MAFFEI STRUCTURAL ENGINEERING

Rating form completed by:

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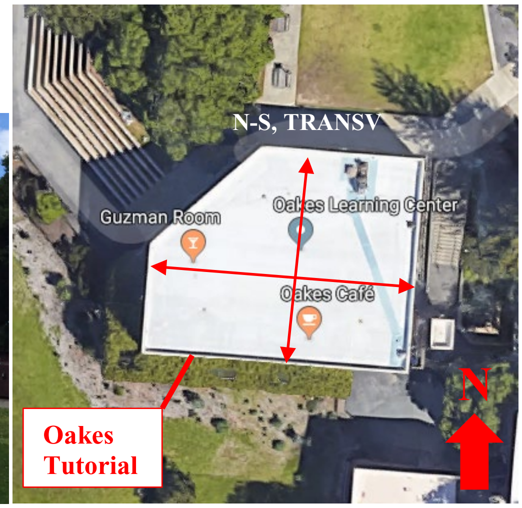
Text in green is to be part of UC Santa Cruz building database and may be part of UCOP database

UC Santa Cruz building seismic ratings

Oakes College Tutorial Commons

CAAN #7419
249 Oakes Field Service Road, Santa Cruz, CA 95064
UCSC Campus: Main Campus

DATE: 2019-06-30



Rating summary	Entry	Notes
UC Seismic Performance Level (rating)	IV (Fair)	
Rating basis	Tier 1	ASCE 41-17[1]
Date of rating	2019	
Recommended UC Santa Cruz priority category for retrofit	None	Priority A=Retrofit ASAP Priority B=Retrofit at next permit application
Ballpark total construction cost to retrofit to IV rating[2]	None	
Is 2018-2019 rating required by UCOP?	Yes	
Further evaluation recommended?	No	If a remodel takes place, consider adding hold-downs at ends of walls

[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 life-safety. See Section III B of the UC Seismic Policy and Method B of Section 321 of the 2016 California Existing Building Code

[2] Per Section 3.A.4.i of the Seismic Program Guidebook, 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

- Structural drawings by Forell Elsesser, “College 7, University of California Santa Cruz” as-built date 21 July 1975.
- Architectural drawings by McCue Boone Tomsick Architects, “College 7, University of California Santa Cruz” as-built date 21 July 1975.
- Trellis drawings by Palmer & Rahe Architects, “Oakes College Coffee Shop Trellis” date 1 November 1988

Additional building information known to exist

- Exterior stair reconstruction drawings by Paul Rodrigues, “Exterior Stairs Reconstruction, Oakes College Learning Center, UCSC” date 18 August 1995.
- Coffee shop remodel by Palmer & Rahe Architects, “Oakes College Coffee Shop Remodel” date 4 April 1988
- Seismic Survey document by Rutherford & Chekene dated 2 March 1998

Scope for completing this form

Reviewed structural drawings for original construction and carried out a site visit to verify that the existing drawings matched the existing structure to the best of our knowledge. An ASCE 41-17 Tier 1 evaluation was completed. We did not perform an ASCE 41 Tier 1 nonstructural evaluation, but we looked for potentially hazardous nonstructural components during our site visit.

Brief description of structure

The Oakes College Tutorial Commons is at the Oakes College (formerly College 7) at the UCSC campus. The building was designed in 1975 by the architectural office of McCue, Boone and Tomsick and the structural office of Forell Elsesser.

The building is a 2-story, rectangular building with the northwest corner truncated at a 45 degree. At the ground level the southwest corner is also truncated to give the floor plan a pentagon like shape. The building is approximately 12,000sf and is 68ft x 85ft with a regular column grid of 17ft x 17ft. The structure measure 31 feet in height from the 1st floor to the top of perimeter walls at the flat roof. The building has a wood trellis attached to its southern face and an exterior elevator to the east. The stairs and site work around the building are on grade and independent of the building structure.

The roof is wood framed with glulam trusses in select locations. The roof is flat with a parapet around the perimeter. The roof is supported by concrete columns for gravity and wood shear walls for lateral. The Level 2 floor consist of a concrete slab and beam system supported by concrete columns and walls. The foundation consists of concrete grade beams, isolated footings, and three piles on the southwest side due to the sloping site. The Level 1 floor is a slab-on-grade and due to the sloping side the north and west concrete walls are retaining.

<u>Identification of levels</u> Two levels. Level 1 at grade with top of slab on grade elevation 590.0, Level 2, Roof.

<u>Foundation system:</u> The foundation consists of isolated footings with grade beams connecting the lateral system and exterior column footings. A slab-on-grade spans the entire Level 1 area to also provide lateral bracings. The site is sloping from north to south so the northern and a portion of the western concrete walls are retaining wall for their full height. There are also three 24” diameter piles at the southwest corner to support the column load as the site quickly drops off.

<u>Structural system for vertical (gravity) load:</u> The roof framing consists of ½” plywood sheathing over 2x12 wood joist framing. The joists frame into glulam beams on the gridlines. Within the large open area, the glulam beams are supported by 8 glulam trusses which are supported by concrete columns.

