Rating form completed by:

RUTHERFORD + CHEKENE
ruthchek.com
Evaluator: JY/WAL/BL

Date: 06/28/2019

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

REGISTERED PROFESSIONAL ENGINEER
BRET LIZUNDIA
No. S3950
Exp. 12-31-20
STRUCTURAL
STATE OF CALIFORNIA
06-28-19

DATE: 2019-06-28

UC Santa Cruz building seismic ratings

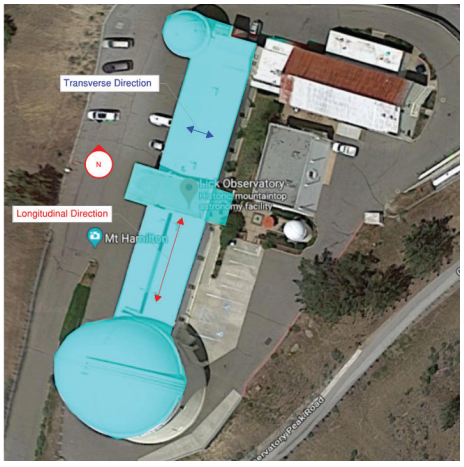
MT Hamilton Main Building

CAAN #7240
29965 MT HAMILTON RD

UCSC Campus: Mt Hamilton Campus

West Elevation (Looking Northeast)

Plan



Rating summary	Entry	Notes
UC Seismic Performance Level (rating)	V (Poor)	
Rating basis	Tier 1	ASCE 41-17[1]
Date of rating	2019	
Recommended UC Santa Cruz priority category for retrofit	Priority B	Priority A=Retrofit ASAP Priority B=Retrofit at next permit application
Ballpark total construction cost to retrofit to IV rating[2]	High ($200-400/sf)	See recommendations on further evaluation and retrofit.
Is 2018-2019 rating required by UCOP?	Yes	Building was not previously rated.
Further evaluation recommended?	Yes	See recommendations on further evaluation and retrofit.

[1] We translate this Tier 1 evaluation to a Seismic Performance Level rating using professional judgment. Non-compliant items in the Tier 1 evaluation do not automatically put a building into a particular rating category, but we evaluate such items along with the combination of building features and potential deficiencies, focused on the potential for collapse or serious damage to the gravity supporting structure that may threaten occupant safety. See Section III.B of the 19 May 2017 *UC Seismic Safety Policy* and Method B of Section 321 of the 2016 *California Building Code*.

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

Building information used in this evaluation

- Partial as-built drawings of the originally construction by Wildman & Morris: "Mt Hamilton Seismic Corrections - Main Building," Sheets AB1 to AB8, dated 16 January 1987.
- Drawings of the seismic correction by Wildman & Morris: "Mt Hamilton Seismic Corrections - Main Building," Sheets 1 to 16, dated 29 January 1988.

Additional building information known to exist

None.

Scope for completing this form

Reviewed drawings by Wildman & Morris for original and seismic correction done, made brief site on 11 June 2019, and carried out ASCE 41-17 Tier 1 evaluation.

Brief description of structure

The Mt. Hamilton Main Building was originally built circa 1888. It is composed of a rectangular central section, with domes at each of the shorter ends. The out-to-out dimensions are approximately 277'-5" in the longitudinal direction (N-S) and 76'4" in the transverse direction (E-W). The rectangular section is divided into the North Hall and the South Hall by the Central Foyer at the center where the main west and east entrances are located. The Central Foyer at the center of the building is 22'-8" in the N-S direction and 55'-5" in the E-W direction. At the north end of the building, the North Hall connects into the two-story North Foyer which measures 19'-2" in the N-S direction by 28'10" in the E-W direction. The North Dome is to the west of the North Foyer, and it is about 22'-5" diameter between inner faces of the perimeter walls. At the south end of the building, the South Hall connects to the South Dome which has a 70'-0" diameter between the inner faces of the perimeter walls. The telescope in the North Dome is used for research; the telescope in the South Dome is used for education outreach.

The domes bear on support bearings or trucks that roll on top of a track at the top of the supporting circular bearing wall. The domes have slots that can open up from the base to the top of the dome to permit telescope viewing and the telescope orientation to vary vertically. The domes can also rotate 360 degrees on the roller trucks, so the viewing slot can be located in any direction in plan. Details regarding the dome are not known.

The rectangular section of the building was originally built typically with unreinforced brick walls. The URM walls were 13" at the interior north-south corridor wall, 8" at the transverse demising walls, and 20" at the perimeter west walls and east wall of the South Hall. The east wall of the North Hall is built out of 9" thick concrete, likely unreinforced. At the larger south dome, the wall was 38" below grade, 34" thick above grade for about 2'-3', and then 29" thick the rest of the height. The smaller north dome is similar.

