
□	N/A	AOC4-Geo1-B1	1-5	Bulk	SM	17	1

ENVIRONMENTAL GEOTECHNOLOGY LABORATORY

Project Name: PG&E Topock

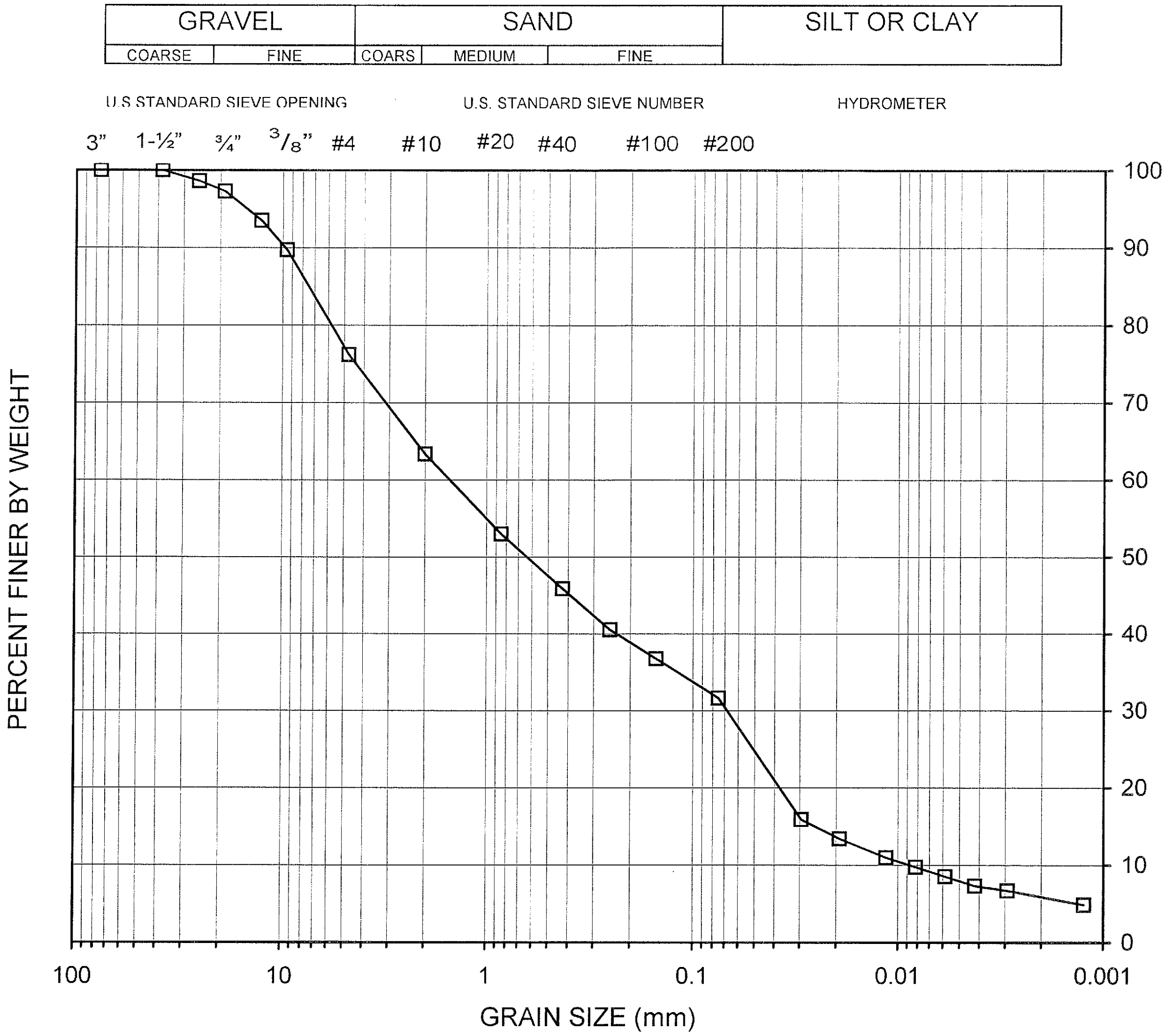
Client Job No.:	382653.FP.03.01
Client Name:	CH2M Hill
EGL Project No:	09-119-001

GRAIN SIZE DISTRIBUTION CURVE

(ASTM D422)

Aug-09

FIGURE



SYMBOL	BORING No.	SAMPLE No.	DEPTH (FT)	SAMPLE TYPE	SOIL TYPE	LIQUID LIMIT	PLASTICITY INDEX
□	N/A	AOC4-Geo1-S2	5-6.5	Bag	SM	N/A	N/A

ENVIRONMENTAL
GEOTECHNOLOGY
LABORATORY

Project Name: PG & E Topock

Client: CH2M Hill

Job No: 382653.FP.03.01

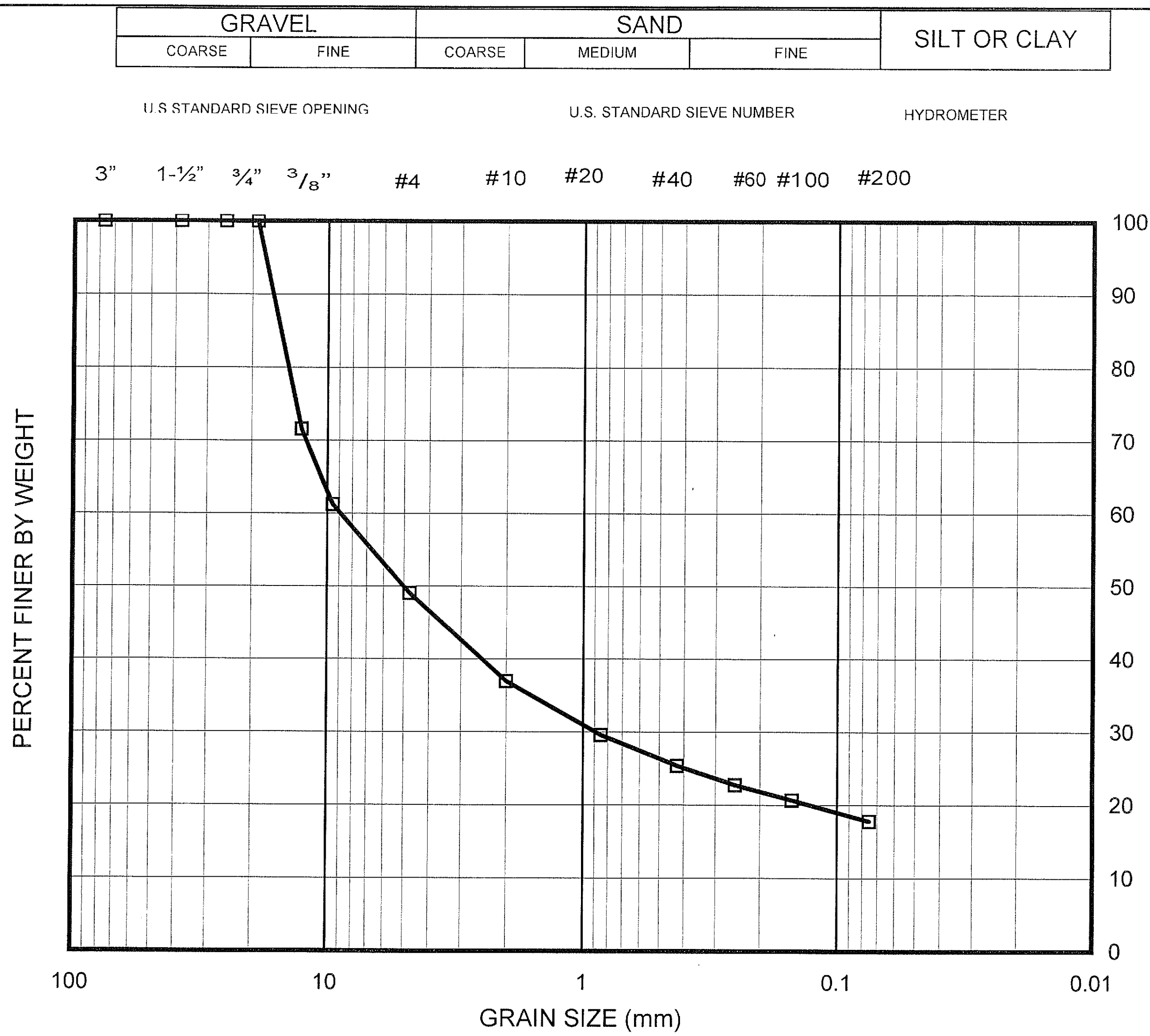
EGL Project No: 09-119-001

GRAINSIZE DISTRIBUTION CURVE

(ASTM D422)

08/21/09

FIGURE



SYMBOL	BORING NO	SAMPLE NO	DEPTH (FT)	SAMPLE TYPE	SOIL TYPE	LIQUID LIMIT	PLASTIC INDEX
□	N/A	AOC4-Geo1-S6	25-26.5	Bag	GM	N/A	N/A

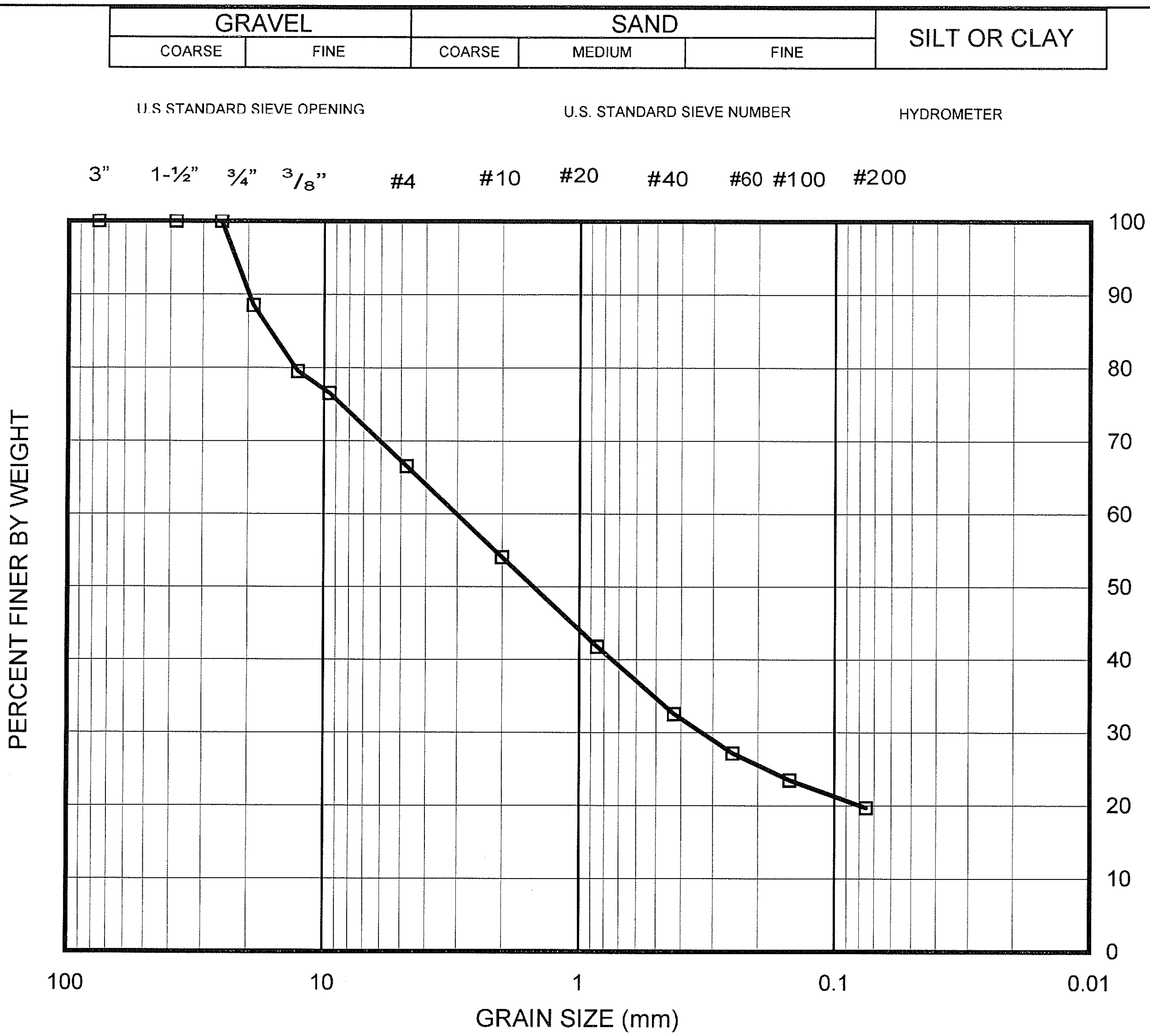
ENVIRONMENTAL GEOTECHNOLOGY LABORATORY	Project Name: PG&E Topock Client Job No.: 382653.FP.03.01 Client Name: CH2M Hill EGL Project No: 09-119-001

GRAIN SIZE DISTRIBUTION CURVE

(ASTM D422)

08/21/09

FIGURE

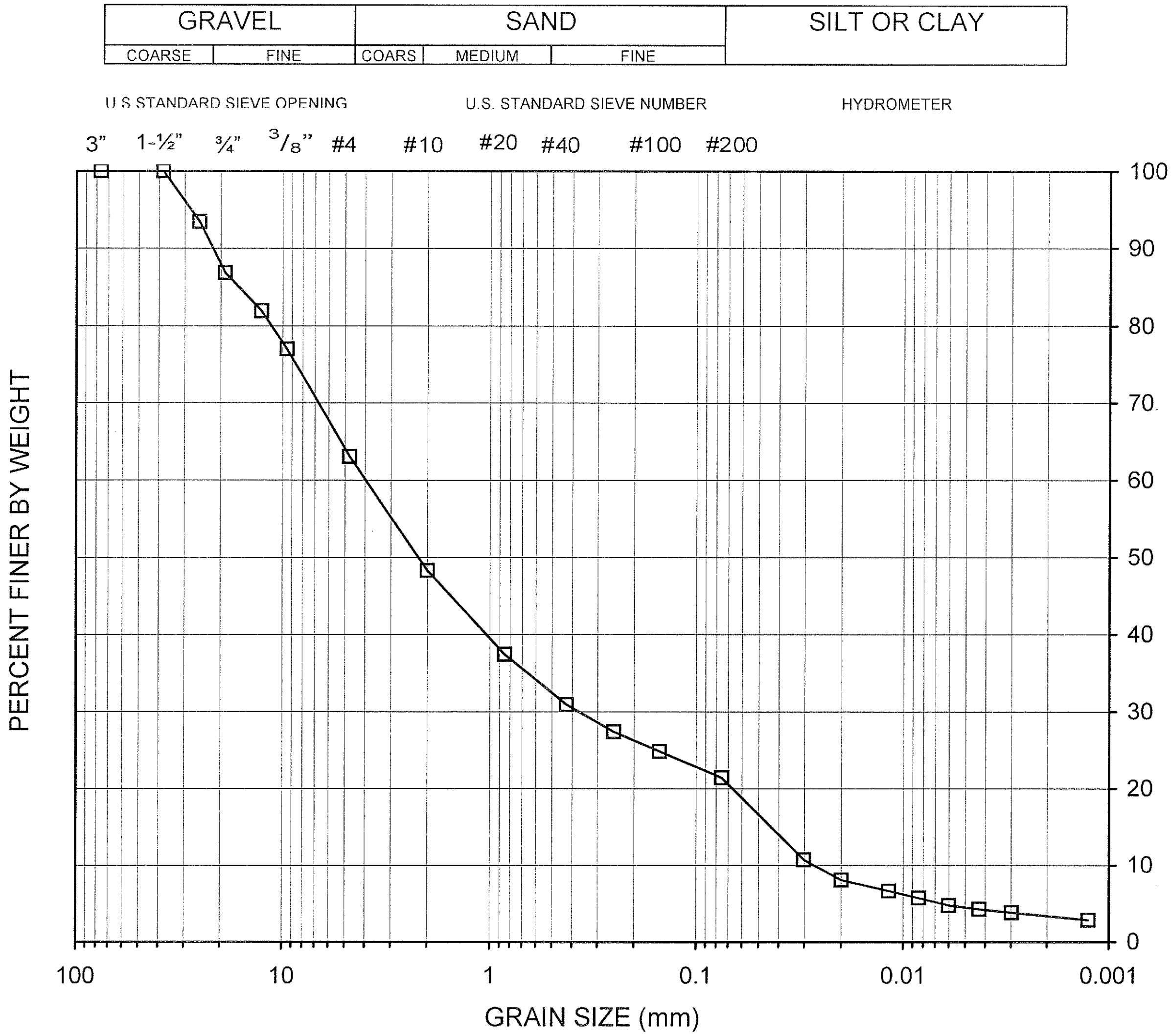


SYMBOL	BORING NO	SAMPLE NO	DEPTH (FT)	SAMPLE TYPE	SOIL TYPE	LIQUID LIMIT	PLASTIC INDEX
□	N/A	AOC4-Geo1-S9	35-36.5	Bag	SM	N/A	N/A

ENVIRONMENTAL GEOTECHNOLOGY LABORATORY	Project Name: PG&E Topock Client Job No.: 382653.FP.03.01 Client Name: CH2M Hill EGL Project No: 09-119-001

GRAIN SIZE DISTRIBUTION CURVE

08/19/09 (ASTM D422) FIGURE



SYMBOL	BORING No.	SAMPLE No.	DEPTH (FT)	SAMPLE TYPE	SOIL TYPE	LIQUID LIMIT	PLASTICITY INDEX
□	N/A	AOC4-Geo2-S4	15-16.5	Bag	SM	19	1

