RUTHERFORD + CHEKENE
ruthchek.com
Evaluator: CLP/EFA/BL

Date: 06/28/2019

*Text in green is to be part of UC Santa Cruz building database and may be part of UCOP database*

DATE: 2019-06-28

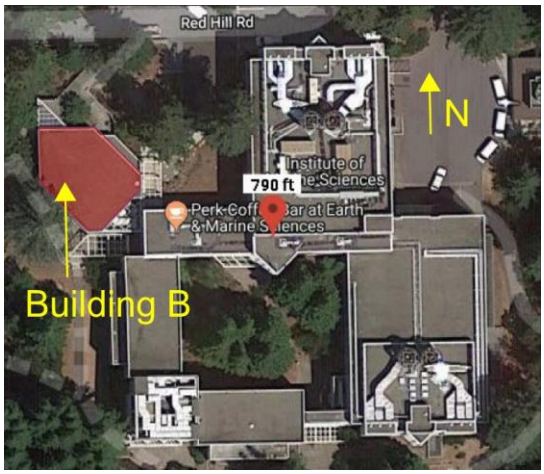

**UC Santa Cruz building seismic ratings**

# Earth & Marine Sciences
# (Lecture Hall B206 Steel Braced Frames)

CAAN #7775.2
552 Red Hill Road, Santa Cruz, CA 95064
UCSC Campus: Main Campus

North Elevation

Plan




| Rating summary | Entry | Notes |
|---|---|---|
| UC Seismic Performance Level (rating) | V (Poor) | |
| Rating basis | Tier 1 | ASCE 41-17[1] |
| Date of rating | 2019 | |
| Recommended UC Santa Cruz priority category for retrofit | Priority B | Priority A=Retrofit ASAP<br>Priority B=Retrofit at next permit application |
| Ballpark total construction cost to retrofit to IV rating[2] | High ($200-400/sf) | See recommendations on further evaluation and retrofit. |
| Is 2018-2019 rating required by UCOP? | Yes | 1998 Revised Rating was Good (3 checklists, 2 reports) |
| Further evaluation recommended? | Yes | Tier 3 nonlinear static |

[1] We translate this Tier 1 evaluation to a Seismic Performance Level rating using professional judgment. Non-compliant items in the Tier 1 evaluation do not automatically put a building into a particular rating category, but we evaluate such items 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. See Section III.B of the 19 May 2017 *UC Seismic Safety Policy* and Method B of Section 321 of the 2016 *California Building Code*.

[2] Per Section III.A.4.i of the 26 March 2019 *UC Seismic Program Guidebook*, *Version 1.3*, the cost includes all construction cost necessitated by the seismic retrofit, including restoration of finishes and any triggered work on utilities or accessibility. It does not include soft costs such as design fees or campus costs. The cost is in 2019 dollars.

**Building information used in this evaluation**

- Architectural drawings by McLellan & Copenhagen, Executive Architects, and Zimmer Gunsul Frasca Partnership, "Earth and Marine Sciences Building, University of California, Santa Cruz," as-built set dated 16 August 1991, Sheets A0.1 to A8.4.3 (165 sheets). Drawings are for whole complex; relevant sheets for steel braced frames are for "Office Block, Office Lobby, and Atrium."
- Structural drawings by Rutherford + Chekene, Structural and Civil Engineers, "Earth and Marine Sciences Building, University of California, Santa Cruz," reference set dated 16 August 1991, Sheets S0.1 to S8.1 (45 sheets). Drawings are for whole complex; relevant sheets for steel braced frames are for "Office Block, Office Lobby, and Atrium."
- Structural Calculations by Rutherford+ Chekene, three volumes obtained from R+C archive dated February 1990.
- UCSC 1998 Seismic Assessment, 2 reports by R+C.

**Additional building information known to exist**

Original Civil, Electrical, Mechanical, Plumbing, Fire Alarm, Honeywell shop drawings not reviewed.

**Scope for completing this form**

Reviewed architectural and structural drawings for original construction, reviewed original 1990 structural calculations, reviewed 1998 Seismic Assessment, made brief site visit on 3 June 2019, and carried out ASCE 41-17 Tier 1 evaluation.

**Brief description of structure**

The Earth and Marine Sciences Building is a complex with seven independent structures that include two concrete shear wall laboratory buildings, four steel moment frame office buildings, and one steel braced frame Lecture Hall. The buildings are arranged around a central courtyard on a site that slopes to the south and are typically separated by small seismic gaps. This report addresses the small steel braced framed Lecture Hall B206 at the northwest corner of the complex classified as Model Building Type S2. This building contains a single large lecture hall and small mezzanine located at the southeast corner of the building.

Building condition: During the site visit, we did not observe signs of deterioration except weathered paint of the exposed exterior steel. All other steel framing was covered by finishes and not visible. Architectural finishes appeared to be in relatively good condition for the age of the structure.

Identification of levels: The one-story building has a small mezzanine at the south end which has two small braces for lateral support. The site slopes down to the south and west, and the north and west entries into the adjacent Atrium are at a lower level than the north entry into the Lecture Hall. The lecture seating and building foundation slope down to the southeast towards the front of the Lecture Hall.

Foundation system: The building has a perimeter stepped wall footing with pilasters to support the steel columns. Two additional transverse lines with bracing have spread footings connected with tie beams. The bottom of footing elevations range from 780 feet at the northwest corner to 765 feet along the south wall.

Structural system for vertical (gravity) load: The gravity framing at the roof consists of metal deck with insulating concrete fill spanning to WF beams, girders, and columns. The principal roof girders span 50'-6" in the transverse direction. Mezzanine framing includes WF beams and metal deck with 2 ½"normal weight concrete fill.

Structural system for lateral forces: The roof is supported by four braced frames located along the two longitudinal sides and along two interior transverse lines of framing. Two additional lines of bracing support the small mezzanine level along the south and east walls. The braced frames along the two longitudinal walls have a single concentric brace; braced frames in the transverse direction include two braces in each frame. The braced frames were designed per the 1988 UBC using an allowable stress design base shear of $V$=0.183$W$ and an $R_w$ value of 8. The connections were not designed for the brace tensile capacity.

**Brief description of seismic deficiencies and expected seismic performance including mechanism of nonlinear response and structural behavior modes**

Identified seismic deficiencies of the building include the following:

- Redundancy: There are only two lines of bracing in each direction and only one brace each in the longitudinal frames.
- Brace connection strength: The brace connections were not designed to develop the capacity of the braces and are likely to fail prematurely in a large earthquake.
- Non-compact brace members: The width-to-thickness ratio of the braces is such that the braces will not exhibit moderately ductile behavior.
- Ceilings: Heavy overhead ceilings and lights with cascading levels, curving surfaces, and unknown boundary conditions may be vulnerable to failure.
- Path of egress: The Lecture Hall has several exits, including through the adjacent Atrium building. The Atrium building has full height glazing supported by flexible moment frames and situated with inadequate seismic gaps to the adjacent wings. Braces are expected to experience overall buckling in compression and yielding in tension. Because of their width-to-thickness ratios, braces are not anticipated to sustain many inelastic cycles of axial deformation. Braces may fracture prematurely. If braces are able to resist many inelastic cycles, brace end connections may fracture at their net sections. If that does not occur, the gusset connection may fracture because of either their inability to form a hinge or because of large tensile forces. Due to the long roof spans and few columns, it is possible the failure of the brace connections could result in a loss of vertical support.

| Structural deficiency | Affects rating? | Structural deficiency | Affects rating? |
|---|---|---|---|
| Lateral system stress check (wall shear, column shear or flexure, or brace axial as applicable) | N | Openings at shear walls (concrete or masonry) | N |
| Load path | N | Liquefaction | N |
| Adjacent buildings | Y | Slope failure | N |
| Weak story | N | Surface fault rupture | N |
| Soft story | N | Masonry or concrete wall anchorage at flexible diaphragm | N |
| Geometry (vertical irregularities) | N | URM wall height-to-thickness ratio | N |
| Torsion | N | URM parapets or cornices | N |
| Mass – vertical irregularity | N | URM chimney | N |
| Cripple walls | N | Heavy partitions braced by ceilings | N |
| Wood sills (bolting) | N | Appendages | N |
| Diaphragm continuity | N | | |

**Summary of review of nonstructural life-safety concerns, including at exit routes.[3]**

The Lecture Hall has heavy overhead ceilings and lights that could be a falling hazard. Additionally, the Lecture Hall depends in part on the Atrium for path of egress. That is an undesirable dependency because the Atrium has full height glazing supported by flexible moment frames and situated with inadequate seismic gaps to the adjacent wings. Pounding between the four adjacent moment frames may result in damage to the glazing leading to a life safety falling hazard.

| UCOP nonstructural checklist item | Life safety hazard? | UCOP nonstructural 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 | Yes | 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 |

[3] For these Tier 1 evaluations, we do not visit all spaces of the building; we rely on campus staff to report to us their understanding of if and where nonstructural hazards may occur.