The building was seismically retrofitted in 1989. Per the 1988 retrofit drawings, the 1985 *Uniform Code for Building Conservation* (UCBC) Appendix Chapter 1 was used with an allowable design base shear of $V = 0.10W$. The retrofit included removal of the outer wythe of the exterior brick walls in the rectangular section and replacement with 4" of shotcrete, leaving 16" of brick. 12" wide x 12" deep vertical ribs were installed at a maximum of 8'0" o.c. The shotcrete was connected to the brick with drilled dowels at 4'0" o.c. at the ribs and at the edge of openings. A similar approach was used at the North Dome. At the larger South Dome, the shotcrete replacement is 20-1/2" thick, leaving 8-1/2" of brick. Stucco was used to cover the exterior shotcrete. Interior brick walls were braced against out-of-plane loading with 6x6 wood posts doweled to the brick, but not strengthened with shotcrete for in-plane loads. Plywood was added to the top of the attic floor which aligns with the top of the walls, and out-of-plane and in-plane ties were installed to connect the attic diaphragm and walls. Roof-to-wall and attic floor ties were added at the Central Foyer as well.

Identification of levels: The building has one story in the North Hall, the South Hall, the North Dome and the South Dome sections, with an unoccupied attic. There are two stories in the North Foyer and the Central Foyer (ground floor and attic floor). Grade is relatively level around the building. The ground floor is about 3'0" above grade over a crawl space, and the North Hall and South Hall attic floors are 16'4" above the ground floor. The attic at the foyers is lower than the other attic floors. The North Foyer attic is 12'7" above the ground floor, and it is 8'9" from the attic floor to the ceiling of the attic. The South Dome has a movable platform floor on hydraulic jacks that is typically

near the ground floor level. It has a crawl space below. The telescope is supported by an assembly in the center of the room. James Lick, the benefactor of the observatory, is buried in a grave at the base of the telescope. There is a catwalk level in the south dome about 16'6" above the first floor, and the top of the wall is about 28'9" above the first floor. At the north dome, there is a floor at 18'0" above the first floor, and then there is 7'3" more to the top of the wall.

Foundation system: All walls extend down to grade as continuous footings, typically 22" in the halls and 38" at the domes. The rocky site at the top the mountain was reportedly leveled using dynamite. Exposed areas of rock can be seen in the crawl space, and the walls bear directly on the rock. 9x9 brick piers are provided as intermediate support for the first floor framing in the halls; they are spaced typically at 5'-10" in the corridors and 10'-0" to 15'-0" in the offices.

Structural system for vertical (gravity) load: Gravity load is delivered from the wood flooring to the wood framing, typically 2x8 @ 19" o.c. at the attic level and 2x12 @ 16" o.c. at the first floor and Central Foyer attic. The wood floor joists typically bear directly on top of the wall steps that are typically 4" wide. At the top of the walls, the joists bear on 3x5 wood sills. The gable roof at the North Hall and South Hall has a central north-south ridge line and has a metal roof supported by 1x sheathing, spanning between 3x4 purlins which bear on carpenter trusses. The domes are metal clad with stiffening ribs.

Structural system for lateral forces:

- E-W loading in the central portion of the building: The walls span out-of-plane between the ground, first floor diaphragm, and attic floor diaphragm. The shotcrete assist sthe brick walls in spanning vertically. The 4" shotcrete at the perimeter wall widens to a 12" wide by 8" deep partial bond beam at the top of the wall. A 3x5 original wood sill is doweled to the concrete at each side of the joist with a ¾" diameter bolt with 6" embedment. The 2x8 joists bear on the sill and are connected to the sill with Simpson F35 clips on each side of every other joist. Attic joists deliver the east-west loads to the attic floor diaphragm which then spans to transverse URM brick walls which have not been strengthened. Loads are transferred down through blocking and FA35 clips to an anchored sill on top of the transverse walls. At the first floor, the floor joists run east-west and are connected to the walls with ¾" diameter through bolts at the interior and ¾" threaded rod drilled dowels at the perimeter which go through the brick and are anchored in the exterior shotcrete.
- N-S loading in the central portion: E-W brick walls and nonstructural wood walls span vertically between the first floor and attic floor. The wood strong backs help brace the wall so it can span vertically. At the top of the wall is a 2x8 sill anchored to the wall with ¾" diameter anchors at 3'0" o.c. Joists run parallel to the top of the wall. One joist bay of blocking on each side of the wall helps the attic diaphragm brace the top of the wall. The diaphragm then spans to the longitudinal brick and concrete walls where blocking and FA35 clips transfer loads to the anchored sill on top of the longitudinal walls.
- Domes: An unusual feature of the domes is the lack of a traditional lid or roof level diaphragm spanning between and bracing the top of the perimeter wall. The dome with its connections through the roller trucks can either be considered to be added inertial weight that adds out-of-plane loads or a curved diaphragm that resists out-of-plane loads, depending on the connections at the roller trucks and the relative stiffness of the dome and accounting for the large slot opening in the dome. The circular perimeter walls have been strengthened with shotcrete and have very few openings. They take loads down through the wall directly to the foundation.

Building condition: There have been water leaks from piping inside walls and from roof leaks over time. Water stains were visible on the framing in the attic. The roof has been repaired. The exterior wall stucco appeared to be in good shape with no signs of significant cracking or water stains. Evidence of the retrofit work could be seen in the attic, and generally appeared to comply with the drawings.