ENVIRONMENTAL GEOTECHNOLOGY LABORATORY

Project Name: PG & E Topock

Client: CH2M Hill

Job No: 382653.FP.03.01

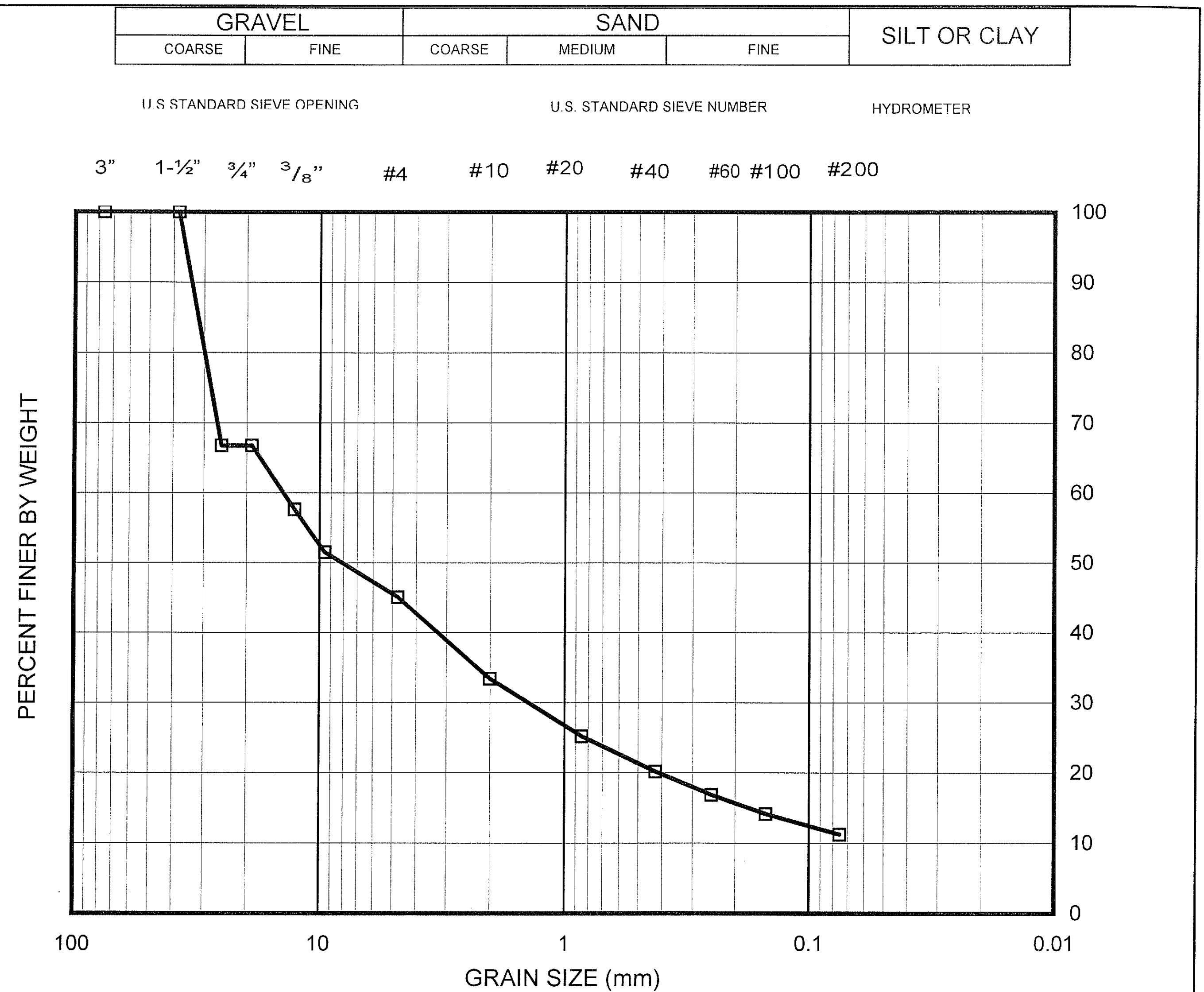
EGL Project No: 09-119-001

GRAINSIZE DISTRIBUTION CURVE

(ASTM D422)

08/24/09

FIGURE

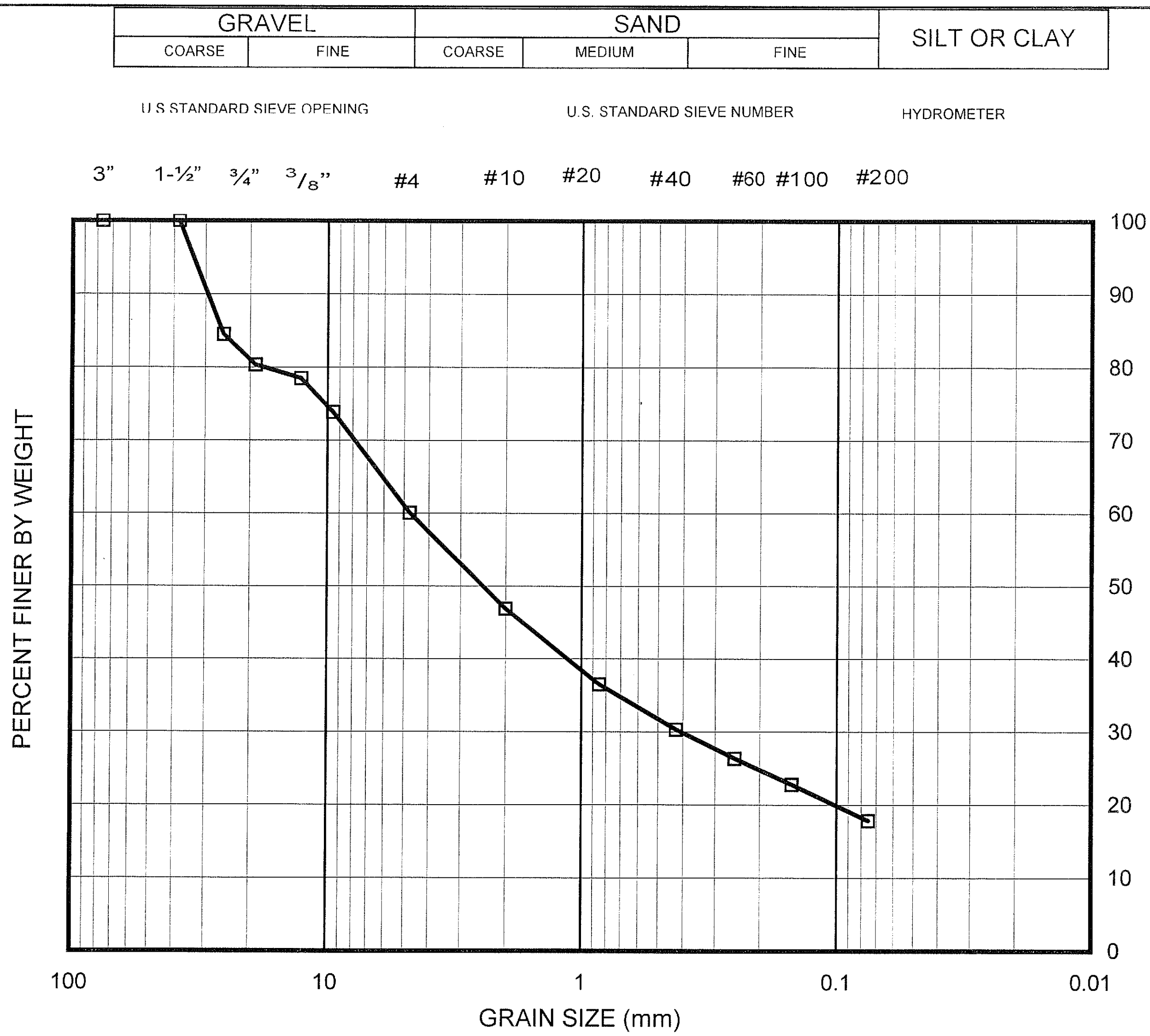


SYMBOL	BORING NO	SAMPLE NO	DEPTH (FT)	SAMPLE TYPE	SOIL TYPE	LIQUID LIMIT	PLASTIC INDEX
□	N/A	AOC4-Geo2-S8	35-36.5	Bag	GP-GM	N/A	N/A

ENVIRONMENTAL GEOTECHNOLOGY LABORATORY	Project Name: PG&E Topock
	Client Job No.: 382653.FP.03.01
	Client Name: CH2M Hill
	EGL Project No: 09-119-001

GRAIN SIZE DISTRIBUTION CURVE

08/21/09 (ASTM D422) FIGURE



SYMBOL	BORING NO	SAMPLE NO	DEPTH (FT)	SAMPLE TYPE	SOIL TYPE	LIQUID LIMIT	PLASTIC INDEX
□	N/A	AOC4-Geo2-S10	45-46.5	Bag	SM	N/A	N/A

ENVIRONMENTAL GEOTECHNOLOGY LABORATORY

Project Name:
PG&E Topock

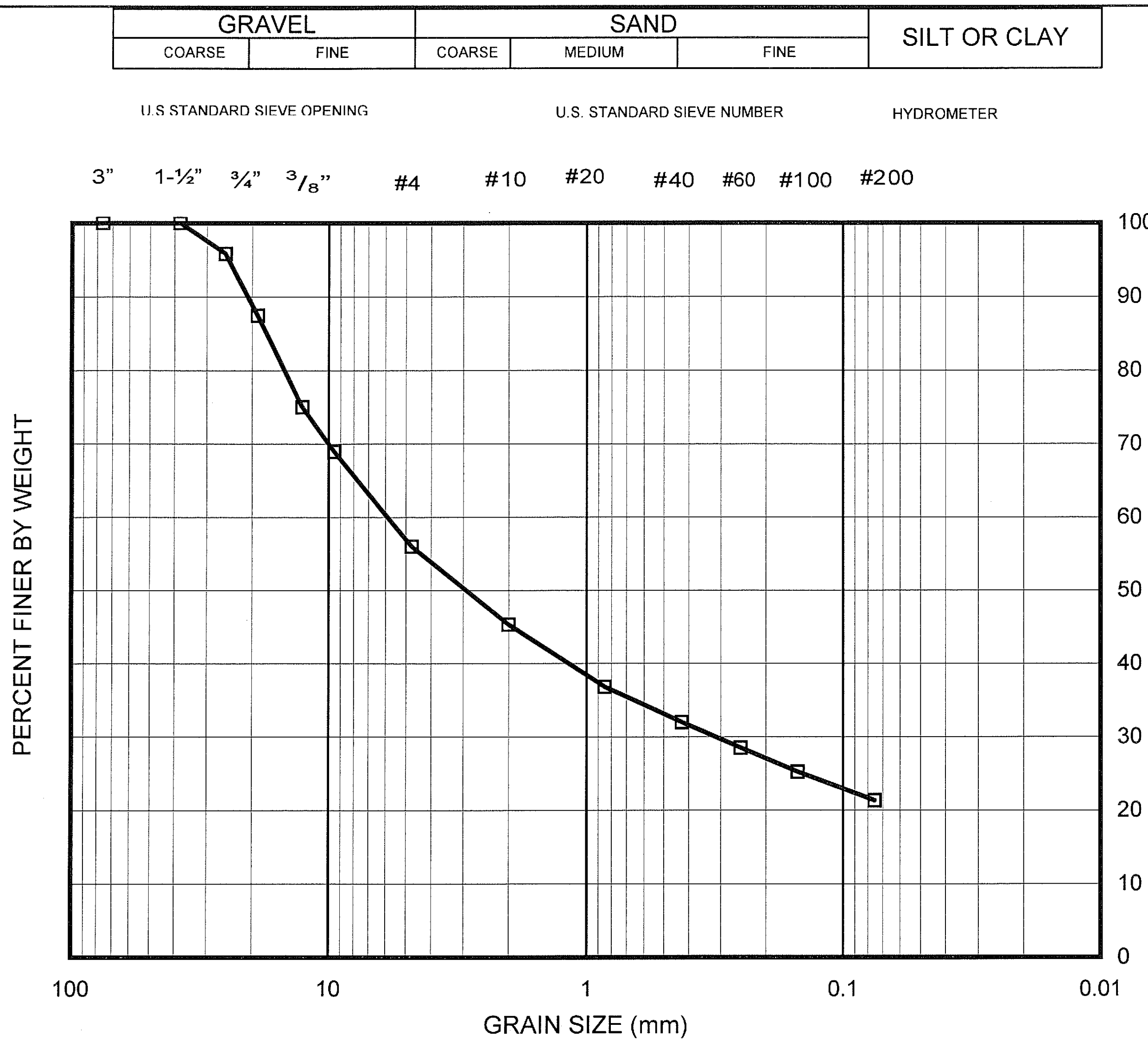
Client Job No.:	382653.FP.03.01
Client Name:	CH2M Hill
EGL Project No:	09-119-001

GRAIN SIZE DISTRIBUTION CURVE

(ASTM D422)

08/21/09

FIGURE



SYMBOL	BORING NO	SAMPLE NO	DEPTH (FT)	SAMPLE TYPE	SOIL TYPE	LIQUID LIMIT	PLASTIC INDEX
□	N/A	AOC4-Geo3-B1	1-5	Bulk	SM	N/A	N/A

ENVIRONMENTAL
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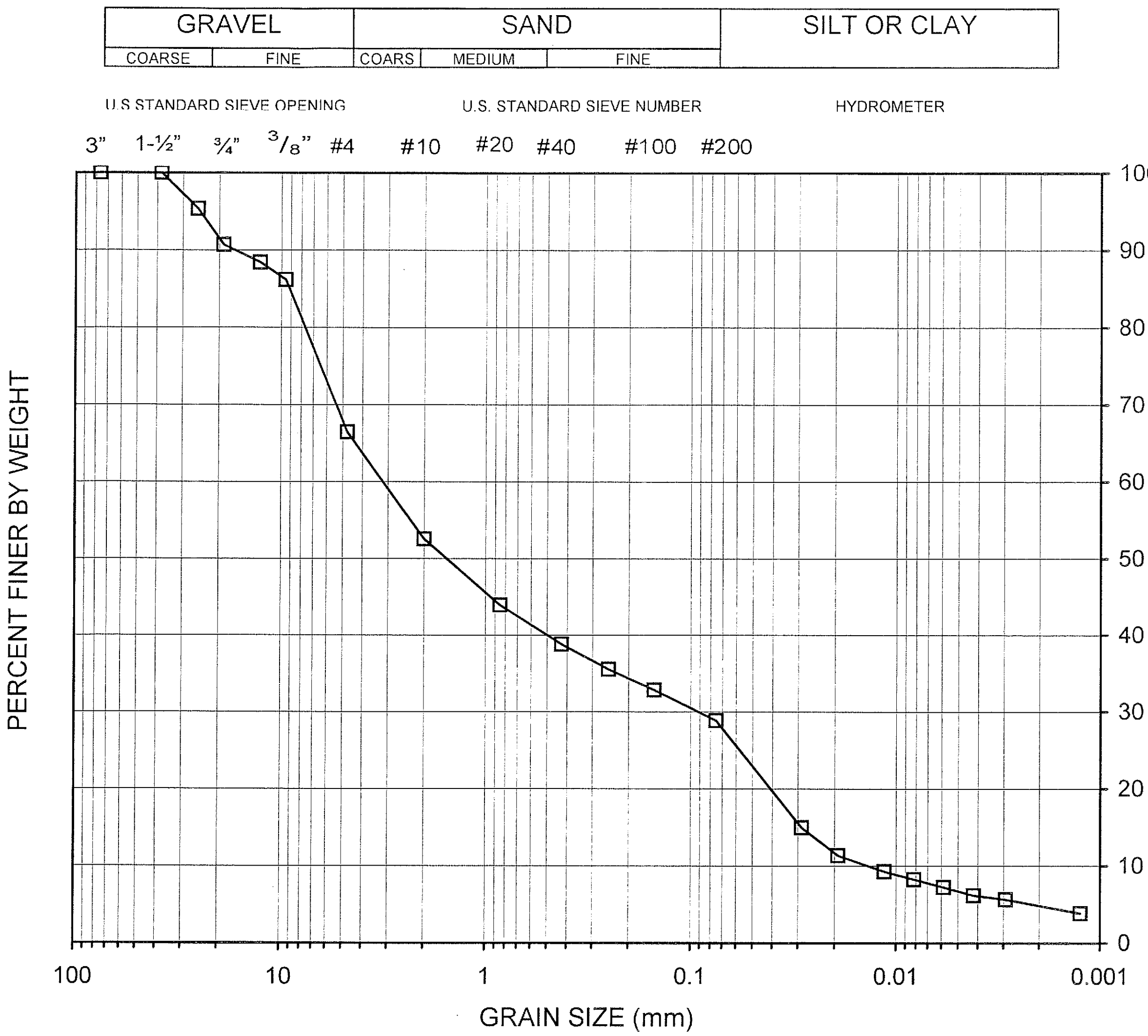
Project Name:
PG&E Topock

Client Job No.:	382653.FP.03.01
Client Name:	CH2M Hill
EGL Project No:	09-119-001

GRAIN SIZE
DISTRIBUTION CURVE
(ASTM D422)

Aug-09

FIGURE



SYMBOL	BORING No.	SAMPLE No.	DEPTH (FT)	SAMPLE TYPE	SOIL TYPE	LIQUID LIMIT	PLASTICITY INDEX
□	N/A	AOC4-Geo3-S4	15-16.5	Bag	SM	N/A	N/A

ENVIRONMENTAL GEOTECHNOLOGY LABORATORY

Project Name: PG & E Topock

Client: CH2M Hill

Job No: 382653.FP.03.01

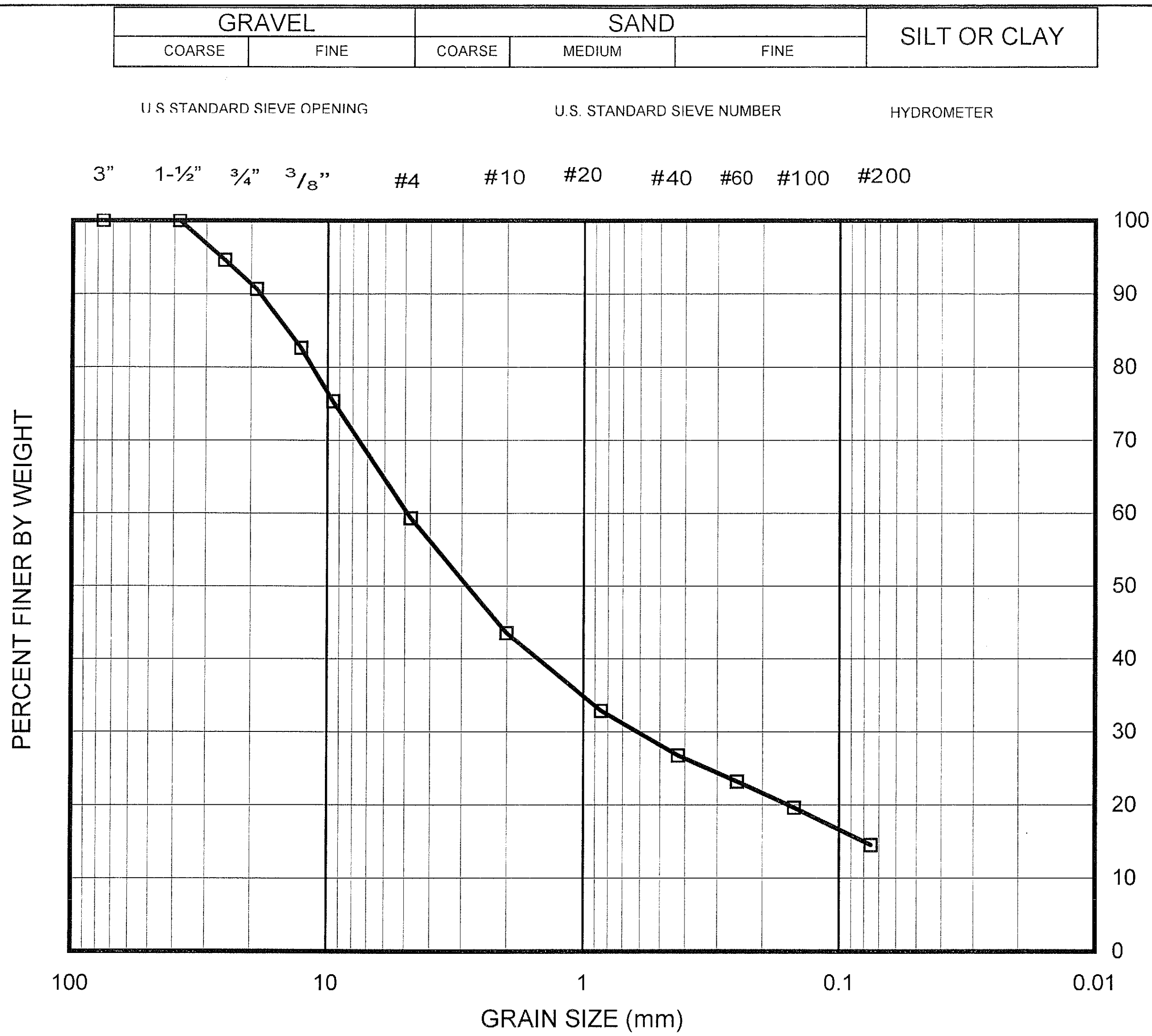
EGL Project No: 09-119-001

GRAINSIZE DISTRIBUTION CURVE

(ASTM D422)