**Basis of rating**

The basis of the V (Poor) rating is based on the deficiencies identified by the Tier 1 check. The steel braced frame lacks redundancy, its members are slender, and its connections are not strong enough or ductile enough for the anticipated loads and deformations.

**Recommendations for further evaluation or retrofit**

We recommend performing a Tier 3 nonlinear evaluation to obtain a more refined quantification of axial loads. We recommend that nonlinear analyses be performed to better quantify the axial demands at both the brace connections and frame columns and determine the likelihood of frame column buckling and loss of vertical load-carrying capability.

**Peer review of rating**

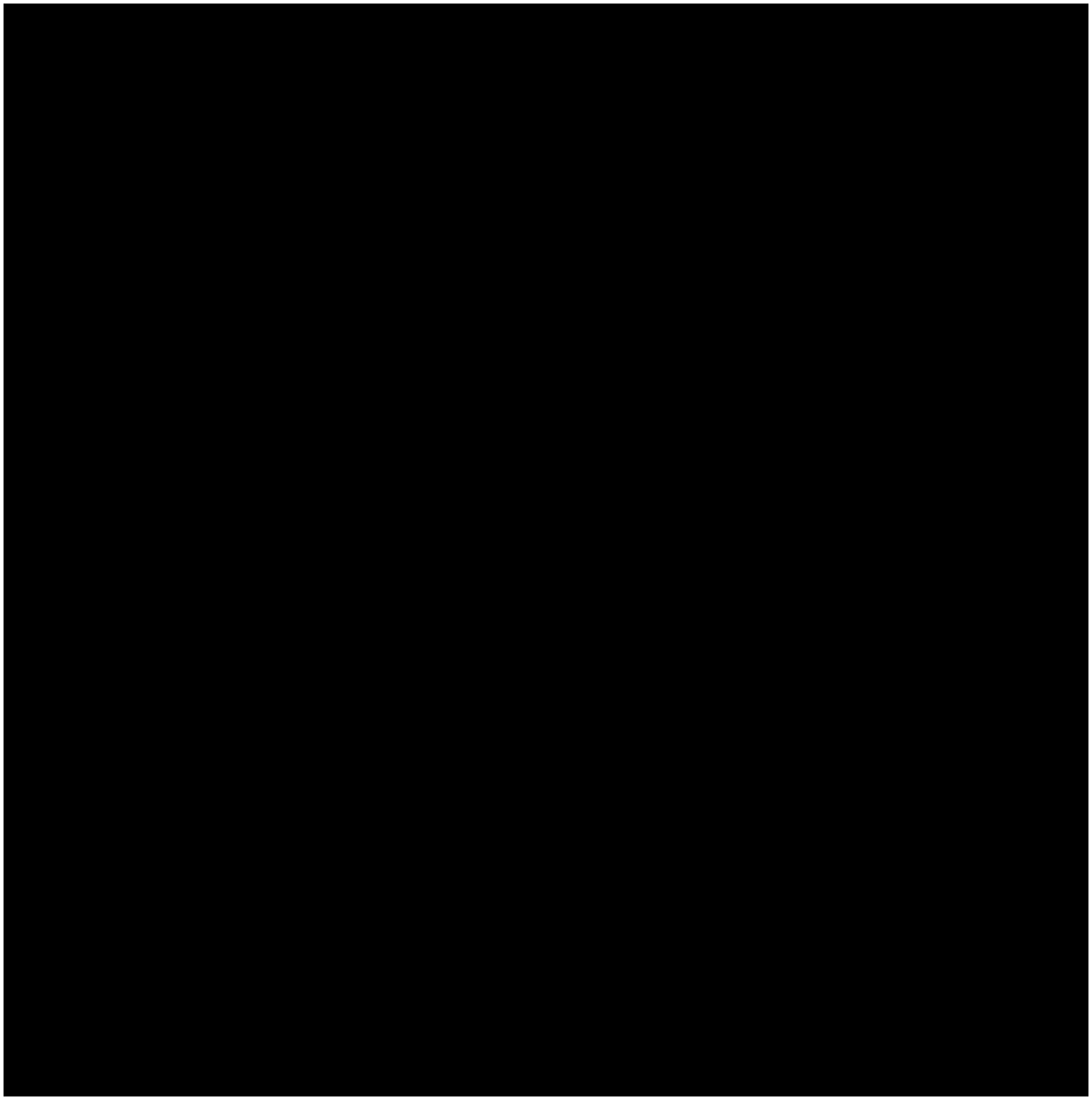
This seismic evaluation was discussed in a peer review meeting on 17 June 2019. Reviewers present were Joe Maffei of Maffei Structural Engineering and Jay Yin of Degenkolb Engineers. Comments from the reviewers have been incorporated into the report. The reviewers agreed with the assigned rating.

| Additional building data | Entry | Notes |
|---|---|---|
| Latitude | 36.997938 | |
| Longitude | -122.059722 | |
| Are there other structures besides this one under the same CAAN# | Yes | |
| Number of stories above lowest perimeter grade | 1 | Plus small mezzanine level |
| Number of stories (basements) below lowest perimeter grade | 0 | |
| Building occupiable area (OGSF) | 4,022 | Computed from plan. |
| Risk Category per 2016 CBC Table 1604.5 | II | |
| Building structural height, $h_n$ | 26.5 ft | Structural height defined per ASCE 7-16 Section 11.2 |
| Coefficient for period, $C_t$ | 0.02 | Estimated using ASCE 41-17 equation 4-4 and 7-18 |
| Coefficient for period, $\beta$ | 0.75 | Estimated using ASCE 41-17 equation 4-4 and 7-18 |
| Estimated fundamental period | 0.23 sec | Estimated using ASCE 41-17 equation 4-4 and 7-18 |
| **Site data** | | |
| 975-year hazard parameters $S_s$, $S_1$ | 1.283, 0.487 | From OSHPD/SEAOC website |
| Site class | D | |
| Site class basis | Geotech[4] | See footnote below |
| Site parameters $F_a$, $F_v$ | 1.0, 1.813 | From OSHPD/SEAOC website |
| Ground motion parameters $S_{cs}$, $S_{c1}$ | 1.283, 0.882 | From OSHPD/SEAOC website |