At the Level 2 slab, the floor consists of an 8” thick two-way concrete slab supported by concrete beams at the gridlines. The beams are supported by either 16” square concrete columns or 12” concrete walls that are either retaining walls or shear walls.

The elevator shaft consists of wood walls that are attached to a steel frame that the elevator rails are attached too. There is also a wooden trellis on the South side that attached to the Level 2 concrete slab at the north and by wooden post on the south.

<u>Structural system for lateral forces:</u> Plywood sheathed roof diaphragms transfer lateral inertial forces from roof to wood sheathed shear walls in-plane, which occur at the perimeter. The shear walls have anchor bolts into the Level 2 slab and where the shear walls are boarded by concrete columns are details to have anchor bolts attaching the shear wall to the columns vertically. This connection behaves as a hold down but is not present at all walls.

At Level 2 there are 26 well-detailed, flexure-controlled concrete columns which will contribute to the roof lateral load resisting system. These columns will behave like cantilever columns and can act as a secondary roof lateral load resisted system. These columns were check for shear failure but were not check as the primary lateral system.

At the Level 2 slab, the concrete slab behaves as a rigid diaphragm and transfers the lateral inertial forces from the roof and Level 2 to the concrete shear wall in-plane. The concrete shear walls are well detailed to transfer the diaphragm forces into the walls and then into the foundations. The concrete shear wall configuration may result in torsion due to a large opening on the southern edge, but the deflection and stress in the walls should be low and torsion should be able to be accommodated.

The elevator shaft is independent of the lateral system but is detailed with plywood shear walls on three sides and is braced off of the Level 2 slab. The connection at Level 2 may not be adequate to carry the seismic loads, but the shaft framing should provide an independent lateral load resistance system.

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:

- The shear walls do not have hold-downs detailed in the drawings. Where shear walls interface with concrete columns, the walls are attached up the vertical face of the column with anchor bolts that will behave like hold-downs. For some of the smaller walls on the east and south, they do not interact with the concrete columns on both sides, but they still have anchor bolts and will be partially resisted by the glulam beams at the roof for uplift. Thus we believe that performance will be acceptable even if hold-downs are lacking.
- The shear wall aspect ratios do not meet the Tier 1 checklist requirements, but the stress check shows that these walls are adequate.
- At Level 1 we expect plan torsion because of the wall placement and the large open area on the south and west side. We expect the inter-story drift and stress in the concrete shear walls at this level to be low because of the amount of wall, and we expect that the torsion response will be acceptable.

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	Y	Liquefaction	N
Adjacent buildings	N	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	Y	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 non-structural life-safety concerns, including at exit routes.[3]

We walked through all floors of the building and looked for potentially hazardous nonstructural components during our site visit on 22 May 2019. As shown in the table below, no non-structural hazards were observed.

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

Discussion of rating

The rating of IV (Fair) takes into account that the building has a well-defined seismic-force path and defined lateral elements. The Level 2 concrete slab is well-supported laterally and the concrete elements are well detailed. Additional deformation is expected at the narrower walls on the east and west because of the wall aspect ratio, but we do not judge this to be a collapse or life-safety concern.

Recommendations for further evaluation or retrofit

Although we rate the building as IV (Fair), if there is remodeling of any walls, we recommend that the Campus consider adding hold-downs at wall ends where the might be lacking.

Peer review of rating

This seismic evaluation was discussed in a peer review meeting on 17 June 2019. Reviewers present were Bret Lizundia of R+C and Robert Graf of Degenkolb. Comments from the reviewers have been incorporated into this report. The reviewers agreed with the assigned rating.

Additional building data	Entry	Notes
Latitude	36.989313	
Longitude	-122.063344	
Are there other structures besides this one under the same CAAN#	No	
Number of stories above lowest perimeter grade	2	
Number of stories (basements) below lowest perimeter grade	0	
Building occupiable area (OGSF)	12,153	
Risk Category per 2016 CBC Table 1604.5	II	Offices at Level 2 & Dining Hall at Level 1
Building structural height, h_n	31 ft	Structural height defined per ASCE 7-16 Section 11.2
Coefficient for period, C_t	0.020	Estimated using ASCE 41-17 equation 4-4 and 7-18
Coefficient for period, β	0.75	Estimated using ASCE 41-17 equation 4-4 and 7-18
Estimated fundamental period	0.26 sec	Estimated using ASCE 41-17 equation 4-4 and 7-18

[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 the type and location of potential non-structural hazards.

