Rating form completed by: Simpson Gumpertz & Heger, SGH.COM
CAO, KDP, KSM

*Text in green is to be part of UCSF building database and may be part of UCOP database.*

Date: 2020-11-02

**UCSF Building Seismic Ratings**

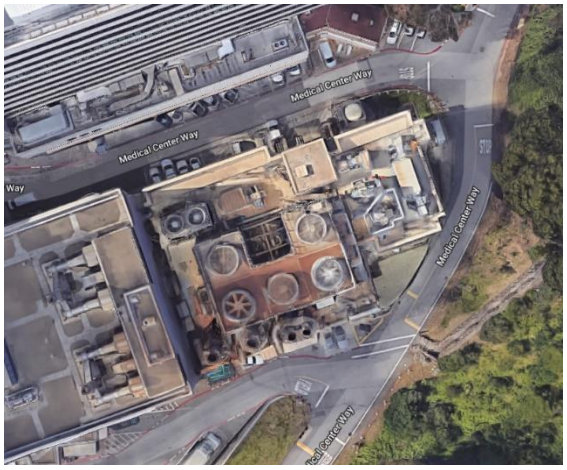
***Central Utilities Plant, Parnassus Avenue***

CAAN# 3006

*25 Medical Center Way, San Francisco, CA 94131*

UCSF Campus Site: *Parnassus*


11/02/2020




| Rating summary | Entry | Notes |
|---|---|---|
| UC Seismic Performance Level (rating) | IV | Findings based on drawing review and ASCE 41-17 Tier 1 evaluation[1] |
| Rating basis | Tier 1 | ASCE 41-17 |
| Date of rating | 2020 | January 21 |
| Recommended UCSF priority category for retrofit | N/A | Priority A=Retrofit ASAP<br>Priority B=Retrofit at next permit application for modification |
| Ballpark total project cost to retrofit to IV rating | | |
| Is 2018-2019 rating required by UCOP? | Yes | Building previously rated IV but does not have a fully documented previous review |
| Further evaluation recommended? | Yes | Because the building provides critical utility support for both campus and healthcare buildings, further evaluation and potential retrofit should be considered. |

[1] The evaluations at UCSF translate the Tier 1 evaluation to a Seismic Performance Level rating using professional judgment discussed among the Seismic Review Committee. Non-compliant items in the Tier 1 evaluation do not automatically put a building into a particular rating category, but such items are evaluated along with the combination of building features and potential deficiencies, focused on the potential for collapse or serious damage to the gravity supporting structure that may threaten occupant safety.

**Building information used in this evaluation**

- Structural drawings entitled "Central Utilities Plant Parnassus Avenue Campus San Francisco, California" issued 14 May 1997 for construction with As-Built Revision 1 dated 8 December 1997 by Jaime Villarroel structural engineer. In this document, we will refer to these drawings as original drawings.
- Architectural drawings entitled "Central Utilities Plant Parnassus Avenue Campus San Francisco, California" issued 14 May 1997 for construction with As-Built Revision 1 dated 8 December 1997 by Ehrlich Rominger Architects.
- Parnassus Chilled Water System – Phase 1; Structural drawings with 100% Submission dated 8 November 1999. In this document, we will refer to these drawings as cooling tower drawings.

**Scope for completing this form**

Reviewed original structural construction drawings and performed an ASCE 41-17 Tier 1 evaluation. Made a visit to the building and verified that structural configuration generally matched the drawings. Observed nonstructural life-safety hazards inside the building and verified anchorage but did not perform calculations to check adequacy of anchorage.

**Brief description of structure**

The Central Utility Plant is a 39,000 sq ft rectangular structure, approximately 50 ft tall with five levels which include the ground floor, an intermediate level, second floor, mezzanine and roof. The building comprises a main building with a footprint of approximately 94 ft in the north-south direction and 103 ft in the east-west direction, and an annex building with a footprint of approximately 49 ft in the north-south direction and 49 ft in the east-west direction. The structure was built circa 1997.

Identification of Levels: The building is sited on a sloping site with grade approximately one level higher at the north side. The grade at the high side is resisted by a cantilevered retaining wall with a movement joint at the top that separates it from the building. All footings are at the same elevation with no adjacent retaining walls or sloping ground around the building. The building levels are denoted as the First Floor or Ground Floor (EL 408 ft-6 in.), Intermediate (El 424 ft-0 in.), Second Floor (El 436 ft-2 in. at the main area and 438 ft-0 in. at the equipment platforms), Mezzanine (El 448 ft-2 in.) and Roof (El 460 ft-6 in. at the low point and 464 ft-7 in. at the high point).

Foundation System: The structural steel gravity columns are founded on steel reinforced concrete shallow spread footings. The structural steel braced frame columns are founded on continuous, reinforced concrete grade beams.

Structural System for Vertical (Gravity) Load: The typical roof and floor framing comprises steel composite wide flange framing supporting a 4-1/4 in. lightweight concrete topping on 2 in. metal deck. Horizontal framing is supported on steel wide flange columns. All gravity beam-to-column connections are typically single-plate shear tabs or WTs welded to columns and bolted to beams. The roof structure supports a cooling tower structure and associated piping and distributed systems.

Structural System for Lateral Loads: A total of twelve bays of diagonal bracing is provided in each direction. Braces are steel tubular sections and occur along Gridlines A (4 bays), C (2 bays), F (2 bays), G (4 bays), 1 (2 bays), 3 (6 bays), and 8 (4 bays). One pair of opposing braces occur at each level in each

frame along Gridlines 1, C and F; two pairs of opposing braces occur at each level in each frame along Gridlines A, G and 8; and three pairs of opposing braces occur at each level along Gridline 3. Several of the frames are multi-tiered at locations where the intermediate and mezzanine levels do not connect to the frames. This occurs in the frames along Gridlines A, G, 3 and 8; W10x33 horizontal struts occur at these levels and provide torsional restraint to the columns through strong-axis bending and complete joint penetration groove welds to the columns. Braces are connected to columns with plates that are flare-bevel-groove welded to each side of the tubes and connected to the beams with complete joint penetration groove welds. Brace frame beams are moment-connected to the braced frame columns.

**Brief description of supplemental analysis model**

A linear response spectrum analysis model was developed in accordance with ASCE 41-17 guidance to determine the detailed seismic response of the building. Per 2019 California Administrative Code, structural performance category of SPC-4D is assigned to this building. Per 2019 California Existing Building Code, SPC-4D using ASCE 41 requires Damage Control Performance Level (S2) at BSE-1E seismic hazard level and Collapse Prevention Structural Performance Level (S5) at BSE-2E seismic hazard level. The acceptance criteria adopted for this building follows the provisions and conservatively uses a more stringent performance level at BSE-2E. The following are the acceptance criteria used for evaluation of this building:

- Damage Control Structural Performance Level (S2) at BSE-1E Seismic Hazard Level
- Limited Safety Structural Performance Level (S4) at BSE-2E Seismic Hazard Level

All steel elements were modeled using defined section properties and expected material characteristics and subjected to representative ground motion parameters appropriate for the site. The extent of modeling was used to determine the demand on structural steel elements that were found to fail Tier 1 level evaluation criteria.

**Brief description of seismic deficiencies and Expected Seismic Performance**

Identified seismic deficiencies include:

- Seventy-seven brace elements fail the compactness requirements in accordance with AISC 341, Table D1.1 (TS 8x8x1/4, TS 8x8x5/16, TS 8x8x3/8 sections)
- Column axial stresses under gravity loads exceed the Quick Check limit of 0.1Fy. However, all columns were found to have Acceptance Ratios below unity for Tier 3 combined compression and flexural stress checks.
- Exterior cladding is attached to girts that span between columns and diagonal bracing.
- The braced frames along Gridlines 1, C and F have width/height ratios equal to 0.414 which is less than the Tier 1 Quick Check limit of 0.6Sa (1.1). Soil bearing demands were found to exceed allowable capacities as noted below.

The items listed above may affect the seismic performance of the building because local failures may occur and negatively affect the global building performance. The braces with 1/4 in., 5/16 in. and 3/8 in. wall thickness exceed the b/t compactness limits for moderately ductile members per AISC 341. Thin-walled braces have reduced low-cycle fatigue capacity and reduced energy dissipation capacity as compared with those that comply with highly ductile compactness requirements of AISC 341. This could result in a concentration of damage and excessive drift in one story. While capacities of the elements may be acceptable, the anticipated low cycle fatigue failures for these HSS members may result in unacceptable damage for a critical facility.

The building has six multi-tier braced frames with the columns oriented such that weak-axis bending occurs within the plane of the frame. The unbraced length of the multi-tier columns for weak axis bending is therefore roughly half of their strong axis unbraced lengths resulting in compression capacity of these columns being governed by strong axis buckling over a two-story height. We checked multi-tier columns and the beams connected to them and deemed the members to be acceptable per provisions in AISC Seismic Provisions (341-16).

The exterior cladding is attached to girts that are attached to the brace near midspan. The girts are bolted to a plate that is welded to the brace and there are two-inch slotted holes in the plate connection to girts. Due to the larger stiffness of the gusset plates in the out-of-plane direction, the braces will likely begin to buckle in-plane during an earthquake. Depending on the magnitude of the shaking, brace buckling deformations can be on the order of 10% of the brace buckling length. Even a small percentage of this would result in the bolt engaging the girt and providing a resistance to further buckling. This could result in bolt fracture causing the cladding to fail. It is also possible that the connection will not fail and the brace will begin to buckle out-of-plane and result in excessive in-plane girt distortion resulting in distress and possible failure of cladding connections.

Several columns do not have adequate axial capacity based on the Tier 1 gravity stress check. The supplemental analysis indicates that the Acceptance Ratios (AR) are below unity for these columns under combined compression and flexural action at the BSE-2E hazard level. The seismic portion of the column axial loads are the minima of values derived from the analytical model or the maximum load that can be delivered considering brace capacities. All columns have adequate capacity at the BSE-1E hazard level considering the combination of axial and flexural demands.

The supplemental analysis indicates that three braces have AR greater than unity for the BSE-R (1.02, 1.06, 1.23) and three have AR greater than unity for the BSE-C (1.02, 1.05, 1.06). The majority of these are only slightly above unity and all are above unity as a result of the b/t ratios reducing the m-factors. A simple solution to this potential behavior condition is to fill the braces with concrete or locally reinforce the braces with plates at the plastic hinge locations.

Diaphragms are adequate to transfer shear to the vertical seismic force-resisting elements with one exception: the roof level of the main building along Gridline 3 (from west of Gridline 3) has an Acceptance Ratio of 1.07.

Foundation bearing demands exceed the soil capacity at Gridlines A, F, G, and 3.

**Summary of review of nonstructural life-safety concerns, including at exit routes**

A rigorous assessment of the nonstructural systems inside the building has not been performed. We observed the equipment and anchorage; no obvious deficiencies were observed. Typical equipment anchorage is shown in Appendix D.

| UCOP non-structural checklist item | Life safety hazard? | UCOP non-structural checklist item | Life safety hazard? |
|---|---|---|---|
| Heavy ceilings, feature or ornamentation above large lecture halls, auditoriums, lobbies or other areas where large numbers of people congregate | None observed | Unrestrained hazardous materials storage | None observed |
| Heavy masonry or stone veneer above exit ways and public access areas | None observed | Masonry chimneys | None observed |
| Unbraced masonry parapets, cornices or other ornamentation above exit ways and public access areas | None observed | Unrestrained natural gas-fueled equipment such as water heaters, boilers, emergency generators, etc. | None observed |

**Basis of seismic performance level rating**

The building rating of IV can be attributed to the identified deficiencies. Further analysis showed that a number of deficiencies remain and may require retrofit to be fully compliant with the quantified acceptance criteria in ASCE 41-17 considering the building in the context of the California Office of Statewide Health Planning and Development (OSHPD); SPC-4D.

**Recommendations for further evaluation or retrofit:**

Considering the importance of this building and its role in providing utility services to general acute care hospital buildings, we recommend that the University perform a more detailed seismic evaluation to determine the size and scope of the retrofit required to achieve a Seismic Performance Level III. Applicable retrofit measures may include adding grout to HSS braces to eliminate the potential for local buckling, strengthening select columns, strengthening horizontal girts supporting cladding and improving shear transfer capacities at diaphragm to frame connections. Further evaluation of geotechnical capacities may be warranted to establish appropriate capacities if considering higher seismic loads associated with BSE-1N and BSE-2N.

**Peer review comments on rating**

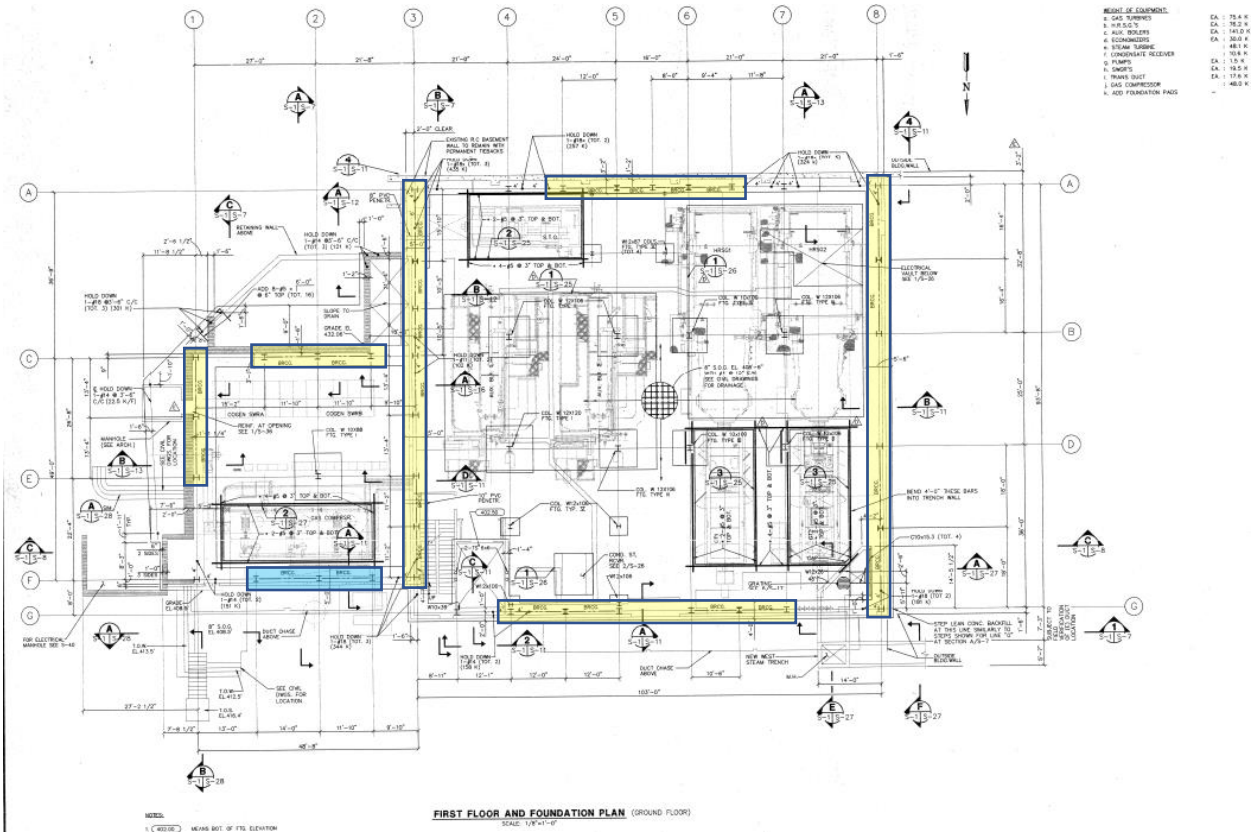
The structural members of the UCSF Seismic Review Committee (SRC) reviewed the evaluation on 8 January 2020 and agree with the rating of IV.

