Source: University of California, Santa Cruz

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

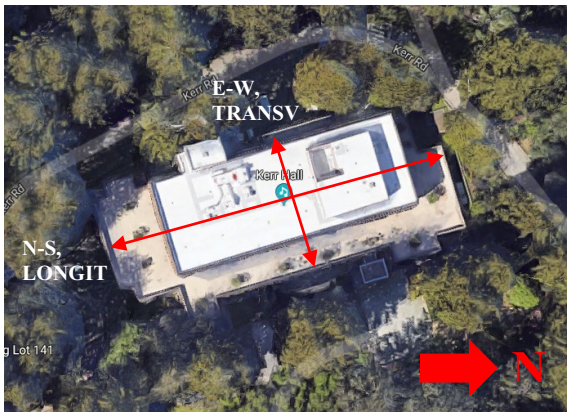
REGISTERED PROFESSIONAL ENGINEER JOSEPH RICHARD MAFFEI No. 3694 STRUCTURAL STATE OF CALIFORNIA

UC Santa Cruz building seismic ratings

Kerr Hall

CAAN #7376
500 Kerr Road, Santa Cruz, CA 95064
UCSC Campus: Main Campus

DATE: 2019-07-15



Rating summary	Entry	Notes
UC Seismic Performance Level (rating)	VI (Very Poor)	
Rating basis	Tier 1	ASCE 41-17[1]
Date of rating	2019	
Recommended UC Santa Cruz priority category for retrofit	Priority A	Priority A=Retrofit ASAP Priority B=Retrofit at next permit application for modification
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	Building was previously rated in 1998
Further evaluation recommended?	Tier 2	Focused on a number of deficiencies including potential hazard of precast cladding

[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 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

- Architectural drawings by Germano, Milono & Associates, "Social Science Unit I, University of California Santa Cruz" record set dated 24 Dec 1970 (original drawings dated 8 December 1969), sheets A1-A30
- Structural drawings by T.Y. Lin, Kulka, Yang & Associate, "Social Science Unit I, University of California Santa Cruz" as-built drawings dated 24 Dec 1970 (original drawings dated 8 December 1969), sheets S1-S20.

Additional building information known to exist

- Record set drawings for Electrical, Landscape, Mechanical, Plumbing, Site Utilities dated December 1970

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, but non-structural life-safety hazards were not evaluated.

Brief description of structure

Kerr Hall is concrete structure, currently used as the primary administration building on campus. The building was designed in 1969 by the architectural office of Germano, Milono & Associates and the structural office of by T.Y. Lin, Kulka, Yang & Associate. Construction was completed in late 1970.

The building has 4 stories above grade and a partial basement below grade and contains approximately 79,363 square feet. In plan the building is roughly rectangular, measuring 220 feet in the north-south direction by 96 feet in the east-west direction at Levels 1 and 2, and 160 feet in the north-south direction by 60 feet in the east-west direction at Levels 3, 4, Roof. Each story is 13 feet in height with an overall building height of 52 feet from the lowest at-grade level at Level 1 to the Roof.

The finished grade at the south side and most of the east and west sides of the building are at Level 1. At the north side and part of the east and west sides of the building, the soil is backfilled against the building perimeter walls such that grade is at Level 2. The main entry lobby to the building is on Level 2 on the east side of the building.

Identification of levels: Basement floor at elevation 710', Level 1 at elevation 723', Level 2 at elevation 736', Level 3 at elevation 749', Level 4 at elevation 762', Roof at elevation 775', machine room roof at elevation 788'.

Foundation system: The superstructure is founded on pier caps over drilled caissons, with caisson diameter varying from 24" to 60", and caisson lengths ranging from 25' to 55' deep. Caissons are located under all columns and concrete walls, and are interconnected by a grid of grade beams.

Structural system for vertical (gravity) load: The above-grade floor and roof are cast-in-place post-tensioned concrete flat slabs, supported by cast-in-place concrete walls and columns. As described below, floors at Levels 1 – 3 are also supported at their perimeter by the exterior precast panel walls.