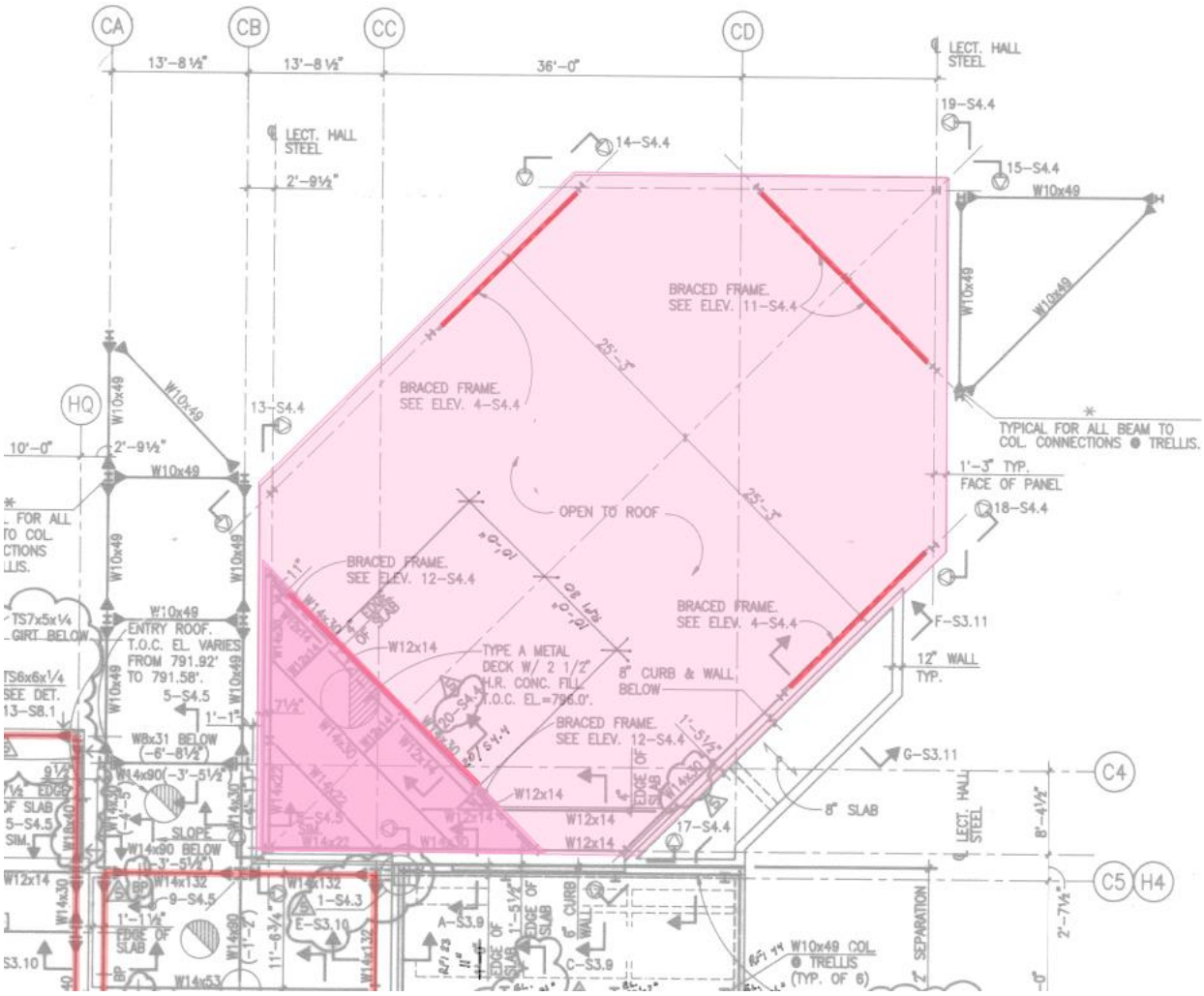
[4] Determination of site class and assessment of geotechnical hazards are based on correspondence with Pacific Crest Geotechnical Engineers and Nolan, Zinn, and Associates Geologists. [*Revised Geology and Geologic Hazards, Santa Cruz Campus, University of California*, Job # 04003-SC 13 May 2005]. Site class is taken as D throughout the main campus of UC Santa Cruz. The following links provide hazard maps for liquefaction, landslide, and fault rupture:
https://gis.santacruzcounty.us/mapgallery/Emergency%20Management/Hazard%20Mitigation/LiquifactionMap2009.pdf
https://gis.santacruzcounty.us/mapgallery/Emergency%20Management/Hazard%20Mitigation/LandslideMap2009.pdf
https://gis.santacruzcounty.us/mapgallery/Emergency%20Management/Hazard%20Mitigation/FaultZoneMap2009.pdf

| | | |
|---|---|---|
| $S_a$ at building period | 1.28 | |
| Site $V_{s30}$ | 900 ft/s | |
| $V_{s30}$ basis | Estimated | Estimated based on site classification of D. |
| Liquefaction potential | Low | |
| Liquefaction assessment basis | County map | See footnote |
| Landslide potential | Low | |
| Landslide assessment basis | County map | See footnote |
| Active fault rupture identified at site | No | |
| Fault rupture assessment basis | County map | See footnote |
| Site-specific ground motion study? | No | |
| **Applicable code** | | |
| Applicable code or approx. date of original construction | Built: 1993<br>Code: 1988 UBC | |
| Applicable code for partial retrofit | None | No partial retrofit. |
| Applicable code for full retrofit | None | No full retrofit |
| **FEMA P-154 data** | | |
| Model building type – north-south | S2<br>Steel Braced Frame | |
| Model building type – east-west | S2<br>Steel Braced Frame | |
| FEMA P-154 score | N/A | Not included here because we performed ASCE 41 Tier 1 evaluation. |
| **Previous ratings** | | |
| Most recent rating | Good | UCSC 1998 Seismic Survey #7775. |
| Date of most recent rating | 1998 | |
| 2nd most recent rating | - | |
| Date of 2nd most recent rating | - | |
| 3rd most recent rating | - | |
| Date of 3rd most recent rating | - | |
| **Appendices** | | |
| ASCE 41 Tier 1 checklist included here? | Yes | Refer to attached checklist file. |

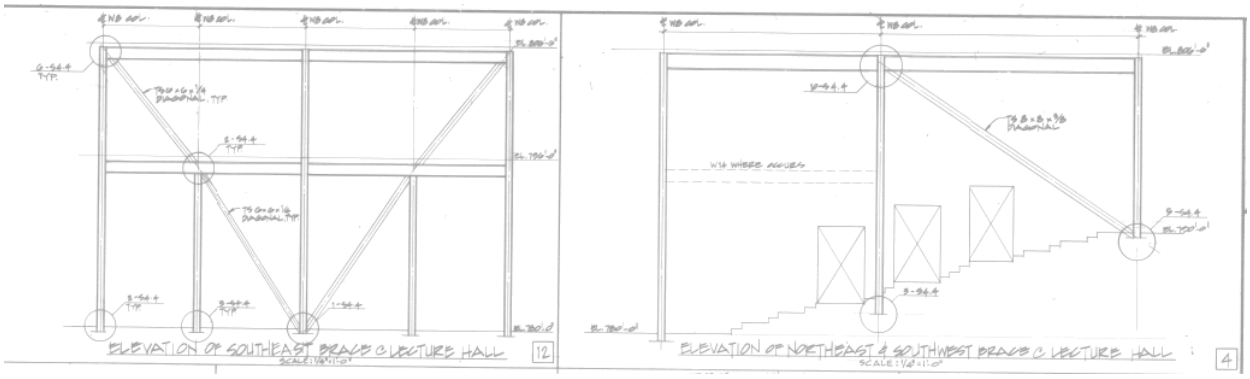
## Site Plan for Orientation



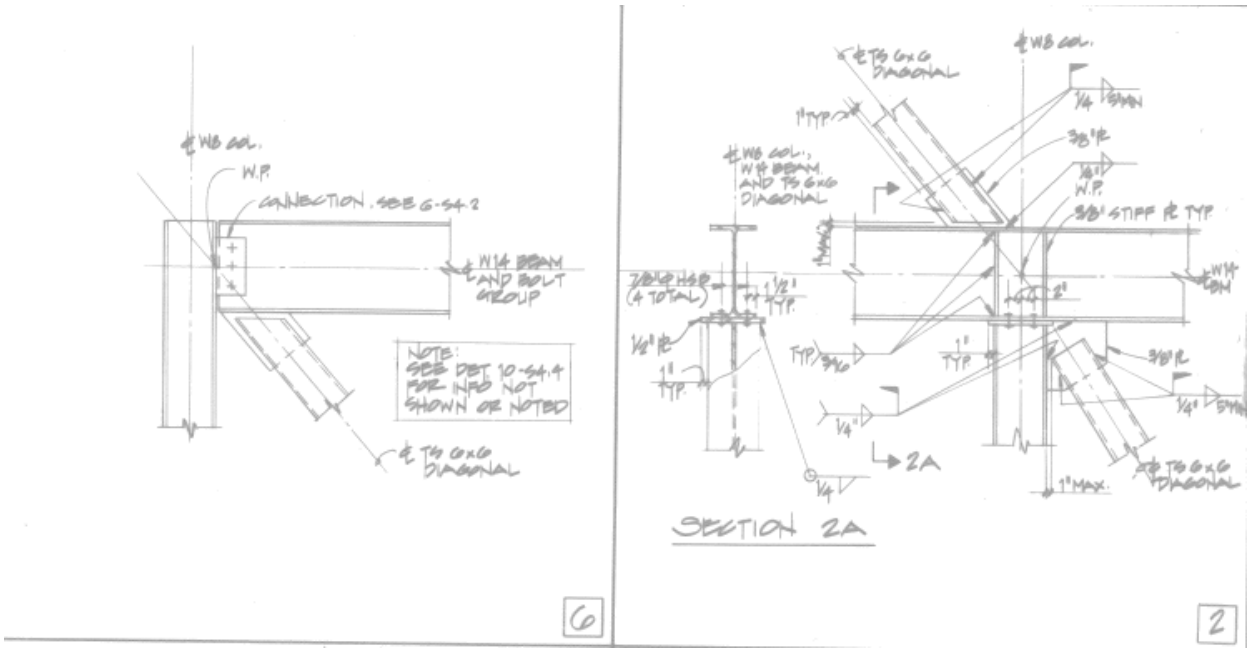
## Structural Plan Level 1 Sheet S2.1.2 Marked with Braced Frames Supporting Roof (Braced Frames Supporting Mezzanine Level Below Not Shown)