| Additional Building Data | Entry | Notes |
|---|---|---|
| Latitude | 37.76249° | |
| Longitude | -122.45676° | |
| Are there other structures besides this one under the same CAAN# | No | |
| Number of stories above lowest perimeter grade | 4 | |
| Number of stories (basements) below lowest perimeter grade | 0 | |
| Building occupiable area (OGSF) | 39,507 | From UCOP spreadsheet (includes garage) |
| Risk Category per 2016 CBC 1604.5 | IV | |
| Building structural height, $h_n$ | 57 ft | As defined per ASCE 7-16 Section 11.2 |
| Coefficient for period, $C_t$ | 0.02 | ASCE 41-17 equation 4-4 and 7-18 |

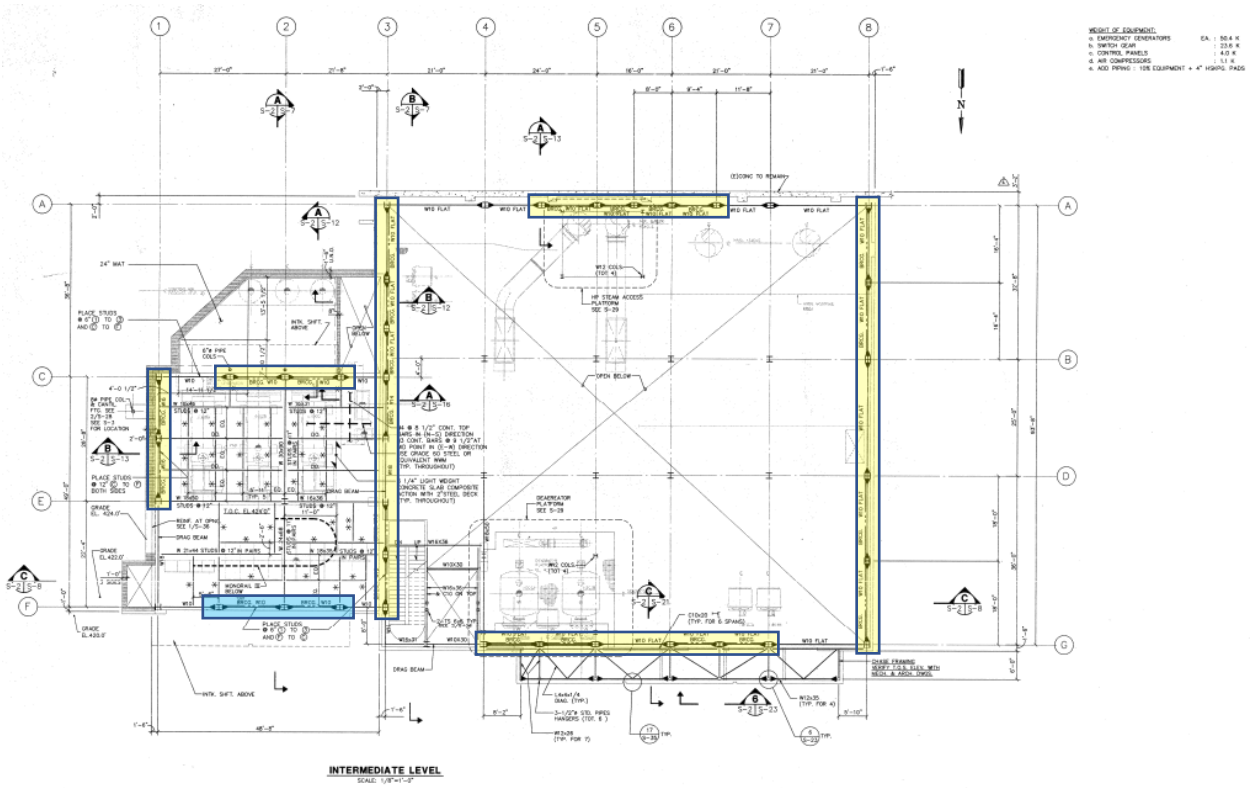
| | | |
|---|---|---|
| Coefficient for period, β | 0.75 | ASCE 41-17 equation 4-4 and 7-18 |
| Estimated fundamental period | 0.41 sec | ASCE 41-17 equation 4-4 and 7-18 |
| **Site data** | | |
| Site class | C | UCSF Group 2 Buildings, Geotechnical Characteristic and Geohazards (2019) |
| BSE-1E hazard parameters $S_S$, $S_1$ | 0.752, 0.272 | https://seismicmaps.org/ |
| BSE-1E Site parameters $F_a$, $F_v$ | 1.2, 1.5 | |
| BSE-1E hazard parameters $S_{XS}$, $S_{X1}$ | 0.903, 0.408 | |
| BSE-1E Long Period $T_L$ | 12 | |
| BSE-2E hazard parameters $S_S$, $S_1$ | 1.538, 0.606 | https://seismicmaps.org/ |
| BSE-2E Site parameters $F_a$, $F_v$ | 1.2, 1.4 | |
| BSE-2E hazard parameters $S_{XS}$, $S_{X1}$ | 1.846, 0.849 | |
| BSE-2E Long Period $T_L$ | 12 | |
| Liquefaction potential | No | UCSF Group 3 Buildings, Geotechnical Characteristic and Geohazards (2019) |
| Liquefaction assessment basis | Estimated | UCSF Group 3 Buildings, Geotechnical Characteristic and Geohazards (2019) |
| Landslide potential | No | UCSF Group 3 Buildings, Geotechnical Characteristic and Geohazards (2019) |
| Landslide assessment basis | - | Rutherford + Chekene Study, 2006 |
| Active fault-rupture hazard identified at site? | No | UCSF Group 3 Buildings, Geotechnical Characteristic and Geohazards (2019) |
| Site-specific ground motion study? | No | |
| **Applicable code** | | |
| Applicable code or approx. date of original construction | As-built drawings dated 1997 | Building was designed per1991 California Building Code |
| Applicable code for partial retrofit | None | No partial retrofit known |
| Applicable code for full retrofit | None | No full retrofit known |
| **Model building data** | | |
| Model building type North-South | S2 | |
| Model building type East-West | S2 | |
| FEMA P-154 score | N/A | Not included here because we performed ASCE 41 Tier 1 evaluation. |
| **Previous ratings** | | |
| Most recent rating | None | |
| Date of most recent rating | - | |
| 2nd most recent rating | - | |
| Date of 2nd most recent rating | - | |
| **Appendices** | | |
| ASCE 41 Tier 1 checklist included here? | Yes | Refer to attached checklist file |

# Appendix A

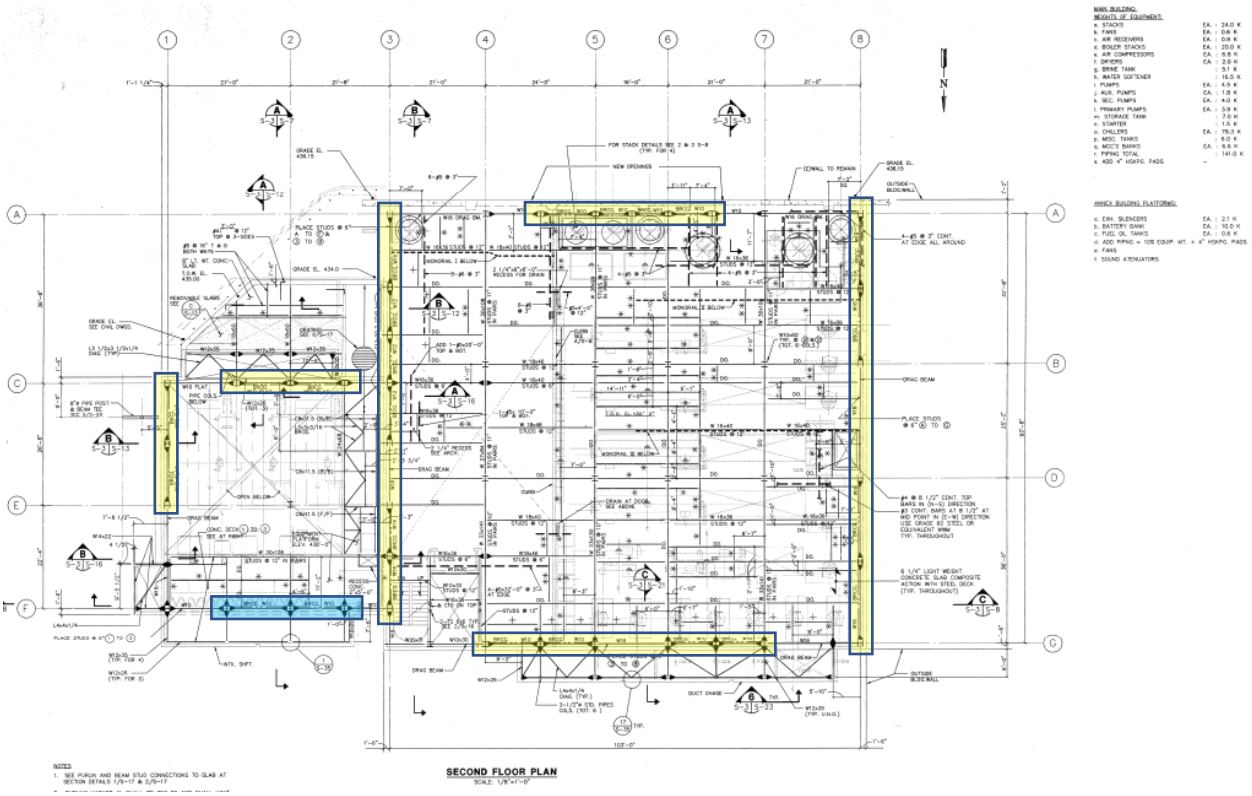
## Drawing Images

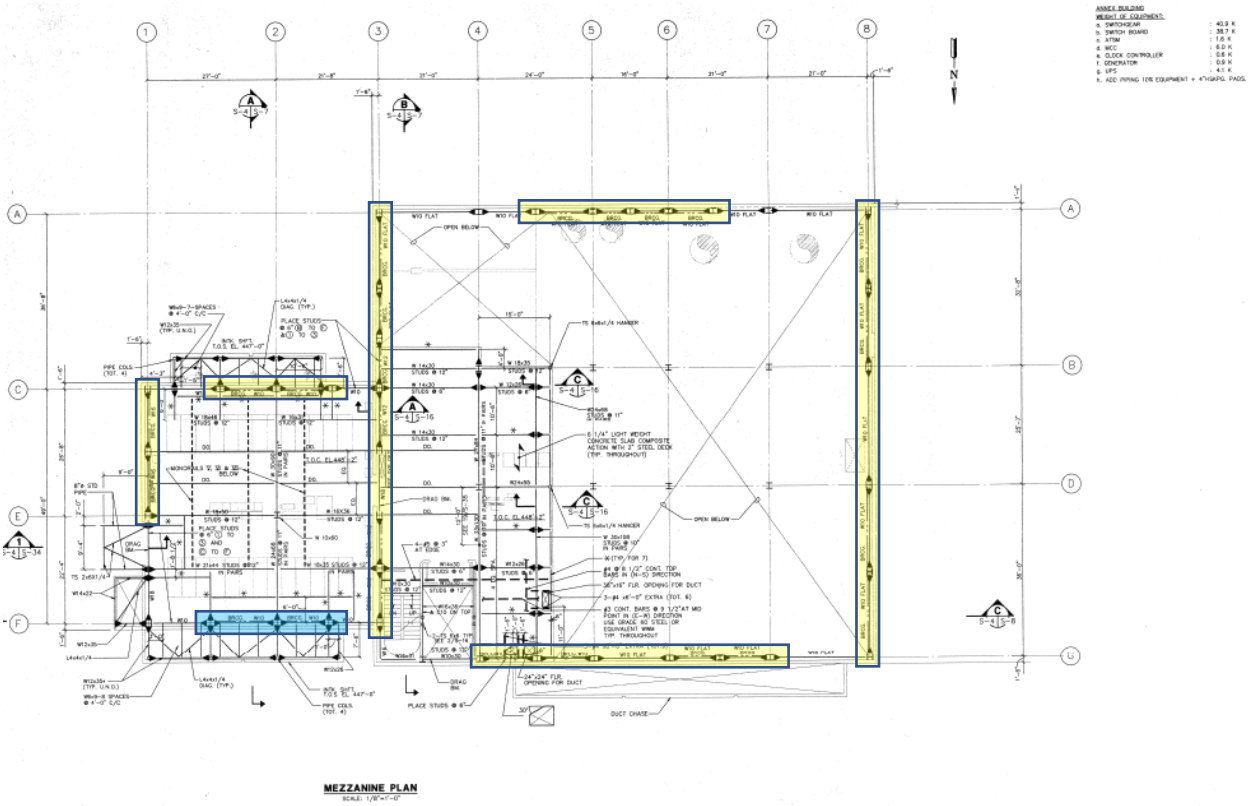



Building Foundation Plan (yellow rectangle indicates multi-tier braced frame; light blue rectangle indicates single-tier braced frame)