The exterior walls are structural lightweight precast concrete panels. From Level 4 to Roof, the panels are non-load-bearing walls. The panels are discontinuous at Level 4, and do not exist between Levels 3 and 4. Below Level 3, the panels are load-bearing walls and support the tributary floor loads from the Level 1, 2, 3 floor slabs. The panels are anchored at each floor with steel angles that connect with shallow anchors into the floor slabs (see details, attached). The individual panels are not interconnected along the panel vertical joints.

Structural system for lateral forces: The lateral-force-resisting system consists of cast-in-place concrete walls provided around and in the vicinity of the stairs and elevators. The walls are 12" thick from their base to Level 4, and 10" thick above Level 4. The 8" slab at each level serves as the floor diaphragm to deliver inertial story forces to the walls, however there is no collector reinforcement provided.

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:

- No collector reinforcement is provided to the wall around and near the stair and elevators. We expect that damage to the slab could occur near the floor to wall intersections.

- Walls in north-south direction are overstressed at Level 2, where the floor plate size increases compared to floors above, but wall length is not increased proportionally.
- Under east-west motions, plan torsion at Level 2 is created by concrete walls at the north end of the building, which were provided to retain soil to create the Level 2 entry plaza. We expect that substantial demand will be placed on the east-west walls at the south end of the building because of the plan torsion.
- Walls at stair core are relatively tall and narrow (L/h = 16'/65' = 0.25) and overturning capacity may be insufficient. A minor concern is that at the base of the walls, caisson vertical reinforcement is not be developed fully into the pile cap (20db provided versus 28db required by ACI 318-14).
- Gravity columns have light transverse reinforcement (#3 ties @12"o.c.) and are flexure/diagonal-tension critical below Level 4, indicating the possibility of shear failure at moderate to high bending ductility demand.
- The exterior precast concrete panel facade is attached to the floor and roof slabs with nonductile shallow anchors. The panel connections do not appear to be detailed to accommodate story drift demands.
- Canopy at Level 2 entry is a concrete moment frame. A separation joint is provided between the canopy and the building (dimension of joint is not shown on the drawing) but it is likely that there will be pounding between the canopy and the abutting building façade, with damage to the façade likely. We recommend further study.

Structural deficiency	Affects rating?	Structural deficiency	Affects rating?
Lateral system stress check (wall shear, column shear or flexure, or brace axial as applicable)	Y	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	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	Y
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 we 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	Precast panels at exterior	Masonry chimneys	None observed
Unbraced masonry parapets, cornices or other ornamentation above exit ways and public access areas	Entry canopy at Level 2	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 the type and location of potential non-structural hazards.

Discussion of rating

The building is rated VI (Very Poor) because of the potential life-safety hazard of the precast panel façade. This facade has nonductile attachments to the floor and roof slabs and may disconnect from the building under story drift demands. The entry canopy at the main entrance at Level 2 also may pound against the building façade and create damage to the façade at the entry way.

If these deficiencies are addressed or shown not to be a high risk, the rating would likely to still be no better than V (Poor) because the lack of collectors, the overstress in the walls in the north-south direction at Level 2, and the overturning demand on the narrow walls and their underlying caissons. Such deficiencies may lead to damage to the floor slab in the areas around the interior walls, which could obstruct the exit ways from the building since the walls are clustered around the stair cores.

Recommendations for further evaluation or retrofit

We recommend that the University perform a more detailed evaluation as a precursor to probable structural retrofit. A Tier 2 evaluation of the deficiencies would be an appropriate starting point.

Peer review of rating

This seismic evaluation was discussed in a peer review meeting on 28 May 2019. Reviewers present were Bret Lizundia of R+C and Holly Razzano and Jay Yin of Degenkolb. Comments from the reviewers have been incorporated into this report. The reviewers agreed that the rating should be no better than V.

