Rating form completed by: MAFFEI STRUCTURAL ENGINEERING
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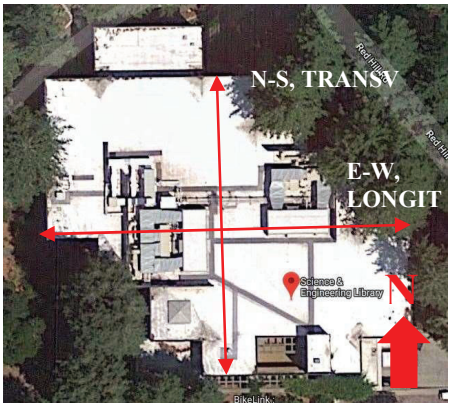
Text in green is to be part of UC Santa Cruz building database and may be part of UCOP database

UC Santa Cruz building seismic ratings

Science and Engineering Library

CAAN #7782
580 Red Hill Road, Santa Cruz, CA 95064
UCSC Campus: Main Campus

DATE: 2018-12-31



Rating summary	Entry	Notes
UC Seismic Performance Level (rating)	IV (Fair)	
Rating basis	Tier 1	ASCE 41-17[1]
Date of rating	2019	
Recommended list assignment (UC Santa Cruz category for retrofit)	Priority B	Priority A=Retrofit ASAP Priority B=Retrofit at next permit application
Ballpark total construction cost to retrofit to IV rating[2]	None	See recommendations on further evaluation and retrofit.
Is 2018-2019 rating required by UCOP?	Yes	Building was not previously rated
Further evaluation recommended?	Tier 2	If remodeling is to be done, recommend investigating whether column fiber wrapping is warranted, in particular below discontinuous concrete 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 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 Esherick, Homsey, Dodge and Davis, "Science Library University of California, Santa Cruz," as-built dated 6 May 1991 (signed 1 February 1989), 55 sheets.
- Structural drawings by Rutherford & Chekene, "Science Library University of California, Santa Cruz," as-built dated 6 May 1991 (signed 1 February 1989), 16 sheets
- University of California building database information, "Science and Engineering Library," provided by José Sanchez (UCSC) on 2019-01-29.
- Soils Reports by Jacobs, Raas & Assoc, "New Science Library", Report #223 dated May 1987 and Report #224 dated July 24, 1987
- Geologist Report by Rogers E. Johnson & Assoc, "UCSC Science Library", Report #283 dated 7 August 1987
- Architectural drawings by EHDD, "UCSC Science & Engineering Library ALC Renovation", "Science Library University of California, Santa Cruz," Sheet A2.01 dated 11/03/2016 and associated specification for access flooring, Section 09 69 33.

Additional building information known to exist

- None

Scope for completing this form

Reviewed structural drawings for original construction and carried out ASCE 41-17 Tier 1 evaluation. Made comparison of wall design requirements based on 1985 CBC with present requirements. Made site visit to observe for renovations and non-structural life-safety hazards.

Brief description of structure

The Science and Engineering Library is a three-story library structure containing 79,773 gross square feet. The building was designed in 1989 by the architectural office of Esherick, Homsey, Dodge and Davis and the structural office of Rutherford & Chekene; construction was completed in 1991. Drawings indicate that the 1985 CBC and 1979 UBC were the governing codes for design.

The structure is of all cast-in-place concrete construction. The façade is comprised of board-formed architectural concrete walls and glazed curtainwall. Floors are waffle slab construction with much of the soffit exposed to view. Where the structure is visible, the concrete appears in excellent condition.

Floor plates are irregular in shape (to respond architecturally to the forested site). Portions of the floor plate step back as the structure rises, resulting in some vertical irregularities in the shear walls. The floor plate is divided into regular 29' square bays. Each floor level is 14'-6" in height yielding an overall building height of 43'-6" feet from the Lower Level to the flat roof. Floors are designated as Lower Level (finished floor elevation 799.0'), Main Level (813.5'), Upper Level (828.0'), and Roof (842.5').

The library floors were designed to support a 150 psf live load (per the drawing General Notes) to allow flexibility for storage of reference materials, as dictated at the time by the State Librarian. Over the past several years, the use of campus library buildings has changed significantly. For this building, nearly all library storage has been removed from the upper two levels and the areas are now used as reading and study areas. A low profile access floor was added over much of the main level in 2016 to support the use of laptop computers and other electronic learning tools. For the purpose of seismic assessment, this report assumes 60 psf live load as prescribed by the building code for library reading rooms and no allowance for the weight of books is assumed in making this assessment.