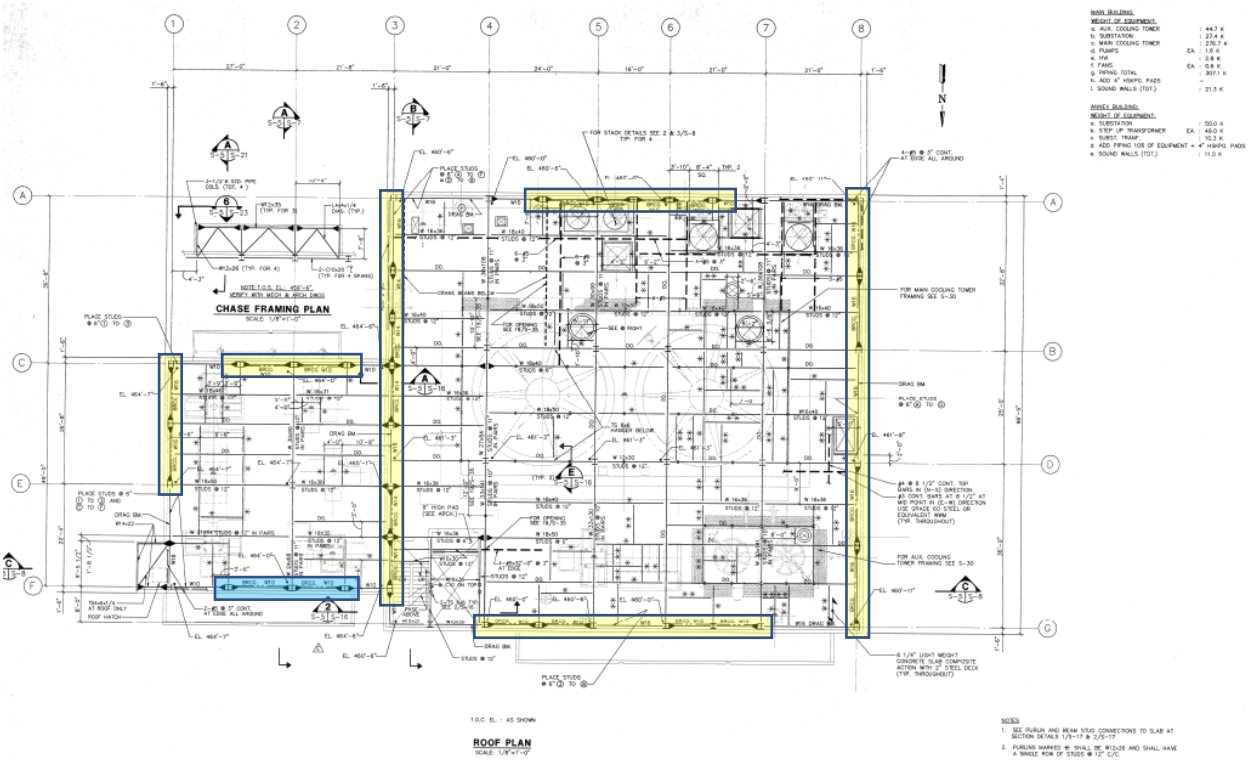


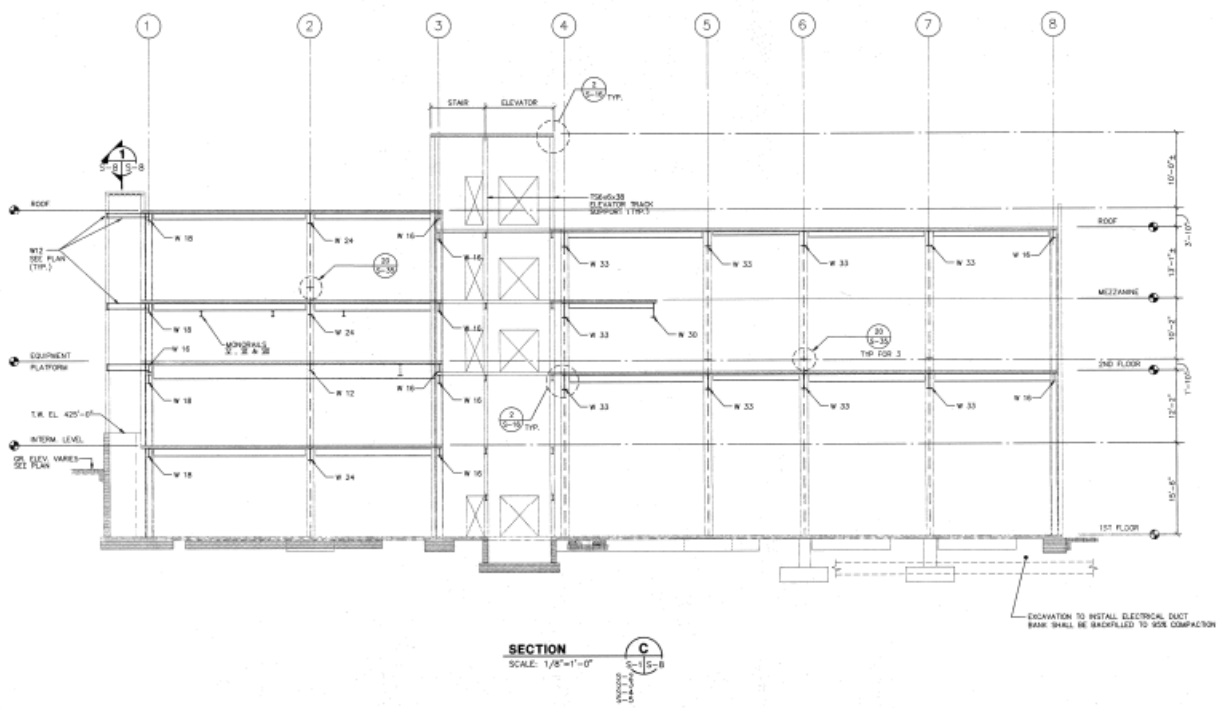

Building Plans (yellow rectangle indicates multi-tier braced frame; light blue rectangle indicates single-tier braced frame)



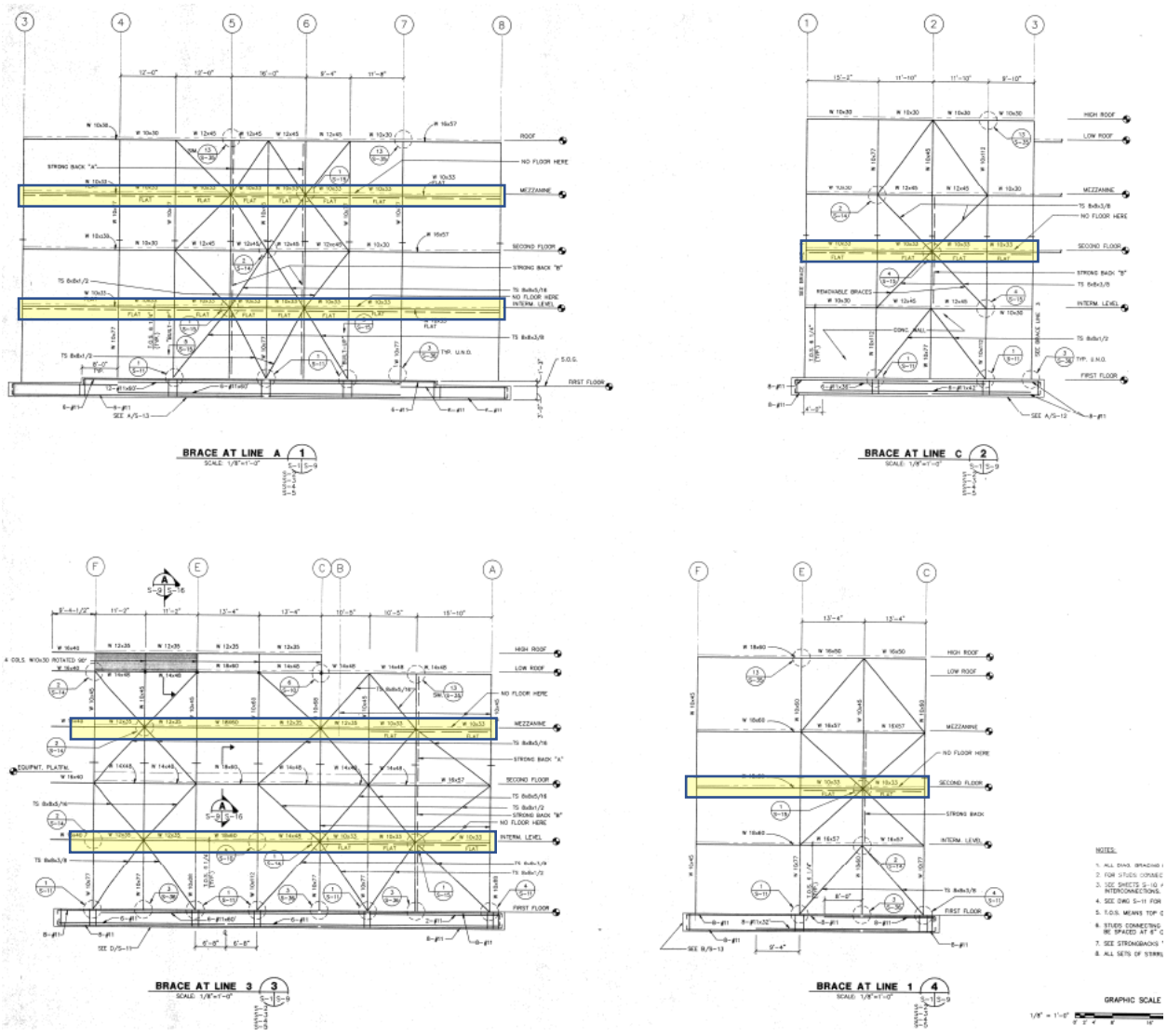



Building Plans (yellow rectangle indicates multi-tier braced frame; light blue rectangle indicates single-tier braced frame)

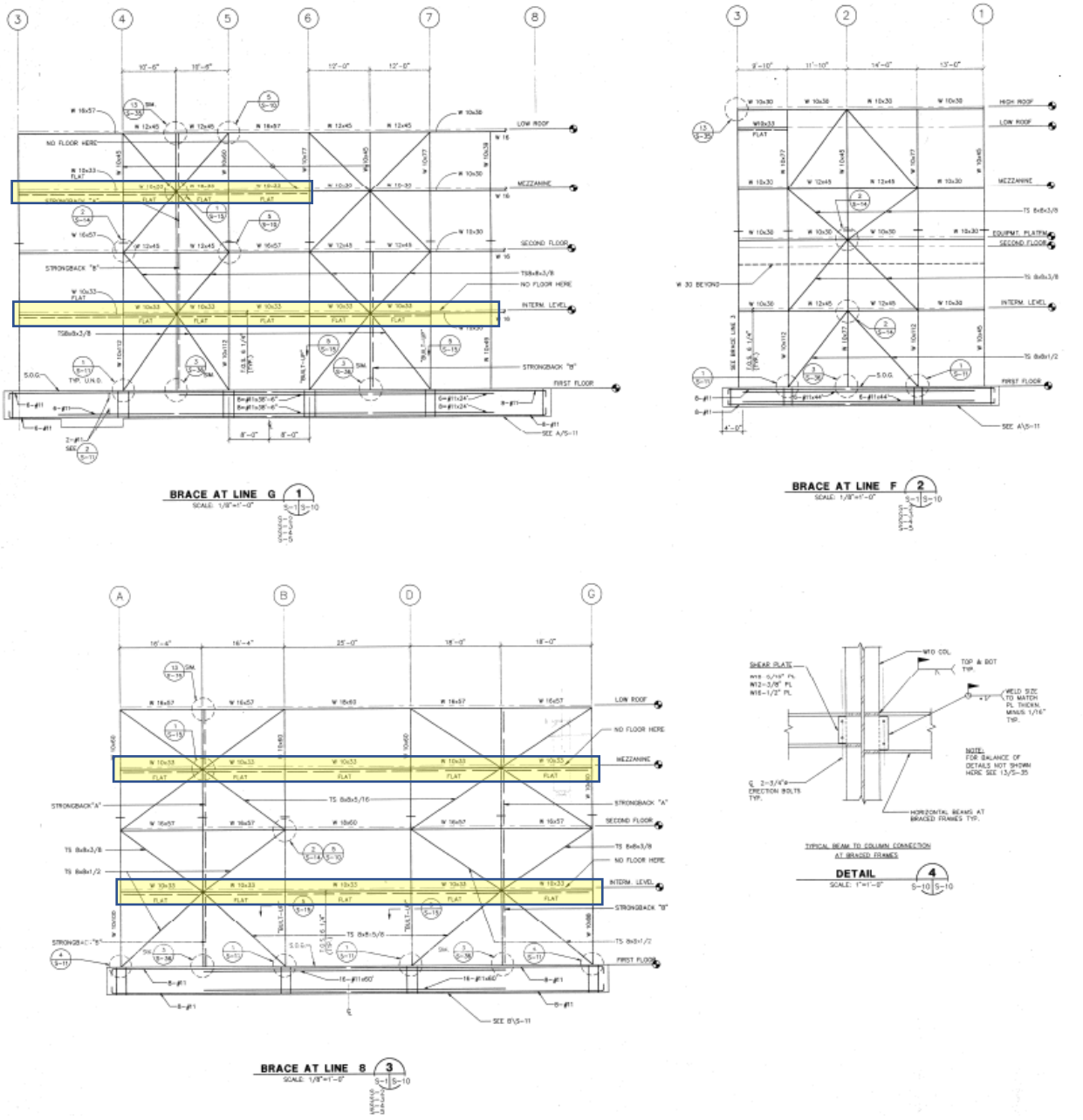




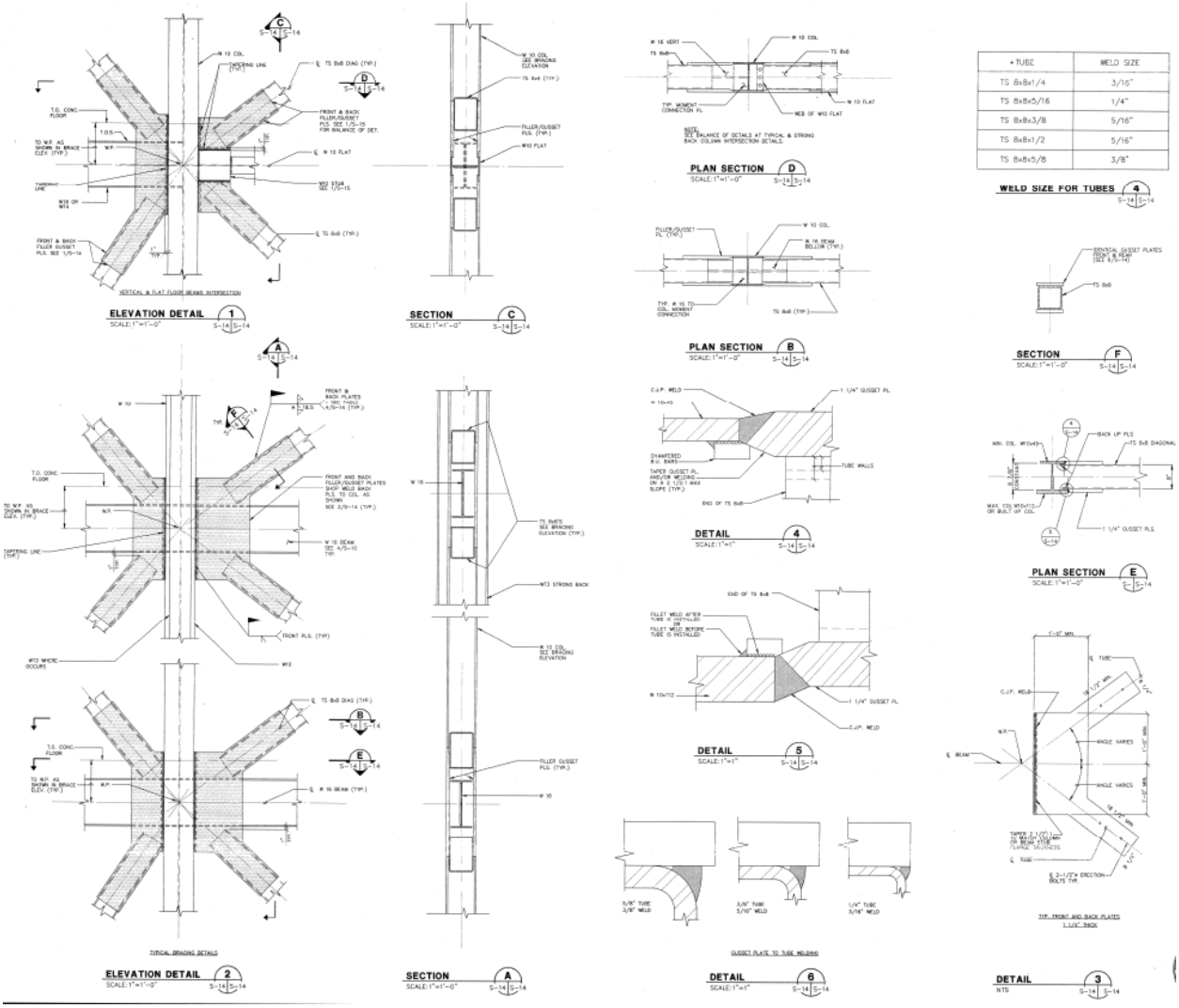

Building Section




Building Braced Frame Section
(yellow rectangle indicates location where no floor occurs – multi-tier braced frame)