Additional building data	Entry	Notes
Latitude	36.996986	
Longitude	-122.062095	
Are there other structures besides this one under the same CAAN#	No	
Number of stories above lowest perimeter grade	5	Elevator and stair towers are not considered a story
Number of stories (basements) below lowest perimeter grade	1	
Building occupiable area (OGSF)	80755	
Risk Category per 2016 CBC Table 1604.5	II	Office occupancy
Building structural height, h_n	52 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	0.39 sec	Estimated using ASCE 41-17 equation 4-4 and 7-18

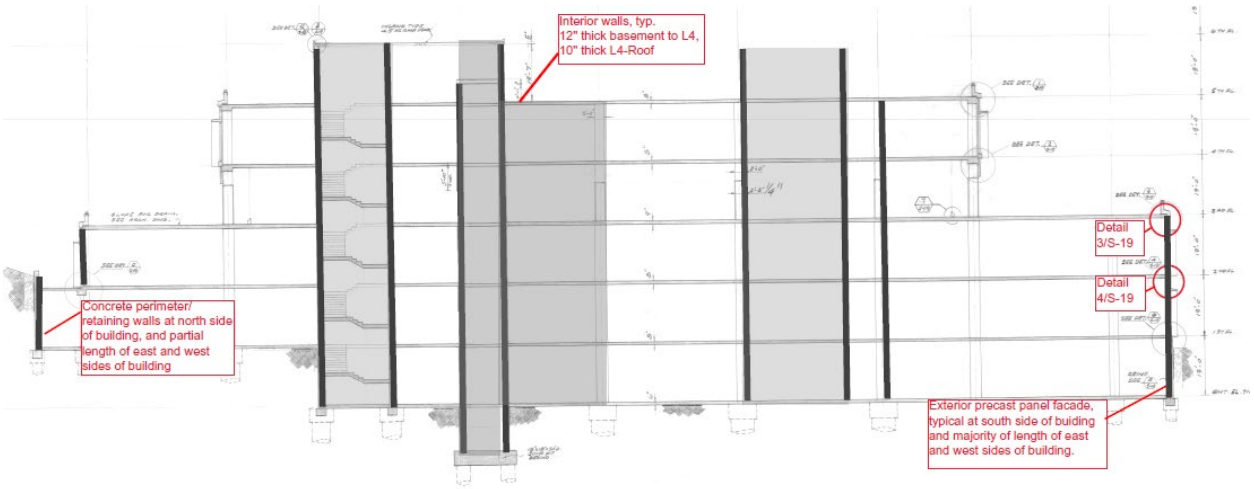
Site data		
975 yr hazard parameters S_s, S_1	1.286, 0.488	
Site class	D	
Site class basis[4]	Geotech	See footnote below
Site parameters F_a, F_v[5]	1, 1.81	
Ground motion parameters S_{xs}, S_{x1}	1.286, 0.881	
S_a at building period	1.28	
Site V_{s30}	900 ft/s	
V_{s30} basis	Estimated	Estimated based 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: 1970 Code: 1967 UBC	
Applicable code for partial retrofit	None	
Applicable code for full retrofit	None	
Model building data		
Model building type North-South	C2 - Conc. wall (Rigid Diaphragm)	
Model building type East-West	C2 - Conc. wall (Rigid Diaphragm)	
FEMA P-154 score	N/A	Not included here. Tier 1 evaluation.
Previous ratings		
Most recent rating	Fair	
Date of most recent rating	April 1998	Rating by Wildman and Morris