Response in the 1989 Loma Prieta Earthquake: Unknown.

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 unretrofitted URM walls in the halls have insufficient in-plane shear capacity. Per the Quick Check evaluation, they have a peak D/C ratio of nearly 3.
- The connection between the perimeter walls and attic joists has insufficient capacity for out-of-plane loads.
- The anchors between the shotcrete and brick at the exterior walls have only 4" embedment into the brick, so the ability of the shotcrete to serve effectively as resistance for out-of-plane bracing or compositely for in-plane loading is potentially limited. Similarly, the anchor between the wood strong backs and interior brick walls has 8" embedment, so it does not reach the far wythe in the 13" thick three-wythe walls.
- The top of the South Dome was capped with an 11" deep bond beam running across the full 29" width of the wall, but it does not have ties confining it, so it cannot act reliably as a beam to resist out-of-plane loads at the top of the wall including those imparted by the dome. At the North Dome, no bond beam was installed; the 4" shotcrete simply continues up to the top of the wall.
- The ability of the steel dome to act as a diaphragm at the top of the circular walls is questionable.
- There is a 2" cavity shown inside the North Dome URM wall between the inner and the outer wythes. The retrofit provided anchors only every 8'0" o.c. at ribs to cross this joint. Height-to-thickness ratios are high, and because of the cavity, even though the outer wythes are reinforced with shotcrete, the inner wythes may act independently and be damaged or fall from out-of-plane and in-plane forces.
- At the intersection between the foyers and halls and domes, the diaphragms are interrupted due to split-level floors and roofs. The walls connecting the diaphragms at different levels from each side will be loaded with additional out-of-plane forces due to this offset. No special bracing is provided at these walls for this force.

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	N
Diaphragm continuity	Y		

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

The south dome is movable and is controlled by hydraulic pressure. The container for the liquid used in this hydraulic system were found not braced.

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

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

Basis of rating

A Seismic Performance Level rating of V is assigned to the building. While the 1989 seismic retrofit was comprehensive, the Tier 1 evaluation found that the connections between walls and diaphragms in the central portion of the building do not have adequate capacity to resist out-of-plane wall demands, the central unretrofitted N-S longitudinal URM wall line is overstressed for in-plane loads, the unretrofitted transverse E-W URM walls are significantly overstressed for in-plane loads, anchorage of the drilled dowels between the shotcrete and brick is relatively shallow and may not be fully effective in helping brace the brick walls for out-of-plane action or work compositely to resist in-plane loads, and the top of circular wall supporting the domes may have limited ability to resist out-of-plane loading due to a lack of a significant tension ring or bond beam.

Recommendations for further evaluation or retrofit

We recommend a Tier 3 linear evaluation of the building. In-plane tests of the existing brick mortar and a closer examination of the current collar joint condition should be performed to determine the URM capacity in order to have a more refined and less conservative estimate of the in-plane capacity of the walls, diaphragm capacity, out-of-plane capacity of the URM wall strengthening, and the ability of the circular walls to support out-of-plane loading.

Peer review of rating

This seismic evaluation was discussed in a peer review meeting on 24 June 2019. Reviewers present were Joe Maffei of Maffei Structural Engineering and Holly Razzano and Jay Yin of Degenkolb Engineers. Comments from the reviewers have been incorporated into this report. The reviewers agreed with the assigned rating.