08/21/09

FIGURE



SYMBOL	BORING NO	SAMPLE NO	DEPTH (FT)	SAMPLE TYPE	SOIL TYPE	LIQUID LIMIT	PLASTIC INDEX
□	N/A	AOC4-Geo4-B1	1-5	Bulk	SM	N/A	N/A

ENVIRONMENTAL GEOTECHNOLOGY LABORATORY

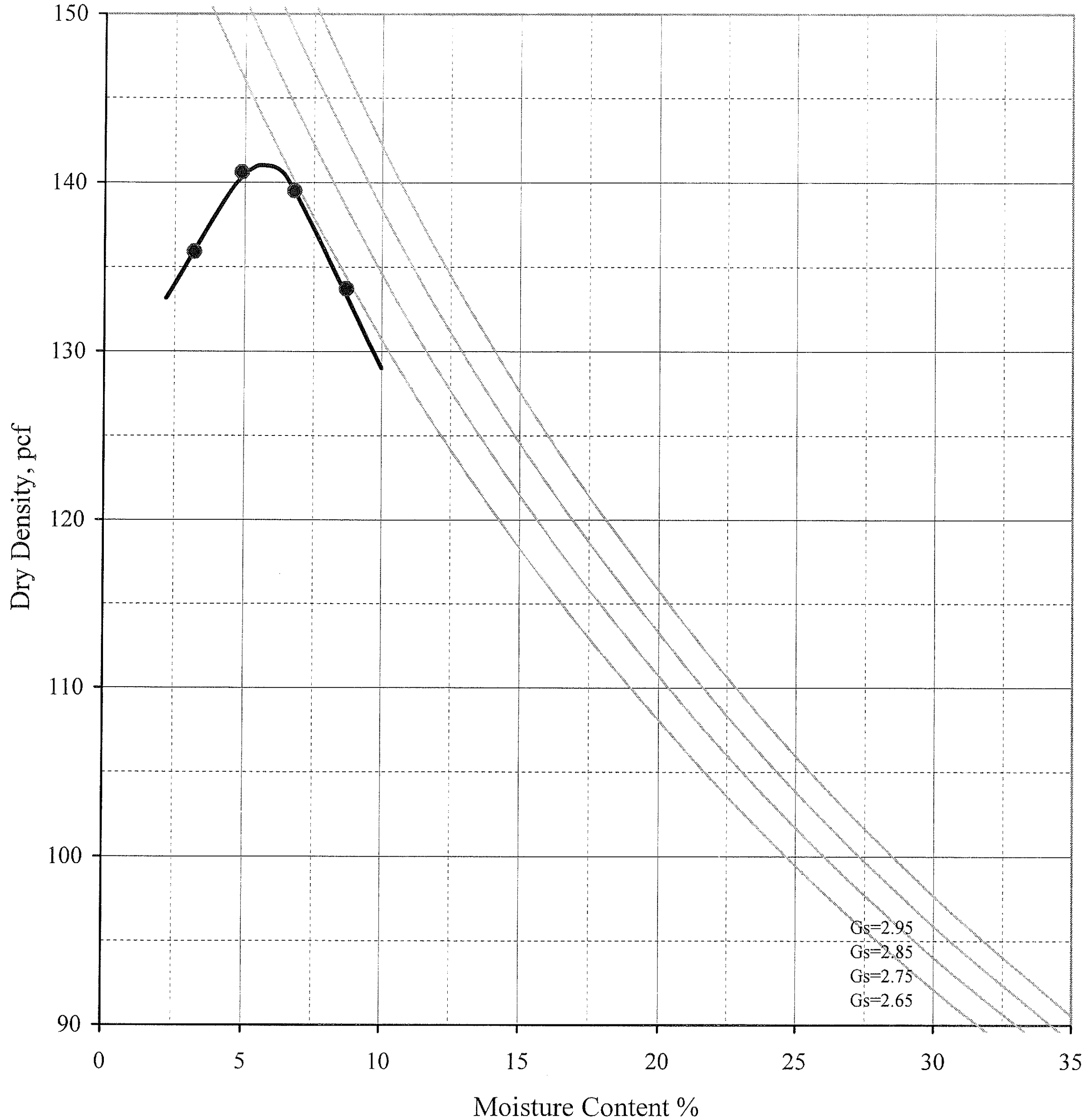
Project Name:
PG&E Topock

Client Job No.: 382653.FP.03.01
Client Name: CH2M Hill
EGL Project No: 09-119-001

GRAIN SIZE DISTRIBUTION CURVE
(ASTM D422)

Aug-09

FIGURE



Maximum Dry Density = 141 pcf

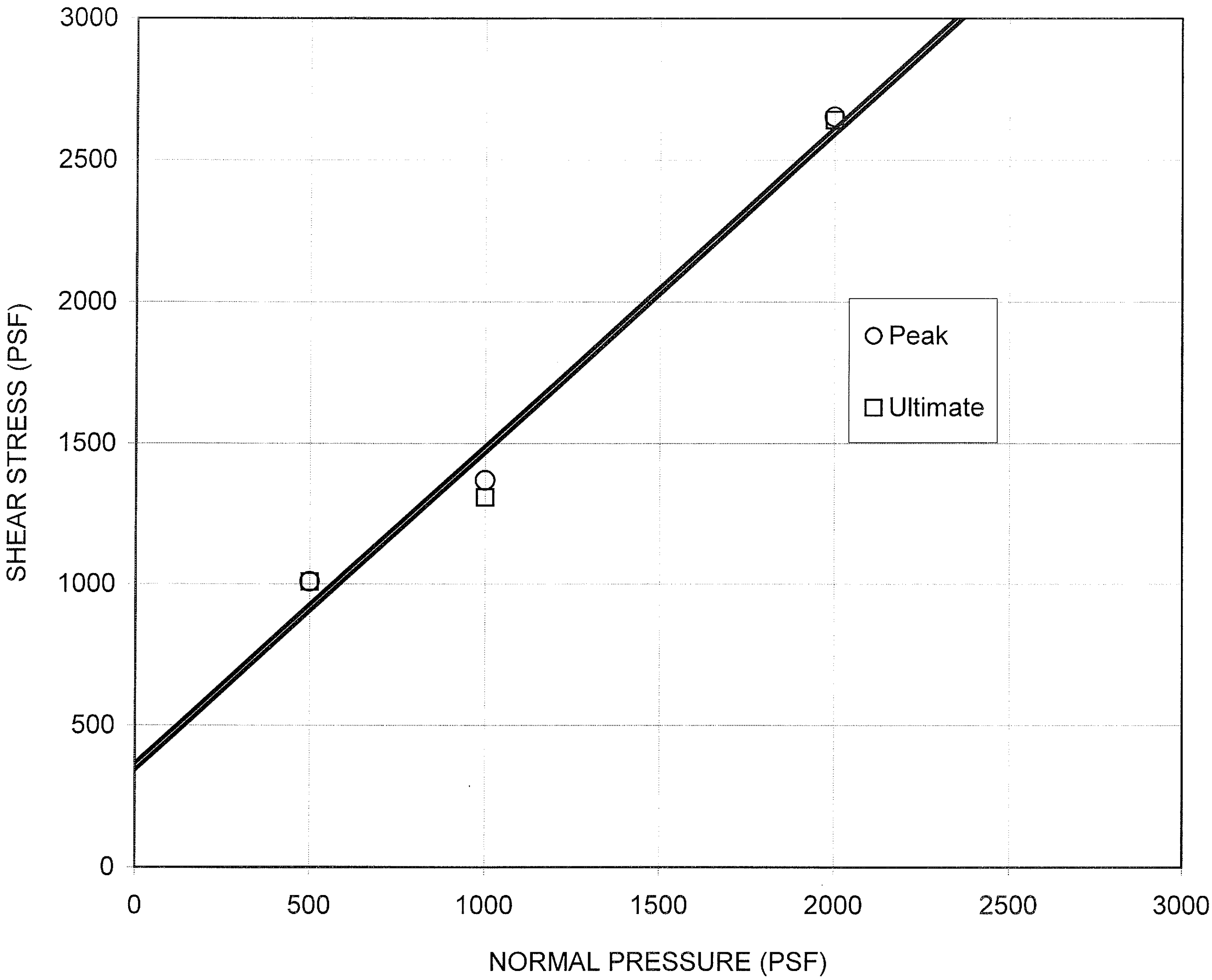
Optimum Moisture Content = 5.5 %

Boring No: N/A	
Sample: ACO4-Geo4-B1	
Depth : 1-5 feet	
Description : SC	
Project Name:	PG & E Topock
	0
Client Name:	CH2M Hill
Job No:	382653.FP.03.01
EGL Project No.:	09-119-001
Date : Aug-09	Figure

Environmental Geotechnology Laboratory

Modified Proctor

(ASTM D1557)



Boring No.:	Sample No.	Depth (ft)	Sample Type	Soil Type	Symbol	Cohesion (PSF)	Friction Angle
N/A	AOC4-Geo1-D3	10-11.5	Ring	SM	○	366	48
					□	342	48

Normal Stress (psf)	Initial Moisture (%)	Final Moisture (%)
500	1.5	14.3
1000	1.5	13.4
2000	1.5	12.1

ENVIRONMENTAL
GEOTECHNOLOGY
LABORATORY

Project Address:
PG&E Topock

Client: CH2M Hill

Project No: 382653.FP.03.01

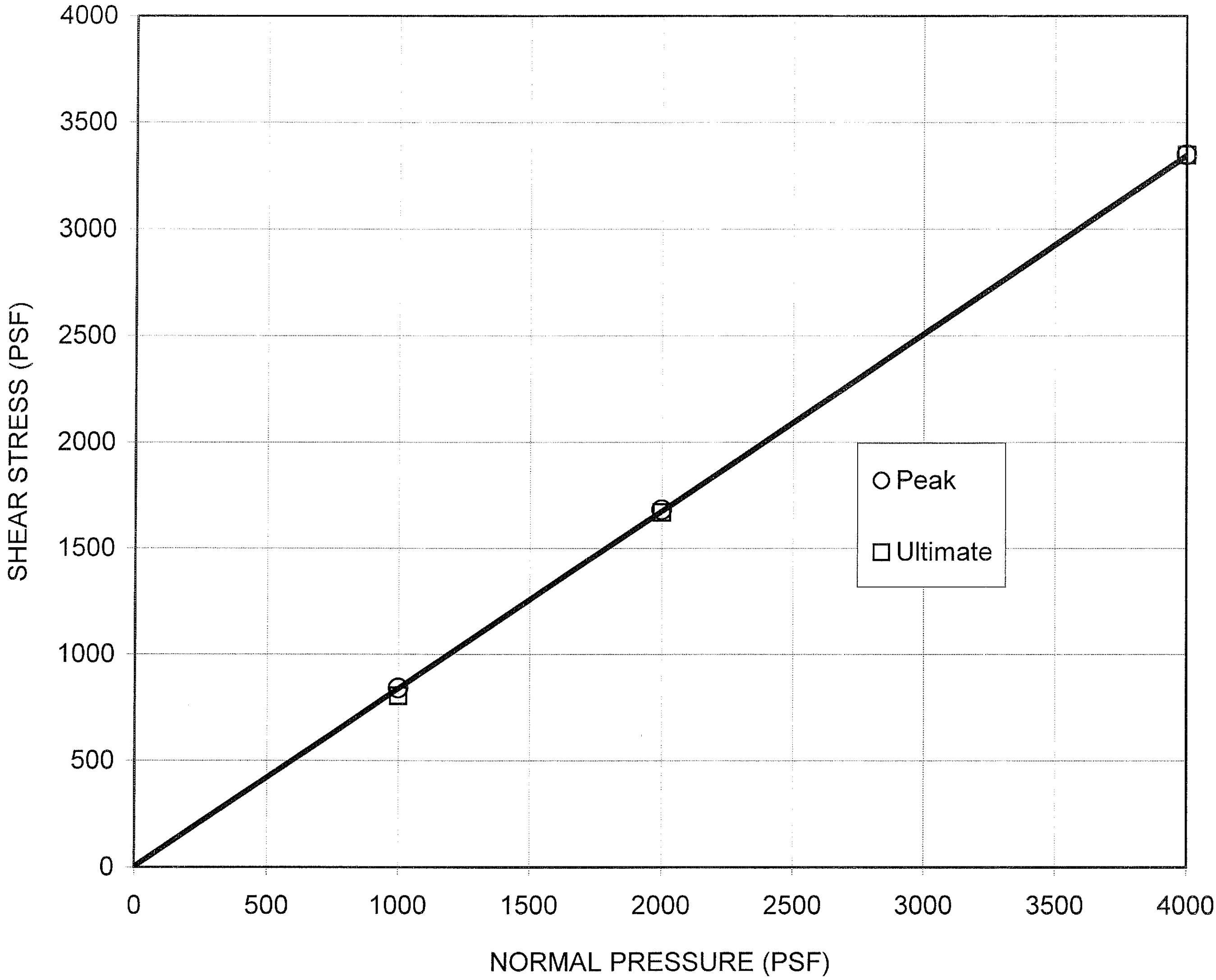
EGL Project No: 09-119-001

DIRECT SHEAR

08/09

(ASTM D3080)

Figure



Boring No.:	Sample No.	Depth (ft)	Sample Type	Soil Type	Symbol	Cohesion (PSF)	Friction Angle
N/A	AOC4-Geo1-D5	20-21.5	Ring	SM	○	6	40
					□	0	40

Normal Stress (psf)	Initial Moisture (%)	Final Moisture (%)
1000	1.7	16.3
2000	1.7	15.7
4000	1.7	15.1

ENVIRONMENTAL GEOTECHNOLOGY LABORATORY

Project Address:
PG&E Topock

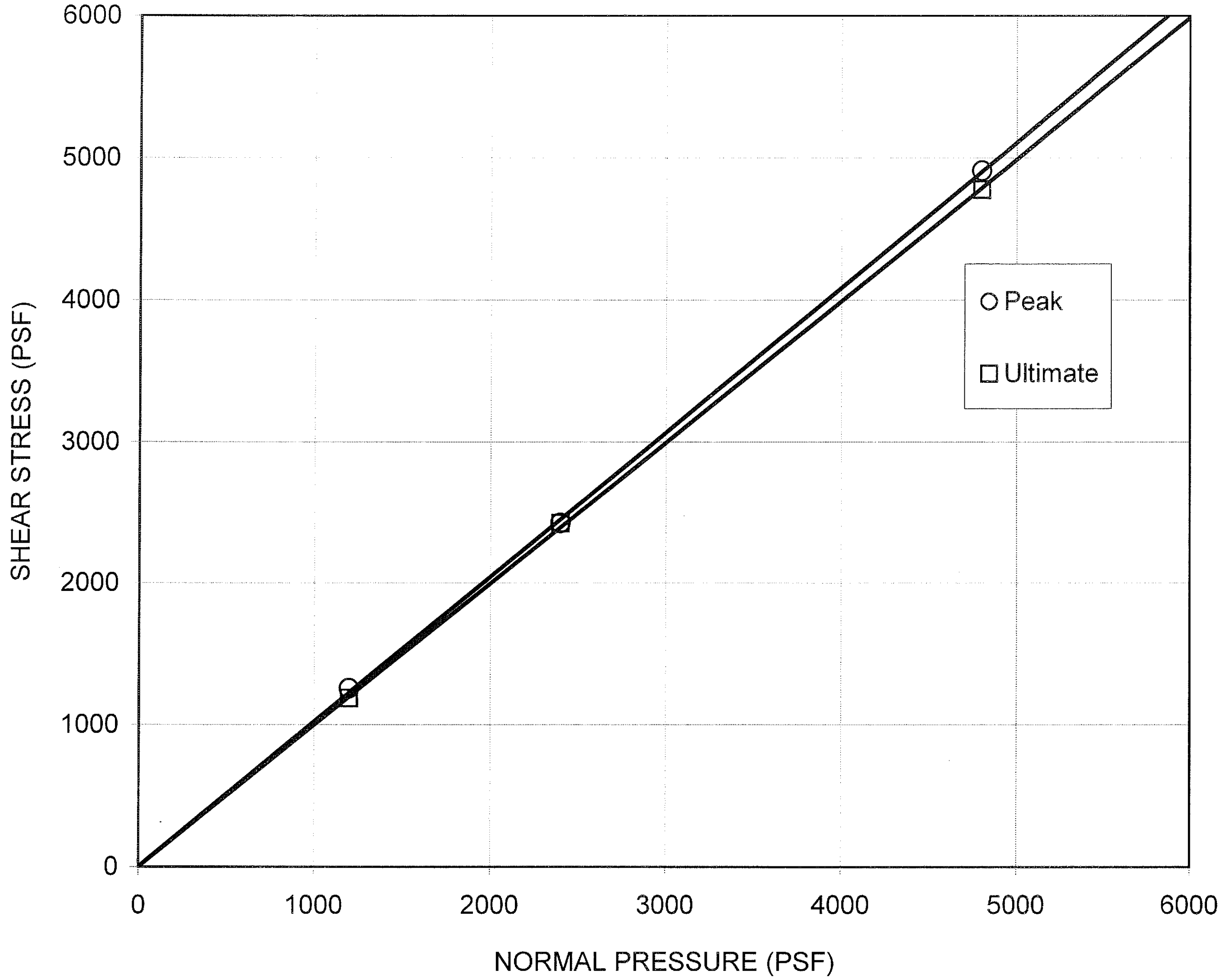
Client: CH2M Hill

Project No: 382653.FP.03.01

EGL Project No: 09-119-001

DIRECT SHEAR

08/09 (ASTM D3080) Figure



Boring No.:	Sample No.	Depth (ft)	Sample Type	Soil Type	Symbol	Cohesion (PSF)	Friction Angle
N/A	AOC4-Geo2-D5	20-21.5	Ring	SM	○	15	45
					□	13	45

Normal Stress (psf)	Initial Moisture (%)	Final Moisture (%)
1200	1.4	14.1
2400	1.4	13.7
4800	1.4	13.2