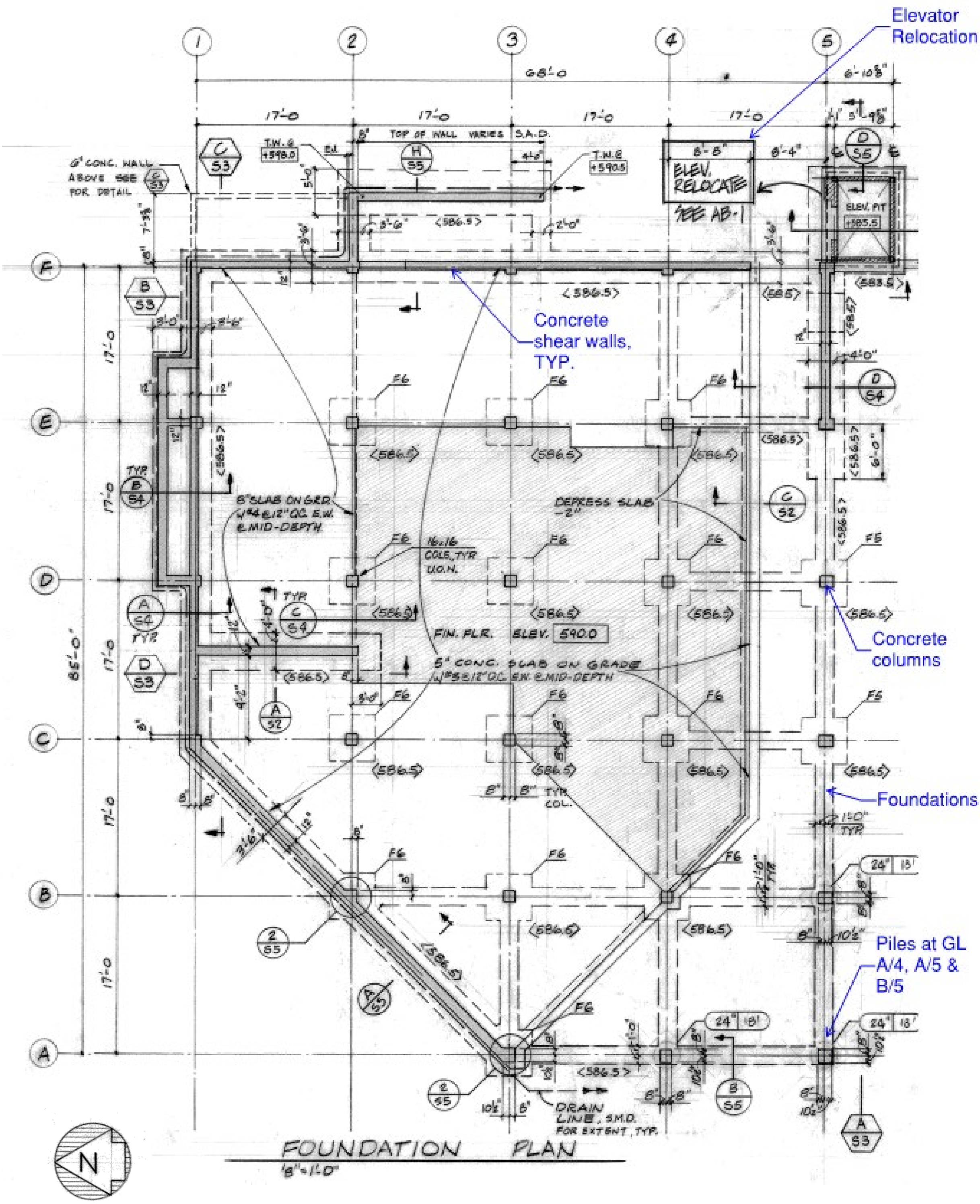
Site data		
975 yr hazard parameters S_s, S_1	1.286, 0.488	
Site class	D	
Site class basis[4]	Geotech	See footnote below
Site parameters F_a, F_v[5]	1, 1.81	
Ground motion parameters S_{cs}, S_{c1}	1.286, 0.885	
S_a at building period	1.28	
Site V_{s30}	900 ft/s	
V_{s30} basis	Estimated	Estimated based on site classification of D.
Liquefaction potential	Low	
Liquefaction assessment basis	County map	See footnote below
Landslide potential	Low	
Landslide assessment basis	County map	See footnote below
Active fault-rupture identified at site?	No	
Fault rupture assessment basis	County map	See footnote below
Site-specific ground motion study?	No	
Applicable code		
Applicable code or approx. date of original construction	Built: 1975 Code: 1973 UBC	Code on drawings
Applicable code for partial retrofit	None	No partial retrofit
Applicable code for full retrofit	None	No full retrofit
Model building data		
Model building type North-South	W2 at roof C2 at level 2	Wood shear walls with a wood roof diaphragm Concrete shear walls with a concrete diaphragm
Model building type East-West	W2 at roof C2 at level 2	Wood shear walls with a wood roof diaphragm Concrete shear walls with a concrete diaphragm
FEMA P-154 score	N/A	Not included here. Tier 1 evaluation.
Previous ratings		
Most recent rating	none	
Date of most recent rating	-	