Foundation System: The site is lightly sloping. Initial soil borings on the site identified the possible presence of an earthquake fault traversing the site. Further investigations were conducted, which determined that the fault is not active. Additionally, the geotechnical engineer determined that shallow spread footings would be suitable for support of the structure, except that foundations in the vicinity of the ancient fault zone should bridge that zone.

Shallow spread footings were used to support building columns, supplemented by strip footings and grade beams at wall locations. See Figure 1 for foundations and location of the inactive fault zone.

Structural system for vertical (gravity) load: Floors are framed with cast-in-place concrete waffle slabs. The overall slab thickness of 20-1/2" is comprised of a 4-1/2" thick slab and 16" deep ribs. Ribs are 7" minimum wide and spaced at 4'-0" on center. A 1'-7" wide rib centered on each grid line is used to make up the 29'-0" bay dimension. Drop panels are 9'-7" square.

Concrete columns are typically 20 inches square at the interior. Columns are reinforced with widely spaced ties (14" spacing) near mid-height, but with more closely spaced ties (7" spacing) in zones above and below the slab where flexural deformation demands may occur.

Columns at the building perimeter are typically 24 inches square and project outward 6-inches from the face of slab. Concrete walls flanking the columns at the exterior typically alleviate concerns regarding potential punching shear of the slab at the column under seismic deformation. Corner columns with windows on each side are connected to slab with edge beams with stirrups at 3" spacing, which mitigates concern for punching shear at corner columns under seismic deformation.

Structural system for lateral forces: Seismic lateral forces are resisted by concrete shear walls, typically located at the building façade. Walls are 12 inches thick and reinforced with #4 bars each face at 12" on center each way, or heavier. Heavy trim bars are provided at wall ends and tied with closed hoops and cross ties at 3" vertical spacing. Ties are also provided at 3-inch spacing in waffle slab edge beams between wall ends and columns, capable of developing flexural strength of edge beam hinging at the ends of walls. Detailing is considered better than average for time of design.

Diaphragms are formed by the 4-1/2" thick slab reinforced with #4 bars at 12" spacing. The waffle rib reinforcement incorporates collector bars at shear wall locations

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:

- Shear walls were designed for forces prescribed by Code at the time. Additional wall was not provided for architectural purposes. Considering the Occupancy Importance Factor that is currently applied to University educational buildings with more than 500 occupants (i.e., Risk Category III), the original design forces for wall shear were 62% of present-day requirements for new buildings. Neglecting the Importance factor for Risk Category III, design forces were 78% of present-day requirements. These estimates of capacity reasonably match the Quick Check results below.
- The Tier 1 Quick Check evidenced demand to capacity ratio of 2 for wall shear stress.
- Because nearly all of the concrete shear walls are located at the building exterior, when the exterior façade steps back at upper level, shear walls at this upper level may discontinue at the two levels below. While the structural design shows some attention to this situation, special transverse reinforcement is not provided in columns below a number of these walls. We recommend additional investigation of the expected performance of the columns below these discontinuous walls, to determine if the fiber wrapping of the columns is warranted.

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

We did not find non-structural items that represent a life-safety concern. Book stacks, which are located at the Lower Level, are equipped with seismic gussets to resist out-of-plane inertial forces and diagonal rod bracing or rigid frames to resist in-plane forces. Ceilings are limited to soffits along grid lines that contain ductwork and piping. Lightweight acoustic materials are typically used.

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

Despite the deficiencies listed above we rate the building as IV (Fair). Although the structure has less shear wall area that is required by current code, we believe this deficiency is mitigated by the good boundary detailing of the walls, the well-balanced seismic force resisting system, and the building height limited to three stories. Shear failure of the walls does not seem likely to lead large displacements imposed on columns, or lead to building collapse.

Recommendations for further evaluation or retrofit

If any renovation is planned for the building, we recommend additional investigation of the expected performance of the columns, in particular below discontinuous walls, to determine if the fiber wrapping of the columns is warranted.

[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.