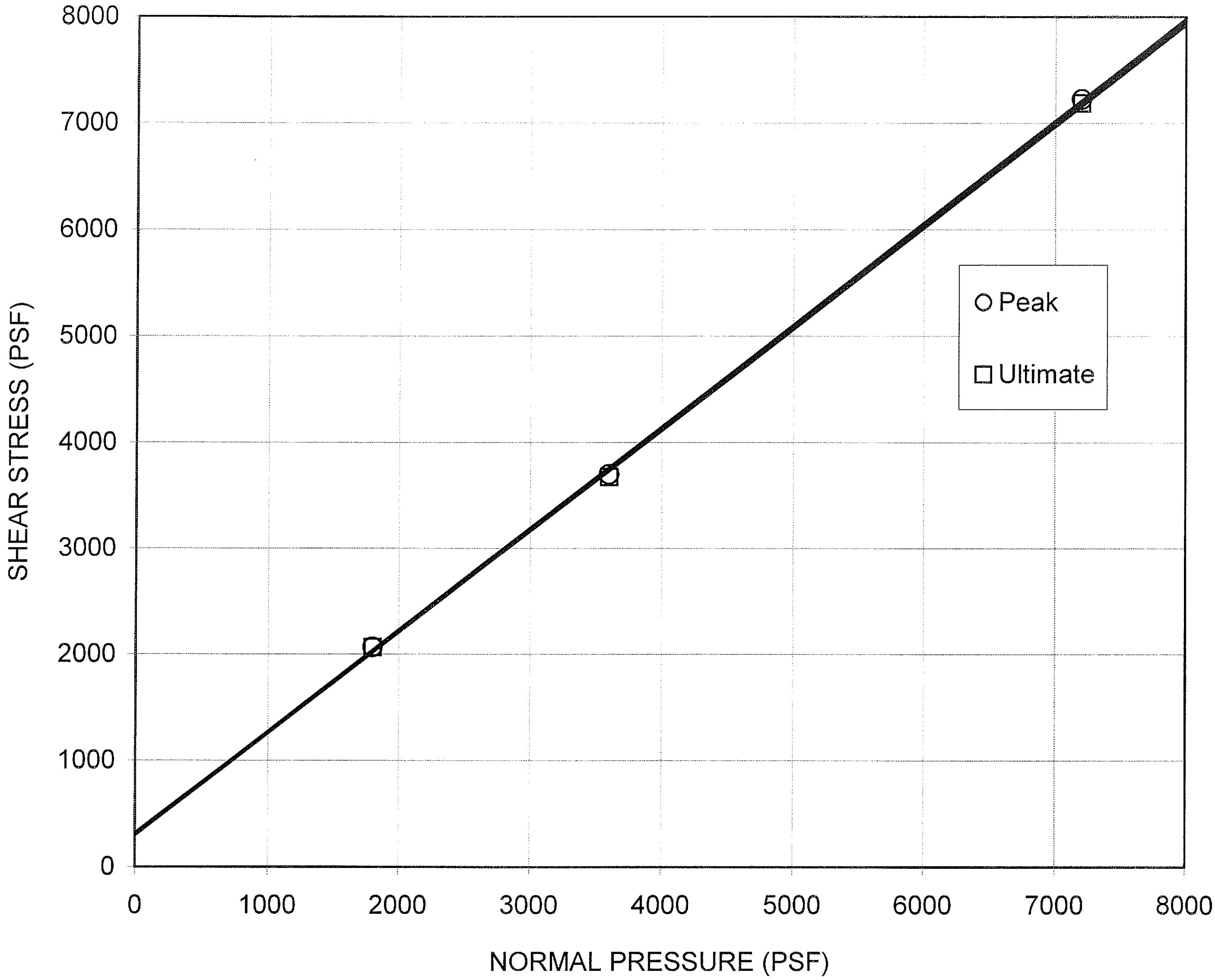
ENVIRONMENTAL GEOTECHNOLOGY LABORATORY

Project Address:
PG&E Topock

Client: CH2M Hill
Project No: 382653.FP.03.01
EGL Project No: 09-119-001

DIRECT SHEAR

08/09 (ASTM D3080) Figure



Boring No.:	Sample No.	Depth (ft)	Sample Type	Soil Type	Symbol	Cohesion (PSF)	Friction Angle
N/A	AOC4-Geo2-D7	30-31.5	Ring	SM	○	301	44
					□	307	44

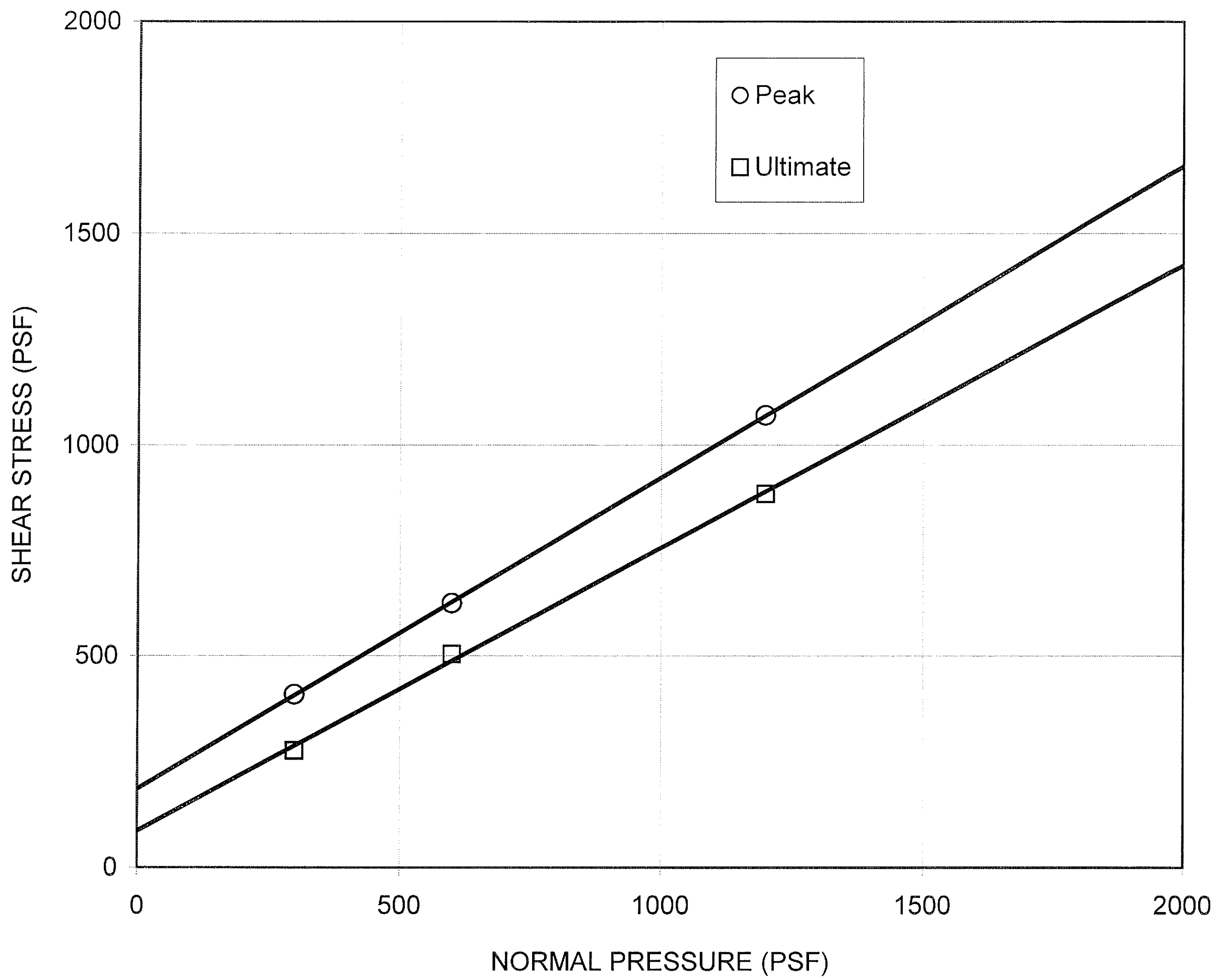
Normal Stress (psf)	Initial Moisture (%)	Final Moisture (%)
1800	0.9	12.8
3600	0.9	12.3
7200	0.9	11.0

EGL
ENVIRONMENTAL
GEOTECHNOLOGY
LABORATORY

Project Address:
PG&E Topock
Client: CH2M Hill
Project No: 382653.FP.03.01
EGL Project No: 09-119-001

DIRECT SHEAR

08/09 (ASTM D3080) Figure



Boring No.:	Sample No.	Depth (ft)	Sample Type	Soil Type	Symbol	Cohesion (PSF)	Friction Angle
N/A	AOC4-Geo2-B1	1-5	Bulk	SM	○	185	36
					□	86	34

Note: Sample was remolded to 90% maximum relative density and optimum moisture

Maximum Dry Density: 141 pcf Optimum Moisture: 5.5 %

Normal Stress (psf)	Initial Moisture (%)	Final Moisture (%)
300	5.5	13.1
600	5.5	12.5
1200	5.5	12.0

ENVIRONMENTAL GEOTECHNOLOGY LABORATORY

Project Address:
PG&E Topock

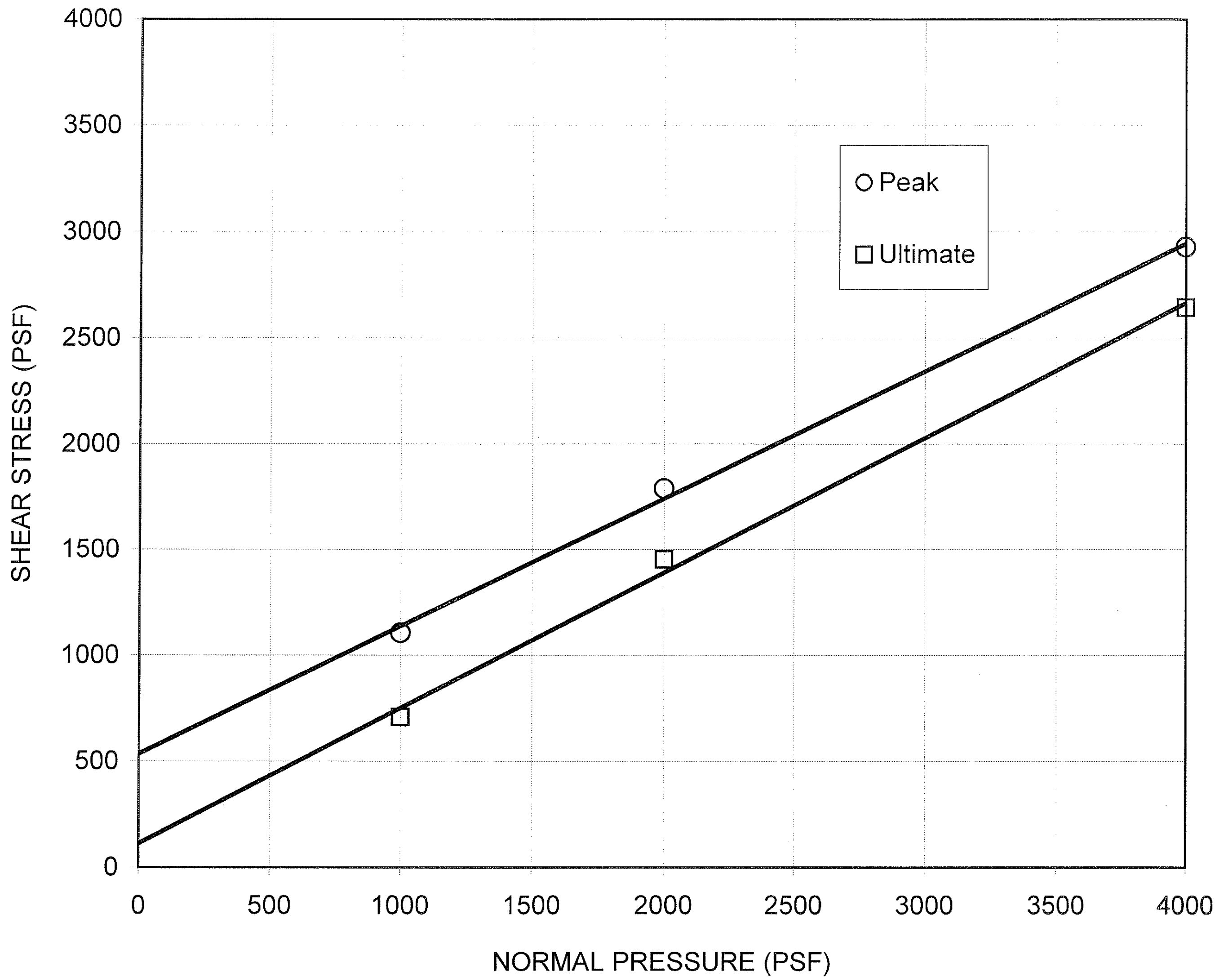
Client: CH2M Hill

Project No: 382653.FP.03.01

EGL Project No: 09-119-001

DIRECT SHEAR

08/09 (ASTM D3080) Figure



Boring No.:	Sample No.	Depth (ft)	Sample Type	Soil Type	Symbol	Cohesion (PSF)	Friction Angle
N/A	AOC4-Geo3-B5	16.5-20.0	Bulk	SM	○	534	31
					□	112	33

Note: Sample was remolded to 90% maximum relative density and optimum moisture

Maximum Dry Density: 141 pcf Optimum Moisture: 5.5 %

Normal Stress (psf)	Initial Moisture (%)	Final Moisture (%)
1000	5.5	12.9
2000	5.5	12.5
4000	5.5	12.3

ENVIRONMENTAL
GEOTECHNOLOGY
LABORATORY

Project Address:
PG&E Topock

Client: CH2M Hill

Project No: 382653.FP.03.01

EGL Project No: 09-119-001

DIRECT SHEAR

08/09 (ASTM D3080) Figure

Attachment D
Remediation Well Design and Field Approach
(*on CD-ROM only*)

1. Introduction

The three primary types of remediation wells that are part of the remedy design are as follows.

1) Extraction Wells
2) Freshwater/Upland Injection Wells
3) In-situ Reactive Zone (IRZ) Injection Wells

Although each type of remediation well has its specific function within the remedy design, there are design and construction objectives in common with each of the remediation wells. For example, each type of remediation well will be constructed within boreholes of 10-inch diameter or larger. Also common to each of the three types of remediation wells are the following overall design goals: (1) optimize the hydraulic connection between the remediation well and the natural subsurface materials (i.e., the formation); (2) select the optimal interval(s) at which to screen the well (i.e., the well screen interval[s]); and (3) build the well to ease/minimize well maintenance.

This Design Bulletin presents an approach for achieving these goals through well design planning and field construction methods. Section 2 presents the general design plan, including three designs for the remediation wells: (1) single-screen wells; (2) multi-screen wells; and (3) bedrock wells. Section 3 is a discussion of field methods to be considered for design and construction of the remediation wells. Additional details on the well construction approach are included in Section 3.2.1 of the Construction/Remedial Action Work Plan (C/RAWP) for the Final Groundwater Remedy (CH2M HILL 2015).

2. Remediation Well Design General Plan

Geology at the site consists of unconsolidated alluvial and fluvial sediments that overlie a conglomerate bedrock unit. The unconsolidated sediments are typically a poorly-sorted mixture of silt, sand, and gravel with varying amounts of clay, and these sediments vary in thickness significantly from north to south, with thicknesses of greater than 400 feet reported to the north near proposed well IRZ-1and less than 75 feet reported to the south near proposed well IRZ-39. The identification of distinct, laterally-continuous lithostratigraphic or hydrostratigraphic zones cannot be correlated from borehole to borehole. Therefore, the screened intervals proposed for the remediation wells as shown on Tables 3.2-1 through 3.2-3 and 3.3-1 of the Final BOD are preliminary, and are based in part on the total vertical thickness of the unconsolidated sediments that are saturated.

Final determination of the screened intervals will be made based on information collected in the field during construction of the wells (see Section 3.2.1 of the C/RAWP). Borehole data, discrete vertical interval sampling, and data from newly constructed wells may be used to inform each well design as the construction program proceeds. Information collected during the drilling of the boreholes can be used to identify permeable portions of the vertical section (i.e., these may represent target intervals for either extraction, injection, or delivery of the carbon source material), and, in the case of the IRZ wells, to identify the zones with the highest concentrations of Cr(VI). The screened intervals will be based on these considerations.

The remediation wells will be constructed using up to 12-inch nominal diameter well casing with one or more screens targeting a specific interval or intervals of the unconsolidated sediments (and also bedrock in several of the extraction wells). The following are three general designs for the remediation wells that will likely be implemented.

1) **Single Screen Wells –** This type of construction would consist of a single screen well installed within the unconsolidated sediments. The length of the screen would be based on formation thickness, the intended function of the well, and potentially other data developed in the field. This is the likely construction of the Freshwater Injection Wells, most of the Extraction Wells, and potentially some of the IRZ Injection Wells. Depending on the geologic conditions encountered in the field, it is possible that one or more blank sections of casing could be inserted within the screen zone to avoid screening intervals where significant fines are encountered.
2) **Multi-Screen Wells –** This type of construction would consist of two or more screens installed within the unconsolidated sediments. The well screen intervals would be selected using field data to target specific zones based on permeability and concentrations of Cr(VI) in groundwater. This is the expected construction for many of the IRZ Wells, although, as noted above, there is the potential that some of the IRZ Wells could be installed using a longer single screen design.
3) **Bedrock Wells –** This type of construction would consist of drilling through the unconsolidated sediments and installing an outer/conductor casing to the top of competent bedrock. After the conductor casing is installed the drilling methodology may change to accommodate drilling in the bedrock formation. Sonic, air rotary, rock hammer, and wire line drilling methods – or combinations of these methods – may be employed to reach the target depth within the bedrock. The final well construction may be either an open hole completion within the bedrock or a well with a single screened interval installed within the bedrock. This will depend on the competency of the bedrock. If the bedrock is weathered and/or unstable, it would be desirable to install a well with a single screen. The most appropriate construction will be deployed based on site conditions encountered in the East Ravine.

Details regarding well materials and surface completions are included in Section 3.2 of the Final BOD.

3. Field Methods

There are a number of potential tools that may be used for the collection and analysis of field data for final well design. Such tools described herein include: pilot borings, grain-size distribution analysis, vertical aquifer sampling, and downhole geophysical logging. These tools can be important in the selection and design of well screens and the associated filter pack material. Also discussed in this section are well drilling, construction, and development methods. Additional details regarding field data collection and well drilling, construction, and development methods are included in Section 3.2 of the C/RAWP (CH2M HILL 2015) and in standard operating procedures (SOPs) included in Appendix B of the C/RAWP (including SOP-A5, SOP-B3, SOP-B4, and SOP-B9).

It is likely that the field program will evolve as data are collected and assessed for the purposes of remediation well design. Thus, it is important that the well design program, including the field methods described below, retain a measure of flexibility.

Pilot Borings

Drilling boreholes of the size and depth necessary to install the remediation wells generally requires the use of rotary drilling methods (see below for further discussion of drilling methods). It is difficult when using rotary drilling methods to gain accurate and depth-specific information on subsurface materials. For this reason, it may be desirable to drill a smaller diameter (4 to 6-inch diameter) pilot boring at selected locations using the sonic drilling method. Pilot borings would facilitate the collection of a continuous core of subsurface materials, allowing more accurate visual assessment of the geology and selection of subsurface sediment and groundwater samples for further analysis in support of well design.