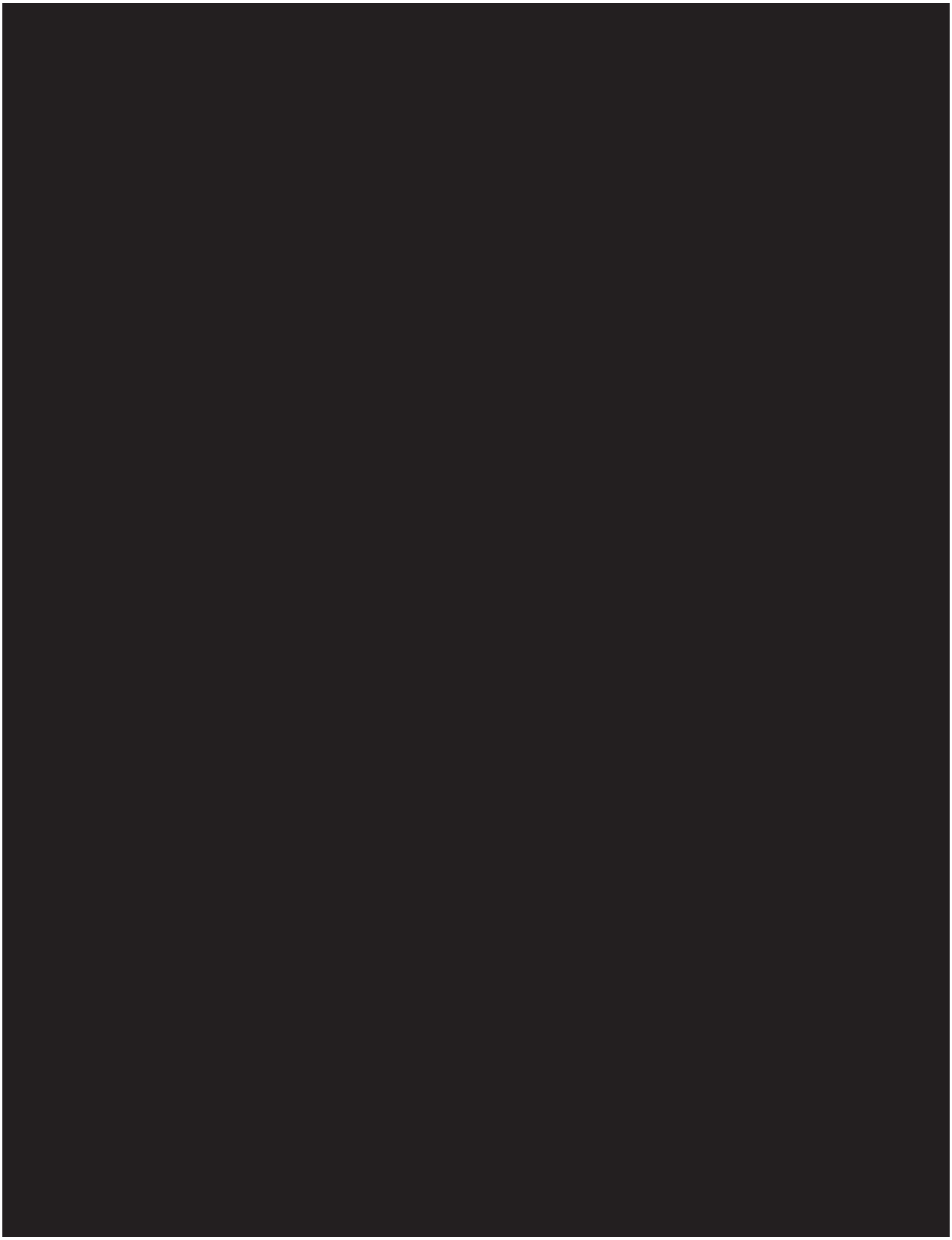
Additional building data	Entry	Notes
Latitude	37.341138	
Longitude	-121.643012	
Are there other structures besides this one under the same CAAN#	No	
Number of stories above lowest perimeter grade	2	
Number of stories (basements) below lowest perimeter grade	1	
Building occupiable area (OGSF)	21,963	From UCSC facilities database.
Risk Category per 2016 CBC Table 1604.5	II	
Estimated fundamental period	0.20 sec	Estimated using ASCE 41-17 equation 4-4 and 7-18
Building structural height, h_n	22 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-year hazard parameters S_s, S_1	1.708, 0.558	From SEAOC/OSHPD website
Site class	B	
Site class basis	Geotech[4]	See footnote below
Site parameters F_a, F_v	0.9, 0.8	From SEAOC/OSHPD website
Ground motion parameters S_{cs}, S_{c1}	1.897, 0.697	From SEAOC/OSHPD website
S_a at building period	1.71	
Site V_{s30}	3750 ft/s	
V_{s30} basis	Estimated	Estimated based on site classification of B, using middle of 2,500-5,000 ft/s range.
Liquefaction potential	Low	
Liquefaction assessment basis	Inferred	Engineering judgment given the lack of surficial soils and mountaintop location.
Landslide potential	Low	
Landslide assessment basis	Inferred	Engineering judgment given the building site is relatively level.
Active fault rupture identified at site?	No	
Fault rupture assessment basis	CGS Website	The Earthquake Zones of Required Investigation Lick Observatory Quadrangle has no Earthquake Fault Zones near Mt. Hamilton. The Mt. Hamilton area was "not evaluated for liquefaction or landslides." See http://gmw.conservation.ca.gov/SHP/EZRIM/Maps/LICK_OBSERVATORY_EZRIM.pdf
Applicable code		
Applicable code or approx. date of original construction	Built: 1888 Code: Pre-code Seismic Retrofit: 1988 Code: 1985 UCBC	
Applicable code for partial retrofit	None	No partial retrofit.
Applicable code for full retrofit	None	No full retrofit