[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

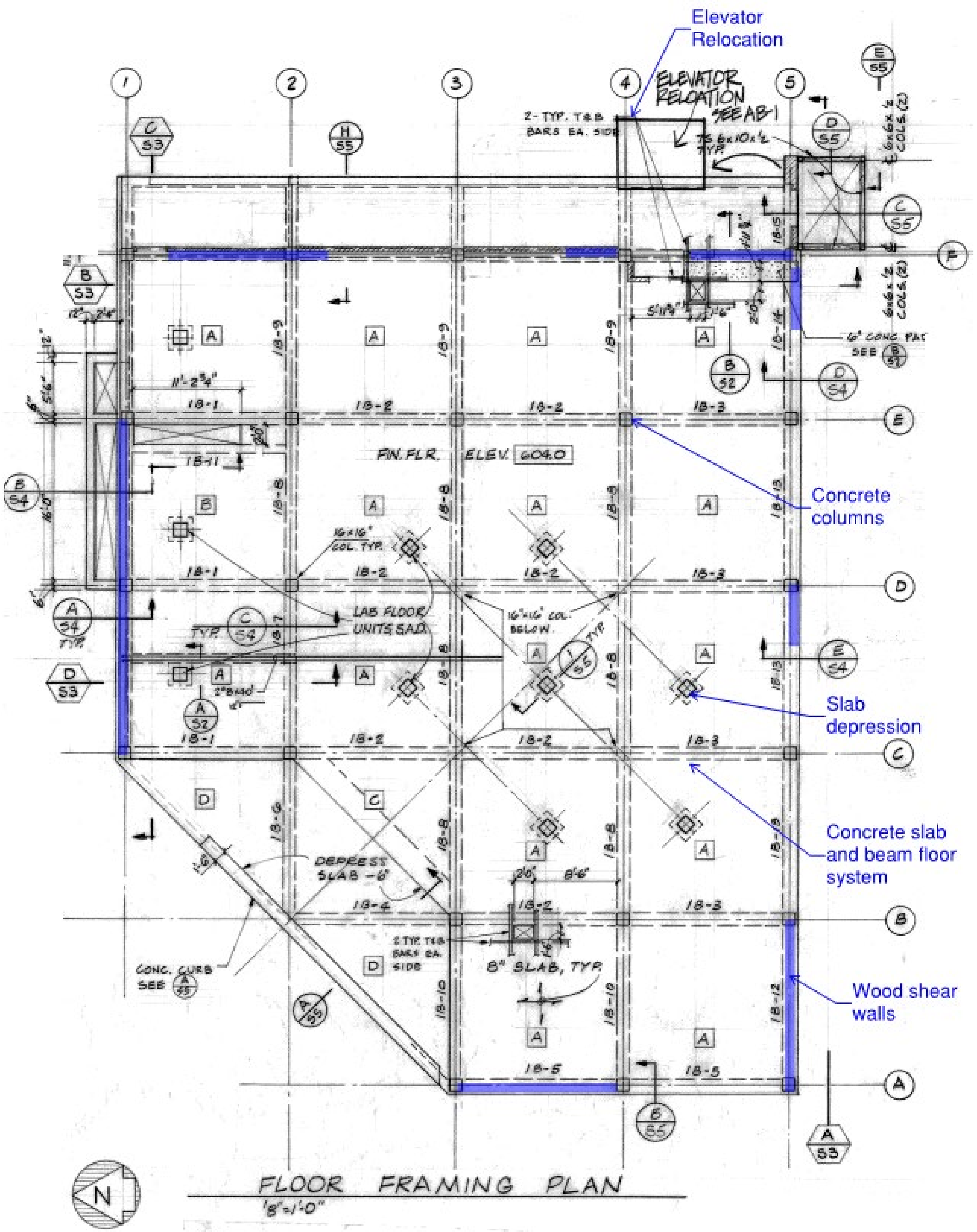
[5] F_V factor used does not include the requirements of Section 11.4.8-3 of ASCE 7-16 that are applicable to Site Class D, and which per Exception 2 would result in an effective F_V factor of 2.72 (1.5 times larger). At the Santa Cruz main campus this only affects structures with T>0.69 seconds. We understand that the appropriateness of this requirement of Section 11.4.8 might be reviewed by UCOP.