Building Braced Frame Section
(yellow rectangle indicates location where no floor occurs – multi-tier braced frame)




| TUBE | WELD SIZE |
|---|---|
| TS 8x8x1/4 | 3/16" |
| TS 8x8x5/16 | 1/4" |
| TS 8x8x3/8 | 5/16" |
| TS 8x8x1/2 | 5/16" |
| TS 8x8x5/8 | 3/8" |

Braced Frame Connections

# Appendix B

Checklists

| UC Campus: | San Francisco – Parnassus | | | Date: | 04 September 2019 | | |
|---|---|---|---|---|---|---|---|
| Building CAAN: | 3006 | Auxiliary CAAN: | | By Firm: | Simpson Gumpertz & Heger | | |
| Building Name: | Central Utilities Plant | | | Initials: | *KDP* | Checked: | *KSM* |
| Building Address: | 25 Medical Center Way, San Francisco, CA 94131 | | | Page: | 1 | of | 3 |

# ASCE 41-17
# Collapse Prevention Basic Configuration Checklist

## LOW SEISMICITY

### BUILDING SYSTEMS - *GENERAL*

| | Description |
|---|---|
| C NC N/A U<br>● ○ ○ ○ | LOAD PATH: The structure contains a complete, well-defined load path, including structural elements and connections, that serves to transfer the inertial forces associated with the mass of all elements of the building to the foundation. (Commentary: Sec. A.2.1.1. Tier 2: Sec. 5.4.1.1)<br><br>**Comments: Concrete diaphragms transfer load to steel braced frames that are positively anchored to the foundation.** |
| C NC N/A U<br>● ○ ○ ○ | ADJACENT BUILDINGS: The clear distance between the building being evaluated and any adjacent building is greater than 0.25% of the height of the shorter building in low seismicity, 0.5% in moderate seismicity, and 1.5% in high seismicity. (Commentary: Sec. A.2.1.2. Tier 2: Sec. 5.4.1.2)<br><br>**Comments: Adjacent building is not closer than 1.5% of the story height of the Central Plant (57 feet high, 1.5%H = 10.3 inches).** |
| C NC N/A U<br>● ○ ○ ○ | MEZZANINES: Interior mezzanine levels are braced independently from the main structure or are anchored to the seismic-force-resisting elements of the main structure. (Commentary: Sec. A.2.1.3. Tier 2: Sec. 5.4.1.3)<br><br>**Comments: Mezzanines are braced or ties to the main structure.** |

### BUILDING SYSTEMS - *BUILDING CONFIGURATION*

| | Description |
|---|---|
| C NC N/A U<br>● ○ ○ ○ | WEAK STORY: The sum of the shear strengths of the seismic-force-resisting system in any story in each direction is not less than 80% of the strength in the adjacent story above. (Commentary: Sec. A2.2.2. Tier 2: Sec. 5.4.2.1)<br><br>**Comments: The shear strengths between stories are the same or stronger in the story below.** |
| C NC N/A U<br>● ○ ○ ○ | SOFT STORY: The stiffness of the seismic-force-resisting system in any story is not less than 70% of the seismic-force-resisting system stiffness in an adjacent story above or less than 80% of the average seismic-force-resisting system stiffness of the three stories above. (Commentary: Sec. A.2.2.3. Tier 2: Sec. 5.4.2.2)<br><br>**Comments: The frame stiffness between stories are the same or stronger in the story below.** |

# ASCE 41-17
# Collapse Prevention Basic Configuration Checklist

| C | NC | N/A | U | |
|---|---|---|---|---|
| ◉ | ○ | ○ | ○ | VERTICAL IRREGULARITIES: All vertical elements in the seismic-force-resisting system are continuous to the foundation. (Commentary: Sec. A.2.2.4. Tier 2: Sec. 5.4.2.3)<br><br>**Comments: All braces frames are planar and are continuous to the foundation.** |
| ◉ | ○ | ○ | ○ | GEOMETRY: There are no changes in the net horizontal dimension of the seismic-force-resisting system of more than 30% in a story relative to adjacent stories, excluding one-story penthouses and mezzanines. (Commentary: Sec. A.2.2.5. Tier 2: Sec. 5.4.2.4)<br><br>**Comments: All frames align between floors.** |
| ◉ | ○ | ○ | ○ | MASS: There is no change in effective mass of more than 50% from one story to the next. Light roofs, penthouses, and mezzanines need not be considered. (Commentary: Sec. A.2.2.6. Tier 2: Sec. 5.4.2.5)<br><br>**Comments: Ignoring mezzanines, the mass does not change by more than approximately 25%.** |
| ◉ | ○ | ○ | ○ | TORSION: The estimated distance between the story center of mass and the story center of rigidity is less than 20% of the building width in either plan dimension. (Commentary: Sec. A.2.2.7. Tier 2: Sec. 5.4.2.6)<br><br>**Comments: The mezzanines shift the center of mass to the west but the frames are configured to account for this.** |

## MODERATE SEISMICITY (COMPLETE THE FOLLOWING ITEMS IN ADDITION TO THE ITEMS FOR LOW SEISMICITY)

### GEOLOGIC SITE HAZARD

| | | | | Description |
|---|---|---|---|---|
| C | NC | N/A | U | |
| ◉ | ○ | ○ | ○ | LIQUEFACTION: Liquefaction-susceptible, saturated, loose granular soils that could jeopardize the building's seismic performance do not exist in the foundation soils at depths within 50 ft (15.2m) under the building. (Commentary: Sec. A.6.1.1. Tier 2: 5.4.3.1)<br><br>**Comments: Liquefaction potential is negligible per Egan (2019).** |
| ◉ | ○ | ○ | ○ | SLOPE FAILURE: The building site is located away from potential earthquake-induced slope failures or rockfalls so that it is unaffected by such failures or is capable of accommodating any predicted movements without failure. (Commentary: Sec. A.6.1.2. Tier 2: 5.4.3.1)<br><br>**Comments: Slope failure unlikely per Egan (2019).** |

**Note:** **C =** Compliant **NC =** Noncompliant **N/A =** Not Applicable **U =** Unknown

| UC Campus: | San Francisco – Parnassus | | | Date: | 04 September 2019 | | |
|---|---|---|---|---|---|---|---|
| Building CAAN: | 3006 | Auxiliary CAAN: | | By Firm: | Simpson Gumpertz & Heger | | |
| Building Name: | Central Utilities Plant | | | Initials: | *KDP* | Checked: | *KSM* |
| Building Address: | 25 Medical Center Way, San Francisco, CA 94131 | | | Page: | 3 | of | 3 |

# ASCE 41-17
# Collapse Prevention Basic Configuration Checklist

## MODERATE SEISMICITY (COMPLETE THE FOLLOWING ITEMS IN addition TO THE ITEMS FOR LOW SEISMICITY)

### GEOLOGIC SITE HAZARD

| C | NC | N/A | U | |
|---|---|---|---|---|
| ◉ | ○ | ○ | ○ | SURFACE FAULT RUPTURE: Surface fault rupture and surface displacement at the building site are not anticipated. (Commentary: Sec. A.6.1.3. Tier 2: 5.4.3.1)<br><br>**Comments: Faults are adequately distant and do not pose a risk at this site per Egan (2019).** |

## HIGH SEISMICITY (COMPLETE THE FOLLOWING ITEMS IN ADDITION TO THE ITEMS FOR MODERATE SEISMICITY)

### FOUNDATION CONFIGURATION

| | | | | Description |
|---|---|---|---|---|
| C | NC | N/A | U | |
| ○ | ◉ | ○ | ○ | OVERTURNING: The ratio of the least horizontal dimension of the seismic-force-resisting system at the foundation level to the building height (base/height) is greater than $0.6S_a$. (Commentary: Sec. A.6.2.1. Tier 2: Sec. 5.4.3.3)<br><br>**Comments: The frames along 1, C and F have width/height ratios equal to 0.415; 0.6Sa = 0.6(1.846) = 1.1. Foundation bearing checks were performed and soil bearing capacity was found to be inadequate under combined seismic and gravity loads.** |
| C | NC | N/A | U | |
| ◉ | ○ | ○ | ○ | TIES BETWEEN FOUNDATION ELEMENTS: The foundation has ties adequate to resist seismic forces where footings, piles, and piers are not restrained by beams, slabs, or soils classified as Site Class A, B, or C. (Commentary: Sec. A.6.2.2. Tier 2: Sec. 5.4.3.4)<br><br>**Comments: Foundation is tied via strip footings and slab-on-grade.** |

| UC Campus: | San Francisco – Parnassus | | | Date: | 07/10/2019 | | |
|---|---|---|---|---|---|---|---|
| Building CAAN: | 3006 | Auxiliary CAAN: | | By Firm: | SGH | | |
| Building Name: | CENTRAL UTILITIES PLANT | | | Initials: | *CAO* | Checked: | *KDP* |
| Building Address: | 25 Medical Center Way, San Francisco, CA 94131 | | | Page: | 1 | of | 4 |

# ASCE 41-17
# Collapse Prevention Structural Checklist For Building Type S2-S2A

## LOW SEISMICITY

### SEISMIC-FORCE-RESISTING SYSTEM

| | Description |
|---|---|
| C NC N/A U<br>● ○ ○ ○ | REDUNDANCY: The number of lines of braced frames in each principal direction is greater than or equal to 2. (Commentary: Sec. A.3.3.1.1. Tier 2: Sec. 5.5.1.1)<br><br>**Comments: There are three lines of bracing in the N-S direction and four lines of bracing in the E-W direction.** |
| C NC N/A U<br>○ ● ○ ○ | COLUMN AXIAL STRESS CHECK: The axial stress caused by gravity loads in columns subjected to overturning forces is less than 0.10$F_y$. Alternatively, the axial stress caused by overturning forces alone, calculated using the Quick Check procedure of Section 4.4.3.6, is less than 0.30$F_y$. (Commentary: Sec. A.3.1.3.2. Tier 2: Sec. 5.5.2.1.3)<br><br>**Comments: The columns in the lower two stories along gridline 3 fail the axial stress check caused by gravity loads (approximately 0.2Fy compared to the allowable 0.1Fy).** |
| C NC N/A U<br>○ ● ○ ○ | BRACE AXIAL STRESS CHECK: The axial stress in the diagonals, calculated using the Quick Check procedure of Section 4.4.3.4, is less than 0.50$F_y$. (Commentary: Sec. A.3.3.1.2. Tier 2: Sec. 5.5.4.1)<br><br>**Comments: The braces stresses vary up to 1.0Fy, compared to the allowable 0.5Fy.** |

### CONNECTIONS

| | Description |
|---|---|
| C NC N/A U<br>● ○ ○ ○ | TRANSFER TO STEEL FRAMES: Diaphragms are connected for transfer of seismic forces to the steel frames. (Commentary: Sec. A.5.2.2. Tier 2: Sec. 5.7.2)<br><br>**Comments: Concrete slab-on-metal-deck diaphragms are attached to collectors and frame beams with shear studs.** |
| C NC N/A U<br>● ○ ○ ○ | STEEL COLUMNS: The columns in seismic-force-resisting frames are anchored to the building foundation. (Commentary: Sec. A.5.3.1. Tier 2: Sec. 5.7.3.1)<br><br>**Comments: Braced frame columns are anchored to grade beams with 1-½" anchor rods and #10 drag bars welded to the underside of the base plates.** |

# ASCE 41-17
# Collapse Prevention Structural Checklist For Building Type S2-S2A

## MODERATE SEISMICITY (COMPLETE THE FOLLOWING ITEMS IN ADDITION TO THE ITEMS FOR LOW SEISMICITY)

### SEISMIC-FORCE-RESISTING SYSTEM

| | Description |
|---|---|
| C NC N/A U<br>● ○ ○ ○ | REDUNDANCY: The number of braced bays in each line is greater than 2. (Commentary: Sec. A.3.3.1.1. Tier 2: Sec. 5.5.1.1)<br><br>**Comments: The number of braced bays vary between 2 and 6 at each line.** |
| C NC N/A U<br>● ○ ○ ○ | CONNECTION STRENGTH: All the brace connections develop the buckling capacity of the diagonals. (Commentary: Sec. A.3.3.1.5. Tier 2: Sec. 5.5.4.4)<br><br>**Comments: The braces are connected to the columns and beams through flare-bevel welds to gusset plates on each side of the brace.** |
| C NC N/A U<br>● ○ ○ ○ | COMPACT MEMBERS: All brace elements meet compact section requirements in accordance with AISC 360, Table B4.1. (Commentary: Sec. A.3.3.1.7. Tier 2: Sec. 5.5.4)<br><br>**Comments: All braces have b/t ratios less than the limit.** |
| C NC N/A U<br>● ○ ○ ○ | K-BRACING: The bracing system does not include K-braced bays. (Commentary: Sec. A.3.3.2.1. Tier 2: Sec. 5.5.4.6)<br><br>**Comments: All bracing is single-diagonal with connections at the floors or have horizontal struts (at the multi-tier frames).** |

## HIGH SEISMICITY (COMPLETE THE FOLLOWING ITEMS IN ADDITION TO THE ITEMS FOR LOW AND MODERATE SEISMICITY)

### SEISMIC-FORCE-RESISTING SYSTEM

| | Description |
|---|---|
| C NC N/A U<br>● ○ ○ ○ | COLUMN SPLICES: All column splice details located in braced frames develop 50% of the tensile strength of the column. (Commentary: Sec. A.3.3.1.3. Tier 2: Sec. 5.5.4.2)<br><br>**Comments: Splices consist of partial joint penetration welds that are ½ the thickness of the flange or web + 1/8".** |