[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

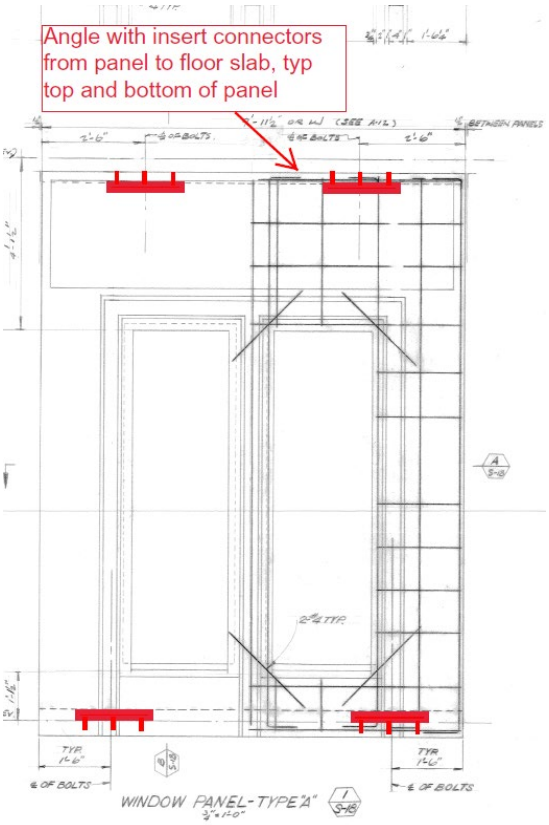
[5] F_V factor used does not include the requirements of Section 11.4.8-3 of ASCE 7-16 that are applicable to Site Class D, and which per Exception 2 would result in an effective F_V factor of 2.72 (1.5 times larger). At the Santa Cruz main campus this only affects structures with T>0.69 seconds. We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

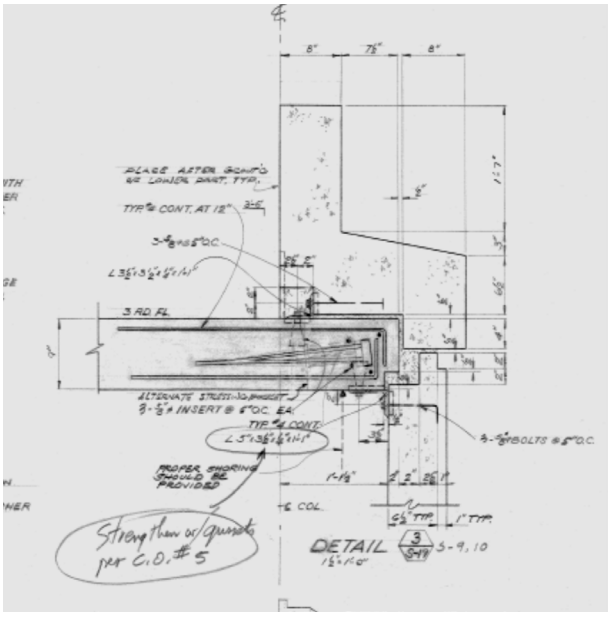
Annotated floor plan (3rd floor shown)

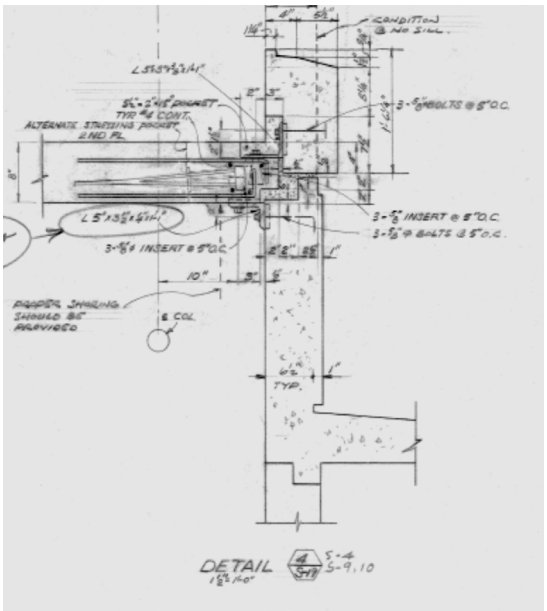


Annotated building section (looking east)



Typical precast panel elevation





Section at precast panel connection to floor slab, Sections 3/S-19 (left) and 3/S-19 (right)