Visual Description and Grain-Size Distribution Analysis

The subsurface materials will be described in the field and written descriptions will be included on the field boring log. If a pilot boring is drilled at a location, then the continuous core would be described. If a pilot boring is not drilled then the cuttings would be described. The descriptions will be used to identify potential screen interval(s).

Subsurface sediment samples may be collected at several intervals and submitted to a geotechnical laboratory (potentially onsite if needed for quick sample analysis turnaround) for grain-size distribution analysis. The lab would run each subsurface sediment sample through a series of sieves to determine grain-size distribution. The grain-size distribution data would be used to custom design the remediation well screen slot size and filter pack (Driscoll 1987).

Vertical Aquifer Sampling

Vertical aquifer sampling (VAS) may be conducted at selected pilot borings to further define the subsurface distribution of Cr(VI) in groundwater. VAS depth interval(s) will be selected based on data developed during drilling of the pilot holes, available data from previous investigations, and general aquifer characteristics (i.e., saturated thickness, grain size distribution, etc.). The decision to conduct VAS at any individual pilot boring and the decision of which depth intervals to sample will likely evolve as the field program progresses.

VAS would likely be conducted as the borehole is advanced using a Hydro-Punch, a temporary well, or another alternate sampling method. The VAS sampling methodology selected would typically depend on drilling conditions and saturated aquifer thickness. In general, the Hydro-Punch method is quicker but typically produces a more turbid sample as compared to a temporary well method. The Hydro-Punch method is essentially a “grab” sample that allows for collection of a groundwater sample at a discrete depth without purging using a specialized tool that is run inside the drill stem using drilling rods. The temporary well sampling method uses a temporary 2-inch diameter well with an inflatable packer above the well screen; and once the target depth is reached, the temporary well is installed inside the drill stem which is then pulled back 5 feet to expose the screen to the formation. The packer is inflated to isolate the well screen from the overlying water column and then the well is purged/pumped to collect the sample.

In instances when drilling conditions are difficult, the Hydro-Punch method would likely be the preferred method. In instances when drilling conditions are not difficult, the temporary well method may be preferred due to its ability to produce a less turbid sample and its greater sample integrity.

Downhole Geophysical Logging

Another type of data that may be collected from the pilot borings is downhole geophysical logs. There are many types of geophysical logging instruments that could potentially be used to develop additional subsurface data at the site to assist with determining appropriate remediation well screened intervals. Some types of downhole geophysical logging devices require direct access to the formation while others can be used inside a casing. Because the borehole may collapse when the drill stem is pulled back within the unconsolidated sediments, downhole geophysical logging methods may be limited to those that can be used inside a casing. One such geophysical logging method that could be used inside a drilling casing would be gamma-ray logging (Keys 1988). If boreholes are stable, then open-hole borehole geophysical tools can be considered, including spontaneous potential, electrical resistivity, and sonic methods along with gamma-ray.

Screen and Filter Pack Design

There are two key well components that can be designed using site-specific lithologic data: well screen slot size and filter pack. The screen slot size for a particular well design may be selected on a site-specific basis using lithologic data collected from a pilot boring as described above (samples selected from a continuous core for grain-size distribution analysis). Otherwise, if there is found to be little variability in the subsurface sediments, a more qualitative averaging approach can be used to select the screen slot size instead.

Typical accepted screen slot size design recommendations for non-homogeneous formations allows for a range of 40-50% of the formation materials to pass through the screen based on the grain size distribution (Driscoll 1987 and Misstear et al. 2006). The percent passing recommendation for screen slot size selection may influence screen interval selection depending on the degree of heterogeneity in the subsurface materials.

Recommendations for well screen slot size design are typically a balance between maximizing open screen area which improves well performance and reduces the frequency of well maintenance, well development requirements which increase as percent passing increases, and the amount of fine-grained heterogeneities that could pose longer term turbidity issues in the well, a potential concern for the remediation wells. In some instances it may be desirable to recommend a different slot size for one portion of a screened interval compared to another or to even recommend that a blank section be installed.

In addition, the filter pack material that surrounds the screen may also be custom designed for each screen section in the well based on the formation grain-size and screen slot size recommendation. Typically, the recommended filter pack will consist of a well sorted, well rounded, sand of a grain size that allows <10% passing through the screen.

Well Drilling/Construction Methods

Unconsolidated Deposits

There are only a few drilling technologies available that will drill boreholes in the unconsolidated sediments of the size and depth needed to install the remediation wells. Drilling methods such as sonic and hollow stem augers are limited in regards to borehole diameter, and the cable tool method is generally considered too slow. Therefore, rotary methods are the likely recommendation for drilling the remediation wells in the unconsolidated sediments due to their speed and ability to drill large diameter (i.e., >12-inch diameter) boreholes to the likely target depths at the site. In general, it will be preferable to avoid the use of drilling mud to optimize the hydraulic connection between the well and the formation and to reduce the required well development time. For these reasons, dual tube rotary or reverse circulation rotary drilling methods which typically use water as drilling fluid would be preferred over the mud rotary drilling method. When pilot borings are needed the likely drilling method would be sonic.

Bedrock

The East Ravine area is the only location at the site where bedrock drilling is anticipated. Geology in this area consists of <200 feet of unconsolidated sediments directly on top of bedrock. As discussed above, the bedrock wells would consist of installing a conductor casing to the top of the bedrock (or perhaps a few feet into the bedrock if the bedrock is weathered) using sonic drilling, followed by changing drilling methods to air rotary, wire line, or another appropriate method to drill the bedrock portion of the borehole.

Well Development Methods

Well development is a primary step in optimizing well performance after well construction and before well operation. A variety of development methods may be used to properly develop the remediation wells, including over pumping, jetting, air lifting, surging, and backwashing. The specific development methods will be determined based on the drilling method, well construction characteristics such as the number and length of well screens, and the grain-size distribution and sorting of the formation.

In general, the goals of well development are to repair damage to the formation incurred during drilling, and to optimize the hydraulic connection of the well to the formation. Typically it is recommended that turbidity and potentially other field parameters such as conductivity and pH are measured in the extracted fluids during well development to assess progress. Additional details regarding well development, including criteria for determining whether a well is developed, are provided in Section 3.2.1 of the C/RAWP (CH2M HILL 2015).

REFERENCES

CH2M HILL. 2015. *Construction/Remedial Action Work Plan for the Final Groundwater Remedy, PG&E Topock Compressor Station, Needles, California*. November.

Driscoll. 1987. *Groundwater and Wells Second Edition*. Pub. Johnson Division, St. Paul, Minnesota 1089p.

Keys. 1988. *Borehole Geophysics Applied To Ground-Water Investigations*. United States Geological Survey Open File Report 87-539, Denver, Colorado 305p.

Misstear, Banks, and Clark. 2006. *Water Wells and Boreholes*. Pub. John Wiley & Sons, LTD, West Sussex, England 498p.

Attachment E
Firewater System Analyses
(*on CD-ROM only*)

By Paul Tjogas, E2 Consulting Engineers
August 2014

Topock Remediation Design

Hydraulic Analysis of Fire Water System

The existing fire water system at Topock Compressor Station needs to be expanded to accommodate new facilities associated with the groundwater remediation system. The existing fire water system is supplied from the freshwater tanks and consists of a pump station discharging to a six inch diameter distribution loop with branches to fourteen hydrants serving buildings and structures at the compressor station. This system needs to be expanded to provide water in case of fire at either the carbon amendment building at the TW bench or the MW-20 bench. A hydraulic network analysis was conducted to determine 1) the size of the expanded piping segments to serve TW and MW-20 bench, 2) whether existing storage capacity is sufficient and 3) if the existing fire pump station is adequate or needs to be modified.

A hydraulic network model of the expanded fire water system proposed for Topock remediation improvements was constructed using EPANET. EPANET is a software program that models water distribution piping systems. EPANET tracks the flow of water at each pipe, the pressure at each node, pumping heads and levels of water in tanks and reservoirs. Chemical species can be tracked, although that was not needed for the fire water system at Topock.

Pipe junctions, reservoirs and tanks are represented as nodes. A listing of nodes is contained on the following pages. Pipes, pumps and valves are represented as links. A listing of links is contained on the pages following the node listing. A schematic map showing the location of all nodes and links is shown on the sheet following the links listing.

The existing fire water system was compiled from as-built drawings when available. In the areas where as-built information was not available, piping routes were hypothesized based on logical assumptions. If more as-built information becomes available, then the analysis can be refined.

The piping routes and corridors for expanded piping segments have been approved by the client, Pacific Gas & Electric; however, they are subject to change pending stakeholder and regulatory review. The following summary describes the development of the hydraulic model:

Ground elevations for pipe junctions and tanks were taken from the final plan and profile sheets, which were based on the Toponex aerial survey. Pipe lengths have been taken off from plant as-built drawings and plan and profile drawings for the final submittal. Pump curve and test data was provided by PG & E

Projected fire flow demands are based on information provided from PG & E's fire protection consultant and data provided by the carbon amendment building designers. For the both the TW bench and MW-20 bench, the worst case fire flow scenario occurs at the carbon amendment buildings with its combustible roof and flammable liquid mixing. The projected fire flow demands are 0.30 gpm per sq ft plus a 500 gpm hose allowance. For the 480 sq ft building at the TW bench, this amounts to 644 gpm (at node 103). At the MW-20 bench this computes to 863 gpm (at node 102).

There are two existing fresh water tanks located above TCS at a base elevation of 672 feet (above sea level). Each tank is 30 feet high and contains 210,000 gallons. A minimum tank level of 2 feet and maximum tank level of 28 feet was assumed for this analysis.

There are two fire water pumps. One is an electric driven pump rated for approximately 900 gpm. The other is a diesel engine backup rated for approximately 1050 gpm.

Hazen-Williams C value of 120 was assumed for all existing pipes. New HDPE pipes were assumed to have a C value of 150.

The hydraulic network model of existing system was calibrated against the most recent pump test data results (September 2012) at hydrant 78. A comparison is shown in the table below.

Hydrant at Node 78	Measured	Modeled
Static pressure (closed)	160	156
Dynamic pressure (flowing)	98	96

Pipe sizing is an iterative process. After the initial simulation, pipe diameters for various segments of pipes are increased or decreased for subsequent simulations until an optimum size is selected for each segment. Typically, the criterion used for determining optimum size is unit head loss. In general, unit head losses of between 1 to 10 feet per 1,000 foot of pipe length yield the optimal combination of pipe capital cost and pumping energy costs. In this instance, the TW bench and MW-20 are sufficiently lower than the existing fire water system so that head losses in excess of 10 feet per 1,000 feet of pipe length are tolerable. The governing factor then becomes providing a minimum of 20 psi dynamic pressure at the hydrant. Hydraulic analysis simulations of 6 inch diameter (5.421 internal diameter for SDR 11 HDPE) for the expanded fire water piping yield sufficient dynamic pressures as shown in the table below:

Location	Pump	Tank Level	Residual Pressure
TW Bench	Electric	High	145
TW Bench	Electric	Low	133
TW Bench	Diesel	High	145
TW Bench	Diesel	Low	133
MW-20 Bench	Electric	High	44
MW-20 Bench	Electric	Low	33
MW-20 Bench	Diesel	High	44
MW-20 Bench	Diesel	Low	33

The criteria for fire flow volume is based on Insurance Services Office standard of one hour duration for each 1,000 gpm of fire flow plus one hour for each increment of 1,000 gpm fire flow. For the worst case scenario of 863 gpm, this indicates a one hour duration and a required fire flow volume of 51,780 gallons. The combined capacity of the 30 foot high freshwater tanks when full is 420,000 gallons, which is more than adequate. If the tanks are less than full, then storage is adequate assuming the following minimum tanks are maintained prior to the onset of a fire:

No. of Tanks in service	Supply wells	Required Minimum tank level
2	On	5.7
2	Off	7.2
1	On	9.4
1	Off	12.3

The required minimum tank level calculation assumes that the bottom two feet of the tank is dead storage and not available for consumption. It is assumed that the supply wells (from Arizona) will fully supply the groundwater remediation system and compressor system water demands during a fire flow emergency. If for some reason the supply wells are off (power outage, etc), then the tank must supply the fire flow (863 gpm) plus the combined remediation and compressor station demand (1200 gpm).

The supply well pumps will be set to maintain tanks levels significantly higher than the highest required minimum tank level (12.3).

The horsepower required to pump fire flows is less than the rated horsepower for the electric motor and diesel engine pumps. The electric driven pump results are summarized as follows:

Location	Q (gpm)	TDH (ft)	Pump Eff	Motor Eff	Hp	Rated Hp
TW bench	644	255.4	0.83	0.90	55.6	69.0
MW-20 bench	863	211.2	0.80	0.90	63.9	69.0

Q and TDH are taken from the hydraulic network simulations. Pump Eff is from the pump curves supplied by PG & E. Motor Eff is assumed at 90%. The rated hp includes a 1.15 service factor.

The diesel engine driven pump results are summarized as follows:

Location	Q (gpm)	TDH (ft)	Pump Eff	Engine Eff	Hp	Rated HP
TW bench	644	256.6	0.72	0.92	63.0	75.0
MW-20 bench	863	212.8	0.76	0.92	66.3	75.0

Q and TDH are taken from the hydraulic network simulations. Pump Eff and Engine Eff are from the pump curves supplied by PG & E. Engine Eff is back calculated from the engine hp curve.

The following conclusions may be drawn from the hydraulic analysis:

- Six inch diameter piping is sufficient for the expanded portion of the fire water system
- Existing storage is adequate for the fire flow scenarios anticipated
- Existing pumps are capable of supplying the worst case fire flows

If building sizes increase, then this analysis may need to be revisited.

By Paul Tjogas, E2 Consulting Engineers
August 2014

TCS Firewater Node Junction and Tank Data

Node	Type	Ground Elev	Demand
1	Tank	672	
2	Tank	672	
3	Junction	672	
4	Junction	627	
4A	Junction	627	
4B	Junction	627	
5	Junction	627	
5A	Junction	627	
5B	Junction	627	
6	Junction	627	
7	Junction	627	
8	Junction	621	
9	Junction	621	
10	Junction	617	
11	Junction	617	
12	Junction	623	
13	Junction	623	
14	Junction	621	
15	Junction	620	
16	Junction	617	
17	Junction	617	
18	Junction	617	
19	Junction	619	
20	Junction	621	
21	Junction	590	
22	Junction	590	
70	Hydrant	626	
71	Hydrant	626	
72	Hydrant	622	
73	Hydrant	626	
74	Hydrant	622	
75	Hydrant	622	
76	Hydrant	625	
77	Hydrant	622	
78	Hydrant	625	920
79	Hydrant	627	
80	Hydrant	622	
81	Hydrant	596	
82	Hydrant	590	
83	Hydrant	595	
101	Junction	532	
102	Junction	500	863
103	Junction	550	644

TCS Fire Water System Pipe and Pump Data

Link	Type	Upstr Node	Downstr Node	Dia (in)	Material	C value	Straight Length	Fitting Length	Equivalent Length	$V^2/2g$
1	Pipe	1	3	8	Stl	120	21	49	70	0.5
2	Pipe	2	3	8	Stl	120	21	49	70	0.5
3	Pipe	3	4	8	Stl	120	263	64	327	
4A	Pipe	4	4A	6	Stl	120	6	58	64	
4B	Pump	4A	4B							
4C	Pipe	4B	5	6	Stl	120	6	76	82	
5	Pipe	4	6	6	Stl	120	6	15	21	
6A	Pipe	6	6A	6	Stl	120	6	58	64	
6B	Pump	6A	6B							
6C	Pipe	6B	7	6	Stl	120	6	76	82	
7	Pipe	5	7	6	Stl	120	6	15	21	
8	Pipe	7	8	6	Stl	120	52	45	97	
9	Pipe	8	9	6	Stl	120	238	27	265	
10	Pipe	9	10	6	Stl	120	123	11	134	
11	Pipe	10	11	6	Stl	120	57	11	68	
12	Pipe	11	12	6	Stl	120	453	35	488	
13	Pipe	12	14	6	Stl	120	287	27	314	
14	Pipe	14	15	6	Stl	120	113	22	135	
15	Pipe	15	16	6	Stl	120	98	11	109	
16	Pipe	16	17	6	Stl	120	41	11	52	
17	Pipe	17	18	6	Stl	120	107	11	118	
18	Pipe	18	19	6	Stl	120	58	11	69	
19	Pipe	19	20	6	Stl	120	213	19	232	
20	Pipe	20	5	6	Stl	120	79	50	129	
21	Pipe	8	70	4	Stl	120	30	34	64	
22	Pipe	9	72	4	Stl	120	39	34	73	
23	Pipe	10	21	4	Stl	120	117	13	130	
24	Pipe	21	81	3	Stl	120	17	31	48	
25	Pipe	21	22	4	Stl	120	13	23	36	
26	Pipe	22	83	4	Stl	120	109	30	139	
27	Pipe	22	82	4	Stl	120	198	30	228	
28	Pipe	11	80	4	Stl	120	26	30	56	
29	Pipe	12	13	6	Stl	120	21	28	49	
30	Pipe	13	79	3	Stl	120	11	14	25	
31	Pipe	14	78	3	Stl	120	31	14	45	
32	Pipe	15	77	4	Stl	120	82	30	112	
33	Pipe	16	76	4	Stl	120	36	30	66	
34	Pipe	17	75	4	Stl	120	9	30	39	
35	Pipe	18	74	4	Stl	120	34	30	64	
36	Pipe	19	73	3	Stl	120	8	14	22	
37	Pipe	20	71	4	Stl	120	16	30	46	
101	Pipe	17	101	7.057	HDPE	150	911	55	966	
102	Pipe	101	102	5.421	HDPE	150	2661	283	2944	
103	Pipe	101	103	5.421	HDPE	150	290	45	335	

TCS Fire Pump Curve Data

Pump Curve Data				
Diesel Pump			Electric Pump	
Flow (gpm)	Head (ft)		Flow (gpm)	Head (ft)
0	144		0	290
200	140		200	286
400	130		400	280
600	117		600	265
800	100		800	229
1000	77		1000	170
1200	47		1200	100
Test Data				
Diesel Pump			Electric Pump	
Flow (gpm)	Head (ft)		Flow (gpm)	Head (ft)
0	334.56		0	281.50
272	318.41		450	276.88
800	230.73		784	239.96
1125	138.44		968	173.05

644 gpm fire flow at TW bench, electric pump on, high water tank levels

Network Table - Nodes

Node ID	Demand GPM	Head ft	Pressure psi
Junc 3	0.00	699.79	12.04
Junc 4	0.00	696.72	30.21
Junc 4A	0.00	694.28	29.15
Junc 4B	0.00	949.72	139.83
Junc 5	0.00	946.59	138.48
Junc 6A	0.00	696.72	30.21
Junc 6B	0.00	946.48	138.43
Junc 6	0.00	696.72	30.21
Junc 7	0.00	946.48	138.43
Junc 8	0.00	945.94	140.80
Junc 9	0.00	944.47	140.16
Junc 10	0.00	943.73	141.57
Junc 11	0.00	943.36	141.41
Junc 12	0.00	940.65	137.64
Junc 13	0.00	940.65	137.64
Junc 14	0.00	938.92	137.75
Junc 15	0.00	938.17	137.86
Junc 16	0.00	937.57	138.90
Junc 17	0.00	937.28	138.78
Junc 18	0.00	939.28	139.65
Junc 19	0.00	940.46	139.29
Junc 20	0.00	944.40	140.13
Junc 21	0.00	943.73	153.27
Junc 22	0.00	943.73	153.27
Junc 70	0.00	945.94	138.63