Additional building data	Entry	Notes
Latitude	36.9990999	
Longitude	-122.0606399	
Are there other structures besides this one under the same CAAN#	No	
Number of stories above lowest perimeter grade	3	
Number of stories (basements) below lowest perimeter grade	0	First level is partially subterranean
Risk Category per 2016 CBC Table 1604.5	III	Educational occupancy over 500
Estimated fundamental period	0.34 sec	Estimated using ASCE 41-17 equation 4-4 and 7-18
Building structural height, h_n	44 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
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	1.29	
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	

[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.

Applicable code		
Applicable code or approx. date of original construction	Built: 1991 Code: 1979 UBC	Drawings list 1985 CBC and 1979 UBC
Applicable code for partial retrofit	None	Wood floor to concrete wall out-of-plane anchors only
Applicable code for full retrofit	None	No full retrofit
FEMA P-154 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 because we performed ASCE 41 Tier 1 evaluation.
Previous ratings		
Most recent rating	N/A	
Date of most recent rating	Unknown	Indicated on spreadsheet
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

Figure 1: Annotated Lower Level (Level 1) floor plan showing fault zone and shear walls

Figure 2: Annotated Upper Level (Level 3) floor plan showing shear walls above and below

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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) **Comments:**
●	○	○	○	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:**
○	○	●	○	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:**

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) **Comments:**
●	○	○	○	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:**
○	●	○	○	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) **Comments:** There are discontinuous walls at upper story due to setbacks. Refer to Figure 4 and discussion in report.

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

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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) **Comments:**
●	○	○	○	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) **Comments:**
●	○	○	○	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) **Comments:**

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) **Comments:**
●	○	○	○	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:** Conditions of ground collapse under the building were investigated at time of construction and it was determined shallow spread footings suitable.
●	○	○	○	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) **Comments:** An inactive fault under the building was investigated at tiem of construction.

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Collapse Prevention Basic Configuration Checklist

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) **Comments:**
○	○	●	○	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) **Comments:**

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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 ○	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:**
C ● NC ○ N/A ○ U ○	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 ○	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:** Refer to comparison of original design criteria (1985) UBC to present requirements (notes and discussion in report). More detailed analysis would be expected to yield comparable results.
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. (Commentary: Sec. A.3.2.2.2. Tier 2: Sec. 5.5.3.1.3) **Comments:**

Connections

	Description
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. (Commentary: Sec. A.5.1.1. Tier 2: Sec. 5.7.1.1) **Comments:**
C ● NC ○ N/A ○ U ○	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:**

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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:**

High Seismicity (Complete The Following Items In Addition To The Items For Low And Moderate Seismicity)

Seismic-Force-Resisting System

				Description
C	NC	N/A	U	
●	○	○	○	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:** Column shear checks performed. beams at ends of walls detailed with closely spaced ties that develop flexural capacity.
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. (Commentary: Sec. A.3.1.6.3. Tier 2: Sec. 5.5.2.5.3) **Comments:**
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. (Commentary: Sec. A.3.2.2.3. Tier 2: Sec. 5.5.3.2.1) **Comments:**

Diaphragms (Stiff Or Flexible)

				Description
C	NC	N/A	U	
●	○	○	○	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	NC	N/A	U	
●	○	○	○	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:**

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Flexible Diaphragms

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

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MAFFEI STRUCTURAL ENGINEERING

Project:_____
Subject:_____
By:_____
Date:_____

SEISMIC EVALUATION OF EXISTING BUILDINGS - TIER 1 SCREENING

ASCE 41-17 Chapter 4

Science and Engineering Library - UCSC

General

			Reference
Architect	EHDD		
Structural Engineer	Rutherford & Chekene		
Location	580 Red Hill Road, Santa Cruz, CA 95064		
Design date	1988	1985 CBC references 1979 UBC per Drawings	
Latitude	36.9990999		https://hazards.atcouncil.org/
Longitude	-122.0606399		"
Stories above grade	3		