CLARK KERR HALL

UC Campus:	UC Santa Cruz			Date:	6/30/2019		
Building CAAN:	7376	Auxiliary CAAN:		By Firm:	Maffei Structural Engineering		
Building Name:	Kerr Hall			Initials:	NY	Checked:	JM
Building Address:	500 Kerr Road, Santa Cruz CA 95064			Page:	1	of	3

ASCE 41-17
Collapse Prevention Basic Configuration Checklist

LOW SEISMICITY

BUILDING SYSTEMS - *GENERAL*

	Description
C NC N/A U ● ○ ○ ○ **NC**	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) **Comments:** Collectors to walls are not provided. Caisson reinforcement is developed only 20db into pier caps versus current ACI 318-14 development length of 28db. .
C NC N/A U ○ ○ ○ ○ **C**	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) **Comments:** C - No adjacent buildings
C NC N/A U ○ ○ ○ ○ **C**	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) **Comments:** C - No mezzanines

BUILDING SYSTEMS - *BUILDING CONFIGURATION*

	Description
C NC N/A U ○ ○ ○ ○ **C**	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) **Comments:** C – wall length/thickness increases with height.
C NC N/A U ○ ○ ○ ○ **C**	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) **Comments:** C

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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)
C				**Comments:** C – interior walls are continuous to 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. (Commentary: Sec. A.2.2.5. Tier 2: Sec. 5.4.2.4)
NC				**Comments:** NC – Level 1 has more than 30% increase in wall length versus Level 2. This is due to the wall added at the north end of the building for retaining soil.
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. (Commentary: Sec. A.2.2.6. Tier 2: Sec. 5.4.2.5)
C				**Comments:** C – There is a 44% change in mass between Level 3 (larger floor footprint) and Level 4 (smaller floor footprint).
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. (Commentary: Sec. A.2.2.7. Tier 2: Sec. 5.4.2.6)
NC				**Comments:** NC – Level 1 has significantly more wall at the north end of the building, resulting in the eccentricity between center of mass and center of rigidity in the north-south direction.

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

GEOLOGIC SITE HAZARD

	Description
C NC N/A U ○ ○ ○ ○ **C**	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) **Comments:**
C NC N/A U ○ ○ ○ ○ **C**	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) **Comments:**

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

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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)
C				**Comments:**

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

FOUNDATION CONFIGURATION

C	NC	N/A	U	Description
○	○	○	○	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)
NC				**Comments: NC – At stair core, wall is 16' long and 65' high (including basement depth), so 16'/65' = 0.25 < 0.6Sa = 0.6*1.28 = 0.77**
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)
C				**Comments:** C – tie beams are provided

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ASCE 41-17
Collapse Prevention Structural Checklist For Building Type C2-C2A

Low And Moderate Seismicity

Seismic-Force-Resisting System

	Description
C NC N/A U NA	COMPLETE FRAMES: Steel or concrete frames classified as secondary components form a complete vertical-load-carrying system. (Commentary: Sec. A.3.1.6.1. Tier 2: Sec. 5.5.2.5.1) **Comments:** NA – no frames provided
C NC N/A U C	REDUNDANCY: The number of lines of shear walls in each principal direction is greater than or equal to 2. (Commentary: Sec. A.3.2.1.1. Tier 2: Sec. 5.5.1.1) **Comments:**
C NC N/A U NC	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 $2\sqrt{f'_c}$. (Commentary: Sec. A.3.2.2.1. Tier 2: Sec. 5.5.3.1.1) **Comments:** NC – walls in north-south direction are overstressed at Level 2 where the building footprint increases but wall length do not increase proportionally.
C NC N/A U C	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. (Commentary: Sec. A.3.2.2.2. Tier 2: Sec. 5.5.3.1.3) **Comments: C**