644 gpm fire flow at TW bench, electric pump on, high water tank levels

Node ID	Demand GPM	Head ft	Pressure psi
Junc 71	0.00	944.40	137.96
Junc 72	0.00	944.47	139.73
Junc 73	0.00	940.46	136.25
Junc 74	0.00	939.28	137.48
Junc 75	0.00	937.28	136.61
Junc 76	0.00	937.57	135.43
Junc 77	0.00	938.17	137.00
Junc 78	0.00	938.92	136.02
Junc 79	0.00	940.65	135.91
Junc 80	0.00	943.36	139.24
Junc 81	0.00	943.73	150.67
Junc 82	0.00	943.73	153.27
Junc 83	0.00	943.73	151.11
Junc 101	0.00	897.39	158.32
Junc 102	0.00	897.39	172.19
Junc 103	644.00	883.56	144.53
Tank 1	-322.01	700.00	12.13
Tank 2	-322.01	700.00	12.13

644 gpm fire flow at TW bench, electric pump on, high water tank levels

Network Table - Links

Link ID	Flow GPM	Velocity fps	Unit Headloss ft/Kft	Status
Pipe 1	322.01	2.06	3.07	Open
Pipe 2	322.01	2.06	3.07	Open
Pipe 3	644.01	4.11	9.38	Open
Pipe 4A	644.01	7.31	38.08	Open
Pipe 4C	644.01	7.31	38.08	Open
Pipe 5	0.00	0.00	0.00	Open
Pipe 6A	0.00	0.00	0.00	Open
Pipe 6C	0.00	0.00	0.00	Open
Pipe 7	227.34	2.58	5.53	Open
Pipe 8	227.34	2.58	5.54	Open
Pipe 9	227.34	2.58	5.54	Open
Pipe 10	227.34	2.58	5.54	Open
Pipe 11	227.34	2.58	5.54	Open
Pipe 12	227.34	2.58	5.54	Open
Pipe 13	227.33	2.58	5.54	Open
Pipe 14	227.33	2.58	5.54	Open
Pipe 15	227.33	2.58	5.54	Open
Pipe 16	227.33	2.58	5.54	Open
Pipe 17	-416.67	4.73	17.00	Open
Pipe 18	-416.67	4.73	17.00	Open
Pipe 19	-416.67	4.73	17.00	Open
Pipe 20	-416.67	4.73	17.00	Open
Pipe 21	0.00	0.00	0.00	Open
Pipe 22	0.00	0.00	0.00	Open
Pipe 23	0.00	0.00	0.00	Open

644 gpm fire flow at TW bench, electric pump on, high water tank levels

Link ID	Flow GPM	Velocity fps	Unit Headloss ft/Kft	Status
Pipe 24	0.00	0.00	0.00	Open
Pipe 25	0.00	0.00	0.00	Open
Pipe 26	0.00	0.00	0.00	Open
Pipe 27	0.00	0.00	0.00	Open
Pipe 28	0.00	0.00	0.00	Open
Pipe 29	0.00	0.00	0.00	Open
Pipe 30	0.00	0.00	0.00	Open
Pipe 31	0.00	0.00	0.00	Open
Pipe 32	0.00	0.00	0.00	Open
Pipe 33	0.00	0.00	0.00	Open
Pipe 34	0.00	0.00	0.00	Open
Pipe 35	0.00	0.00	0.00	Open
Pipe 36	0.00	0.00	0.00	Open
Pipe 37	0.00	0.00	0.00	Open
Pipe 101	644.00	8.95	41.29	Open
Pipe 102	0.00	0.00	0.00	Open
Pipe 103	644.00	8.95	41.29	Open
Pump 4B	644.01	0.00	-255.43	Open
Pump 6B	0.00	0.00	0.00	Closed

644 gpm fire flow at TW bench, electric pump on, low water tank levels

Network Table - Nodes

Node ID	Demand GPM	Head ft	Pressure psi
Junc 3	0.00	673.79	0.77
Junc 4	0.00	670.72	18.94
Junc 4A	0.00	668.28	17.89
Junc 4B	0.00	923.72	128.57
Junc 5	0.00	920.59	127.21
Junc 6A	0.00	670.72	18.94
Junc 6B	0.00	920.48	127.16
Junc 6	0.00	670.72	18.94
Junc 7	0.00	920.48	127.16
Junc 8	0.00	919.94	129.53
Junc 9	0.00	918.47	128.90
Junc 10	0.00	917.73	130.31
Junc 11	0.00	917.35	130.14
Junc 12	0.00	914.65	126.37
Junc 13	0.00	914.65	126.37
Junc 14	0.00	912.92	126.49
Junc 15	0.00	912.17	126.60
Junc 16	0.00	911.56	127.63
Junc 17	0.00	911.28	127.51
Junc 18	0.00	913.28	128.38
Junc 19	0.00	914.46	128.02
Junc 20	0.00	918.40	128.86
Junc 21	0.00	917.73	142.01
Junc 22	0.00	917.73	142.01
Junc 70	0.00	919.94	127.36

644 gpm fire flow at TW bench, electric pump on, low water tank levels

Node ID	Demand GPM	Head ft	Pressure psi
Junc 71	0.00	918.40	126.70
Junc 72	0.00	918.47	128.46
Junc 73	0.00	914.46	124.99
Junc 74	0.00	913.28	126.21
Junc 75	0.00	911.28	125.34
Junc 76	0.00	911.56	124.17
Junc 77	0.00	912.17	125.73
Junc 78	0.00	912.92	124.75
Junc 79	0.00	914.65	124.64
Junc 80	0.00	917.35	127.98
Junc 81	0.00	917.73	139.41
Junc 82	0.00	917.73	142.01
Junc 83	0.00	917.73	139.84
Junc 101	0.00	871.39	147.06
Junc 102	0.00	871.39	160.92
Junc 103	644.00	857.56	133.26
Tank 1	-322.01	674.00	0.87
Tank 2	-322.01	674.00	0.87

644 gpm fire flow at TW bench, electric pump on, low water tank levels

Network Table - Links

Link ID	Flow GPM	Velocity fps	Unit Headloss ft/Kft	Status
Pipe 1	322.01	2.06	3.07	Open
Pipe 2	322.01	2.06	3.07	Open
Pipe 3	644.01	4.11	9.38	Open
Pipe 4A	644.01	7.31	38.08	Open
Pipe 4C	644.01	7.31	38.08	Open
Pipe 5	0.00	0.00	0.00	Open
Pipe 6A	0.00	0.00	0.00	Open
Pipe 6C	0.00	0.00	0.00	Open
Pipe 7	227.34	2.58	5.54	Open
Pipe 8	227.34	2.58	5.54	Open
Pipe 9	227.34	2.58	5.54	Open
Pipe 10	227.34	2.58	5.54	Open
Pipe 11	227.34	2.58	5.54	Open
Pipe 12	227.34	2.58	5.54	Open
Pipe 13	227.33	2.58	5.54	Open
Pipe 14	227.33	2.58	5.54	Open
Pipe 15	227.33	2.58	5.54	Open
Pipe 16	227.33	2.58	5.54	Open
Pipe 17	-416.67	4.73	17.00	Open
Pipe 18	-416.67	4.73	17.00	Open
Pipe 19	-416.67	4.73	17.00	Open
Pipe 20	-416.67	4.73	17.00	Open
Pipe 21	0.00	0.00	0.00	Open
Pipe 22	0.00	0.00	0.00	Open
Pipe 23	0.00	0.00	0.00	Open

644 gpm fire flow at TW bench, electric pump on, low water tank levels

Link ID	Flow GPM	Velocity fps	Unit Headloss ft/Kft	Status
Pipe 24	0.00	0.00	0.00	Open
Pipe 25	0.00	0.00	0.00	Open
Pipe 26	0.00	0.00	0.00	Open
Pipe 27	0.00	0.00	0.00	Open
Pipe 28	0.00	0.00	0.00	Open
Pipe 29	0.00	0.00	0.00	Open
Pipe 30	0.00	0.00	0.00	Open
Pipe 31	0.00	0.00	0.00	Open
Pipe 32	0.00	0.00	0.00	Open
Pipe 33	0.00	0.00	0.00	Open
Pipe 34	0.00	0.00	0.00	Open
Pipe 35	0.00	0.00	0.00	Open
Pipe 36	0.00	0.00	0.00	Open
Pipe 37	0.00	0.00	0.00	Open
Pipe 101	644.00	8.95	41.29	Open
Pipe 102	0.00	0.00	0.00	Open
Pipe 103	644.00	8.95	41.29	Open
Pump 4B	644.01	0.00	-255.43	Open
Pump 6B	0.00	0.00	0.00	Closed

644 gpm fire flow at TW bench, diesel pump on, high water tank levels

Network Table - Nodes

Node ID	Demand GPM	Head ft	Pressure psi
Junc 3	0.00	699.79	12.04
Junc 4	0.00	696.72	30.21
Junc 4A	0.00	696.72	30.21
Junc 4B	0.00	946.64	138.50
Junc 5	0.00	946.64	138.50
Junc 6A	0.00	693.48	28.81
Junc 6B	0.00	950.12	140.01
Junc 6	0.00	695.92	29.86
Junc 7	0.00	947.00	138.65
Junc 8	0.00	946.44	141.01
Junc 9	0.00	944.93	140.36
Junc 10	0.00	944.16	141.76
Junc 11	0.00	943.77	141.59
Junc 12	0.00	940.98	137.78
Junc 13	0.00	940.98	137.78
Junc 14	0.00	939.19	137.87
Junc 15	0.00	938.41	137.97
Junc 16	0.00	937.79	139.00
Junc 17	0.00	937.49	138.87
Junc 18	0.00	939.46	139.72
Junc 19	0.00	940.62	139.36
Junc 20	0.00	944.49	140.17
Junc 21	0.00	944.16	153.46
Junc 22	0.00	944.16	153.46
Junc 70	0.00	946.44	138.85

644 gpm fire flow at TW bench, diesel pump on, high water tank levels

Node ID	Demand GPM	Head ft	Pressure psi
Junc 71	0.00	944.49	138.00
Junc 72	0.00	944.93	139.92
Junc 73	0.00	940.62	136.32
Junc 74	0.00	939.46	137.56
Junc 75	0.00	937.49	136.70
Junc 76	0.00	937.79	135.53
Junc 77	0.00	938.41	137.10
Junc 78	0.00	939.19	136.14
Junc 79	0.00	940.98	136.05
Junc 80	0.00	943.77	139.42
Junc 81	0.00	944.16	150.86
Junc 82	0.00	944.16	153.46
Junc 83	0.00	944.16	151.29
Junc 101	0.00	897.61	158.42
Junc 102	0.00	897.61	172.28
Junc 103	644.00	883.77	144.62
Tank 1	-322.00	700.00	12.13
Tank 2	-322.00	700.00	12.13

644 gpm fire flow at TW bench, diesel pump on, high water tank levels

Network Table - Links

Link ID	Flow GPM	Velocity fps	Unit Headloss ft/Kft	Status
Pipe 1	322.00	2.06	3.07	Open
Pipe 2	322.00	2.06	3.07	Open
Pipe 3	644.00	4.11	9.38	Open
Pipe 4A	0.00	0.00	0.00	Open
Pipe 4C	0.00	0.00	0.00	Open
Pipe 5	644.00	7.31	38.08	Open
Pipe 6A	644.00	7.31	38.08	Open
Pipe 6C	644.00	7.31	38.08	Open
Pipe 7	-412.67	4.68	16.70	Open
Pipe 8	231.33	2.62	5.72	Open
Pipe 9	231.33	2.62	5.72	Open
Pipe 10	231.33	2.62	5.72	Open
Pipe 11	231.33	2.62	5.72	Open
Pipe 12	231.33	2.62	5.72	Open
Pipe 13	231.33	2.62	5.72	Open
Pipe 14	231.33	2.62	5.72	Open
Pipe 15	231.33	2.62	5.72	Open
Pipe 16	231.33	2.62	5.72	Open
Pipe 17	-412.67	4.68	16.70	Open
Pipe 18	-412.67	4.68	16.70	Open
Pipe 19	-412.67	4.68	16.70	Open
Pipe 20	-412.67	4.68	16.70	Open
Pipe 21	0.00	0.00	0.00	Open
Pipe 22	0.00	0.00	0.00	Open
Pipe 23	0.00	0.00	0.00	Open

644 gpm fire flow at TW bench, diesel pump on, high water tank levels

Link ID	Flow GPM	Velocity fps	Unit Headloss ft/Kft	Status
Pipe 24	0.00	0.00	0.00	Open
Pipe 25	0.00	0.00	0.00	Open
Pipe 26	0.00	0.00	0.00	Open
Pipe 27	0.00	0.00	0.00	Open
Pipe 28	0.00	0.00	0.00	Open
Pipe 29	0.00	0.00	0.00	Open
Pipe 30	0.00	0.00	0.00	Open
Pipe 31	0.00	0.00	0.00	Open
Pipe 32	0.00	0.00	0.00	Open
Pipe 33	0.00	0.00	0.00	Open
Pipe 34	0.00	0.00	0.00	Open
Pipe 35	0.00	0.00	0.00	Open
Pipe 36	0.00	0.00	0.00	Open
Pipe 37	0.00	0.00	0.00	Open
Pipe 101	644.00	8.95	41.29	Open
Pipe 102	0.00	0.00	0.00	Open
Pipe 103	644.00	8.95	41.29	Open
Pump 4B	0.00	0.00	0.00	Closed
Pump 6B	644.00	0.00	-256.64	Open

644 gpm fire flow at TW bench, diesel pump on, low water tank levels

Network Table - Nodes

Node ID	Demand GPM	Head ft	Pressure psi
Junc 3	0.00	673.79	0.77
Junc 4	0.00	670.72	18.94
Junc 4A	0.00	670.72	18.94
Junc 4B	0.00	920.64	127.24
Junc 5	0.00	920.64	127.24
Junc 6A	0.00	667.48	17.54
Junc 6B	0.00	924.12	128.74
Junc 6	0.00	669.92	18.60
Junc 7	0.00	921.00	127.39
Junc 8	0.00	920.44	129.75
Junc 9	0.00	918.93	129.09
Junc 10	0.00	918.16	130.49
Junc 11	0.00	917.77	130.32
Junc 12	0.00	914.98	126.52
Junc 13	0.00	914.98	126.52
Junc 14	0.00	913.19	126.60
Junc 15	0.00	912.41	126.70
Junc 16	0.00	911.79	127.73
Junc 17	0.00	911.49	127.60
Junc 18	0.00	913.46	128.46
Junc 19	0.00	914.62	128.09
Junc 20	0.00	918.49	128.90
Junc 21	0.00	918.16	142.19
Junc 22	0.00	918.16	142.19
Junc 70	0.00	920.44	127.58

644 gpm fire flow at TW bench, diesel pump on, low water tank levels

Node ID	Demand GPM	Head ft	Pressure psi
Junc 71	0.00	918.49	126.74
Junc 72	0.00	918.93	128.66
Junc 73	0.00	914.62	125.06
Junc 74	0.00	913.46	126.29
Junc 75	0.00	911.49	125.44
Junc 76	0.00	911.79	124.27
Junc 77	0.00	912.41	125.84
Junc 78	0.00	913.19	124.87
Junc 79	0.00	914.98	124.78
Junc 80	0.00	917.77	128.16
Junc 81	0.00	918.16	139.59
Junc 82	0.00	918.16	142.19
Junc 83	0.00	918.16	140.03
Junc 101	0.00	871.61	147.15
Junc 102	0.00	871.61	161.02
Junc 103	644.00	857.77	133.36
Tank 1	-322.00	674.00	0.87
Tank 2	-322.00	674.00	0.87

644 gpm fire flow at TW bench, diesel pump on, low water tank levels

Network Table - Links

Link ID	Flow GPM	Velocity fps	Unit Headloss ft/Kft	Status
Pipe 1	322.00	2.06	3.07	Open
Pipe 2	322.00	2.06	3.07	Open
Pipe 3	644.00	4.11	9.38	Open
Pipe 4A	0.00	0.00	0.00	Open
Pipe 4C	0.00	0.00	0.00	Open
Pipe 5	644.00	7.31	38.08	Open
Pipe 6A	644.00	7.31	38.08	Open
Pipe 6C	644.00	7.31	38.08	Open
Pipe 7	-412.67	4.68	16.70	Open
Pipe 8	231.33	2.62	5.72	Open
Pipe 9	231.33	2.62	5.72	Open
Pipe 10	231.33	2.62	5.72	Open
Pipe 11	231.33	2.62	5.72	Open
Pipe 12	231.33	2.62	5.72	Open
Pipe 13	231.33	2.62	5.72	Open
Pipe 14	231.33	2.62	5.72	Open
Pipe 15	231.33	2.62	5.72	Open
Pipe 16	231.33	2.62	5.72	Open
Pipe 17	-412.67	4.68	16.70	Open
Pipe 18	-412.67	4.68	16.70	Open
Pipe 19	-412.67	4.68	16.70	Open
Pipe 20	-412.67	4.68	16.70	Open
Pipe 21	0.00	0.00	0.00	Open
Pipe 22	0.00	0.00	0.00	Open
Pipe 23	0.00	0.00	0.00	Open

644 gpm fire flow at TW bench, diesel pump on, low water tank levels

Link ID	Flow GPM	Velocity fps	Unit Headloss ft/Kft	Status
Pipe 24	0.00	0.00	0.00	Open
Pipe 25	0.00	0.00	0.00	Open
Pipe 26	0.00	0.00	0.00	Open
Pipe 27	0.00	0.00	0.00	Open
Pipe 28	0.00	0.00	0.00	Open
Pipe 29	0.00	0.00	0.00	Open
Pipe 30	0.00	0.00	0.00	Open
Pipe 31	0.00	0.00	0.00	Open
Pipe 32	0.00	0.00	0.00	Open
Pipe 33	0.00	0.00	0.00	Open
Pipe 34	0.00	0.00	0.00	Open
Pipe 35	0.00	0.00	0.00	Open
Pipe 36	0.00	0.00	0.00	Open
Pipe 37	0.00	0.00	0.00	Open
Pipe 101	644.00	8.95	41.29	Open
Pipe 102	0.00	0.00	0.00	Open
Pipe 103	644.00	8.95	41.29	Open
Pump 4B	0.00	0.00	0.00	Closed
Pump 6B	644.00	0.00	-256.64	Open