# ASCE 41-17
# Collapse Prevention Structural Checklist For Building Type S2-S2A

| C | NC | N/A | U | |
|---|---|---|---|---|
| ● | ○ | ○ | ○ | SLENDERNESS OF DIAGONALS: All diagonal elements required to carry compression have *Kl*/*r* ratios less than 200. (Commentary: Sec. A.3.3.1.4. Tier 2: Sec. 5.5.4.3)<br><br>**Comments: All brace slenderness ratios are less than 100.** |
| ● | ○ | ○ | ○ | CONNECTION STRENGTH: All the brace connections develop the yield capacity of the diagonals. (Commentary: Sec. A.3.3.1.5. Tier 2: Sec. 5.5.4.4)<br><br>**Comments: Connections can develop full yield capacity of braces in tension and can also develop the plastic moment of the braces.** |
| ○ | ● | ○ | ○ | COMPACT MEMBERS: All brace elements meet section requirements in accordance with AISC 341, Table D1.1, for moderately ductile members. (Commentary: Sec. A.3.3.1.7. Tier 2: Sec.5.5.4)<br><br>**Comments: The braces with wall thicknesses of 1/4, 5/16 and 3/8 inches do not comply with the moderately ductile requirements of AISC 341.** |
| ○ | ○ | ● | ○ | CHEVRON BRACING: Beams in chevron, or V-braced, bays are capable of resisting the vertical load resulting from the simultaneous yielding and buckling of the brace pairs. (Commentary: Sec. A.3.3.2.3. Tier 2: Sec. 5.5.4.6)<br><br>**Comments: All braces are in single-diagonal configurations with concentric connections at the beam-column joints.** |
| ● | ○ | ○ | ○ | CONCENTRICALLY BRACED FRAME JOINTS: All the diagonal braces frame into the beam–column joints concentrically. (Commentary: Sec. A.3.3.2.4. Tier 2: Sec. 5.5.4.8)<br><br>**Comments: All braces are in single-diagonal configuration with concentric connections at the beam-column joints.** |

## DIAPHRAGMS (STIFF OR FLEXIBLE)

| | Description |
|---|---|
| C NC N/A U<br>● ○ ○ ○ | OPENINGS AT FRAMES: Diaphragm openings immediately adjacent to the braced frames extend less than 25% of the frame length. (Commentary: Sec. A.4.1.5. Tier 2: Sec. 5.6.1.3)<br><br>**Comments: No major diaphragm openings are adjacent to the frames (lack of floors at the multi-tiered frames notwithstanding).** |

## FLEXIBLE DIAPHRAGMS

| | Description |
|---|---|

Note: **C** = Compliant **NC** = Noncompliant **N/A** = Not Applicable **U** = Unknown

| UC Campus: | San Francisco – Parnassus | | | Date: | 07/10/2019 | | |
|---|---|---|---|---|---|---|---|
| Building CAAN: | 3006 | Auxiliary CAAN: | | By Firm: | SGH | | |
| Building Name: | CENTRAL UTILITIES PLANT | | | Initials: | *CAO* | Checked: | *KDP* |
| Building Address: | 25 Medical Center Way, San Francisco, CA 94131 | | | Page: | 4 | of | 4 |

# ASCE 41-17
# Collapse Prevention Structural Checklist For Building Type S2-S2A

| C | NC | N/A | U | |
|---|---|---|---|---|
| ○ | ○ | ◉ | ○ | CROSS TIES: There are continuous cross ties between diaphragm chords. (Commentary: Sec. A.4.1.2. Tier 2: Sec. 5.6.1.2)<br><br>**Comments: Diaphragms are concrete slab-on-metal deck.** |
| ○ | ○ | ◉ | ○ | STRAIGHT SHEATHING: All straight-sheathed diaphragms have aspect ratios less than 2-to-1 in the direction being considered. (Commentary: Sec. A.4.2.1. Tier 2: Sec. 5.6.2)<br><br>**Comments: Diaphragms are concrete slab-on-metal deck.** |
| ○ | ○ | ◉ | ○ | SPANS: All wood diaphragms with spans greater than 24 ft (7.3 m) consist of wood structural panels or diagonal sheathing. (Commentary: Sec. A.4.2.2. Tier 2: Sec. 5.6.2)<br><br>**Comments: Diaphragms are concrete slab-on-metal deck.** |
| ○ | ○ | ◉ | ○ | DIAGONALLY SHEATHED AND UNBLOCKED DIAPHRAGMS: All diagonally sheathed or unblocked wood structural panel diaphragms have horizontal spans less than 40 ft (12.2 m) and aspect ratios less than or equal to 4-to-1. (Commentary: Sec. A.4.2.3. Tier 2: Sec. 5.6.2)<br><br>**Comments: Diaphragms are concrete slab-on-metal deck.** |
| ◉ | ○ | ○ | ○ | OTHER DIAPHRAGMS: Diaphragms do not consist of a system other than wood, metal deck, concrete, or horizontal bracing. (Commentary: Sec. A.4.7.1. Tier 2: Sec. 5.6.5)<br><br>**Comments: Diaphragms are concrete slab-on-metal deck.** |

# Appendix C

## UCOP Seismic Safety Policy Falling Hazards Assessment Summary

| UC Campus: | **UCSF – Parnassus** | | | Date: | **04 September 2019** | | |
|---|---|---|---|---|---|---|---|
| Building CAAN: | **3006** | Auxiliary CAAN: | | By Firm: | **Simpson Gumpertz & Heger** | | |
| Building Name: | **Central Utilities Plant** | | | Initials: | ***KDP*** | Checked: | ***KSM*** |
| Building Address: | **25 Medical Center Way, San Francisco, CA 94133** | | | Page: | **1** | of | **1** |

# UCOP SEISMIC SAFETY POLICY
# Falling Hazard Assessment Summary

| | Description |
|---|---|
| **P** ☐ **N/A** ☒ | **Heavy ceilings, features or ornamentation above large lecture halls, auditoriums, lobbies, or other areas where large numbers of people congregate (50 ppl or more)**<br>**Comments:** No areas of congregation of over 50 people are located within the building. |
| **P** ☐ **N/A** ☒ | **Heavy masonry or stone veneer above exit ways or public access areas**<br>**Comments:** No masonry or stone veneer is located near exit ways or public access areas. |
| **P** ☐ **N/A** ☒ | **Unbraced masonry parapets, cornices, or other ornamentation above exit ways or public access areas**<br>**Comments:** There are no masonry parapets, cornices, or other ornamentation. |
| **P** ☐ **N/A** ☒ | **Unrestrained hazardous material storage**<br>**Comments:** Ammonia is housed in the building but is anchored within a steel frame. Several natural gas lines run through the building and are braced. Liquid oxygen is stored in tanks anchored to the ground in a locked area outside the building. |
| **P** ☐ **N/A** ☒ | **Masonry chimneys**<br>**Comments:** No masonry chimneys are in the building. |
| **P** ☐ **N/A** ☒ | **Unrestrained natural gas-fueled equipment such as water heaters, boilers, emergency generators, etc.**<br>**Comments:** There are numerous pieces of gas-fueled equipment and all of it is anchored. |
| **P** ☐ **N/A** ☐ | **Other:**<br>**Comments:** |
| **P** ☐ **N/A** ☐ | **Other:**<br>**Comments:** |
| **P** ☐ **N/A** ☐ | **Other:**<br>**Comments:** |

Falling Hazards Risk: *Low*

Note: P= Present, N/A = Not Applicable; Falling Hazards Risk: Low, Moderate, or High

# Appendix D

## Tier 1 Calculations

SIMPSON GUMPERTZ & HEGER

Engineering of Structures
and Building Enclosures

SHEET NO. 1

PROJECT NO. 197042.00

DATE 07/10/2019

BY CAO

CHECKED KDP

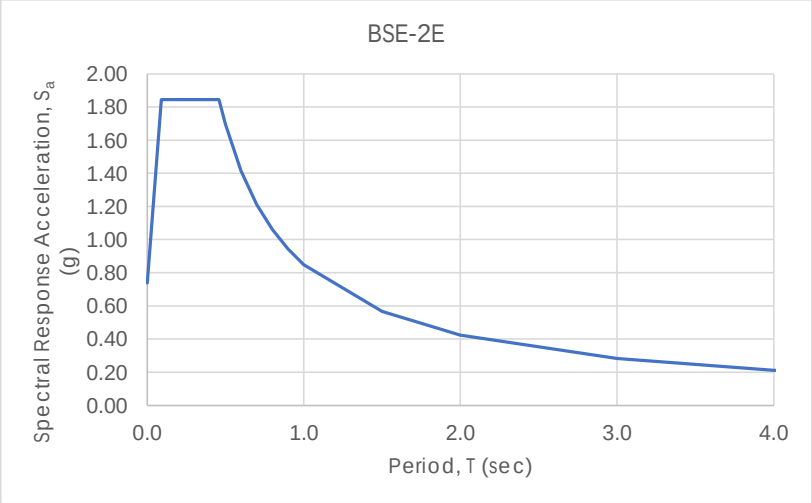
CLIENT UCSF

SUBJECT CUP Tier 1 - Quick Checks - BSE-2E Hazard

**Hazard Level BSE-2E**

| | | |
|---|---|---|
| $MCE_R$ ground motion (period=0.2s) | $S_S$ | 1.538 g |
| $MCE_R$ ground motion (period=1.0s) | $S_1$ | 0.606 g |
| Site amplification factor at 0.2s | $F_a$ | 1.2 |
| Site amplification factor at 1.0s | $F_v$ | 1.4 |
| Site modified spectral response (0.2s) | $S_{XS}$ | 1.846 g |
| Site modified spectral response (1.0s) | $S_{X1}$ | 0.848 g |
| Long-period transition period (s) | $T_L$ | 12 sec |
| | $T_0$ | 0.092 sec |
| | $T_S$ | 0.460 sec |

| T | $S_a$ |
|---|---|
| sec | g |
| 0.0 | 0.738 |
| 0.092 | 1.846 |
| 0.460 | 1.846 |
| 0.50 | 1.697 |
| 0.60 | 1.414 |
| 0.70 | 1.212 |
| 0.80 | 1.061 |
| 0.9 | 0.943 |
| 1.0 | 0.848 |
| 1.5 | 0.566 |
| 2.0 | 0.424 |
| 3.0 | 0.283 |
| 4.0 | 0.212 |
| 6.0 | 0.141 |
| 8.0 | 0.106 |
| 10.0 | 0.085 |
| 12.0 | 0.071 |



## Seismic Mass

GL 1 to 3 (Annex)

| | [ft] | [ft$^2$] | [ft$^2$] | | [plf] | [ft] | [ft] |
|---|---|---|---|---|---|---|---|
| **Floor** | **Story Height** | **Deck Area** | **Pad Area** | | **Column Wt** | **Façade Length** | **Elevation** |
| Roof | 16.92 | 2385 | 616 | | 1193 | 154 | 56.58 |
| Mezzanine | 10.17 | 2385 | 0 | | 1193 | 154 | 39.67 |
| 2nd | 14.00 | 1613 | 140 | | 1611 | 154 | 29.50 |
| Intermediate | 15.50 | 3095 | 956 | | 1611 | 154 | 15.50 |
| 1st | | | | | | | |

| | [lb] | [lb] | [lb] | [lb] | [lb] | [lb] | [lb] | [kip] |
|---|---|---|---|---|---|---|---|---|
| **Floor** | **Deck** | **Pad** | **SDL** | **Framing** | **Equipment** | **Column** | **Façade** | **W** |
| Roof | 116849 | 30817 | 59617 | 24819 | 185130 | 10091 | 15013 | 442 |
| Mezzanine | 116849 | 0 | 59617 | 23892 | 102080 | 16155 | 24035 | 343 |
| 2nd | 79017 | 6986 | 40315 | 18387 | 34470 | 17341 | 21447 | 218 |
| Intermediate | 151675 | 47823 | 77385 | 24065 | 197890 | 23762 | 26180 | 549 |
| 1st | 0 | 0 | 0 | 0 | 0 | 12485 | 13756 | 26 |

W 1578 kip

## Masses

Reinforced concrete deck

| | | |
|---|---|---|
| d | 5.25 in | (2" Deck + 4.25" Topping = 5.25" Equivalent) |
| γ | 112 pcf | (Per General Notes) |

Reinforced concrete pad

| | | |
|---|---|---|
| d | 4 in | |
| γ | 150 pcf | (Per General Notes) |

Other weight (superimposed dead load)

25 psf (Finishes + Utilities)

**EXTERIOR WALLS**

| Level | Material | Framing *(psf)* | Seismic *(psf)* | Remarks |
|---|---|---|---|---|
| ALL | 1 1/2" semi-rigid insulation | 1.5 | 1.5 | |
| " | 20 GA 3/4" sub girts @ 4'-0" o.c. | 0.5 | 0.5 | |
| " | 18 GA flat sheet | 2.0 | 2.0 | |
| " | 18 GA 2"x5"x2" Z-GIRT @ 4'-0" o.c. | 0.5 | 0.5 | |
| " | 18 GA flat sheet | 2.0 | 2.0 | |
| " | 1 1/2" metal panel | 2.0 | 2.0 | |
| " | 5" thick mineral wool insulation | 3.0 | 3.0 | |
| | *Sum of Dead Loads* | **12** | **12** | **psf** |

## Pseudo Seismic Force

GL 1 to 3 (Annex)

| | [kip] | [ft] | [ft] | [kip-ft] | | [kip] | [kip] |
|---|---|---|---|---|---|---|---|
| **Floor** | **$W_i$** | **$h_i$** | **$(h_i)^k$** | **$W_i(h_i)^k$** | **$C_{vi}$** | **$F_i$** | **$V_i$** |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| Roof | 442.3 | 56.6 | 47.4 | 20983 | 0.460 | 1339 | 1339 |
| Mezzanine | 342.6 | 39.7 | 33.8 | 11572 | 0.254 | 738 | 2077 |
| 2nd | 218.0 | 29.5 | 25.4 | 5546 | 0.121 | 354 | 2431 |
| Intermediate | 548.8 | 15.5 | 13.8 | 7546 | 0.165 | 481 | 2912 |
| 1st | Seismic Base | | | | | | |
| | 1552 | | | 45647 | 1.00 | 2912 | |

| | | |
|---|---|---|
| T | 0.413 | sec |
| k | 0.96 | |
| W | 1578 | kip |
| C | 1.0 | [Modification factor, buildings 4 stories or greater] |
| $S_a$ | 1.846 | g |
| V | 2912 | kip |

## Approximate Period of Structure

System // Braced frame systems of steel

| | | |
|---|---|---|
| $h_n$ | 56.58 | ft |
| β | 0.75 | [Other systems] |
| $C_t$ | 0.02 | [Other systems] |
| T | 0.413 | sec |
| $S_a$ | 1.846 | g |