Connections

	Description
C NC N/A U NA	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. (Commentary: Sec. A.5.1.1. Tier 2: Sec. 5.7.1.1) **Comments: NA – rigid diaphragm at floor and roof**
C NC N/A U NC	TRANSFER TO SHEAR WALLS: Diaphragms are connected for transfer of seismic forces to the shear walls. (Commentary: Sec. A.5.2.1. Tier 2: Sec. 5.7.2) **Comments:** NC – no collectors provided

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Collapse Prevention Structural Checklist For Building Type C2-C2A

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. (Commentary: Sec. A.5.3.5. Tier 2: Sec. 5.7.3.4) **Comments: C**
C				

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
○	○	○	○	DEFLECTION COMPATIBILITY: Secondary components have the shear capacity to develop the flexural strength of the components. (Commentary: Sec. A.3.1.6.2. Tier 2: Sec. 5.5.2.5.2) **Comments:** NC – gravity columns do not have shear capacity to develop their flexural strength, at levels 3 and below.
NC				
○	○	○	○	FLAT SLABS: Flat slabs or plates not part of the seismic-force-resisting system have continuous bottom steel through the column joints. (Commentary: Sec. A.3.1.6.3. Tier 2: Sec. 5.5.2.5.3) **Comments:**
C				
○	○	○	○	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. (Commentary: Sec. A.3.2.2.3. Tier 2: Sec. 5.5.3.2.1) **Comments:**
C				

Diaphragms (Stiff Or Flexible)

C	NC	N/A	U	Description
○	○	○	○	DIAPHRAGM CONTINUITY: The diaphragms are not composed of split-level floors and do not have expansion joints. (Commentary: Sec. A.4.1.1. Tier 2: Sec. 5.6.1.1) **Comments:**
C				
○	○	○	○	OPENINGS AT SHEAR WALLS: Diaphragm openings immediately adjacent to the shear walls are less than 25% of the wall length. (Commentary: Sec. A.4.1.4. Tier 2: Sec. 5.6.1.3) **Comments:**
C				

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ASCE 41-17
Collapse Prevention Structural Checklist For Building Type C2-C2A

Flexible Diaphragms

C NC N/A U	Description
NA	CROSS TIES: There are continuous cross ties between diaphragm chords. (Commentary: Sec. A.4.1.2. Tier 2: Sec. 5.6.1.2) **Comments:**
NA	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) **Comments:**
NA	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) **Comments:**
NA	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) **Comments:**
NA	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) **Comments:**

Connections

C NC N/A U	Description
NC	UPLIFT AT PILE CAPS: Pile caps have top reinforcement, and piles are anchored to the pile caps. (Commentary: Sec. A.5.3.8. Tier 2: Sec. 5.7.3.5) **Comments:** NC – pile caps have top reinforcement, but pile reinforcement is inadequately developed into pile cap (development length is specified 20db and not 28db as required by ACI 318-14)

SEISMIC EVALUATION OF EXISTING BUILDINGS - TIER 1 SCREENING

ASCE 41-17 Chapter 4

General				Reference	Location
Building	Kerr Hall				
Architect	Germano, Milono & Associates				
Structural Engineer	T.Y. Lin, Kulka, Yang & Associate				
Location	513 Cowell Service Road, Santa Cruz, CA 95064				
Design date	1969				
Latitude	36.99699			https://hazards.atcouncil.org/	
Longitude	-122.06210			"	
Stories above grade	4				

Seismic parameters					
Risk Category	II	2016 CBC Table 1604.5			
Site Class	D			(ASCE 41-17 2.4.1.6, ASCE 7-16 Chapter 20)	See ASCE 7
Liquefaction hazard	Low	http://data-sccgis.opendata.arcgis.com/datasets/77d380d355934b38a44894154377e28d_62		(ASCE 41-17 3.3.4)	See ASCE 41
Landslide hazard	Low	http://data-sccgis.opendata.arcgis.com/datasets/7984aabd55ec4a4794ae33d7919bd9c7_133			
S_{DS}	0.85	https://hazards.atcouncil.org/	Based on ASCE 7-16 DE, used to determine "Level of Seismicity"	(ASCE 41-17 Eq 2-4)	See ASCE 41
S_{D1}	0.59	https://hazards.atcouncil.org/	Based on ASCE 7-16 DE, used to determine "Level of Seismicity"	(ASCE 41-17 Eq 2-5)	See ASCE 41
S_{XS}	1.281	For BSE-2E hazard level	https://hazards.atcou	(ASCE 41-17 Table 2-2)	Copied at right
S_{X1}	0.88	For BSE-2E hazard level	https://hazards.atcouncil.org/	(ASCE 41-17 Table 2-2)	Copied at right