## Structural Details of Braced Frames




## Typical Brace Connection Detail (Not Designed for Capacity of Braces)



# APPENDIX A

# Additional Photos

Plan Showing Building Designations (Lecture Hall B206 at top is an S2 Steel Braced Frame)

Lecture Hall B206 Entry at North Elevation (Looking Southwest)

Lecture Hall (Looking Southwest, Atrium at Left)


Atrium North Elevation and East Wall of Lecture Hall B206 at Right (Lecture Hall Exit via Atrium)

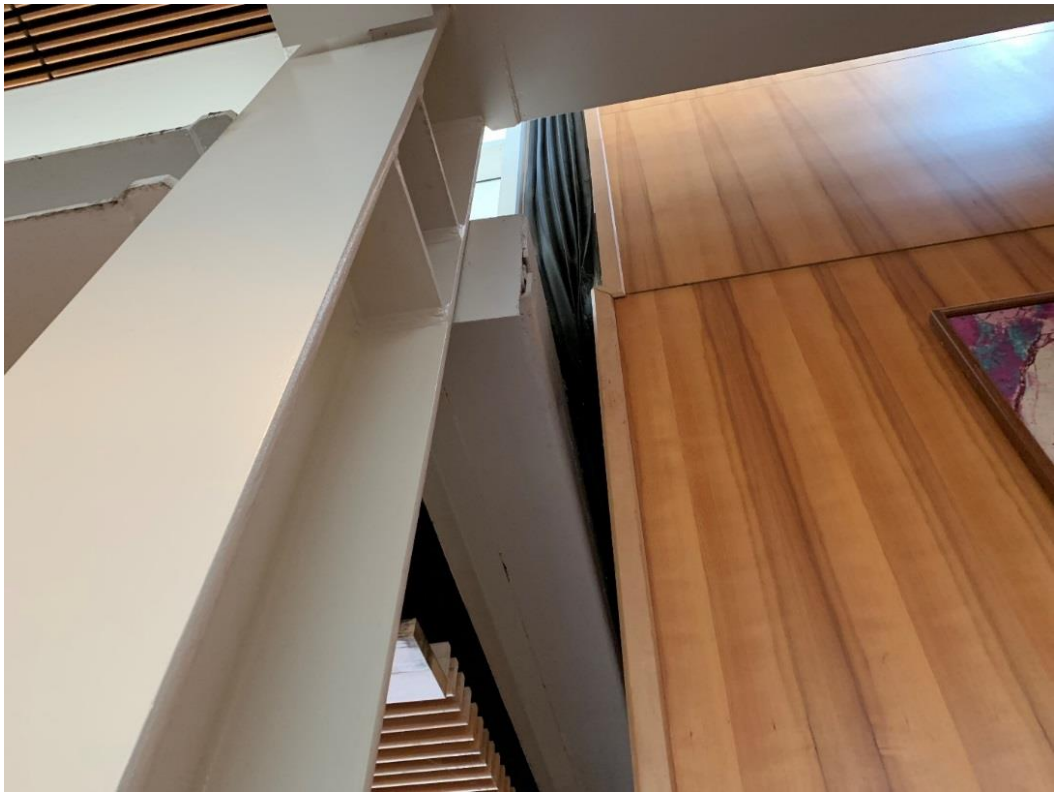
West Elevation Lecture Hall B

Southwest Elevation Building B

West Atrium Exit (Lecture Hall Exit via Atrium)

Interior Lecture Hall B206 (Looking Northwest)


Interior View at Front of Lecture Hall B206



Interior View Looking Up at Boundary Between Building B and Atrium

# APPENDIX B

# ASCE 41-17 Tier 1 Checklists (Structural)

| UC Campus: | Santa Cruz | | | Date: | 06/28/2019 | | |
|---|---|---|---|---|---|---|---|
| Building CAAN: | 7775.2 | Auxiliary CAAN: | | By Firm: | Rutherford + Chekene | | |
| Building Name: | Earth & Marine Sciences (B206) | | | Initials: | CLP, EFA | Checked: | WAL/BL |
| Building Address: | 552 Red Hill Road, Santa Cruz, CA 95064 | | | Page: | 1 | of | 3 |

# ASCE 41-17
# Collapse Prevention Basic Configuration Checklist

## LOW SEISMICITY

### BUILDING SYSTEMS - *GENERAL*

| C | NC | N/A | U | Description |
|---|---|---|---|---|
| ● | ○ | ○ | ○ | 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:** General comment: Original design by R+C and structural calculations available for review. |
| ○ | ● | | | 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:** Gap required is 26.5'x12"x0.015=4.77". Gap provided not clearly shown but approx. 2". |
| ● | ○ | ○ | ○ | 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:** There is a small mezzanine level that has independent dedicated braced frames. |

### BUILDING SYSTEMS - *BUILDING CONFIGURATION*

| C | NC | N/A | U | Description |
|---|---|---|---|---|
| ○ | ○ | ● | ○ | 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:**. One story. |
| ○ | ○ | ● | ○ | 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:** One story. |
| ● | ○ | ○ | ○ | 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 columns continuous to foundation. |

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

| UC Campus: | Santa Cruz | | | Date: | 06/28/2019 | | |
|---|---|---|---|---|---|---|---|
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# ASCE 41-17
# Collapse Prevention Basic Configuration Checklist

| C | NC | N/A | U | |
|---|---|---|---|---|
| ○ | ○ | ◉ | ○ | 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:** One story. |
| ○ | ○ | ◉ | ○ | 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:** One story. |
| ◉ | ○ | ○ | ○ | 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:**. Plan layout symmetric. |

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

### GEOLOGIC SITE HAZARD

| C | NC | N/A | U | Description |
|---|---|---|---|---|
| ○ | ○ | ○ | ◉ | 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:** There is no mapped liquefaction on https://gis.santacruzcounty.us/mapgallery/Emergency%20Management/Hazard%20Mitigation/LiquifactionMap2009.pdf. |
| ○ | ○ | ○ | ◉ | 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:** There are no mapped landslides on https://gis.santacruzcounty.us/mapgallery/Emergency%20Management/Hazard%20Mitigation/LandslideMap2009.pdf. |
| ○ | ○ | ○ | ◉ | 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:** There are no faults at the project site per https://gis.santacruzcounty.us/mapgallery/Emergency%20Management/Hazard%20Mitigation/FaultZoneMap2009.pdf. |

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

| UC Campus: | Santa Cruz | | | Date: | 06/28/2019 | | |
|---|---|---|---|---|---|---|---|
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# ASCE 41-17
# Collapse Prevention Basic Configuration Checklist

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

### FOUNDATION CONFIGURATION

| | Description |
|---|---|
| C NC N/A U<br>● ○ ○ ○ | 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:**<br>Transverse Frame width B = 53', Building Height is H = 26.5', B/H = 2<br>Sa = 1.283g per ATC at BSE-2E<br>0.6 x Sa = 0.77<br>B/H >0.6 Sa |
| C NC N/A U<br>● ○ ○ ○ | 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:** Site Class D per Geotech. All foundation elements tied together with continuous strip footings. |