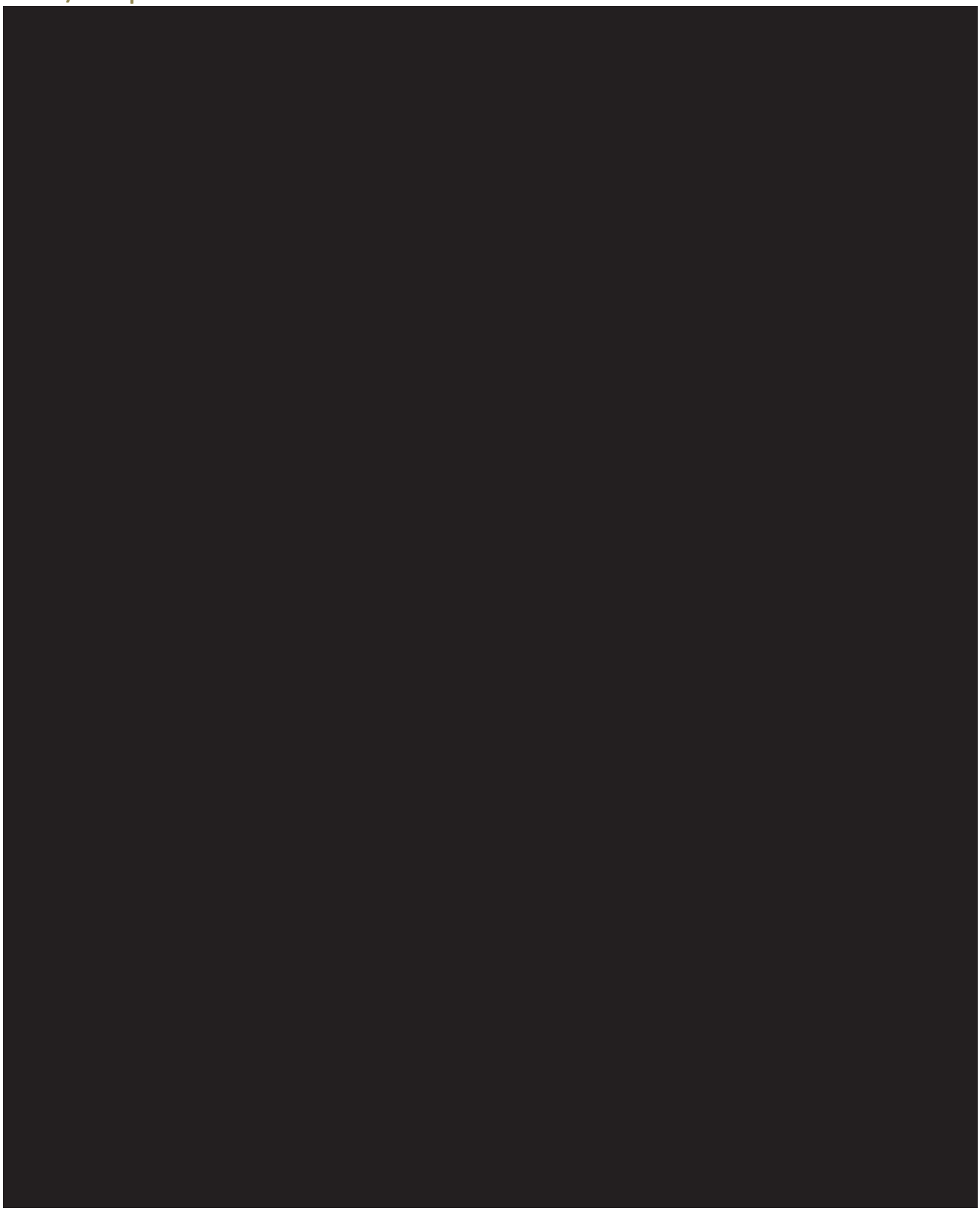
[4] Determination of site class and assessment of geotechnical hazards are based on correspondence with Pacific Crest Geotechnical Engineers and Nolan, Zinn, and Associates Geologists. [*Revised Geology and Geologic Hazards, Santa Cruz Campus, University of California*, Job # 04003-SC 13 May 2005]. Site 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

FEMA P-154 data		
Model building type - north-south	C2a-Concrete shear wall with flexible diaphragm URMa-Unreinforced masonry wall with flexible diaphragm	C2a & URMa checklist in ASCE 41-17.
Model building type - east-west	C2a-Concrete shear wall with flexible diaphragm URMa-Unreinforced masonry wall with flexible diaphragm	C2a & URMa checklist in ASCE 41-17.
FEMA P-154 score	N/A	Not included here because we performed ASCE 41 Tier 1 evaluation.
Previous ratings		
Most recent rating	-	
Date of most recent rating	-	
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.