Scope				
Performance level	Collapse Prevention		(ASCE 41-17 Table 2-2)	Copied at right
Seismic hazard level	BSE-2E		(ASCE 41-17 Table 2-2)	Copied at right
Level of seismicity	High		(ASCE 41-17 Table 2-4)	Copied at right
Building type	C2: Concrete shear walls with rigid diaphragms		(ASCE 41-17 Table 3-1)	Copied at right

Material properties				Notes		
Concrete	f'_c	4000	psi	Specified on drawings, NWC	(ASCE 41-17 Table 10-4)	See ASCE 41
Reinf.	f_y	40	ksi	Specified on Drawings for #5 and smaller	(ASCE 41-17 Table 10-4)	See ASCE 41
		60	ksi	Specified on Drawings for #6 and larger		
Steel	F_y	N/A	ksi	N/A	(ASCE 41-17 Table 9-1)	See ASCE 41

Checklists

Benchmark building	No	Retrofit also pre-benchmark	(ASCE 41-17 Table 3-2)	Copied at right
Checklist(s) req'd	17.1.2 Basic Configuration		(ASCE 41-17 Table 4-6)	Copied at right
	17.12 Structural Checklist for Building Types C2a		(ASCE 41-17 Table 4-6)	Copied at right
	~~17.19 Nonstructural Checklist~~	(not performed)	(ASCE 41-17 Table 4-6)	Copied at right

Seismic forces

V	16589	kip	$V = Cs_a W$	= 1.28W	(ASCE 41-17 Eq 4-1)	See ASCE 41
W	12950	kip	building weight		(ASCE 41-17 4.4.2.1)	See ASCE 41
C	1.0		Convert linear elastic to inelastic disp.		(ASCE 41-17 Table 4-7)	Copied at right
S_a	1.28	g	$S_a = S_{x1}/T \le S_{XS}$		(ASCE 41-17 Eq 4-3)	See ASCE 41
T	0.39	sec	$T = C_t h_n^{\beta}$		(ASCE 41-17 Eq 4-4)	See ASCE 41
C_t	0.020				(ASCE 41-17 Eq 4-4)	Copied at right
β	0.75				(ASCE 41-17 Eq 4-4)	Copied at right
h_n	52	ft	building height		(ASCE 41-17 Eq 4-4)	Copied at right

Story Forces (ASCE 41-17 4-2a) (ASCE 41-17 4-2b)

Story	w kip	story ht ft	h ft	wh^k	F_{story}	F_{story} kip	V_{story} kip
Roof	2069		52	107588	0.29	4828	
4	2447	13.0	39	95433	0.26	4283	4828
3	4385	13.0	26	114010	0.31	5116	4828
2	4049	13.0	13	52637	0.14	2362	14227
1		13.0	0				16589
Total	12950			369668	1.0	16589	
k	1.00	k = 1.0 for T < 0.5, 2.0 for T > 2.5, linear interpolation between					

$F_{story} = V(wh^k)/(\Sigma wh^k)$ (ASCE 41-17 4-2a)

$V_{story} = \Sigma_{above} F_{story}$ (ASCE 41-17 4-2b)

Shear stress in shear walls (ASCE 41-17 4-8) (ASCE 41-17 4-8)