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

| UC Campus: | Santa Cruz | | | Date: | 06/28/2019 | | |
|---|---|---|---|---|---|---|---|
| Building CAAN: | 7775.2 | Auxiliary CAAN: | | By Firm: | Rutherford + Chekene | | |
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# 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:** One braced frame on each of four sides to support roof; two additional frames support mezzanine. |
| 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 $0.10F_y$. Alternatively, the axial stress caused by overturning forces alone, calculated using the Quick Check procedure of Section 4.4.3.6, is less than $0.30F_y$. (Commentary: Sec. A.3.1.3.2. Tier 2: Sec. 5.5.2.1.3)<br><br>**Comments:** Axial stress 1.34ksi <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 $0.50F_y$. (Commentary: Sec. A.3.3.1.2. Tier 2: Sec. 5.5.4.1)<br><br>**Comments:** 6.9 ksi less than 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:** Metal deck anchored to framing. |
| 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 all anchored to foundation. |

| UC Campus: | Santa Cruz | | | Date: | 06/28/2019 | | |
|---|---|---|---|---|---|---|---|
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# 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

| C | NC | N/A | U | Description |
|---|---|---|---|---|
| ○ | ◉ | ○ | ○ | 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:** One brace on each long side (NE and SW); two braces each on transverse walls (NW and SE). |
| ○ | ◉ | ○ | ○ | 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:** Pre-Northridge connections. Gusset dimension typically 1" more than size of TS brace; connections do not develop buckling capacity by inspection. |
| ◉ | ○ | ○ | ○ | 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:** TS6x6x1/4 b/t=22. TS8x8x3/8 b/t=19.33. Both < 39.74 limit. OK |
| ○ | ○ | ◉ | ○ | 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:** No K-braces. |

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

### SEISMIC-FORCE-RESISTING SYSTEM

| C | NC | N/A | U | Description |
|---|---|---|---|---|
| ○ | ○ | ◉ | ○ | 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:** No spliced columns. |

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

| UC Campus: | Santa Cruz | | | Date: | 06/28/2019 | | |
|---|---|---|---|---|---|---|---|
| Building CAAN: | 7775.2 | Auxiliary CAAN: | | By Firm: | Rutherford + Chekene | | |
| Building Name: | Earth & Marine Sciences (B206) | | | Initials: | CLP, EFA | Checked: | WAL/BL |
| Building Address: | 552 Red Hill Road, Santa Cruz, CA 95064 | | | Page: | 3 | of | 4 |

# 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>**Comments:** kl/r=109<200 |
| ○ | ● | ○ | ○ | 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>**Comments:** Pre-Northridge connections. Gusset dimension typically 1" more than size of TS brace; connections do not develop yield capacity by inspection. |
| ○ | ● | ○ | ○ | 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>**Comments:** TS6x6x1/4 b/t=22. TS8x8x3/8 b/t=19.33. Both > limits 15.61 moderate and 18.17 high. NG |
| ○ | ○ | ● | ○ | 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>**Comments:** No chevron braces. |
| ● | ○ | ○ | ○ | 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>**Comments:** Concentric brace details at all joints. |

## DIAPHRAGMS (STIFF OR FLEXIBLE)

| | | | | Description |
|---|---|---|---|---|
| C | NC | N/A | U | |
| ○ | ○ | ● | ○ | 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>**Comments:** No large roof openings. |

## FLEXIBLE DIAPHRAGMS

| | | | | Description |
|---|---|---|---|---|
| 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>**Comments:** Steel framing and metal deck, WF beam spans full 50' distance. |

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

| UC Campus: | Santa Cruz | | | Date: | 06/28/2019 | | |
|---|---|---|---|---|---|---|---|
| Building CAAN: | 7775.2 | Auxiliary CAAN: | | By Firm: | Rutherford + Chekene | | |
| Building Name: | Earth & Marine Sciences (B206) | | | Initials: | CLP, EFA | Checked: | WAL/BL |
| Building Address: | 552 Red Hill Road, Santa Cruz, CA 95064 | | | Page: | 4 | of | 4 |

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

| C | NC | N/A | U | |
|---|---|---|---|---|
| ○ | ○ | ◉ | ○ | 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:** No wood diaphragms. |
| ○ | ○ | ◉ | ○ | 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:** No wood diaphragms. |
| ○ | ○ | ◉ | ○ | 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:** No wood diaphragms. |
| ○ | ○ | ◉ | ○ | 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:** Metal deck and insulating concrete fill. |

# APPENDIX C

# UCOP Seismic Safety Policy Falling Hazards Assessment Summary

| UC Campus: | Santa Cruz | | | Date: | 06/28/2019 | | |
|---|---|---|---|---|---|---|---|
| Building CAAN: | 7775.2 | Auxiliary CAAN: | | By Firm: | Rutherford + Chekene | | |
| Building Name: | Earth & Marine Sciences (B206) | | | Initials: | CLP, EFA | Checked: | WAL/BL |
| Building Address: | 552 Red Hill Road, Santa Cruz, CA 95064 | | | 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:** Heavy ceiling and lights over large lecture hall. Did not inspect but assume not anchored to current standards. Building very flexible and may result in falling hazard. |
| P ☐ N/A ☒ | **Heavy masonry or stone veneer above exit ways or public access areas**<br>**Comments:** There is no masonry or stone veneer. |
| 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:** No hazardous material storage was observed. |
| P ☐ N/A ☒ | **Masonry chimneys**<br>**Comments:** There are no masonry chimneys. |
| P ☐ N/A ☒ | **Unrestrained natural gas-fueled equipment such as water heaters, boilers, emergency generators, etc.**<br>**Comments:** Unknown. |
| P ☒ N/A ☐ | **Other:**. Overhead speakers and screen at front of lecture hall; projector in projection booth.<br>**Comments:** Not anchored to current standards. |
| P ☒ N/A ☐ | **Other:** Full height glazing in Atrium that serves as exits for Lecture Hall.<br>**Comments:** We recommend this be checked by the University to confirm the glazing is tempered or the like. |
| P ☐ N/A ☐ | **Other:**<br>**Comments:** |

Falling Hazards Risk: Moderate

Note: P= Present, N/A = Not Applicable

# APPENDIX D

# Quick Check Calculations

# Unit Weights:

Unit weight were not calculated because we had the original design calcualtions shown below

RUTHERFORD & CHEKENE
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487 BRYANT STREET
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Project UCSC - EMS
Subject
Job No. 880175 By PCR
Date 29 DEC 88 Sheet 2 LHS

AUDITORIUM

BUILDING WEIGHT

ROOF LEVEL :

ROOF = 3700 ϕ × 40 #/ϕ + 550 ϕ × 10 #/ϕ (screen) = 154 k
WALLS = (64' × 12' + 104' × 16' + 126' × 11') 50 #/ϕ = 191 k
} $W_R$ = 345 k

cons. for final config.