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

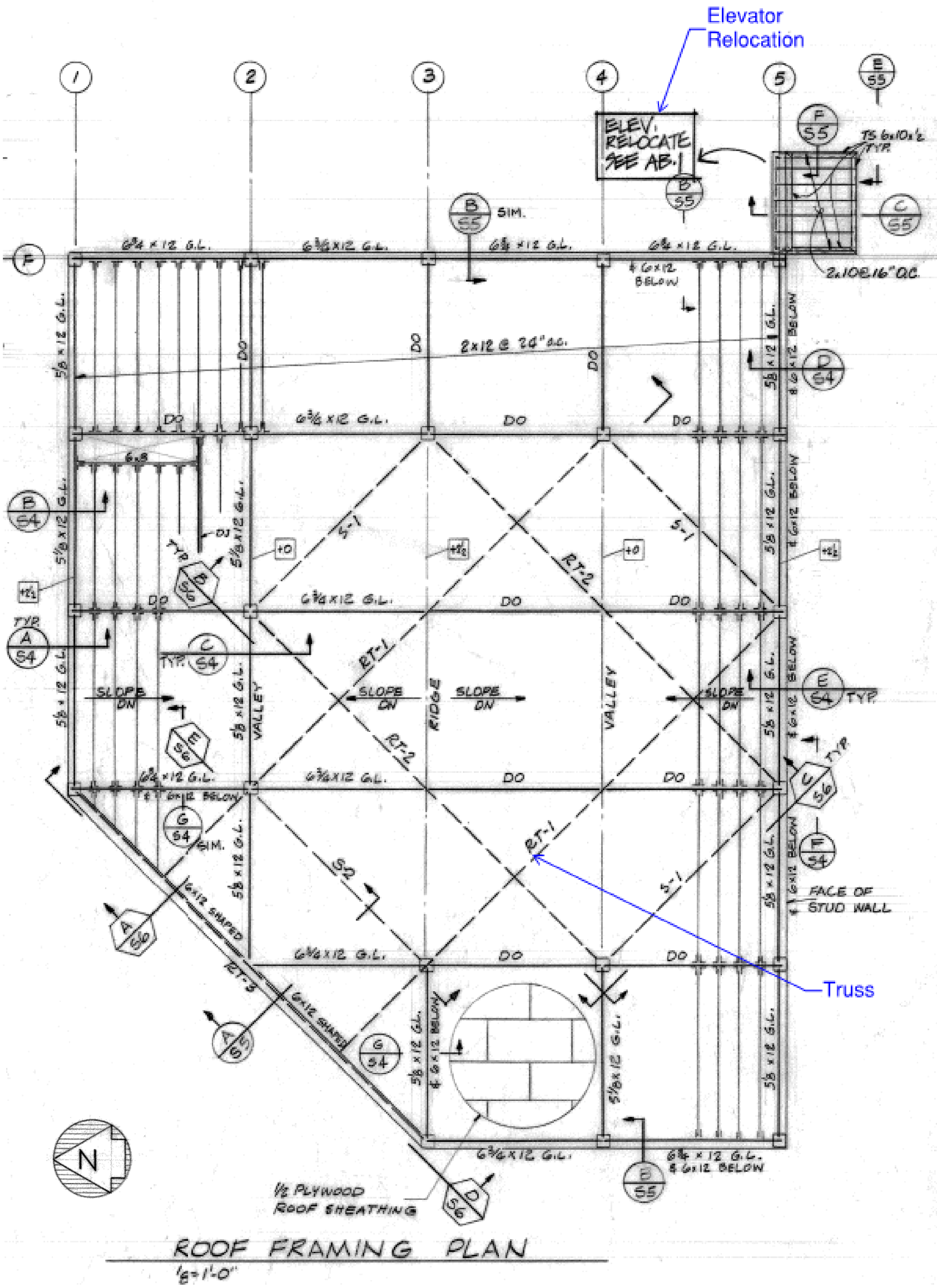
Annotated Foundation Plan:



Annotated Level 2 Plan:



Annotated Roof Plan:



Wood shear wall over concrete shear wall typical detail:

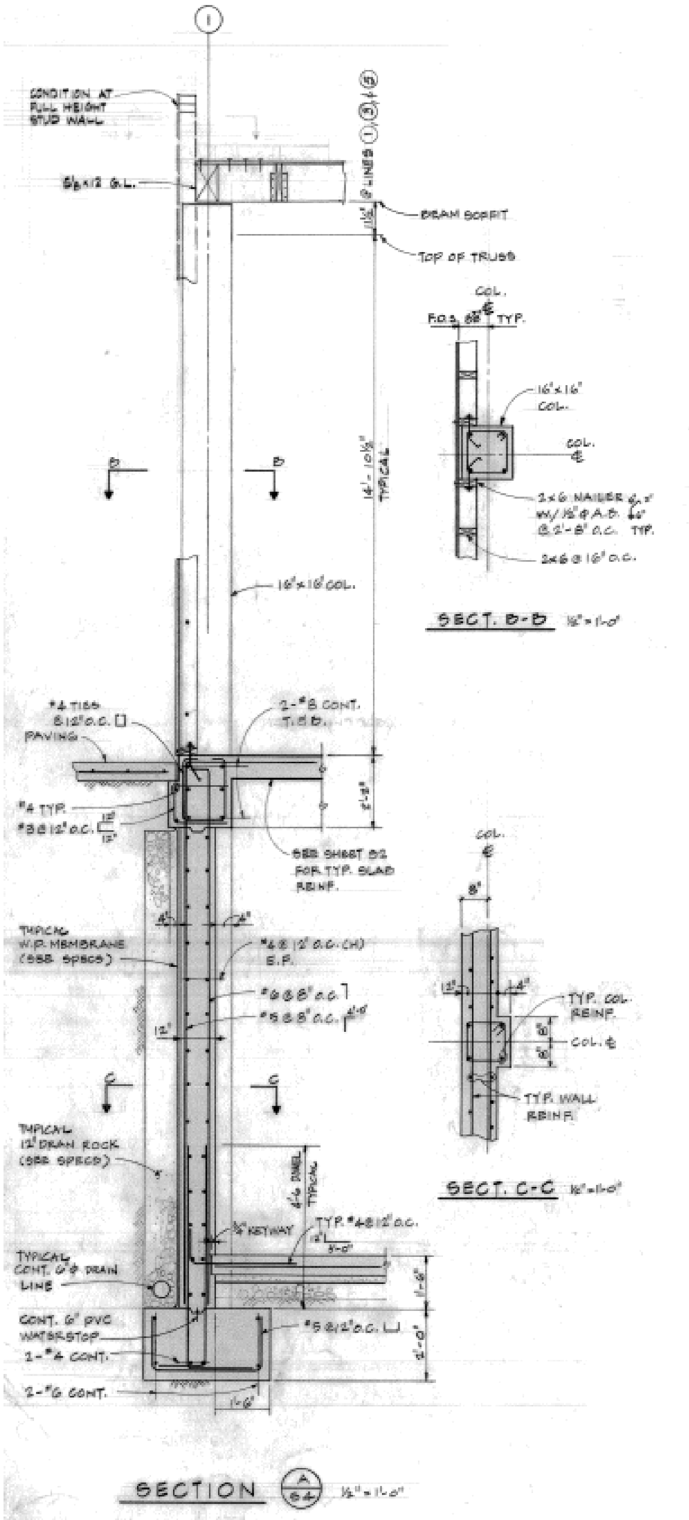


Table 17-2. Collapse Prevention Basic Configuration Checklist

Status	Evaluation Statement
Low Seismicity	
Building System—General	
C NC N/A U	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.
C NC N/A U	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.
C NC N/A U	MEZZANINES: Interior mezzanine levels are braced independently from the main structure or are anchored to the seismic-force-resisting elements of the main structure.
Building System—Building Configuration	
C NC N/A U	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.
C NC N/A U	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.
C NC N/A U	VERTICAL IRREGULARITIES: All vertical elements in the seismic-force-resisting system are continuous to the foundation.
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.
C NC N/A U	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.
C NC N/A U	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.

No Mezzanine

At L01 the continuous walls at the North and East face combined with the opening on the South and West will create torsion, but we expect drifts and the wall stress to be low

Status	Evaluation Statement
Moderate Seismicity (Complete the Following Items in Addition to the Items for Low Seismicity)	
Geologic Site Hazards	
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 (15.2 m) under the building.
C NC N/A U	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.
C NC N/A U	SURFACE FAULT RUPTURE: Surface fault rupture and surface displacement at the building site are not anticipated.
High Seismicity (Complete the Following Items in Addition to the Items for Moderate Seismicity)	
Foundation Configuration	
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 $0.6S_a$.
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.

18ft/31ft = 0.58 < 0.6*1.28g

Note: C = Compliant, NC = Noncompliant, N/A = Not Applicable, and U = Unknown.

Table 17-24. Collapse Prevention Structural Checklist for Building Types C2 and C2a

Status | **Evaluation Statement**

Low and Moderate Seismicity
Seismic-Force-Resisting System

C NC N/A U COMPLETE FRAMES: Steel or concrete frames classified as secondary components form a complete vertical-load-carrying system.

C NC N/A U REDUNDANCY: The number of lines of shear walls in each principal direction is greater than or equal to 2.

C NC N/A U SHEAR STRESS CHECK: The shear stress in the concrete shear walls, calculated using the Quick Check procedure of Section 4.4.3.3, is less than the greater of 100 lb/in.^{2} (0.69 MPa) or $2\sqrt{f'_c}$.

C NC N/A U REINFORCING STEEL: The ratio of reinforcing steel area to gross concrete area is not less than 0.0012 in the vertical direction and 0.0020 in the horizontal direction.

Min. #4@12" O.C. E.F. E.W.

Connections

C NC N/A U WALL ANCHORAGE AT FLEXIBLE DIAPHRAGMS: Exterior concrete or masonry walls that are dependent on flexible diaphragms for lateral support are anchored for out-of-plane forces at each diaphragm level with steel anchors, reinforcing dowels, or straps that are developed into the diaphragm. Connections have strength to resist the connection force calculated in the Quick Check procedure of Section 4.4.3.7.

C NC N/A U TRANSFER TO SHEAR WALLS: Diaphragms are connected for transfer of seismic forces to the shear walls.

Bottom & top bars develop into shear wall

C NC N/A U FOUNDATION DOWELS: Wall reinforcement is doweled into the foundation with vertical bars equal in size and spacing to the vertical wall reinforcing directly above the foundation.

Per general notes

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 DEFLECTION COMPATIBILITY: Secondary components have the shear capacity to develop the flexural strength of the components.

See supplementary calcs.

C NC N/A U FLAT SLABS: Flat slabs or plates not part of the seismic-force-resisting system have continuous bottom steel through the column joints.

Beams frame into all column joints

C NC N/A U COUPLING BEAMS: The ends of both walls to which the coupling beam is attached are supported at each end to resist vertical loads caused by overturning.