## Seismic Mass

GL 3 to 8 (Main Area)

| | [ft] | [ft$^2$] | [ft$^2$] | | [plf] | [ft] | [ft] |
|---|---|---|---|---|---|---|---|
| **Floor** | **Story Height** | **Deck Area** | **Pad Area** | | **Column Wt** | **Façade Length** | **Elevation** |
| Roof | 13.08 | 9931 | 730 | | 1080 | 356 | 52.75 |
| Mezzanine | 10.17 | 2280 | 0 | | 1080 | | 39.67 |
| 2nd | 14.00 | 9648 | 1498 | | 2112 | 309 | 29.50 |
| Intermediate | 15.50 | 0 | 0 | | 2112 | | 15.50 |
| 1st | | | | | | | |

| | [lb] | [lb] | [lb] | [lb] | [lb] | [lb] | [lb] | [kip] |
|---|---|---|---|---|---|---|---|---|
| **Floor** | **Deck** | **Pad** | **SDL** | **Framing** | **Equipment** | **Column** | **Façade** | **W** |
| Roof | 486617 | 36483 | 248274 | 91924 | 682200 | 7063 | 47546 | 1600 |
| Mezzanine | 111720 | 0 | 57000 | 31205 | 0 | 12553 | 0 | 212 |
| 2nd | 472737 | 74920 | 241193 | 96584 | 973300 | 20274 | 93627 | 1973 |
| Intermediate | 0 | 0 | 0 | 9991 | 0 | 31152 | 0 | 41 |
| 1st | | | | | | 16368 | 52363 | 69 |

W 3895 kip

## Masses

Reinforced concrete deck

| | | |
|---|---|---|
| d | 5.25 in | (2" Deck + 4.25" Topping = 5.25" Equivalent) |
| γ | 112 pcf | (Per General Notes) |

Reinforced concrete pad

| | | |
|---|---|---|
| d | 4 in | |
| γ | 150 pcf | (Per General Notes) |

Other weight (superimposed dead load)

25 psf (Finishes + Utilities)

**EXTERIOR WALLS**

| Level | Material | Framing *(psf)* | Seismic *(psf)* | Remarks |
|---|---|---|---|---|
| ALL | 1 1/2" semi-rigid insulation | 1.5 | 1.5 | |
| " | 20 GA 3/4" sub girts @ 4'-0" o.c. | 0.5 | 0.5 | |
| " | 18 GA flat sheet | 2.0 | 2.0 | |
| " | 18 GA 2"x5"x2" Z-GIRT @ 4'-0" o.c. | 0.5 | 0.5 | |
| " | 18 GA flat sheet | 2.0 | 2.0 | |
| " | 1 1/2" metal panel | 2.0 | 2.0 | |
| " | 5" thick mineral wool insulation | 3.0 | 3.0 | |
| | *Sum of Dead Loads* | **12** | **12** | **psf** |

## Pseudo Seismic Force

GL 3 to 8 (Main Area)

| | [kip] | [ft] | [ft] | [kip-ft] | | [kip] | [kip] |
|---|---|---|---|---|---|---|---|
| **Floor** | **$W_i$** | **$h_i$** | **$(h_i)^k$** | **$W_i(h_i)^k$** | **$C_{vi}$** | **$F_i$** | **$V_i$** |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| Roof | 1600.1 | 56.6 | 47.4 | 75903 | 0.567 | 4077 | 4077 |
| Mezzanine | 212.5 | 39.7 | 33.8 | 7176 | 0.054 | 385 | 4462 |
| 2nd | 1972.6 | 29.5 | 25.4 | 50194 | 0.375 | 2696 | 7158 |
| Intermediate | 41.1 | 15.5 | 13.8 | 566 | 0.004 | 30 | 7189 |
| 1st | Seismic Base | | | | | | |
| | 3826 | | | 133839 | 1.00 | 7189 | |

| | | |
|---|---|---|
| T | 0.413 | sec |
| k | 0.96 | |
| W | 3895 | kip |
| C | 1.0 | [Modification factor, buildings 4 stories or greater] |
| $S_a$ | 1.846 | g |
| V | 7189 | kip |

## Approximate Period of Structure

System // Braced frame systems of steel

| | | |
|---|---|---|
| $h_n$ | 56.58 | ft |
| β | 0.75 | [Other systems] |
| $C_t$ | 0.02 | [Other systems] |
| T | 0.413 | sec |
| $S_a$ | 1.846 | g |

COLUMN AXIAL STRESS CHECK: The axial stress caused by gravity loads in columns subjected to overturning forces is less than $0.10F_y$. Alternatively, the axial stress caused by overturning forces alone, calculated using the Quick Check procedure of Section 4.4.3.6, is less than $0.30F_y$.

$f_y$ 50.0 ksi
$0.10f_y$ 5.0 ksi (Quick Check Limit for Gravity Axial Stresses)

## GL 1 to 3

| Floor | W [kip] |
|---|---|
| Roof | 442 |
| Mezzanine | 343 |
| 2nd | 218 |
| Intermediate | 549 |
| 1st | 26 |

| Col E1 | $A_g$ [in$^2$] | $P_{col}$ [kip] | σ [ksi] | σ/Fy | DCR | Check |
|---|---|---|---|---|---|---|
| W10x60 | 17.7 | 28 | 1.6 | 0.03 | 0.31 | OK |
| W10x60 | 17.7 | 49 | 2.8 | 0.06 | 0.55 | OK |
| W10x77 | 22.7 | 63 | 2.8 | 0.06 | 0.55 | OK |
| W10x77 | 22.7 | 97 | 4.3 | 0.09 | 0.85 | OK |
| | | | | | | |

## GL 3 to 8

Unit: kip

| Floor | W |
|---|---|
| Roof | 1600 |
| Mezzanine | 212 |
| 2nd | 1973 |
| Intermediate | 41 |
| 1st | 69 |

| Col G5 | $A_g$ [in$^2$] | $P_{col}$ [kip] | σ [ksi] | σ/Fy [ksi] | DCR | Check |
|---|---|---|---|---|---|---|
| W10x60 | 17.7 | 44 | 2.5 | 0.05 | 0.50 | OK |
| W10x60 | 17.7 | 62 | 3.5 | 0.07 | 0.70 | OK |
| W10x112 | 32.9 | 117 | 3.6 | 0.07 | 0.71 | OK |
| W10x112 | 32.9 | 118 | 3.6 | 0.07 | 0.72 | OK |
| | | | | | | |

## Matchline @ GL 3

Unit: kip

| Floor | W |
|---|---|
| Roof | 72 |
| Mezzanine | 111 |
| 2nd | 180 |
| Intermediate | 215 |
| 1st | |

| Col C3 | $A_g$ [in$^2$] | $P_{col}$ [kip] | σ [ksi] | σ/Fy [ksi] | DCR | Check |
|---|---|---|---|---|---|---|
| W10x68 | 17.7 | 72 | 4.1 | 0.08 | 0.81 | OK |
| W10x68 | 17.7 | 111 | 6.3 | 0.13 | 1.26 | Not OK |
| W10x77 | 22.7 | 180 | 7.9 | 0.16 | 1.58 | Not OK |
| W10x77 | 22.7 | 215 | 9.5 | 0.19 | 1.89 | Not OK |
| | | | | | | |

BRACE AXIAL STRESS CHECK: The axial stress in the diagonals, calculated using the Quick Check procedure of Section 4.4.3.4, is less than $0.50F_y$.

| | | |
|---|---|---|
| $f_y$ | 46.0 ksi | |
| $0.50f_y$ | 23.0 ksi | (Quick Check Limit for Seismic Axial Stresses) |
| $f_{ye}$ | 57.5 ksi | |
| $90/(f_{ye})^{0.5}$ | 11.87 | Number of braces 12 |
| $190/(f_{ye})^{0.5}$ | 25.06 | |

Level 1 - Intermediate East-West

| | b/t | $M_s$ | $A_g$ [in$^2$] | s [ft] | h [ft] | L [ft] | $V_i$ [kip] | $f_j$ [ksi] | σ/Fy | DCR | Check |
|---|---|---|---|---|---|---|---|---|---|---|---|
| TSS 8x8x3/8 | 19.9 | 4.9 | 10.4 | 12.0 | 15.5 | 19.6 | 10101.0 | 27.2 | 0.59 | 1.18 | Not OK |
| TSS 8x8x1/2 | 14.2 | 6.4 | 13.5 | 8.0 | 15.5 | 17.4 | 10101.0 | 21.3 | 0.46 | 0.93 | OK |
| TSS 8x8x1/2 | 14.2 | 6.4 | 13.5 | 8.0 | 15.5 | 17.4 | 10101.0 | 21.3 | 0.46 | 0.93 | OK |
| TSS 8x8x3/8 | 19.9 | 4.9 | 10.4 | 9.3 | 15.5 | 18.1 | 10101.0 | 32.2 | 0.70 | 1.40 | Not OK |
| TSS 8x8x1/2 | 14.2 | 6.4 | 13.5 | 11.8 | 15.5 | 19.5 | 10101.0 | 16.1 | 0.35 | 0.70 | OK |
| TSS 8x8x1/2 | 14.2 | 6.4 | 13.5 | 11.8 | 15.5 | 19.5 | 10101.0 | 16.1 | 0.35 | 0.70 | OK |
| TSS 8x8x3/8 | 19.9 | 4.9 | 10.4 | 10.5 | 15.5 | 18.7 | 10101.0 | 29.6 | 0.64 | 1.29 | Not OK |
| TSS 8x8x3/8 | 19.9 | 4.9 | 10.4 | 10.5 | 15.5 | 18.7 | 10101.0 | 29.6 | 0.64 | 1.29 | Not OK |
| TSS 8x8x3/8 | 19.9 | 4.9 | 10.4 | 12.0 | 15.5 | 19.6 | 10101.0 | 27.2 | 0.59 | 1.18 | Not OK |
| TSS 8x8x3/8 | 19.9 | 4.9 | 10.4 | 12.0 | 15.5 | 19.6 | 10101.0 | 27.2 | 0.59 | 1.18 | Not OK |
| TSS 8x8x1/2 | 14.2 | 6.4 | 13.5 | 11.8 | 15.5 | 19.5 | 10101.0 | 16.1 | 0.35 | 0.70 | OK |
| TSS 8x8x1/2 | 14.2 | 6.4 | 13.5 | 14.0 | 15.5 | 20.9 | 10101.0 | 14.6 | 0.32 | 0.63 | OK |

Level 1 - Intermediate North-South

| | b/t | $M_s$ | $A_g$ [in$^2$] | s [ft] | h [ft] | L [ft] | $V_i$ [kip] | $f_j$ [ksi] | σ/Fy | DCR | Check |
|---|---|---|---|---|---|---|---|---|---|---|---|
| TSS 8x8x3/8 | 19.9 | 4.9 | 10.4 | 11.2 | 15.5 | 19.1 | 10101.0 | 28.4 | 0.62 | 1.24 | Not OK |
| TSS 8x8x3/8 | 19.9 | 4.9 | 10.4 | 11.2 | 15.5 | 19.1 | 10101.0 | 28.4 | 0.62 | 1.24 | Not OK |
| TSS 8x8x3/8 | 19.9 | 4.9 | 10.4 | 13.3 | 15.5 | 20.4 | 10101.0 | 25.5 | 0.55 | 1.11 | Not OK |
| TSS 8x8x1/2 | 14.2 | 6.4 | 13.5 | 10.4 | 15.5 | 18.7 | 10101.0 | 17.5 | 0.38 | 0.76 | OK |
| TSS 8x8x1/2 | 14.2 | 6.4 | 13.5 | 10.4 | 15.5 | 18.7 | 10101.0 | 17.5 | 0.38 | 0.76 | OK |
| TSS 8x8x3/8 | 19.9 | 4.9 | 10.4 | 15.8 | 15.5 | 22.2 | 10101.0 | 23.3 | 0.51 | 1.01 | Not OK |
| TSS 8x8x3/8 | 19.9 | 4.9 | 10.4 | 13.3 | 15.5 | 20.4 | 10101.0 | 25.5 | 0.55 | 1.11 | Not OK |
| TSS 8x8x3/8 | 19.9 | 4.9 | 10.4 | 13.3 | 15.5 | 20.4 | 10101.0 | 25.5 | 0.55 | 1.11 | Not OK |
| TSS 8x8x1/2 | 14.2 | 6.4 | 13.5 | 16.3 | 15.5 | 22.5 | 10101.0 | 13.5 | 0.29 | 0.59 | OK |
| TSS 8x8x5/8 | 10.8 | 7.0 | 16.4 | 16.3 | 15.5 | 22.5 | 10101.0 | 10.1 | 0.22 | 0.44 | OK |
| TSS 8x8x5/8 | 10.8 | 7.0 | 16.4 | 18.0 | 15.5 | 23.8 | 10101.0 | 9.7 | 0.21 | 0.42 | OK |
| TSS 8x8x1/2 | 14.2 | 6.4 | 13.5 | 18.0 | 15.5 | 23.8 | 10101.0 | 12.9 | 0.28 | 0.56 | OK |

Intermediate - Level 2 East-West

| | b/t | $M_s$ | $A_g$ [in$^2$] | s [ft] | h [ft] | L [ft] | $V_i$ [kip] | $f_j$ [ksi] | σ/Fy | DCR | Check |
|---|---|---|---|---|---|---|---|---|---|---|---|
| TSS 8x8x1/2 | 14.2 | 6.4 | 13.5 | 12.0 | 12.2 | 17.1 | 9589.2 | 13.2 | 0.29 | 0.57 | OK |
| TSS 8x8x5/16 | 24.5 | 3.6 | 8.8 | 8.0 | 12.2 | 14.6 | 9589.2 | 45.5 | 0.99 | 1.98 | Not OK |
| TSS 8x8x5/16 | 24.5 | 3.6 | 8.8 | 8.0 | 12.2 | 14.6 | 9589.2 | 45.5 | 0.99 | 1.98 | Not OK |
| TSS 8x8x1/2 | 14.2 | 6.4 | 13.5 | 9.3 | 12.2 | 15.3 | 9589.2 | 15.2 | 0.33 | 0.66 | OK |
| TSS 8x8x3/8 | 19.9 | 4.9 | 10.4 | 11.8 | 12.2 | 17.0 | 9589.2 | 22.6 | 0.49 | 0.98 | OK |
| TSS 8x8x3/8 | 19.9 | 4.9 | 10.4 | 11.8 | 12.2 | 17.0 | 9589.2 | 22.6 | 0.49 | 0.98 | OK |
| TSS 8x8x3/8 | 19.9 | 4.9 | 10.4 | 10.5 | 12.2 | 16.1 | 9589.2 | 24.2 | 0.53 | 1.05 | Not OK |
| TSS 8x8x3/8 | 19.9 | 4.9 | 10.4 | 10.5 | 12.2 | 16.1 | 9589.2 | 24.2 | 0.53 | 1.05 | Not OK |
| TSS 8x8x3/8 | 19.9 | 4.9 | 10.4 | 12.0 | 12.2 | 17.1 | 9589.2 | 22.5 | 0.49 | 0.98 | OK |
| TSS 8x8x3/8 | 19.9 | 4.9 | 10.4 | 12.0 | 12.2 | 17.1 | 9589.2 | 22.5 | 0.49 | 0.98 | OK |
| TSS 8x8x3/8 | 19.9 | 4.9 | 10.4 | 11.8 | 14.0 | 18.3 | 9589.2 | 24.4 | 0.53 | 1.06 | Not OK |
| TSS 8x8x3/8 | 19.9 | 4.9 | 10.4 | 14.0 | 14.0 | 19.8 | 9589.2 | 22.3 | 0.49 | 0.97 | OK |

BRACE AXIAL STRESS CHECK: The axial stress in the diagonals, calculated using the Quick Check procedure of Section 4.4.3.4, is less than $0.50F_y$.