Story	$A_{w\,N\text{-}S}$ in^2	$A_{w\,E\text{-}W}$ in^2	v_{NS}^{avg} psi	v_{EW}^{avg} psi	D/C_{NS}	D/C_{EW}
Roof						
4	11220	18860	96	57	0.8	0.4
3	13464	20760	80	52	0.6	0.4
2	17735	26208	178	121	1.4	1.0
1	48936	48480	75	76	0.6	0.6
Total						

M_s 4.50 (ASCE 41-17 Table 4-8)

v_{limit} 126 psi $v_{limit} = 2\sqrt{f_c'} \geq 100$ psi

$v^{avg} = (1/M_S)(V_{story}/A_w)$ (ASCE 41-17 Eq 4-8)

SHEAR STRENGTH OF CONCRETE ELEMENTS

FEMA 306 Section 5.3.6

Input

f'_{ce}	4000	psi	concrete expected strength
λ	1.00		lightweight aggregate factor = 1.0 NWC, 0.85 sand LWC, 0.75 LWC
μ	1.4	λ	per ACI 318 11.7.4 = 1.4 monolithic, 1.0 roughened, 0.6 not roughened, 0.7 bars
$f_{ye\_transverse}$	46	ksi	expected transverse steel yield strength
$f_{ye\_longitudina}$	70	ksi	expected shear friction steel yield strength
b_w	32.0	in	width
l_w	24.0	in	length of wall (depth of beam or column)
h_w	12.3	ft	clear height of wall or column (length of beam or spandrel)
ρ_n	0.00115		transverse reinforcement ratio
A_s	8.0	in^2	longitudinal reinforcement area
P	600	kip	axial load
M_{n_1}	645	k-ft	moment strength at one end of element (e.g. top)
M_{n_2}	645	k-ft	moment strength at other end of element (e.g. bottom)
c	12.5	in	distance from extreme compressive fiber to neutral axis
θ	35	degrees	35 degrees unless limited to larger angles by the potential corner to corner crack

for corner to corner crack, use θ= max(35, atan(l_w/h_w))= 35

Behavior Mode **Flexure/ Diagonal**

$V_{n\_flexure} = (M_{n1} + M_{n2})/h$ =	105	kip	
$V_{n\_diagonal\_tension\_at\_low\_ductility\_demand}$ =	170	kip	($\mu \le 2$)
$V_{n\_diagonal\_tension\_at\_high\_ductility\_demand}$ =	91	kip	($\mu \ge 5$)
$V_{n\_sliding\_shear}$ =	614	kip	

Diagonal Tension Shear

	$\mu \le 2$	$\mu \ge 5$		
				flexural ductility demand
$V_{n\_diagonal}$	170	91	kip	$= V_c + V_s + V_p$
V_c	96	17	kip	$= \alpha\beta k_{rc} (f'_{ce})^{1/2} b_w (0.8 l_w)$
V_s	28	28	kip	$= \rho_n f_{ye} b_w h_d$
V_p	46	46	kip	$= ((l_w - c) N_u) / (2M/V)$
k_{rc}	3.5	0.6		
α	1.0	1.0		$= 3 - M/(0.8 l_w V)$ ($1.0 \le \alpha \le 1.5$)
β	0.708	0.708		$= 0.5 + 20\rho_g$ (≤ 1.0)
ρ_g	0.01042	0.01042		longitudinal reinforcement ratio
M/V	74.0	74.0	in	$= h_w/2$ assumes that beams/floors are stiffer than column (fixed- Adjust M/V calculation for other conditions.
h_d	16.4	16.4	in	$= (l_w - c)\cot\theta$ ($\le h_w$)
N_u	600	600	k	axial load
$2M/V$	147.96	147.96	in	$= h_w$ assumes that beams/floors are stiffer than column (fixed- Adjust M/V calculation for other conditions.

Sliding Shear

$V_{n\_sliding}$	614	kip	$= A_{vf} f_y \mu$	($\le 0.2 f_c A_c$, $800 A_c$)

A_{vf}	8.0 in^2	area of shear friction reinforcement