Diaphragms (Stiff or Flexible)

C NC N/A U DIAPHRAGM CONTINUITY: The diaphragms are not composed of split-level floors and do not have expansion joints.

C NC N/A U OPENINGS AT SHEAR WALLS: Diaphragm openings immediately adjacent to the shear walls are less than 25% of the wall length.

Flexible Diaphragms

C NC N/A U CROSS TIES: There are continuous cross ties between diaphragm chords.

C NC N/A U STRAIGHT SHEATHING: All straight-sheathed diaphragms have aspect ratios less than 2-to-1 in the direction being considered.

No flexible diaphragms frame into the C2 portion of the building

C NC N/A U SPANS: All wood diaphragms with spans greater than 24 ft (7.3 m) consist of wood structural panels or diagonal sheathing.

C NC N/A U 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.

C NC N/A U OTHER DIAPHRAGMS: Diaphragms do not consist of a system other than wood, metal deck, concrete, or horizontal bracing.

Connections

C NC N/A U UPLIFT AT PILE CAPS: Pile caps have top reinforcement, and piles are anchored to the pile caps.

Piles develop through grade beam into column above

Note: C = Compliant, NC = Noncompliant, N/A = Not Applicable, and U = Unknown.

Table 17-6. Collapse Prevention Structural Checklist for Building Type W2

Status	Evaluation Statement
Low and Moderate Seismicity	
Seismic-Force-Resisting System	
C NC N/A U	REDUNDANCY: The number of lines of shear walls in each principal direction is greater than or equal to 2.
C NC N/A U	SHEAR STRESS CHECK: The shear stress in the shear walls, calculated using the Quick Check procedure of Section 4.4.3.3, is less than the following values: Structural panel sheathing 1,000 lb/ft Diagonal sheathing 700 lb/ft Straight sheathing 100 lb/ft All other conditions 100 lb/ft
C NC N/A U	STUCCO (EXTERIOR PLASTER) SHEAR WALLS: Multi-story buildings do not rely on exterior stucco walls as the primary seismic-force-resisting system.
C NC N/A U	GYPSUM WALLBOARD OR PLASTER SHEAR WALLS: Interior plaster or gypsum wallboard is not used for shear walls on buildings more than one story high with the exception of the uppermost level of a multi-story building.
C NC N/A U	NARROW WOOD SHEAR WALLS: Narrow wood shear walls with an aspect ratio greater than 2-to-1 are not used to resist seismic forces.
C NC N/A U	WALLS CONNECTED THROUGH FLOORS: Shear walls have an interconnection between stories to transfer overturning and shear forces through the floor.
C NC N/A U	HILLSIDE SITE: For structures that are taller on at least one side by more than one-half story because of a sloping site, all shear walls on the downhill slope have an aspect ratio less than 1-to-1.
C NC N/A U	CRIPPLE WALLS: Cripple walls below first-floor-level shear walls are braced to the foundation with wood structural panels.
C NC N/A U	OPENINGS: Walls with openings greater than 80% of the length are braced with wood structural panel shear walls with aspect ratios of not more than 1.5-to-1 or are supported by adjacent construction through positive ties capable of transferring the seismic forces.
Connections	
C NC N/A U	WOOD POSTS: There is a positive connection of wood posts to the foundation.
C NC N/A U	WOOD SILLS: All wood sills are bolted to the foundation.
C NC N/A U	GIRDER–COLUMN CONNECTION: There is a positive connection using plates, connection hardware, or straps between the girder and the column support.
High Seismicity (Complete the Following Items in Addition to the Items for Low and Moderate Seismicity)	
Connections	
C NC N/A U	WOOD SILL BOLTS: Sill bolts are spaced at 6 ft (1.8 m) or less with acceptable edge and end distance provided for wood and concrete.
Diaphragms	
C NC N/A U	DIAPHRAGM CONTINUITY: The diaphragms are not composed of split-level floors and do not have expansion joints.
C NC N/A U	ROOF CHORD CONTINUITY: All chord elements are continuous, regardless of changes in roof elevation.
C NC N/A U	DIAPHRAGM REINFORCEMENT AT OPENINGS: There is reinforcing around all diaphragm openings larger than 50% of the building width in either major plan dimension.
C NC N/A U	STRAIGHT SHEATHING: All straight-sheathed diaphragms have aspect ratios less than 2-to-1 in the direction being considered.
C NC N/A U	SPANS: All wood diaphragms with spans greater than 24 ft (7.3 m) consist of wood structural panels or diagonal sheathing.

Drawings do not callout hold downs. At some locations the wood walls are connected to columns which will behave like a hold down.

Check doesn't apply for W2 portion of the building

All columns are concrete

Girders connected with embeds at concrete col.

Continuity provided though the concrete column embed and column cage

Table 17-6 *(Continued)*. Collapse Prevention Structural Checklist for Building Type W2

Status	Evaluation Statement
C NC N/A U	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 have aspect ratios less than or equal to 4-to-1.
C NC N/A U	OTHER DIAPHRAGMS: The diaphragms do not consist of a system other than wood, metal deck, concrete, or horizontal bracing.