| | | | |
|---|---|---|---|
| $f_y$ | 46.0 | ksi | |
| $0.50f_y$ | 23.0 | ksi | (Quick Check Limit for Seismic Axial Stresses) |
| $f_{ye}$ | 57.5 | ksi | |
| $90/(f_{ye})^{0.5}$ | 11.87 | | Number of braces 12 |
| $190/(f_{ye})^{0.5}$ | 25.06 | | |

Intermediate - Level 2 North-South

| | b/t | $M_s$ | $A_g$ [in$^2$] | s [ft] | h [ft] | L [ft] | $V_i$ [kip] | $f_j$ [ksi] | σ/Fy | DCR | Check |
|---|---|---|---|---|---|---|---|---|---|---|---|
| TSS 8x8x5/16 | 24.5 | 3.6 | 8.8 | 11.2 | 12.2 | 16.5 | 9589.2 | 37.0 | 0.80 | 1.61 | Not OK |
| TSS 8x8x5/16 | 24.5 | 3.6 | 8.8 | 11.2 | 12.2 | 16.5 | 9589.2 | 37.0 | 0.80 | 1.61 | Not OK |
| TSS 8x8x1/2 | 14.2 | 6.4 | 13.5 | 13.3 | 12.2 | 18.1 | 9589.2 | 12.6 | 0.27 | 0.55 | OK |
| TSS 8x8x5/16 | 24.5 | 3.6 | 8.8 | 10.4 | 12.2 | 16.0 | 9589.2 | 38.5 | 0.84 | 1.67 | Not OK |
| TSS 8x8x5/16 | 24.5 | 3.6 | 8.8 | 10.4 | 12.2 | 16.0 | 9589.2 | 38.5 | 0.84 | 1.67 | Not OK |
| TSS 8x8x1/2 | 14.2 | 6.4 | 13.5 | 15.8 | 12.2 | 20.0 | 9589.2 | 11.7 | 0.25 | 0.51 | OK |
| TSS 8x8x1/4 | 31.3 | 3.5 | 7.1 | 13.3 | 12.2 | 18.1 | 9589.2 | 43.5 | 0.95 | 1.89 | Not OK |
| TSS 8x8x1/4 | 31.3 | 3.5 | 7.1 | 13.3 | 12.2 | 18.1 | 9589.2 | 43.5 | 0.95 | 1.89 | Not OK |
| TSS 8x8x3/8 | 19.9 | 4.9 | 10.4 | 16.3 | 12.2 | 20.4 | 9589.2 | 19.7 | 0.43 | 0.86 | OK |
| TSS 8x8x1/2 | 14.2 | 6.4 | 13.5 | 16.3 | 12.2 | 20.4 | 9589.2 | 11.6 | 0.25 | 0.50 | OK |
| TSS 8x8x1/2 | 14.2 | 6.4 | 13.5 | 18.0 | 12.2 | 21.7 | 9589.2 | 11.2 | 0.24 | 0.49 | OK |
| TSS 8x8x3/8 | 19.9 | 4.9 | 10.4 | 18.0 | 12.2 | 21.7 | 9589.2 | 19.0 | 0.41 | 0.83 | OK |

Level 2 - Mezzanine East-West

| | b/t | $M_s$ | $A_g$ [in$^2$] | s [ft] | h [ft] | L [ft] | $V_i$ [kip] | $f_j$ [ksi] | σ/Fy | DCR | Check |
|---|---|---|---|---|---|---|---|---|---|---|---|
| TSS 8x8x1/4 | 31.3 | 3.5 | 7.1 | 12.0 | 12.0 | 17.0 | 6539.4 | 31.0 | 0.67 | 1.35 | Not OK |
| TSS 8x8x1/4 | 31.3 | 3.5 | 7.1 | 8.0 | 12.0 | 14.4 | 6539.4 | 39.5 | 0.86 | 1.72 | Not OK |
| TSS 8x8x1/4 | 31.3 | 3.5 | 7.1 | 8.0 | 12.0 | 14.4 | 6539.4 | 39.5 | 0.86 | 1.72 | Not OK |
| TSS 8x8x1/4 | 31.3 | 3.5 | 7.1 | 9.3 | 12.0 | 15.2 | 6539.4 | 35.7 | 0.78 | 1.55 | Not OK |
| TSS 8x8x3/8 | 19.9 | 4.9 | 10.4 | 11.8 | 12.0 | 16.9 | 6539.4 | 15.3 | 0.33 | 0.67 | OK |
| TSS 8x8x3/8 | 19.9 | 4.9 | 10.4 | 11.8 | 12.0 | 16.9 | 6539.4 | 15.3 | 0.33 | 0.67 | OK |
| TSS 8x8x1/4 | 31.3 | 3.5 | 7.1 | 10.5 | 12.0 | 15.9 | 6539.4 | 33.3 | 0.72 | 1.45 | Not OK |
| TSS 8x8x1/4 | 31.3 | 3.5 | 7.1 | 10.5 | 12.0 | 15.9 | 6539.4 | 33.3 | 0.72 | 1.45 | Not OK |
| TSS 8x8x1/4 | 31.3 | 3.5 | 7.1 | 12.0 | 12.0 | 17.0 | 6539.4 | 31.0 | 0.67 | 1.35 | Not OK |
| TSS 8x8x1/4 | 31.3 | 3.5 | 7.1 | 12.0 | 12.0 | 17.0 | 6539.4 | 31.0 | 0.67 | 1.35 | Not OK |
| TSS 8x8x3/8 | 19.9 | 4.9 | 10.4 | 11.8 | 10.2 | 15.6 | 6539.4 | 14.2 | 0.31 | 0.62 | OK |
| TSS 8x8x3/8 | 19.9 | 4.9 | 10.4 | 14.0 | 10.2 | 17.3 | 6539.4 | 13.3 | 0.29 | 0.58 | OK |

Level 2 - Mezzanine North-South

| | b/t | $M_s$ | $A_g$ [in$^2$] | s [ft] | h [ft] | L [ft] | $V_i$ [kip] | $f_j$ [ksi] | σ/Fy | DCR | Check |
|---|---|---|---|---|---|---|---|---|---|---|---|
| TSS 8x8x5/16 | 24.5 | 3.6 | 8.8 | 11.2 | 12.0 | 16.4 | 6539.4 | 25.0 | 0.54 | 1.09 | Not OK |
| TSS 8x8x5/16 | 24.5 | 3.6 | 8.8 | 11.2 | 12.0 | 16.4 | 6539.4 | 25.0 | 0.54 | 1.09 | Not OK |
| TSS 8x8x5/16 | 24.5 | 3.6 | 8.8 | 13.3 | 12.0 | 17.9 | 6539.4 | 22.9 | 0.50 | 1.00 | OK |
| TSS 8x8x1/4 | 31.3 | 3.5 | 7.1 | 10.4 | 12.0 | 15.9 | 6539.4 | 33.5 | 0.73 | 1.45 | Not OK |
| TSS 8x8x1/4 | 31.3 | 3.5 | 7.1 | 10.4 | 12.0 | 15.9 | 6539.4 | 33.5 | 0.73 | 1.45 | Not OK |
| TSS 8x8x5/16 | 24.5 | 3.6 | 8.8 | 15.8 | 12.0 | 19.9 | 6539.4 | 21.4 | 0.47 | 0.93 | OK |
| TSS 8x8x1/4 | 31.3 | 3.5 | 7.1 | 13.3 | 12.0 | 17.9 | 6539.4 | 29.5 | 0.64 | 1.28 | Not OK |
| TSS 8x8x1/4 | 31.3 | 3.5 | 7.1 | 13.3 | 12.0 | 17.9 | 6539.4 | 29.5 | 0.64 | 1.28 | Not OK |
| TSS 8x8x1/4 | 31.3 | 3.5 | 7.1 | 16.3 | 12.0 | 20.3 | 6539.4 | 27.2 | 0.59 | 1.18 | Not OK |
| TSS 8x8x5/16 | 24.5 | 3.6 | 8.8 | 16.3 | 12.0 | 20.3 | 6539.4 | 21.2 | 0.46 | 0.92 | OK |
| TSS 8x8x5/16 | 24.5 | 3.6 | 8.8 | 18.0 | 12.0 | 21.6 | 6539.4 | 20.5 | 0.45 | 0.89 | OK |
| TSS 8x8x1/4 | 31.3 | 3.5 | 7.1 | 18.0 | 12.0 | 21.6 | 6539.4 | 26.4 | 0.57 | 1.15 | Not OK |

BRACE AXIAL STRESS CHECK: The axial stress in the diagonals, calculated using the Quick Check procedure of Section 4.4.3.4, is less than $0.50F_y$.

| | | | |
|---|---|---|---|
| $f_y$ | 46.0 | ksi | |
| $0.50f_y$ | 23.0 | ksi | (Quick Check Limit for Seismic Axial Stresses) |
| $f_{ye}$ | 57.5 | ksi | |
| $90/(f_{ye})^{0.5}$ | 11.87 | | Number of braces 12 |
| $190/(f_{ye})^{0.5}$ | 25.06 | | |

Mezzanine - Roof East-West

| | b/t | $M_s$ | $A_g$ [in$^2$] | s [ft] | h [ft] | L [ft] | $V_i$ [kip] | $f_j$ [ksi] | σ/Fy | DCR | Check |
|---|---|---|---|---|---|---|---|---|---|---|---|
| TSS 8x8x1/4 | 31.3 | 3.5 | 7.1 | 12.0 | 13.1 | 17.8 | 5415.6 | 26.9 | 0.58 | 1.17 | Not OK |
| TSS 8x8x1/4 | 31.3 | 3.5 | 7.1 | 8.0 | 13.1 | 15.3 | 5415.6 | 34.8 | 0.76 | 1.51 | Not OK |
| TSS 8x8x1/4 | 31.3 | 3.5 | 7.1 | 8.0 | 13.1 | 15.3 | 5415.6 | 34.8 | 0.76 | 1.51 | Not OK |
| TSS 8x8x1/4 | 31.3 | 3.5 | 7.1 | 9.3 | 13.1 | 16.1 | 5415.6 | 31.3 | 0.68 | 1.36 | Not OK |
| TSS 8x8x1/4 | 31.3 | 3.5 | 7.1 | 11.8 | 16.9 | 20.6 | 5415.6 | 31.7 | 0.69 | 1.38 | Not OK |
| TSS 8x8x1/4 | 31.3 | 3.5 | 7.1 | 11.8 | 16.9 | 20.6 | 5415.6 | 31.7 | 0.69 | 1.38 | Not OK |
| TSS 8x8x1/4 | 31.3 | 3.5 | 7.1 | 10.5 | 13.1 | 16.8 | 5415.6 | 29.0 | 0.63 | 1.26 | Not OK |
| TSS 8x8x1/4 | 31.3 | 3.5 | 7.1 | 10.5 | 13.1 | 16.8 | 5415.6 | 29.0 | 0.63 | 1.26 | Not OK |
| TSS 8x8x1/4 | 31.3 | 3.5 | 7.1 | 12.0 | 13.1 | 17.8 | 5415.6 | 26.9 | 0.58 | 1.17 | Not OK |
| TSS 8x8x1/4 | 31.3 | 3.5 | 7.1 | 12.0 | 13.1 | 17.8 | 5415.6 | 26.9 | 0.58 | 1.17 | Not OK |
| TSS 8x8x1/4 | 31.3 | 3.5 | 7.1 | 11.8 | 16.9 | 20.6 | 5415.6 | 31.7 | 0.69 | 1.38 | Not OK |
| TSS 8x8x1/4 | 31.3 | 3.5 | 7.1 | 14.0 | 16.9 | 22.0 | 5415.6 | 28.5 | 0.62 | 1.24 | Not OK |

Mezzanine - Roof North-South

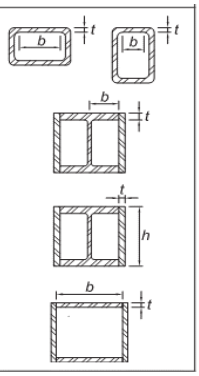
| | b/t | $M_s$ | $A_g$ [in$^2$] | s [ft] | h [ft] | L [ft] | $V_i$ [kip] | $f_j$ [ksi] | σ/Fy | DCR | Check |
|---|---|---|---|---|---|---|---|---|---|---|---|
| TSS 8x8x1/4 | 31.3 | 3.5 | 7.1 | 11.2 | 13.1 | 17.2 | 5415.6 | 30.5 | 0.66 | 1.33 | Not OK |
| TSS 8x8x1/4 | 31.3 | 3.5 | 7.1 | 11.2 | 13.1 | 17.2 | 5415.6 | 30.5 | 0.66 | 1.33 | Not OK |
| TSS 8x8x1/4 | 31.3 | 3.5 | 7.1 | 13.3 | 13.1 | 18.7 | 5415.6 | 27.8 | 0.60 | 1.21 | Not OK |
| TSS 8x8x5/16 | 24.5 | 3.6 | 8.8 | 10.4 | 13.1 | 16.7 | 5415.6 | 24.7 | 0.54 | 1.08 | Not OK |
| TSS 8x8x5/16 | 24.5 | 3.6 | 8.8 | 10.4 | 13.1 | 16.7 | 5415.6 | 24.7 | 0.54 | 1.08 | Not OK |
| - | | | | | | | | | 0.00 | 0.00 | |
| TSS 8x8x1/4 | 31.3 | 3.5 | 7.1 | 13.3 | 16.9 | 21.5 | 5415.6 | 32.0 | 0.70 | 1.39 | Not OK |
| TSS 8x8x1/4 | 31.3 | 3.5 | 7.1 | 13.3 | 16.9 | 21.5 | 5415.6 | 32.0 | 0.70 | 1.39 | Not OK |
| TSS 8x8x1/4 | 31.3 | 3.5 | 7.1 | 16.3 | 13.1 | 20.9 | 5415.6 | 25.4 | 0.55 | 1.10 | Not OK |
| TSS 8x8x1/4 | 31.3 | 3.5 | 7.1 | 16.3 | 13.1 | 20.9 | 5415.6 | 25.4 | 0.55 | 1.10 | Not OK |
| TSS 8x8x1/4 | 31.3 | 3.5 | 7.1 | 18.0 | 13.1 | 22.3 | 5415.6 | 24.5 | 0.53 | 1.06 | Not OK |
| TSS 8x8x1/4 | 31.3 | 3.5 | 7.1 | 18.0 | 13.1 | 22.3 | 5415.6 | 24.5 | 0.53 | 1.06 | Not OK |

COMPACT MEMBERS: All brace elements meet compact section requirements in accordance with AISC 360, Table B4.1.