MEZZ LEVEL :

FLOOR = 477 ϕ × 82 #/ϕ = 39 k
WALLS = (80' × 16' + 46' × 6') 50 #/ϕ = 78 k
} $W_m$ = 117 k

W = 462 k

# Story Weights

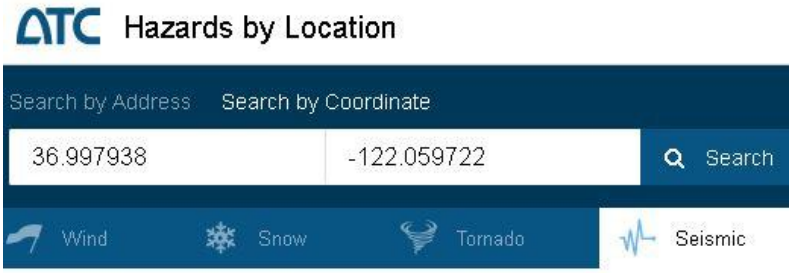
This is the summary of the story weight obtained from calculations

| Building Lecture Hall | | |
|---|---|---|
| Floor | Weight (kip) | Total weight (kip) |
| roof | 345 | |
| Mezz | 117 | |
| | | 462 |

# Period

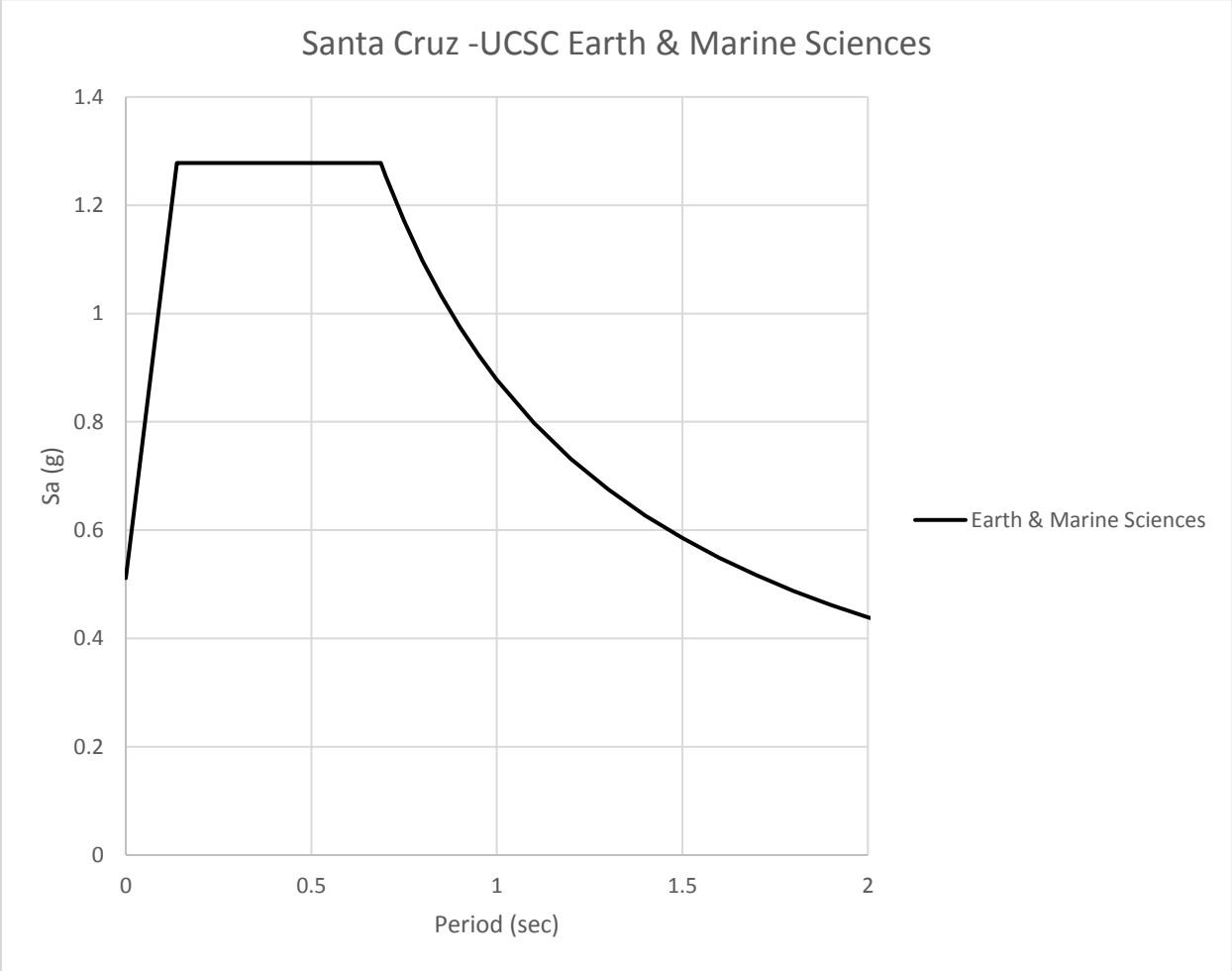
Period is calculated using Mathcad and is attached with the Mathcad calculations below

# BSE-2E Response Spectrum




**Hazard Level BSE-2E**

| Name | Value | Description |
|---|---|---|
| $S_S$ | 1.283 | $MCE_R$ ground motion (period=0.2s) |
| $F_a$ | 1 | Site amplification factor at 0.2s |
| $S_{XS}$ | 1.283 | Site modified spectral response (0.2s) |
| $S_1$ | 0.487 | $MCE_R$ ground motion (period=1.0s) |
| $F_v$ | 1.813 | Site amplification factor at 1.0s |
| $S_{X1}$ | 0.882 | Site modified spectral response (1.0s) |


Santa Cruz -UCSC Earth & Marine Sciences
1.4
1.2
1
0.8
0.6
0.4
0.2
0
Sa (g)
0
0.5
1
1.5
2
Period (sec)
Earth & Marine Sciences

# Calculations required for checklists were performed using the program Mathcad, and are attached in the following pages

# Lecture Hall check

Column Axial check

Period Calculation

Calculation of total shear force

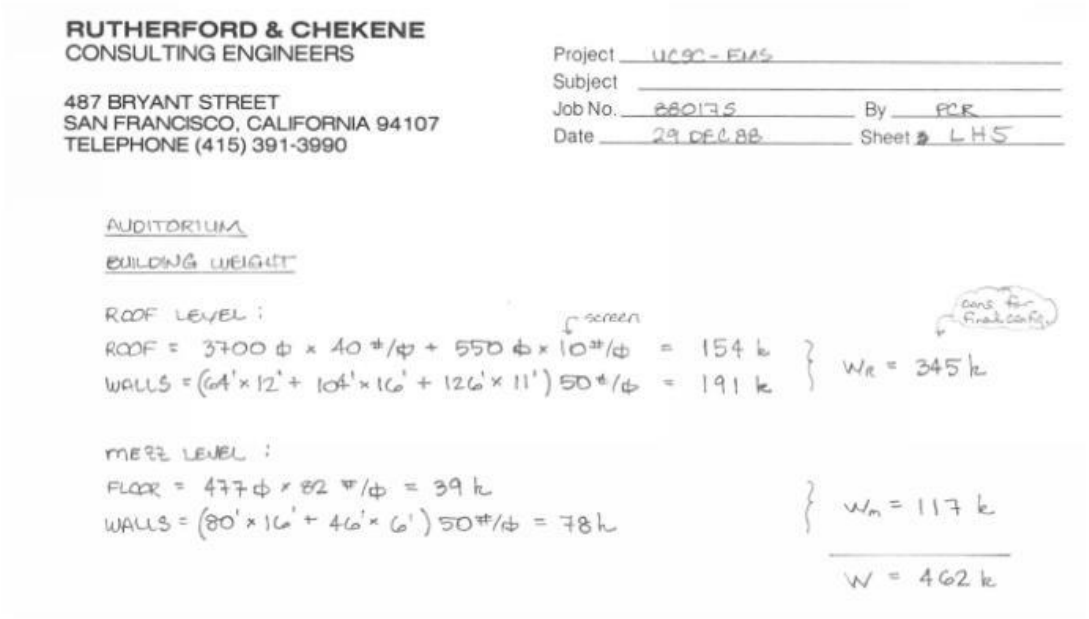
Calculation of axial stress in the braces

KL/r check

Connection of brace strength

# Column Axial stress check

From Calculations of R+C



RUTHERFORD & CHEKENE
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Project UCSC - EMS
Subject
Job No. 880135 By PCR
Date 29 DEC 88 Sheet 2 LHS

AUDITORIUM
BUILDING WEIGHT

ROOF LEVEL :
ROOF = 3700 ϕ × 40 #/ϕ + 550 ϕ × 10 #/ϕ (screen) = 154 k
WALLS = (64' × 12' + 104' × 16' + 126' × 11') 50 #/ϕ = 191 k
} $W_R$ = 345 k (cons for final config)

MEZZ LEVEL :
FLOOR = 477 ϕ × 82 #/ϕ = 39 k
WALLS = (80' × 16' + 46' × 6') 50 #/ϕ = 78 k
} $W_m$ = 117 k