Note: C = Compliant, NC = Noncompliant, N/A = Not Applicable, and U = Unknown.

ASCE 41-17 - Tier 1 Calculations

Oakes Tutorial

Building Properties:

Seismic Parameters:

Risk Category: II   2016 CBC table 1604.5

Site Class: D   Assummed

Probability: 5% in 50 years

$S_{XS} = 1.276$ for BSE-2E hazard level

$S_{X1} = 0.877$ for BSE-2E hazard level

Seismic Forces:

$T = C_t \cdot h_n^{\beta} \rightarrow 0.26\ \text{sec}$ (ASCE 41-17 Eqn. 4-4)

$C_t = 0.02$

$\beta = 0.75$

$h_n = 31\ \text{ft}$

$S_a = min\left(\frac{S_{X1}}{T}, S_{XS}\right) \rightarrow 1.28\ \text{g}$ (ASCE 41-17 Eqn. 4-3)

$V_{base} = C_{base} \cdot S_a \cdot W_{total} \rightarrow 2{,}400\ kips$ (ASCE 41-17 Eqn. 4-1)

$C_{base} = 1.4$ (ASCE41-17 Table 4-7) worst case (1 level of C2)

Due to weight difference between floors ASCE 41-17 Eqn. 4-2a is not appropriate for load distribution

$V_{L02} = C_{roof} \cdot S_a \cdot roof_{weight} \rightarrow 269\ kips$ (ASCE 41-17 Eqn. 4-1)

$C_{roof} = 1.3$ (ASCE41-17 Table 4-7) worst case (1 level of W2)

Building Weight:

$A_{floor} = 6060 ft^2 \rightarrow 6{,}060 ft^2$

$floor_{unit.weight} = \Sigma\left(tbl_{floor\,Unit_{weight}}\right) \rightarrow 195\ psf$

$floor_{weight} = \Sigma\left(tbl_{floor\,Weight_{floor}}\right) \rightarrow 1{,}182\ kips$

$roof_{unit.weight} = \Sigma\left(tbl_{roof\,Unit_{weight}}\right) \rightarrow 30\ psf$

$roof_{weight} = \Sigma\left(tbl_{roof\,Weight_{roof}}\right) \rightarrow 162\ kips$

$A_{roof} = 5400 ft^2$

$W_{total} = floor_{weight} + roof_{weight} \rightarrow 1{,}344\ kips$

ASCE 41-17 - Tier 1 Calculations

Oakes Tutorial

W2 Shear Stress Check: ASCE 41-17 Sec. 4.4.3.3

$L_{w,W2} = 24\,ft + 36\,ft \rightarrow 60\,ft$ 2 bays one one side and 1.5 bays on the other

$M_{s,W2} = 4.5$ (ASCE 41-17 Table 4-8)

$$v_j = \frac{1}{M_{s,W2}} \cdot \left(\frac{V_{L02}}{L_{w,W2}}\right) \rightarrow 995\,plf$$

Shear stress OK, Limit 1000plf

C2 Shear Stress Check: ASCE 41-17 Sec. 4.4.3.3

$A_{w,C2} = 2 \cdot 18\,ft \cdot 12\,in \rightarrow 5{,}184\,in^2$ assuming 2 bays of wall in each direction, conservative

$M_{s,C2} = 4.5$ (ASCE 41-17 Table 4-8)

$$v_j = \frac{1}{M_{s,C2}} \cdot \left(\frac{V_{base}}{A_{w,C2}}\right) \rightarrow 103\,psi$$

$$v_n = 2 \cdot \sqrt{4000\,psi \cdot psi} \rightarrow 126\,psi$$

Shear stress OK with concrete only

Deflection Compatibility Check

Columns:

$$M_{n,e,col} = 1.25 \cdot 60\,ksi \cdot 2 \cdot 1.27\,in^2 \cdot 14\,in \rightarrow 2{,}667\,kip \cdot in$$

$$V_{max,col} = \frac{2 \cdot M_{n,e,col}}{12\,ft} \rightarrow 37\,kips$$

$$V_u = 2 \cdot \sqrt{4000\,psi \cdot psi} \cdot 16\,in \cdot 14\,in + 40\,ksi \cdot 2 \cdot 0.2\,in^2 \cdot \frac{14\,in}{8\,in} \rightarrow 56.3\,kips$$

Ductility of Column OK

Beams:

$$M_{n,e,beam} = 1.25 \cdot 40\,ksi \cdot 3 \cdot 0.79\,in^2 \cdot 45\,in \rightarrow 5{,}333\,kip \cdot in$$

$$V_{max,beam} = \frac{2 \cdot M_{n,e,beam}}{16\,ft} \rightarrow 55.5\,kips$$

$$V_u = 2 \cdot \sqrt{4000\,psi \cdot psi} \cdot 16\,in \cdot 45\,in + 40\,ksi \cdot 2 \cdot 0.2\,in^2 \cdot \frac{45\,in}{12\,in} \rightarrow 151\,kips$$

Ductility of Beam OK