COMPACT MEMBERS: All brace elements meet section requirements in accordance with AISC 341, Table D1.1, for moderately ductile members.

| | | | |
|---|---|---|---|
| $f_y$ | 46 ksi | $R_y$ | 1.4 |
| E | 29000 ksi | $0.76[E/(R_y f_y)]^{0.5}$ | 16.1 |
| $1.40(E/f_y)^{0.5}$ | 35.2 | | |

| | | AISC 360 | AISC 341 |
|---|---|---|---|
| | b/t | Compact? | Compact? |
| TSS 8x8x1/4 | 31.3 | YES | NO |
| TSS 8x8x5/16 | 24.5 | YES | NO |
| TSS 8x8x3/8 | 19.9 | YES | NO |
| TSS 8x8x1/2 | 14.2 | YES | YES |
| TSS 8x8x5/8 | 10.8 | YES | YES |

| | | | | | |
|---|---|---|---|---|---|
| Stiffened Elements | Walls of rectangular HSS used as diagonal braces | b/t | $0.65\sqrt{\frac{E}{R_y F_y}}$ | $0.76\sqrt{\frac{E}{R_y F_y}}$ |  |
| | Flanges of boxed I-shaped sections | b/t | | | |
| | Side plates of boxed I-shaped sections and walls of built-up box shapes used as diagonal braces | h/t | | | |
| | Flanges of built-up box shapes used as link beams | b/t | | | |

CONNECTION STRENGTH: All the brace connections develop the buckling capacity of the diagonals.

CONNECTION STRENGTH: All the brace connections develop the yield capacity of the diagonals.

Buckling capacity of diagonals

K 1.0 [pinned-pinned]

AISC Table 4-14

| | $r_y$ [in] | L [ft] | KL/r | $A_g$ [in$^2$] | $\Phi F_{cr}$ [ksi] | $P_n$ [kip] |
|---|---|---|---|---|---|---|
| TSS 8x8x1/4 | 3.15 | 22.3 | 84.8 | 7.1 | 25.5 | 201 |
| TSS 8x8x5/16 | 3.13 | 19.9 | 76.2 | 8.8 | 28.1 | 274 |
| TSS 8x8x3/8 | 3.10 | 22.2 | 85.8 | 10.4 | 25.2 | 291 |
| TSS 8x8x1/2 | 3.04 | 24.4 | 96.4 | 13.5 | 22.2 | 332 |
| TSS 8x8x5/8 | 2.99 | 24.4 | 98.0 | 16.4 | 21.7 | 395 |

Yield capacity of diagonals

$f_y$ 46 ksi

| | $A_g$ [in$^2$] | $P_n$ [kip] |
|---|---|---|
| TSS 8x8x1/4 | 7.1 | 327 |
| TSS 8x8x5/16 | 8.8 | 403 |
| TSS 8x8x3/8 | 10.4 | 478 |
| TSS 8x8x1/2 | 13.5 | 621 |
| TSS 8x8x5/8 | 16.4 | 754 |

Brace connection capacity

$F_{EXX}$ 70 ksi
L 74 in

| | Weld D | $V_n$ [kip] | DCR | Check |
|---|---|---|---|---|
| TSS 8x8x1/4 | 0.19 | 412 | 0.79 | OK |
| TSS 8x8x5/16 | 0.25 | 549 | 0.73 | OK |
| TSS 8x8x3/8 | 0.31 | 687 | 0.70 | OK |
| TSS 8x8x1/2 | 0.31 | 687 | 0.90 | OK |
| TSS 8x8x5/8 | 0.38 | 824 | 0.92 | OK |

Plate capacity

$f_y$ 36 ksi
t 1.25 in
d 24 in
$V_n$ 1296 kip

| | |
|---|---|
| DCR | 0.58 |
| Check | OK |

SLENDERNESS OF DIAGONALS: All diagonal elements required to carry compression have *Kl/r* ratios less than 200.

K 1.0 [pinned-pinned]

| | $r_y$ [in] | L [ft] | KL/r | < 200? |
|---|---|---|---|---|
| TSS 8x8x1/4 | 3.15 | 22.3 | 84.8 | YES |
| TSS 8x8x5/16 | 3.13 | 19.9 | 76.2 | YES |
| TSS 8x8x3/8 | 3.10 | 22.2 | 85.8 | YES |
| TSS 8x8x1/2 | 3.04 | 24.4 | 96.4 | YES |
| TSS 8x8x5/8 | 2.99 | 24.4 | 98.0 | YES |

## Overturning Check

GL 1

L 26.7 ft  $A_{found}$ 128.6 $ft^2$

| Floor | $V_i$ [kip] | $h_i$ [ft] | OTM [kip-ft] | OTM/L [kip] | DEAD [kip] |
|---|---|---|---|---|---|
| Roof | 669.3 | 56.6 | 37874 | 2305 | 105.2 |
| Mezzanine | 369.1 | 39.7 | 14643 | | |
| 2nd | 176.9 | 29.5 | 5219 | | |
| Intermediate | 240.7 | 15.5 | 3731 | | |
| 1st | 0.0 | 0.0 | 0 | | |
| | | | 61467 | | |

| | | | |
|---|---|---|---|
| $\sigma_{allow}$ | 11.0 | ksf | |
| $\sigma_{applied}$ | 13.4 | ksf | |
| DCR | 1.21 | | Not OK |
| h/L | 0.471 | | |
| $0.6S_a$ | 1.1 | | Not OK |

GL C

L 23.7 ft  $A_{found}$ 182.3 $ft^2$

| Floor | $V_i$ [kip] | $h_i$ [ft] | OTM [kip-ft] | OTM/L [kip] | DEAD [kip] |
|---|---|---|---|---|---|
| Roof | 669.3 | 56.6 | 37874 | 2597 | 105.2 |
| Mezzanine | 369.1 | 39.7 | 14643 | | |
| 2nd | 176.9 | 29.5 | 5219 | | |
| Intermediate | 240.7 | 15.5 | 3731 | | |
| 1st | 0.0 | 0.0 | 0 | | |
| | | | 61467 | | |

| | | | |
|---|---|---|---|
| $\sigma_{allow}$ | 11.0 | ksf | |
| $\sigma_{applied}$ | 10.6 | ksf | |
| DCR | 0.96 | | OK |
| h/L | 0.418 | | |
| $0.6S_a$ | 1.1 | | Not OK |

GL F

L 25.8 ft  $A_{found}$ 148.5 $ft^2$

| Floor | $V_i$ [kip] | $h_i$ [ft] | OTM [kip-ft] | OTM/L [kip] | DEAD [kip] |
|---|---|---|---|---|---|
| Roof | 669.3 | 56.6 | 37874 | 2379 | 105.2 |
| Mezzanine | 369.1 | 39.7 | 14643 | | |
| 2nd | 176.9 | 29.5 | 5219 | | |
| Intermediate | 240.7 | 15.5 | 3731 | | |
| 1st | 0.0 | 0.0 | 0 | | |
| | | | 61467 | | |

| | | | |
|---|---|---|---|
| $\sigma_{allow}$ | 11.0 | ksf | |
| $\sigma_{applied}$ | 11.9 | ksf | |
| DCR | 1.08 | | Not OK |
| h/L | 0.457 | | |
| $0.6S_a$ | 1.1 | | Not OK |

# Appendix E

## Equipment Anchorage Photos


Photo 1. Gas Turbine Anchorage


Photo 2. Ammonia Tank Anchorage

Photo 3. Boiler Anchorage


Photo 4. Auxiliary Generator Anchorage


Photo 5. Overhead Pipe/Conduit Bracing


Photo 6. Conduit Bracing

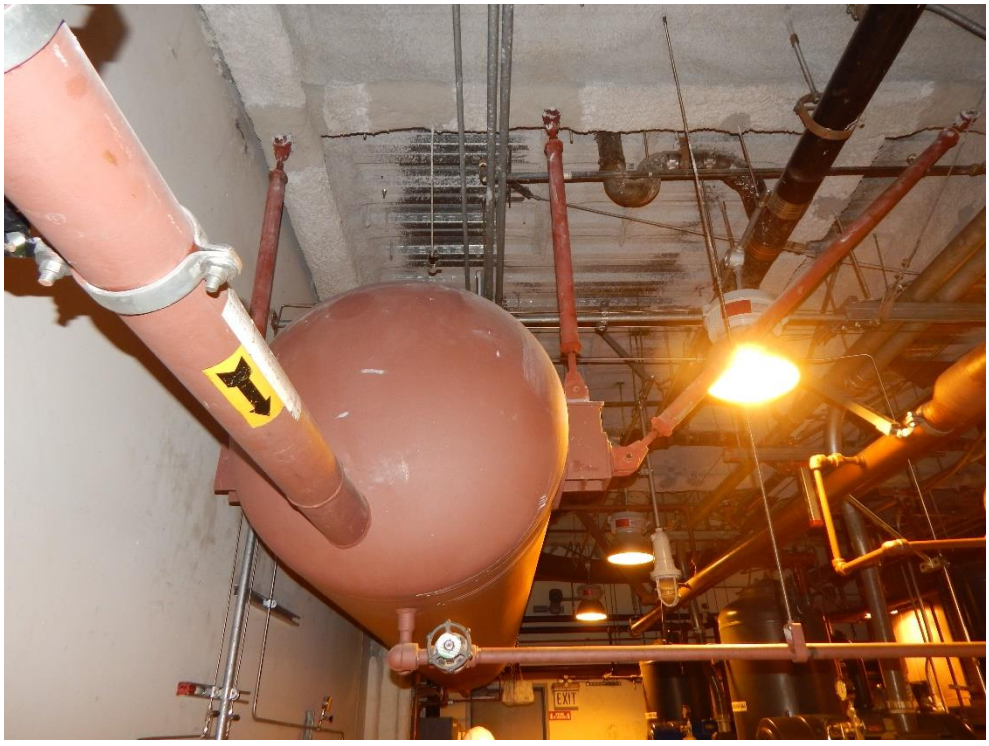


Photo 7. Tank Bracing


Photo 8. Gas Compressor Skid

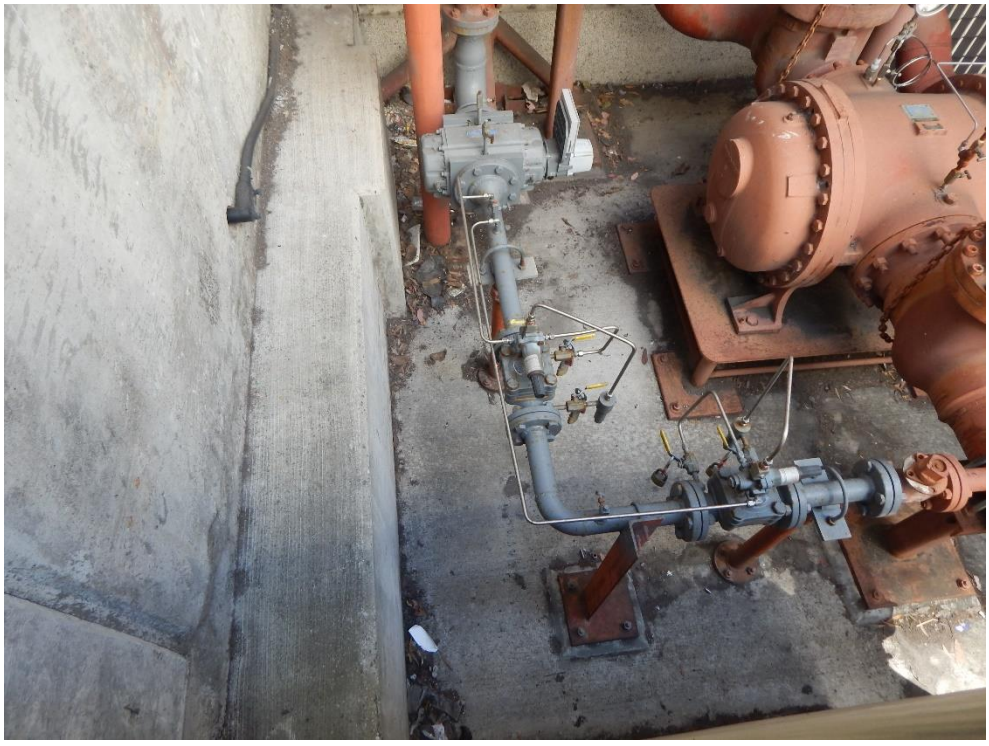


Photo 9. Gas Pump Anchorage


Photo 10. Oxygen Tank Anchorage

Photo 11. Diesel Generator Anchorage


Photo 12. Generator Duct Bracing

Photo 13. Boiler Tank Anchorage


Photo 14. Brine Tank Anchorage

Photo 15. Pump & Pipe Stanchion Anchorage

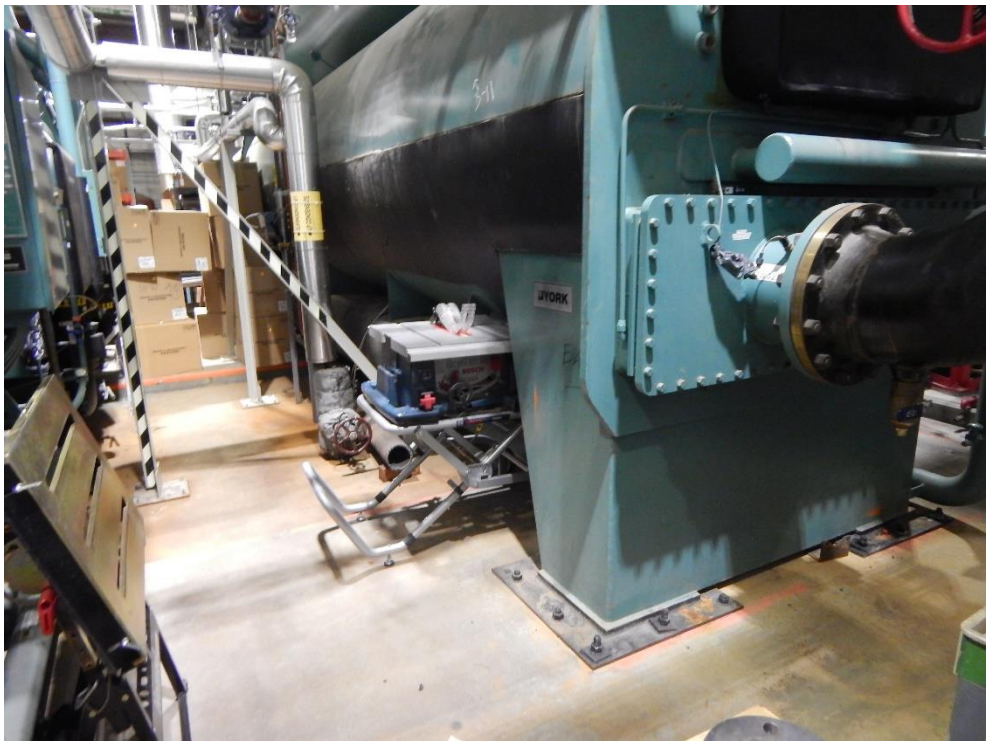


Photo 16. Chiller Anchorage

Photo 17. Substation Anchorage

Photo 18. Auxiliary Cooling Tower Base

Photo 19. Cooling Tower Pump Anchorage


Photo 20. Pipe Bracing Frames


Photo 21. Filtration Tank Anchorage

Photo 22. Exhaust Duct Frame

Photo 23. Storage Tank Anchorage

Photo 24. Transformer Anchorage

Photo 25. Cooling Tower Base


Photo 26. Cooling Tower Base