W = 462 k

Roof weight for columns $W_{roof} := 154kip$

Area of roof $A_{roof} := 3233ft^2$

$$w_{roof} := \frac{W_{roof}}{A_{roof}} = 47.634 \cdot psf$$

Forces in column

$A_{trib} := 554ft^2$

$F_{col} := w_{roof} \cdot A_{trib} = 26.389 \cdot kip$

columns is W8x67 $A_{col} := 19.7in^2$ $Fy := 36ksi$

Limit $0.1Fy = 3.6 \cdot ksi$

$$f_{col} := \frac{F_{col}}{A_{col}} = 1.34 \cdot ksi$$

less than 0.1Fy Ok complies

## Diagonal Braces

***4.4.3.4 Diagonal Bracing.*** The average axial stress in diagonal bracing elements, $f_j^{avg}$, shall be calculated in accordance with Eq. (4-9).

$$f_j^{avg} = \frac{1}{M_s}\left(\frac{V_j}{sN_{br}}\right)\left(\frac{L_{br}}{A_{br}}\right) \quad (4\text{-}9)$$

where

$L_{br}$ = Average length of the braces (ft);
$N_{br}$ = Number of braces in tension and compression if the braces are designed for compression, number of diagonal braces in tension if the braces are designed for tension only;
$s$ = Average span length of braced spans (ft);
$A_{br}$ = Average area of a diagonal brace (in.$^2$);
$V_j$ = Maximum story shear at each level (kip); and
$M_s$ = System modification factor; $M_s$ shall be taken from Table 4-9.

**Table 4-9. $M_s$ Factors for Diagonal Braces**

| | | Level of Performance | | |
|---|---|---|---|---|
| **Brace Type** | ***d/t*** [b] | **CP** [a] | **LS** [a] | **IO** [a] |
| Tube[b] | $<90/(F_{ye})^{1/2}$ | 7.0 | 4.5 | 2.0 |
| | $>190/(F_{ye})^{1/2}$ | 3.5 | 2.5 | 1.25 |
| Pipe[c] | $<1{,}500/F_{ye}$ | 7.0 | 4.5 | 2.0 |
| | $>6{,}000/F_{ye}$ | 3.5 | 2.5 | 1.25 |
| Tension-only | | 3.5 | 2.5 | 1.25 |
| Cold-formed steel strap-braced wall | | 3.5 | 2.5 | 1.25 |
| All others | | 7.0 | 4.5 | 2.0 |

*Note:* $F_{ye} = 1.25F_y$; expected yield stress.
[a] CP = Collapse Prevention, LS = Life Safety, IO = Immediate Occupancy.
[b] Depth-to-thickness ratio.
[c] Interpolation to be used for tubes and pipes.

## Period calculation

***4.4.2.4 Period.*** The fundamental period of a building, in the direction under consideration, shall be calculated in accordance with Eq. (4-4).

$$T = C_t h_n^{\beta} \qquad (4\text{-}4)$$

where

$T$ = Fundamental period (s) in the direction under consideration;
$C_t$ = 0.035 for moment-resisting frame systems of steel (Building Types S1 and S1a);
= 0.018 for moment-resisting frames of reinforced concrete (Building Type C1);
= 0.030 for eccentrically braced steel frames (Building Types S2 and S2a);
= 0.020 for all other framing systems;
$h_n$ = Height (ft) above the base to the roof level;

$\beta$ = 0.80 for moment-resisting frame systems of steel (Building Types S1 and S1a);
= 0.90 for moment-resisting frame systems of reinforced concrete (Building Type C1); and
= 0.75 for all other framing systems.

$C_t := 0.02$ $\quad h_{tot} := 26.5\,\frac{ft}{ft}$ $\quad \beta := 0.75$

$T_1 := C_t \cdot h_{tot}^{\beta} = 0.234$

$S_{x1} := 0.882$

## Calculation of total shear force

$S_{a1} := \frac{S_{x1}}{T_1} = 3.776$ Use $S_a := 1.283$

$C_{mod} := 1.4$

$W_{total} := 345kip$

$V_{total} := C_{mod} \cdot S_a \cdot W_{total} = 619.689 \cdot kip$

$d_{brace} := 8in - 0.75in \quad t_{brace} := \frac{3in}{8} = 0.375 \cdot in$

$\frac{d_{brace}}{t_{brace}} = 19.333$

$Fy = 36 \cdot ksi$

$Fy_e := 1.25Fy = 45 \cdot ksi$

$Ratio_{limit1} := \left( \frac{90}{\sqrt{\frac{Fy_e}{ksi}}} \right) = 13.416 \qquad Ratio_{limit2} := \left( \frac{190}{\sqrt{\frac{Fy_e}{ksi}}} \right) = 28.324$

$Ms_{brace1} := 7 \qquad Ms_{brace2} := 3.5$

Use Ms=5 $\qquad Ms_{brace} := 5$

$N_{braces} := 2 \qquad s_{brace} := 24ft + 2in \qquad L_{brace} := 28ft + 2in \qquad A_{brace} := 10.4in^2$

## Calculation of Axial stress in the brace

$f_{bracelimit} := 0.5Fy = 18 \cdot ksi$

$f_{javg} := \frac{1}{Ms_{brace}} \left( \frac{V_{total}}{s_{brace} \cdot N_{braces}} \right) \left( \frac{L_{brace}}{A_{brace}} \right) = 6.945 \cdot ksi$

less than 18 ksi Ok complies

$E_s := 29000ksi$

$1.4 \cdot \sqrt{\frac{E_s}{Fy}} = 39.735 \qquad bovertratio := \frac{d_{brace}}{t_{brace}} = 19.333$ complies for moderate