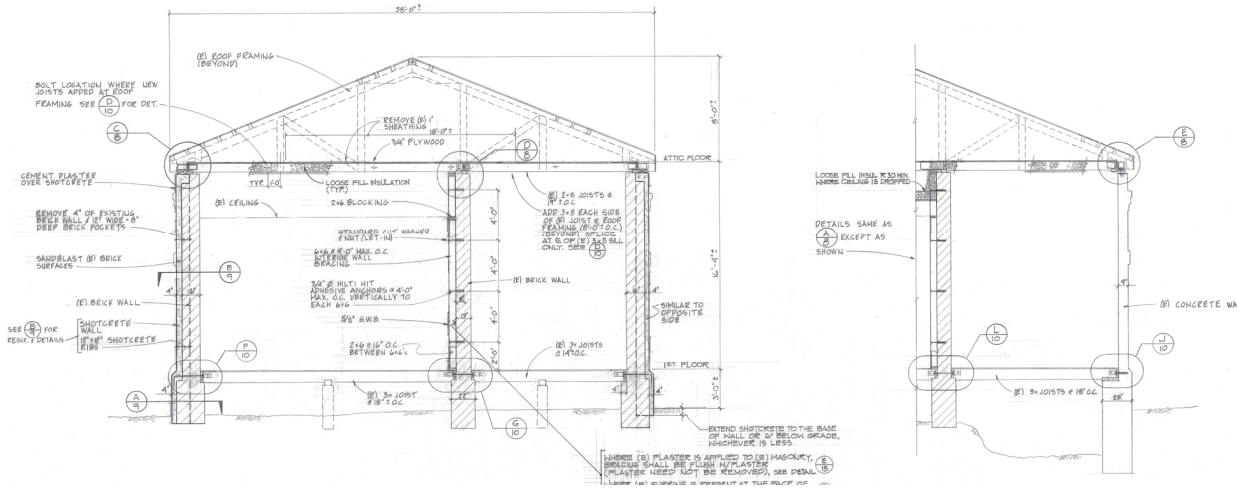
Color-coded Floor Plan



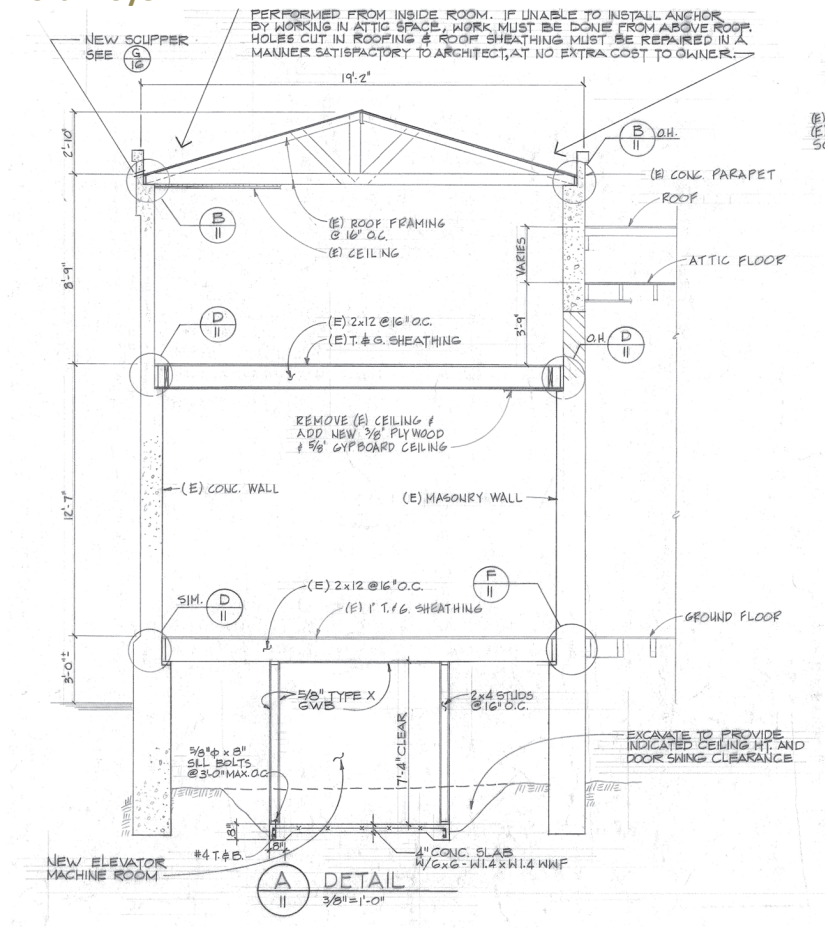
Roof/Attic plan



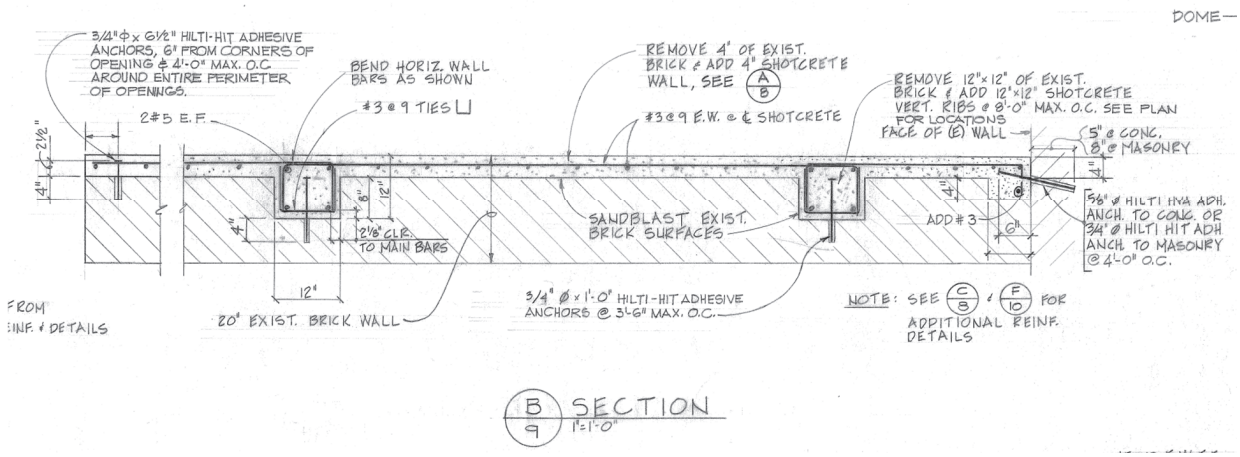