863 gpm fire flow at MW-20 bench, electric pump on, high water tank levels

Network Table - Nodes

Node ID	Demand GPM	Head ft	Pressure psi
Junc 3	0.00	699.63	11.97
Junc 4	0.00	694.36	29.19
Junc 4A	0.00	690.16	27.37
Junc 4B	0.00	901.39	118.89
Junc 5	0.00	896.02	116.57
Junc 6A	0.00	694.36	29.19
Junc 6B	0.00	895.82	116.48
Junc 6	0.00	694.36	29.19
Junc 7	0.00	895.82	116.48
Junc 8	0.00	894.90	118.68
Junc 9	0.00	892.38	117.59
Junc 10	0.00	891.10	118.77
Junc 11	0.00	890.45	118.49
Junc 12	0.00	885.81	113.88
Junc 13	0.00	885.81	113.88
Junc 14	0.00	882.82	113.45
Junc 15	0.00	881.54	113.32
Junc 16	0.00	880.50	114.17
Junc 17	0.00	880.00	113.96
Junc 18	0.00	883.45	115.45
Junc 19	0.00	885.47	115.46
Junc 20	0.00	892.25	117.53
Junc 21	0.00	891.10	130.47
Junc 22	0.00	891.10	130.47
Junc 70	0.00	894.90	116.51

863 gpm fire flow at MW-20 bench, electric pump on, high water tank levels

Node ID	Demand GPM	Head ft	Pressure psi
Junc 71	0.00	892.25	115.37
Junc 72	0.00	892.38	117.15
Junc 73	0.00	885.47	112.43
Junc 74	0.00	883.45	113.29
Junc 75	0.00	880.00	111.79
Junc 76	0.00	880.50	110.71
Junc 77	0.00	881.54	112.46
Junc 78	0.00	882.82	111.71
Junc 79	0.00	885.81	112.14
Junc 80	0.00	890.45	116.32
Junc 81	0.00	891.10	127.87
Junc 82	0.00	891.10	130.47
Junc 83	0.00	891.10	128.30
Junc 101	0.00	811.41	121.07
Junc 102	863.00	602.37	44.36
Junc 103	0.00	811.41	113.27
Tank 1	-431.51	700.00	12.13
Tank 2	-431.51	700.00	12.13

863 gpm fire flow at MW-20 bench, electric pump on, high water tank levels

Network Table - Links

Link ID	Flow GPM	Velocity fps	Unit Headloss ft/Kft	Status
Pipe 1	431.51	2.75	5.31	Open
Pipe 2	431.51	2.75	5.31	Open
Pipe 3	863.01	5.51	16.13	Open
Pipe 4A	863.01	9.79	65.48	Open
Pipe 4C	863.01	9.79	65.48	Open
Pipe 5	0.00	0.00	0.00	Open
Pipe 6A	0.00	0.00	0.00	Open
Pipe 6C	0.00	0.00	0.00	Open
Pipe 7	304.65	3.46	9.52	Open
Pipe 8	304.65	3.46	9.52	Open
Pipe 9	304.65	3.46	9.52	Open
Pipe 10	304.65	3.46	9.52	Open
Pipe 11	304.64	3.46	9.52	Open
Pipe 12	304.64	3.46	9.52	Open
Pipe 13	304.64	3.46	9.52	Open
Pipe 14	304.64	3.46	9.52	Open
Pipe 15	304.64	3.46	9.52	Open
Pipe 16	304.64	3.46	9.52	Open
Pipe 17	-558.36	6.34	29.23	Open
Pipe 18	-558.36	6.34	29.23	Open
Pipe 19	-558.36	6.34	29.23	Open
Pipe 20	-558.36	6.34	29.23	Open
Pipe 21	0.00	0.00	0.00	Open
Pipe 22	0.00	0.00	0.00	Open
Pipe 23	0.00	0.00	0.00	Open

863 gpm fire flow at MW-20 bench, electric pump on, high water tank levels

Link ID	Flow GPM	Velocity fps	Unit Headloss ft/Kft	Status
Pipe 24	0.00	0.00	0.00	Open
Pipe 25	0.00	0.00	0.00	Open
Pipe 26	0.00	0.00	0.00	Open
Pipe 27	0.00	0.00	0.00	Open
Pipe 28	0.00	0.00	0.00	Open
Pipe 29	0.00	0.00	0.00	Open
Pipe 30	0.00	0.00	0.00	Open
Pipe 31	0.00	0.00	0.00	Open
Pipe 32	0.00	0.00	0.00	Open
Pipe 33	0.00	0.00	0.00	Open
Pipe 34	0.00	0.00	0.00	Open
Pipe 35	0.00	0.00	0.00	Open
Pipe 36	0.00	0.00	0.00	Open
Pipe 37	0.00	0.00	0.00	Open
Pipe 101	863.00	12.00	71.01	Open
Pipe 102	863.00	12.00	71.01	Open
Pipe 103	0.00	0.00	0.00	Open
Pump 4B	863.01	0.00	-211.23	Open
Pump 6B	0.00	0.00	0.00	Closed

863 gpm fire flow at MW-20 bench, electric pump on, low water tank levels

Network Table - Nodes

Node ID	Demand GPM	Head ft	Pressure psi
Junc 3	0.00	673.63	0.71
Junc 4	0.00	668.36	17.92
Junc 4A	0.00	664.16	16.10
Junc 4B	0.00	875.39	107.63
Junc 5	0.00	870.02	105.30
Junc 6A	0.00	668.36	17.92
Junc 6B	0.00	869.82	105.22
Junc 6	0.00	668.36	17.92
Junc 7	0.00	869.82	105.22
Junc 8	0.00	868.90	107.42
Junc 9	0.00	866.38	106.32
Junc 10	0.00	865.10	107.50
Junc 11	0.00	864.45	107.22
Junc 12	0.00	859.81	102.61
Junc 13	0.00	859.81	102.61
Junc 14	0.00	856.82	102.18
Junc 15	0.00	855.54	102.06
Junc 16	0.00	854.50	102.91
Junc 17	0.00	854.00	102.69
Junc 18	0.00	857.45	104.19
Junc 19	0.00	859.47	104.20
Junc 20	0.00	866.25	106.27
Junc 21	0.00	865.10	119.20
Junc 22	0.00	865.10	119.20
Junc 70	0.00	868.90	105.25

863 gpm fire flow at MW-20 bench, electric pump on, low water tank levels

Node ID	Demand GPM	Head ft	Pressure psi
Junc 71	0.00	866.25	104.10
Junc 72	0.00	866.38	105.89
Junc 73	0.00	859.47	101.16
Junc 74	0.00	857.45	102.02
Junc 75	0.00	854.00	100.53
Junc 76	0.00	854.50	99.44
Junc 77	0.00	855.54	101.19
Junc 78	0.00	856.82	100.45
Junc 79	0.00	859.81	100.88
Junc 80	0.00	864.45	105.06
Junc 81	0.00	865.10	116.60
Junc 82	0.00	865.10	119.20
Junc 83	0.00	865.10	117.04
Junc 101	0.00	785.41	109.80
Junc 102	863.00	576.37	33.09
Junc 103	0.00	785.41	102.00
Tank 1	-431.51	674.00	0.87
Tank 2	-431.51	674.00	0.87

863 gpm fire flow at MW-20 bench, electric pump on, low water tank levels

Network Table - Links

Link ID	Flow GPM	Velocity fps	Unit Headloss ft/Kft	Status
Pipe 1	431.51	2.75	5.31	Open
Pipe 2	431.51	2.75	5.31	Open
Pipe 3	863.01	5.51	16.13	Open
Pipe 4A	863.01	9.79	65.48	Open
Pipe 4C	863.01	9.79	65.48	Open
Pipe 5	0.00	0.00	0.00	Open
Pipe 6A	0.00	0.00	0.00	Open
Pipe 6C	0.00	0.00	0.00	Open
Pipe 7	304.65	3.46	9.52	Open
Pipe 8	304.65	3.46	9.52	Open
Pipe 9	304.65	3.46	9.52	Open
Pipe 10	304.65	3.46	9.52	Open
Pipe 11	304.64	3.46	9.52	Open
Pipe 12	304.64	3.46	9.52	Open
Pipe 13	304.64	3.46	9.52	Open
Pipe 14	304.64	3.46	9.52	Open
Pipe 15	304.64	3.46	9.52	Open
Pipe 16	304.64	3.46	9.52	Open
Pipe 17	-558.36	6.34	29.23	Open
Pipe 18	-558.36	6.34	29.23	Open
Pipe 19	-558.36	6.34	29.23	Open
Pipe 20	-558.36	6.34	29.23	Open
Pipe 21	0.00	0.00	0.00	Open
Pipe 22	0.00	0.00	0.00	Open
Pipe 23	0.00	0.00	0.00	Open

863 gpm fire flow at MW-20 bench, electric pump on, low water tank levels

Link ID	Flow GPM	Velocity fps	Unit Headloss ft/Kft	Status
Pipe 24	0.00	0.00	0.00	Open
Pipe 25	0.00	0.00	0.00	Open
Pipe 26	0.00	0.00	0.00	Open
Pipe 27	0.00	0.00	0.00	Open
Pipe 28	0.00	0.00	0.00	Open
Pipe 29	0.00	0.00	0.00	Open
Pipe 30	0.00	0.00	0.00	Open
Pipe 31	0.00	0.00	0.00	Open
Pipe 32	0.00	0.00	0.00	Open
Pipe 33	0.00	0.00	0.00	Open
Pipe 34	0.00	0.00	0.00	Open
Pipe 35	0.00	0.00	0.00	Open
Pipe 36	0.00	0.00	0.00	Open
Pipe 37	0.00	0.00	0.00	Open
Pipe 101	863.00	12.00	71.01	Open
Pipe 102	863.00	12.00	71.01	Open
Pipe 103	0.00	0.00	0.00	Open
Pump 4B	863.01	0.00	-211.23	Open
Pump 6B	0.00	0.00	0.00	Closed

863 gpm fire flow at MW-20 bench, diesel pump on, high water tank levels

Network Table - Nodes

Node ID	Demand GPM	Head ft	Pressure psi
Junc 3	0.00	699.63	11.97
Junc 4	0.00	694.36	29.19
Junc 4A	0.00	694.36	29.19
Junc 4B	0.00	895.65	116.41
Junc 5	0.00	895.65	116.41
Junc 6A	0.00	688.79	26.77
Junc 6B	0.00	901.63	119.00
Junc 6	0.00	692.98	28.59
Junc 7	0.00	896.26	116.67
Junc 8	0.00	895.30	118.86
Junc 9	0.00	892.70	117.73
Junc 10	0.00	891.38	118.89
Junc 11	0.00	890.71	118.60
Junc 12	0.00	885.91	113.92
Junc 13	0.00	885.91	113.92
Junc 14	0.00	882.83	113.45
Junc 15	0.00	881.50	113.31
Junc 16	0.00	880.43	114.14
Junc 17	0.00	879.92	113.92
Junc 18	0.00	883.31	115.39
Junc 19	0.00	885.29	115.38
Junc 20	0.00	891.95	117.40
Junc 21	0.00	891.38	130.59
Junc 22	0.00	891.38	130.59
Junc 70	0.00	895.30	116.69

863 gpm fire flow at MW-20 bench, diesel pump on, high water tank levels

Node ID	Demand GPM	Head ft	Pressure psi
Junc 71	0.00	891.95	115.24
Junc 72	0.00	892.70	117.29
Junc 73	0.00	885.29	112.35
Junc 74	0.00	883.31	113.22
Junc 75	0.00	879.92	111.76
Junc 76	0.00	880.43	110.68
Junc 77	0.00	881.50	112.44
Junc 78	0.00	882.83	111.72
Junc 79	0.00	885.91	112.19
Junc 80	0.00	890.71	116.43
Junc 81	0.00	891.38	127.99
Junc 82	0.00	891.38	130.59
Junc 83	0.00	891.38	128.42
Junc 101	0.00	811.33	121.03
Junc 102	863.00	602.29	44.32
Junc 103	0.00	811.33	113.23
Tank 1	-431.51	700.00	12.13
Tank 2	-431.51	700.00	12.13

863 gpm fire flow at MW-20 bench, diesel pump on, high water tank levels

Network Table - Links

Link ID	Flow GPM	Velocity fps	Unit Headloss ft/Kft	Status
Pipe 1	431.51	2.75	5.31	Open
Pipe 2	431.51	2.75	5.31	Open
Pipe 3	863.01	5.51	16.13	Open
Pipe 4A	0.00	0.00	0.00	Open
Pipe 4C	0.00	0.00	0.00	Open
Pipe 5	863.01	9.79	65.48	Open
Pipe 6A	863.01	9.79	65.48	Open
Pipe 6C	863.01	9.79	65.48	Open
Pipe 7	-553.00	6.28	28.72	Open
Pipe 8	310.01	3.52	9.83	Open
Pipe 9	310.01	3.52	9.83	Open
Pipe 10	310.01	3.52	9.83	Open
Pipe 11	310.00	3.52	9.83	Open
Pipe 12	310.00	3.52	9.83	Open
Pipe 13	310.00	3.52	9.83	Open
Pipe 14	310.00	3.52	9.83	Open
Pipe 15	310.00	3.52	9.83	Open
Pipe 16	310.00	3.52	9.83	Open
Pipe 17	-553.00	6.27	28.72	Open
Pipe 18	-553.00	6.27	28.72	Open
Pipe 19	-553.00	6.28	28.72	Open
Pipe 20	-553.00	6.28	28.72	Open
Pipe 21	0.00	0.00	0.00	Open
Pipe 22	0.00	0.00	0.00	Open
Pipe 23	0.00	0.00	0.00	Open

863 gpm fire flow at MW-20 bench, diesel pump on, high water tank levels

Link ID	Flow GPM	Velocity fps	Unit Headloss ft/Kft	Status
Pipe 24	0.00	0.00	0.00	Open
Pipe 25	0.00	0.00	0.00	Open
Pipe 26	0.00	0.00	0.00	Open
Pipe 27	0.00	0.00	0.00	Open
Pipe 28	0.00	0.00	0.00	Open
Pipe 29	0.00	0.00	0.00	Open
Pipe 30	0.00	0.00	0.00	Open
Pipe 31	0.00	0.00	0.00	Open
Pipe 32	0.00	0.00	0.00	Open
Pipe 33	0.00	0.00	0.00	Open
Pipe 34	0.00	0.00	0.00	Open
Pipe 35	0.00	0.00	0.00	Open
Pipe 36	0.00	0.00	0.00	Open
Pipe 37	0.00	0.00	0.00	Open
Pipe 101	863.00	12.00	71.01	Open
Pipe 102	863.00	12.00	71.01	Open
Pipe 103	0.00	0.00	0.00	Open
Pump 4B	0.00	0.00	0.00	Closed
Pump 6B	863.01	0.00	-212.84	Open

863 gpm fire flow at MW-20 bench, diesel pump on, low water tank levels

Network Table - Nodes

Node ID	Demand GPM	Head ft	Pressure psi
Junc 3	0.00	673.63	0.71
Junc 4	0.00	668.36	17.92
Junc 4A	0.00	668.36	17.92
Junc 4B	0.00	869.65	105.14
Junc 5	0.00	869.65	105.14
Junc 6A	0.00	662.79	15.51
Junc 6B	0.00	875.63	107.73
Junc 6	0.00	666.98	17.32
Junc 7	0.00	870.26	105.40
Junc 8	0.00	869.30	107.59
Junc 9	0.00	866.70	106.46
Junc 10	0.00	865.38	107.62
Junc 11	0.00	864.71	107.33
Junc 12	0.00	859.91	102.65
Junc 13	0.00	859.91	102.65
Junc 14	0.00	856.83	102.18
Junc 15	0.00	855.50	102.04
Junc 16	0.00	854.43	102.88
Junc 17	0.00	853.92	102.66
Junc 18	0.00	857.31	104.12
Junc 19	0.00	859.29	104.12
Junc 20	0.00	865.95	106.14
Junc 21	0.00	865.38	119.32
Junc 22	0.00	865.38	119.32
Junc 70	0.00	869.30	105.42

863 gpm fire flow at MW-20 bench, diesel pump on, low water tank levels

Node ID	Demand GPM	Head ft	Pressure psi
Junc 71	0.00	865.95	103.97
Junc 72	0.00	866.70	106.03
Junc 73	0.00	859.29	101.08
Junc 74	0.00	857.31	101.96
Junc 75	0.00	853.92	100.49
Junc 76	0.00	854.43	99.41
Junc 77	0.00	855.50	101.18
Junc 78	0.00	856.83	100.45
Junc 79	0.00	859.91	100.92
Junc 80	0.00	864.71	105.17
Junc 81	0.00	865.38	116.72
Junc 82	0.00	865.38	119.32
Junc 83	0.00	865.38	117.16
Junc 101	0.00	785.33	109.77
Junc 102	863.00	576.29	33.06
Junc 103	0.00	785.33	101.97
Tank 1	-431.51	674.00	0.87
Tank 2	-431.51	674.00	0.87

863 gpm fire flow at MW-20 bench, diesel pump on, low water tank levels

Network Table - Links

Link ID	Flow GPM	Velocity fps	Unit Headloss ft/Kft	Status
Pipe 1	431.51	2.75	5.31	Open
Pipe 2	431.51	2.75	5.31	Open
Pipe 3	863.01	5.51	16.13	Open
Pipe 4A	0.00	0.00	0.00	Open
Pipe 4C	0.00	0.00	0.00	Open
Pipe 5	863.01	9.79	65.48	Open
Pipe 6A	863.01	9.79	65.48	Open
Pipe 6C	863.01	9.79	65.48	Open
Pipe 7	-553.00	6.28	28.72	Open
Pipe 8	310.01	3.52	9.83	Open
Pipe 9	310.01	3.52	9.83	Open
Pipe 10	310.01	3.52	9.83	Open
Pipe 11	310.00	3.52	9.83	Open
Pipe 12	310.00	3.52	9.83	Open
Pipe 13	310.00	3.52	9.83	Open
Pipe 14	310.00	3.52	9.83	Open
Pipe 15	310.00	3.52	9.83	Open
Pipe 16	310.00	3.52	9.83	Open
Pipe 17	-553.00	6.27	28.72	Open
Pipe 18	-553.00	6.27	28.72	Open
Pipe 19	-553.00	6.28	28.72	Open
Pipe 20	-553.00	6.28	28.72	Open
Pipe 21	0.00	0.00	0.00	Open
Pipe 22	0.00	0.00	0.00	Open
Pipe 23	0.00	0.00	0.00	Open