Seismic parameters

				Reference
Risk Category	III	High Occupant Load, Education		2016 CBC Table 1604.5
Site Class	C	Assumed; note that Sa is same for B and C based on building height and type.		(ASCE 41-17 2.4.1.6, ASCE 7-16 Chapter 20)
Liquefaction hazard	Low	Assumed		(ASCE 41-17 3.3.4)
Landslide hazard	Low	Assumed		
S_{DS}	1.306	https://hazards.atcouncil.org/	Based on ASCE 7-16 DE, used to determine "Level of Seismicity"	(ASCE 41-17 Eq 2-4)
S_{D1}	0.584	https://hazards.atcouncil.org/	Based on ASCE 7-16 DE, used to determine "Level of Seismicity"	(ASCE 41-17 Eq 2-5)
S_{XS}	1.286	For BSE-2E hazard level	https://hazards.atcouncil.org/	(ASCE 41-17 Table 2-2)
S_{X1}	0.89	For BSE-2E hazard level	https://hazards.atcouncil.org/	(ASCE 41-17 Table 2-2)

Scope

				Reference
Performance level	Limited Safety	Ms = 3.75	(ASCE 41-17 Sec 4.4.3.2)	(ASCE 41-17 Table 2-2)
Seismic hazard level	BSE-2E			(ASCE 41-17 Table 2-2)
Level of seismicity	High			(ASCE 41-17 Table 2-4)
Building type	C2 - Concrete Shear Walls			(ASCE 41-17 Table 3-1)

Material properties

				Notes	Reference
Concrete	f'_c	4,000 NWC	psi	Columns, Walls, Floors	Drawings
		3,000 NWC	psi	Foundations	Drawings
Reinf.	f_y	60	ksi	Typical	Drawings
Steel	F_y	N/A	ksi	N/A	(ASCE 41-17 Table 9-1)

Checklists

Benchmark building	No	(ASCE 41-17 Table 3-2)
Checklist(s) req'd	17.1.2 Basic Configuration	(ASCE 41-17 Table 4-6)
	17.12 Structural Checklist for Building Types C2	(ASCE 41-17 Table 4-6)
	~~17.19 Nonstructural Checklist~~ (not performed)	(ASCE 41-17 Table 4-6)

Seismic forces

V	21218	kip	$V = Cs_a W$	= 1.29W	(ASCE 41-17 Eq 4-1)
W	16499	kip	building weight		(ASCE 41-17 4.4.2.1)
C	1.0		Convert linear elastic to inelastic disp.		(ASCE 41-17 Table 4-7)
S_a	1.29	g	$S_a = S_{x1}/T \le S_{XS}$		(ASCE 41-17 Eq 4-3)
T	0.34	sec	$T = C_t h_n^{\beta}$		(ASCE 41-17 Eq 4-4)
C_t	0.020				(ASCE 41-17 Eq 4-4)
β	0.75				(ASCE 41-17 Eq 4-4)
h_n	44	ft	building height		(ASCE 41-17 Eq 4-4)

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	5793		44	251996	0.52	11059	
3	5258	14.5	29	152482	0.32	6692	11059
2	5448	14.5	15	78996	0.16	3467	17751
1		14.5	0				21218
Total	16499			483474	1.0	21218	

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 Cast-in-place walls (ASCE 41-17 4-7)

Story	$A_{c\,N\text{-}S}$ in^2	$A_{c\,E\text{-}W}$ in^2	v_{NS}^{avg} psi	v_{EW}^{avg} psi	D/C_{NS}	D/C_{EW}
Roof						
3	21454	29566	137	100	1.1	0.8
2	20014	29566	237	160	1.9	1.3
1	36527	49870	155	113	1.2	0.9

M_s	3.75		(ASCE 41-17 Table 4-8)
v_{limit}	124	psi	$v_{limit} = 2\sqrt{f_c'} \geq 100$ psi
$v^{avg} = (1/M_S)(V_{story}/A_c)$			(ASCE 41-17 Eq 4-8)

Mass take-off

Roof				
Roofing and slab (ft^2)	23396	212	psf	4960.0 k
AHU (3 total)	1	120000	lb	120.0 k
Concrete wall (lf)	412.25	1124	plf	463.4 k
Window wall (lf)	388.5	642	plf	249.4 k
				5793 k
Upper floor				
Low roof (ft^2)	2523	212	psf	534.9 k
Floor (ft^2)	22707	161	psf	3655.8 k
Concrete wall (lf)	412.25	2030	plf	836.9 k
Window wall (lf)	388.5	594	plf	230.8 k
				5258 k
Main floor				
Access floor (ft^2)	6308	6	psf	37.8 k
Floor (ft^2)	26970	161	psf	4342.2 k
Concrete wall (lf)	412.25	2030	plf	836.9 k
Window wall (lf)	388.5	594	plf	230.8 k
				5448 k