Corridor Cross-Section



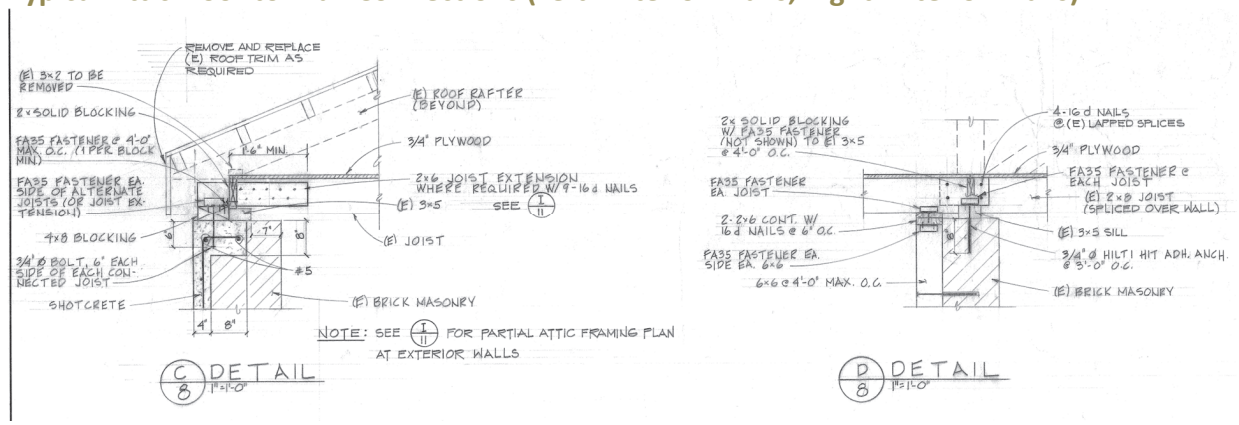
North Foyer



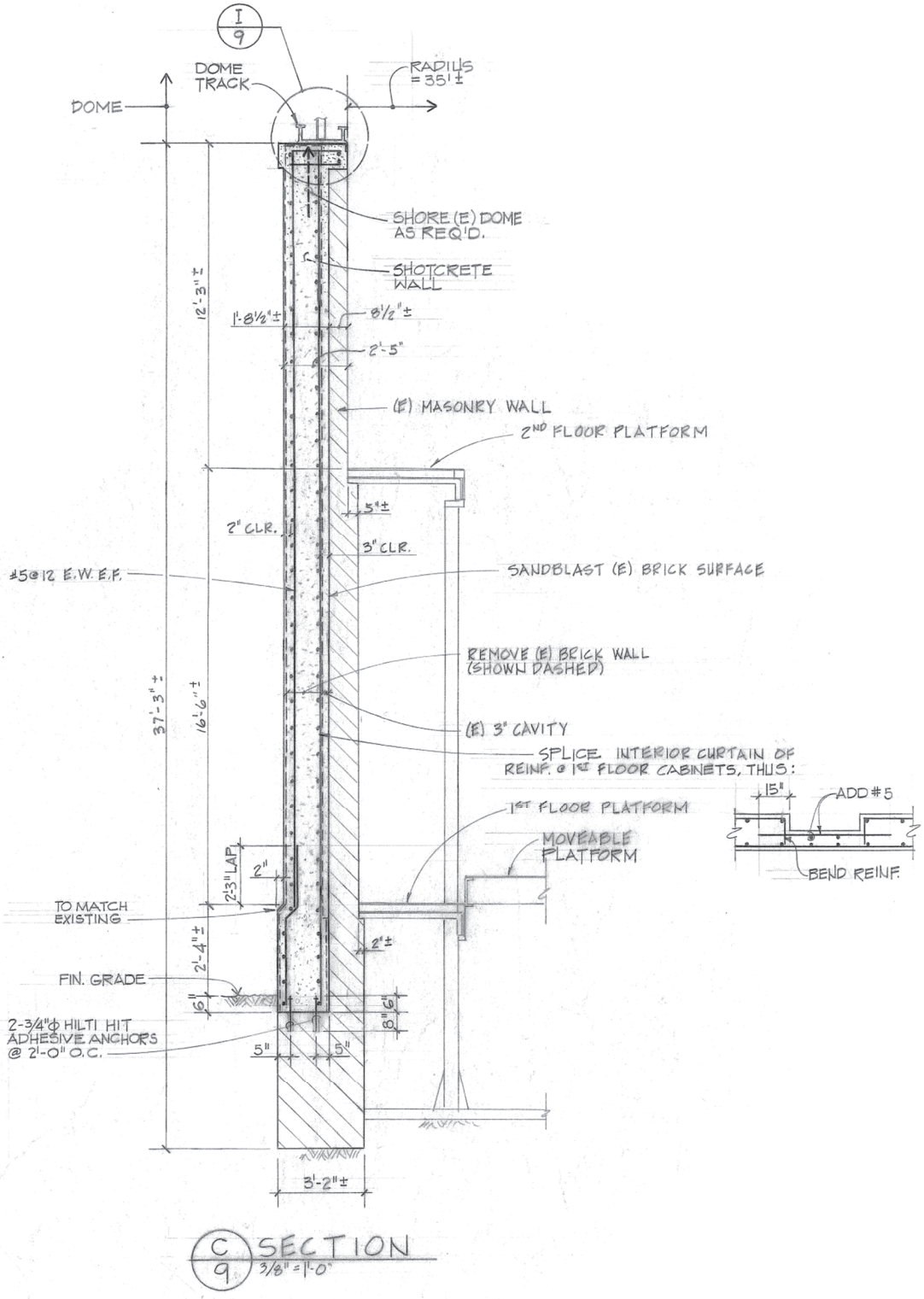
Typical Shotcrete Strengthening and North and South Halls