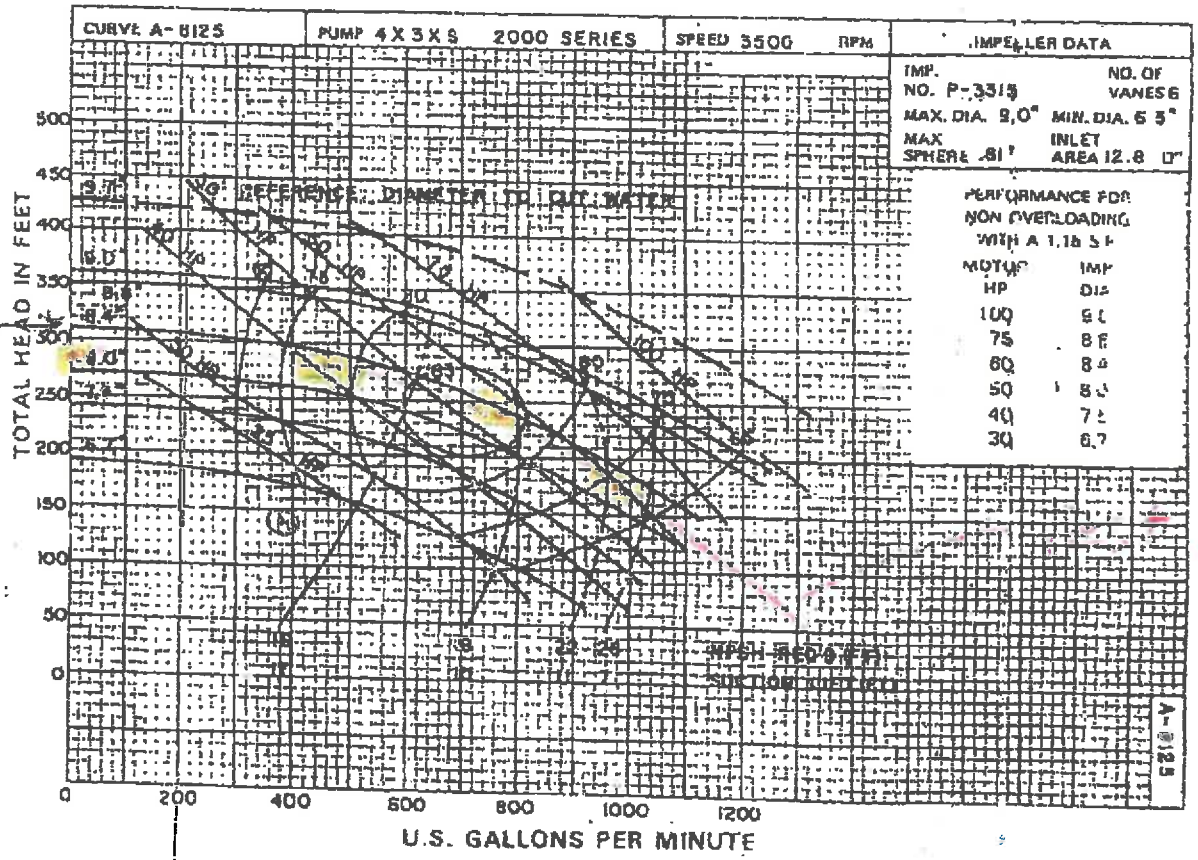
863 gpm fire flow at MW-20 bench, diesel pump on, low water tank levels

Link ID	Flow GPM	Velocity fps	Unit Headloss ft/Kft	Status
Pipe 24	0.00	0.00	0.00	Open
Pipe 25	0.00	0.00	0.00	Open
Pipe 26	0.00	0.00	0.00	Open
Pipe 27	0.00	0.00	0.00	Open
Pipe 28	0.00	0.00	0.00	Open
Pipe 29	0.00	0.00	0.00	Open
Pipe 30	0.00	0.00	0.00	Open
Pipe 31	0.00	0.00	0.00	Open
Pipe 32	0.00	0.00	0.00	Open
Pipe 33	0.00	0.00	0.00	Open
Pipe 34	0.00	0.00	0.00	Open
Pipe 35	0.00	0.00	0.00	Open
Pipe 36	0.00	0.00	0.00	Open
Pipe 37	0.00	0.00	0.00	Open
Pipe 101	863.00	12.00	71.01	Open
Pipe 102	863.00	12.00	71.01	Open
Pipe 103	0.00	0.00	0.00	Open
Pump 4B	0.00	0.00	0.00	Closed
Pump 6B	863.01	0.00	-212.84	Open

END SUCTION PUMPS

2000 Series — Single-Stage Close-Coupled or Frame Mounted with Mechanical Seals or Packing Performance Curves — Key 66 — 3500 Rpm

TOPOCK ELECTRIC FIRE PUMP



KEY 66 3500

ITT A-C Pump

A unit of ITT Corporation

DTP-F3

5808-0231

IMPELLER DWG.	IMPELLER DIA.	SPECIFIC GRAVITY	VISCOSITY
52-233-459-116	10.500 in.	1.000	32.0 SSU

Topock Diesel Fire Pump

CURVE NO. B94915-03-01-1E1

SIZE 6x4x10H-M TYPE 8100

500 G.P.M. 125 P.S.I. 3000 R.P.M.

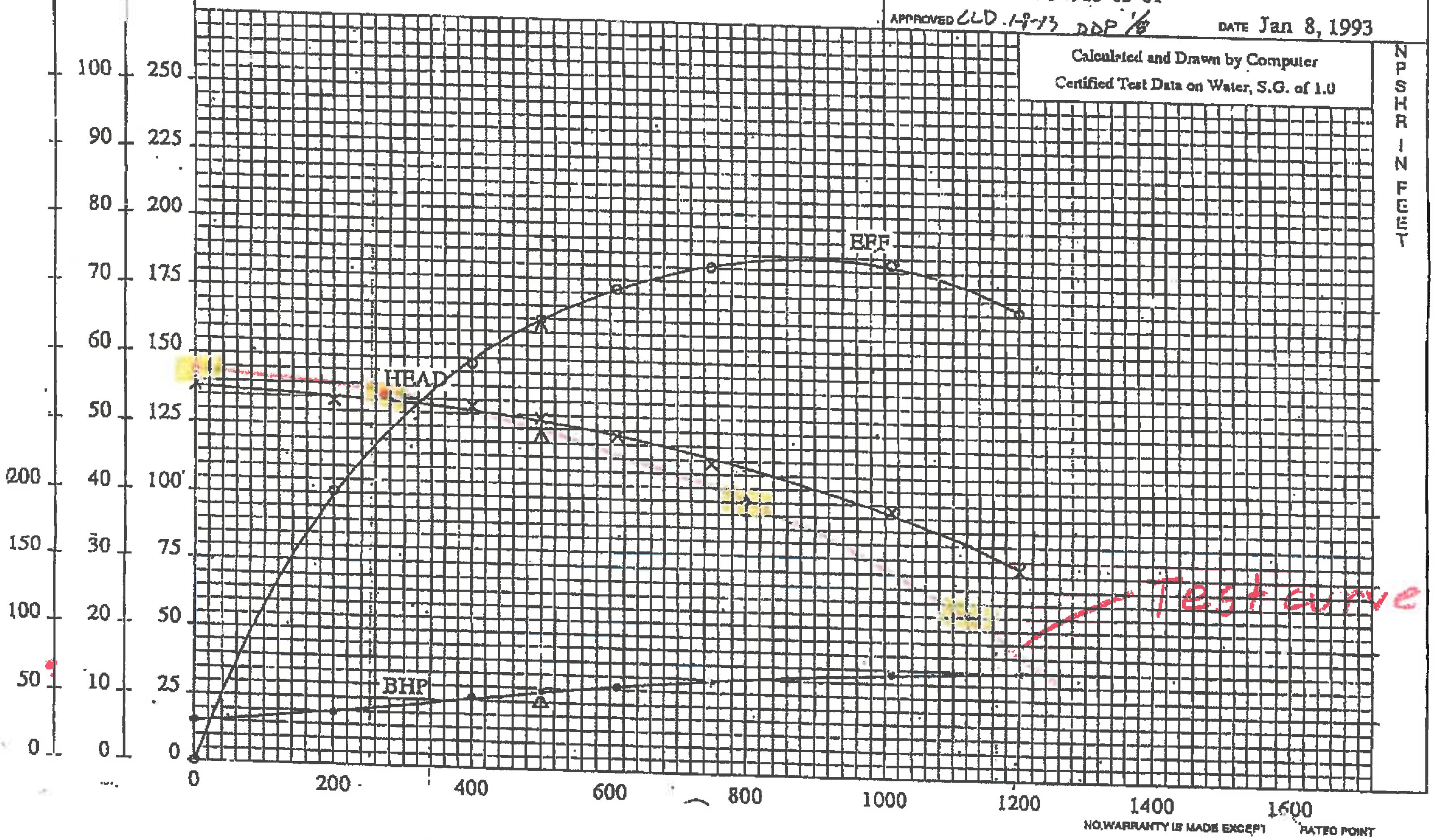
CUSTOMER PACIFIC GAS & ELECTRIC

ORDER 1-5224-94915-03-01*

APPROVED CLD 1-8-93 DDP 1/8 DATE Jan 8, 1993

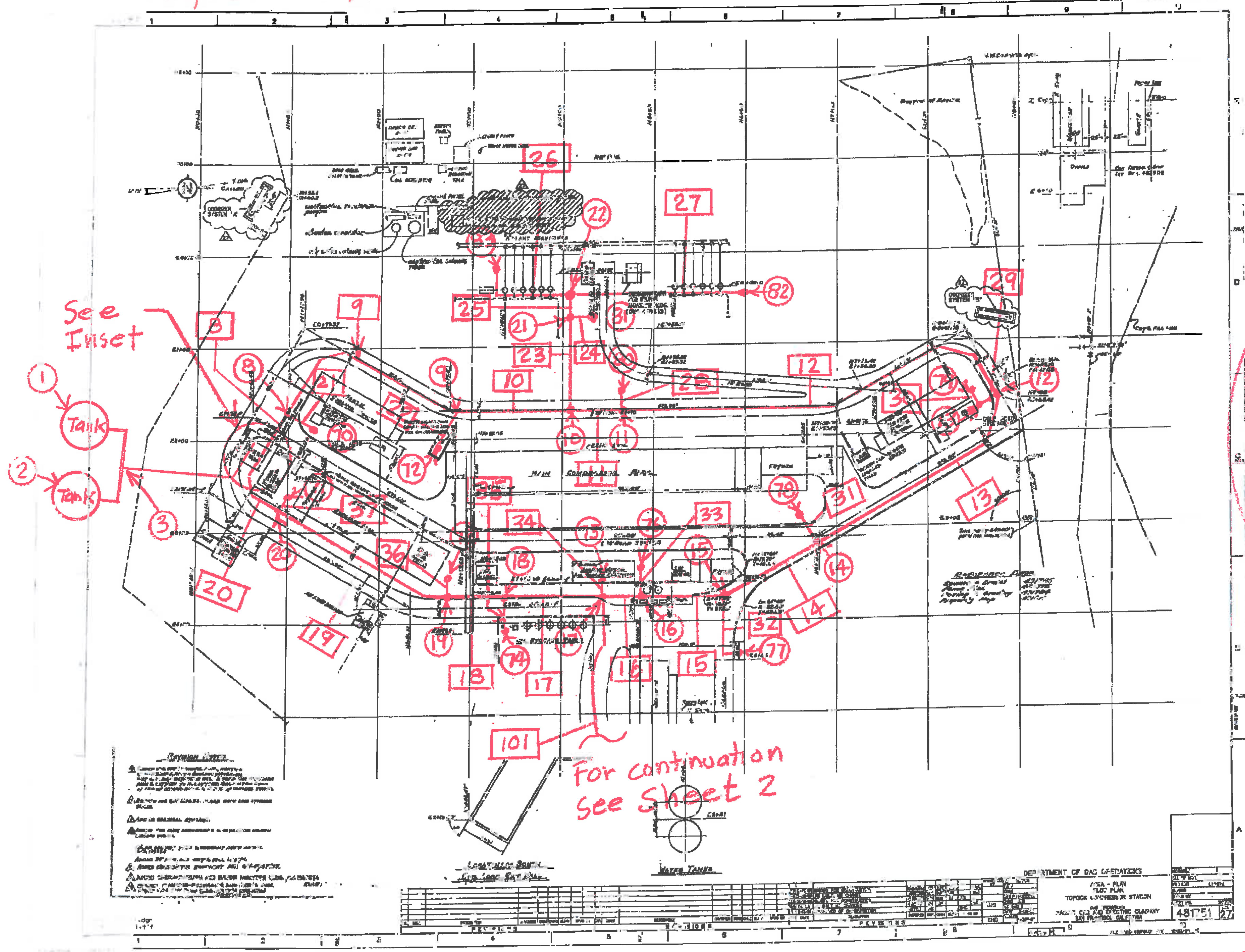
Calculated and Drawn by Computer

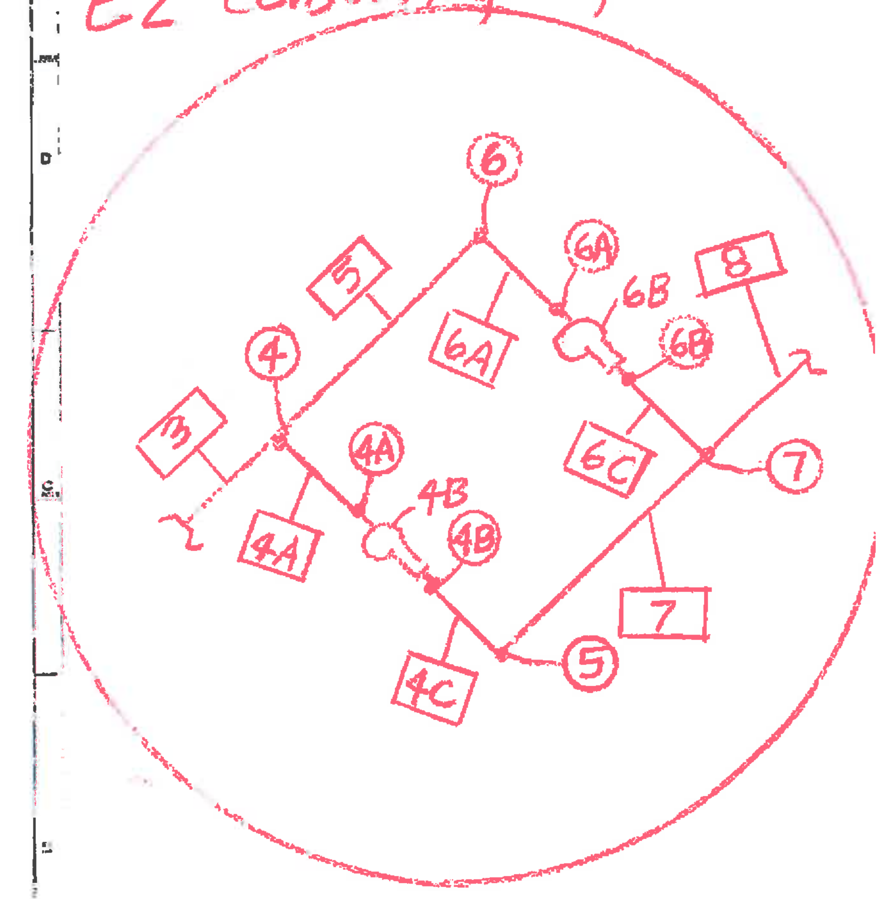
Certified Test Data on Water, S.G. of 1.0



August 2014

Topock Remediation Design - Hydraulic Analysis of Fire Water System - By Paul Tjogas, Ez Consulting Engineers





Inset

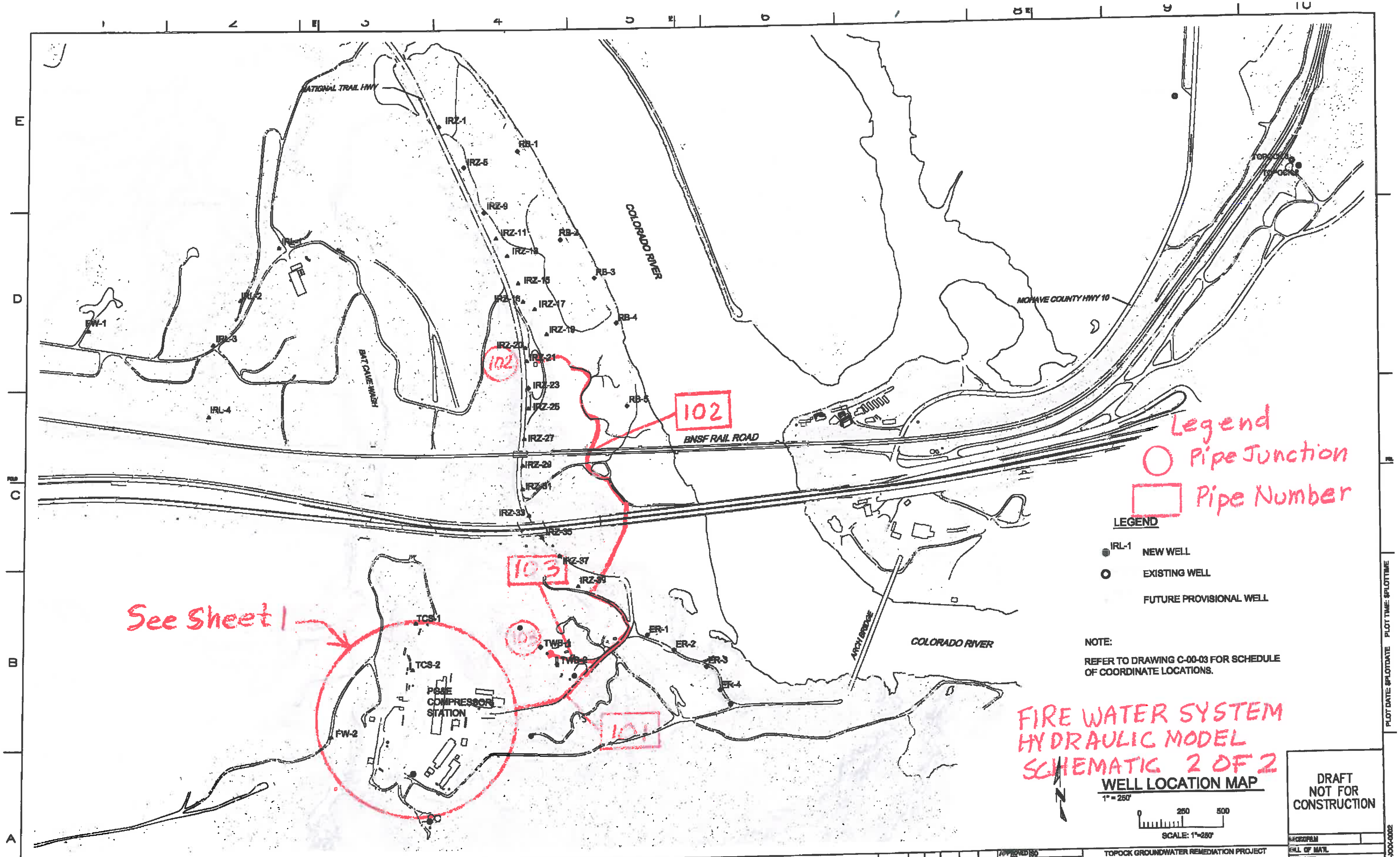
Legend

○ Pipe Junction or Tank Node

▭ Pipe Number

Pump

FIRE WATER SYSTEM HYDRAULIC MODEL SCHEMATIC 1 OF 2



E2 Consulting Engineers, Inc.

CH2MHILL

REVISIONS

REVISIONS

0 | INTERMEDIATE (30%) DESIGN SUBMITTAL

TOPOCK GROUNDWATER REMEDIATION PROJECT

WELL LOCATION MAP

GAS TRANSMISSION & DISTRIBUTION
PACIFIC GAS AND ELECTRIC COMPANY
SAN FRANCISCO, CALIFORNIA

C-00-02