$0.55 \cdot \sqrt{\frac{E_s}{Fy}} = 15.61$ does not comply for high seismicity

$0.64 \cdot \sqrt{\frac{E_s}{Fy}} = 18.165$

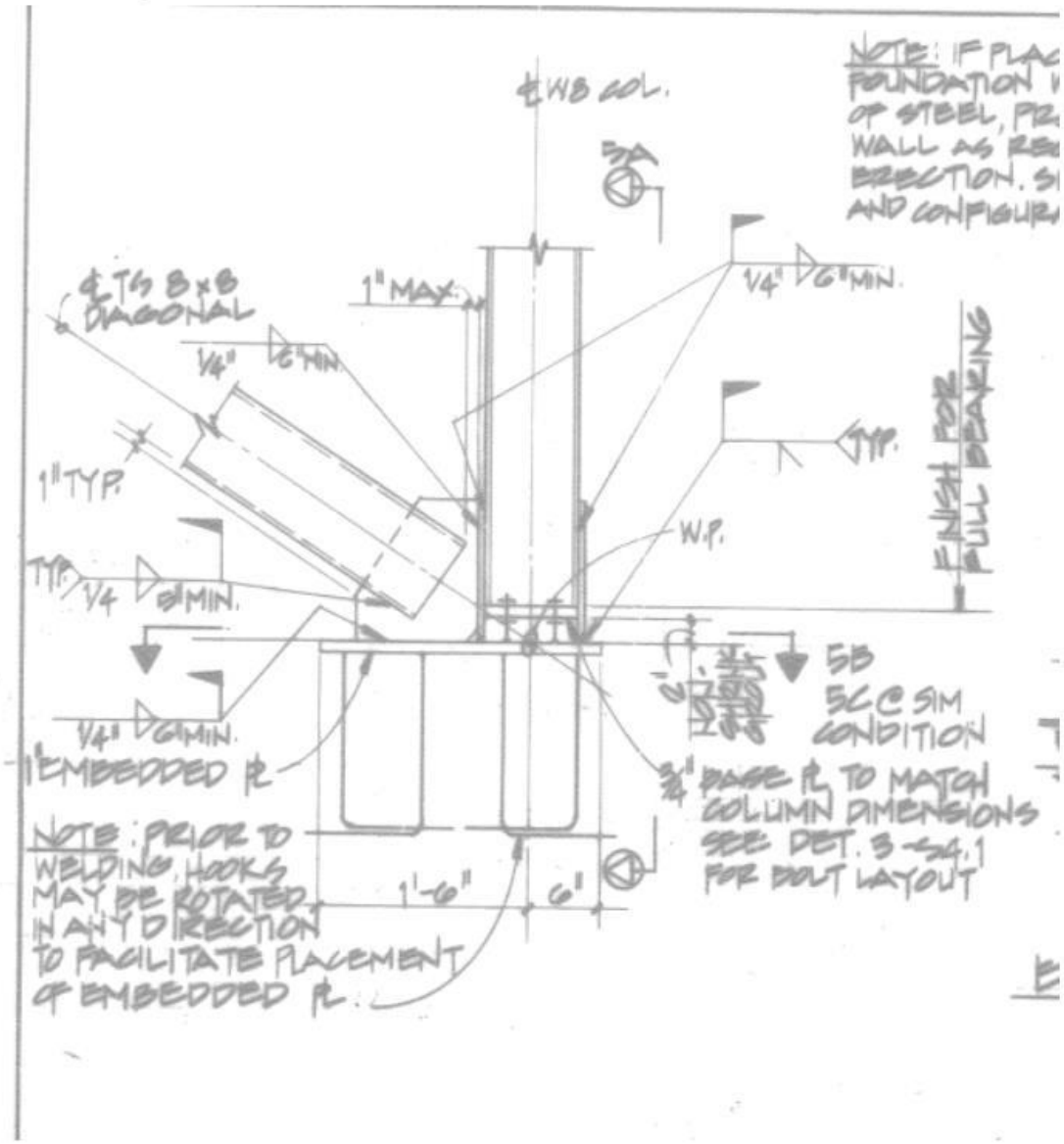
## Check Kl/r

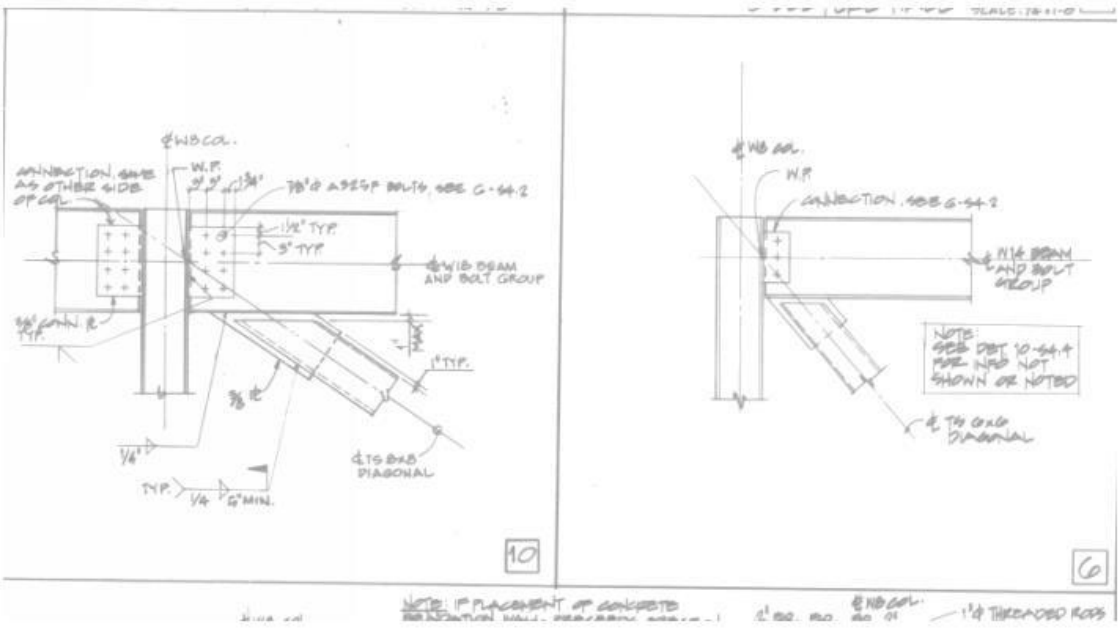
$k_{brace} := 1$ $L_{brace} = 338 \cdot in$ $r := 3.1in$

$$\frac{k_{brace} \cdot L_{brace}}{r} = 109.032$$ less than 200 ok complies

## Check connection strength

from drawings sheet S4.4



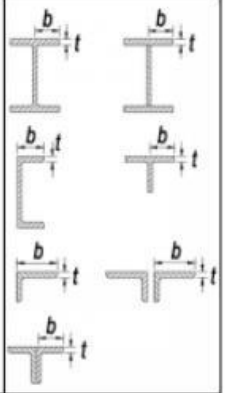
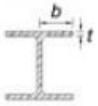
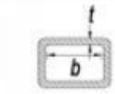



The demand claculated using the capacity of the braces is

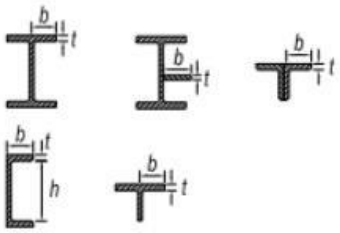
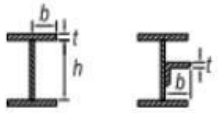
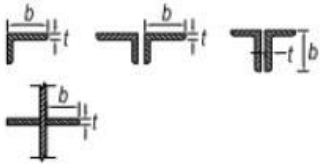
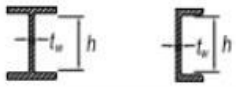
$$F_{demandbrace} := A_{brace} \cdot 1.25 \cdot Fy = 468 \cdot kip$$

This is a very large force. the connections can not develop this force by inspection. Does not comply

# TABLE D1.1
## Limiting Width-to-Thickness Ratios for Compression Elements For Moderately Ductile and Highly Ductile Members

| | Description of Element | Width-to-Thickness Ratio | Limiting Width-to-Thickness Ratio | | Example |
|---|---|---|---|---|---|
| | | | $\lambda_{hd}$ Highly Ductile Members | $\lambda_{md}$ Moderately Ductile Members | |
| Unstiffened Elements | Flanges of rolled or built-up I-shaped sections, channels and tees; legs of single angles or double angle members with separators; outstanding legs of pairs of angles in continuous contact | $b/t$ | $0.30\sqrt{E/F_y}$ | $0.38\sqrt{E/F_y}$ |  |
| | Flanges of H-pile sections per Section D4 | $b/t$ | $0.45\sqrt{E/F_y}$ | not applicable |  |
| | Stems of tees | $d/t$ | $0.30\sqrt{E/F_y}$ [a] | $0.38\sqrt{E/F_y}$ |  |
| Stiffened Elements | Walls of rectangular HSS | $b/t$ | $0.55\sqrt{E/F_y}$ [b] | $0.64\sqrt{E/F_y}$ [c] |  |
| | Flanges of boxed I-shaped sections and built-up box sections | $b/t$ | | |  |
| | Side plates of boxed I-shaped sections and walls of built-up box shapes used as diagonal braces | $h/t$ | | |  |

# TABLE B4.1a
## Width-to-Thickness Ratios: Compression Elements Members Subject to Axial Compression

| | Case | Description of Element | Width-to-Thickness Ratio | Limiting Width-to-Thickness Ratio $\lambda_r$ (nonslender/slender) | Examples |
|---|---|---|---|---|---|
| Unstiffened Elements | 1 | Flanges of rolled I-shaped sections, plates projecting from rolled I-shaped sections; outstanding legs of pairs of angles connected with continuous contact, flanges of channels, and flanges of tees | $b/t$ | $0.56\sqrt{\frac{E}{F_y}}$ |  |
| | 2 | Flanges of built-up I-shaped sections and plates or angle legs projecting from built-up I-shaped sections | $b/t$ | $0.64\sqrt{\frac{k_c E}{F_y}}$ [a] |  |
| | 3 | Legs of single angles, legs of double angles with separators, and all other unstiffened elements | $b/t$ | $0.45\sqrt{\frac{E}{F_y}}$ |  |
| | 4 | Stems of tees | $d/t$ | $0.75\sqrt{\frac{E}{F_y}}$ |  |
| Stiffened Elements | 5 | Webs of doubly-symmetric I-shaped sections and channels | $h/t_w$ | $1.49\sqrt{\frac{E}{F_y}}$ |  |
| | 6 | Walls of rectangular HSS and boxes of uniform thickness | $b/t$ | $1.40\sqrt{\frac{E}{F_y}}$ |  |
| | 7 | Flange cover plates | | | |