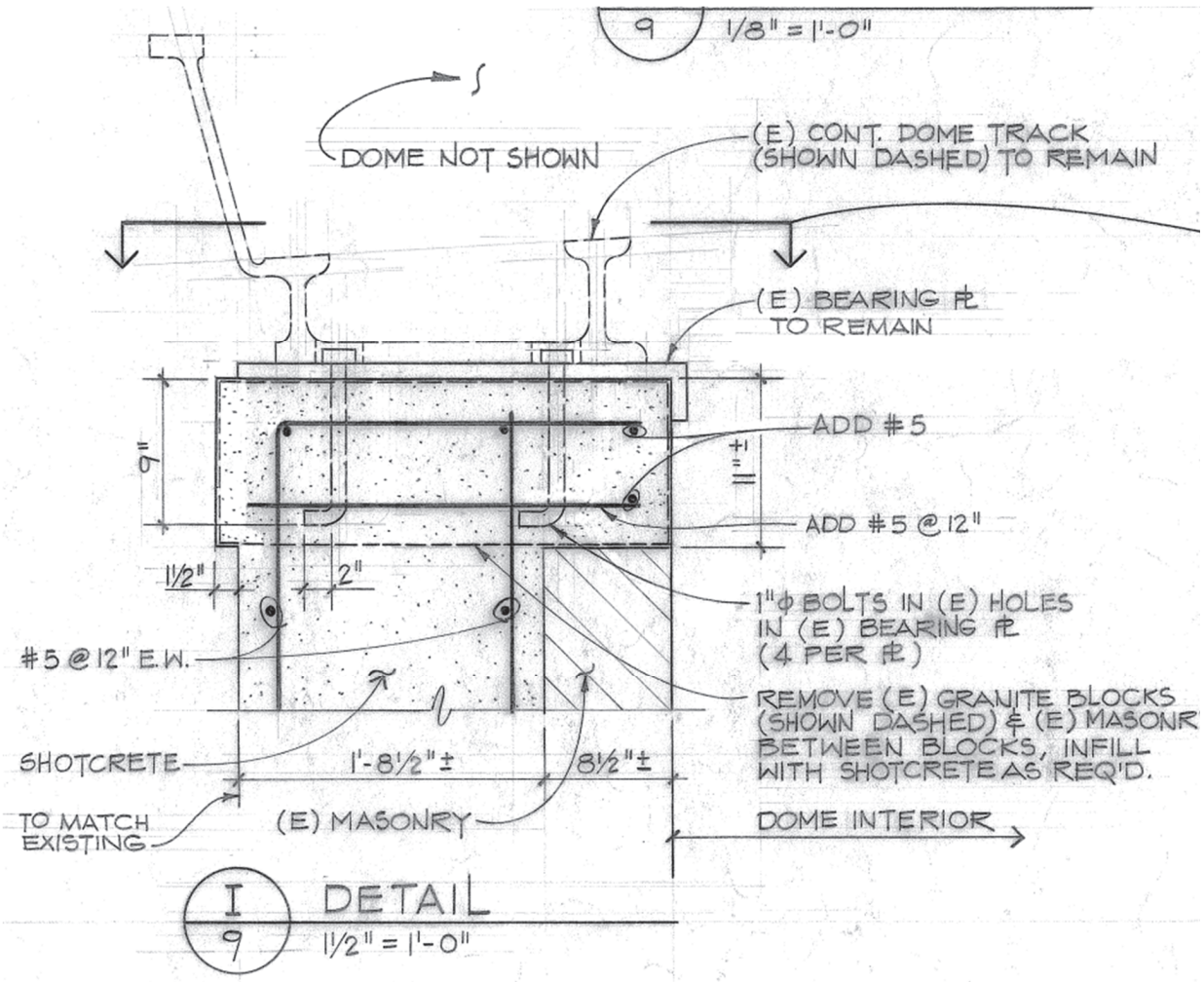
Typical Attic Floor to Wall Connections (Left: Exterior Walls; Right: Interior Walls)



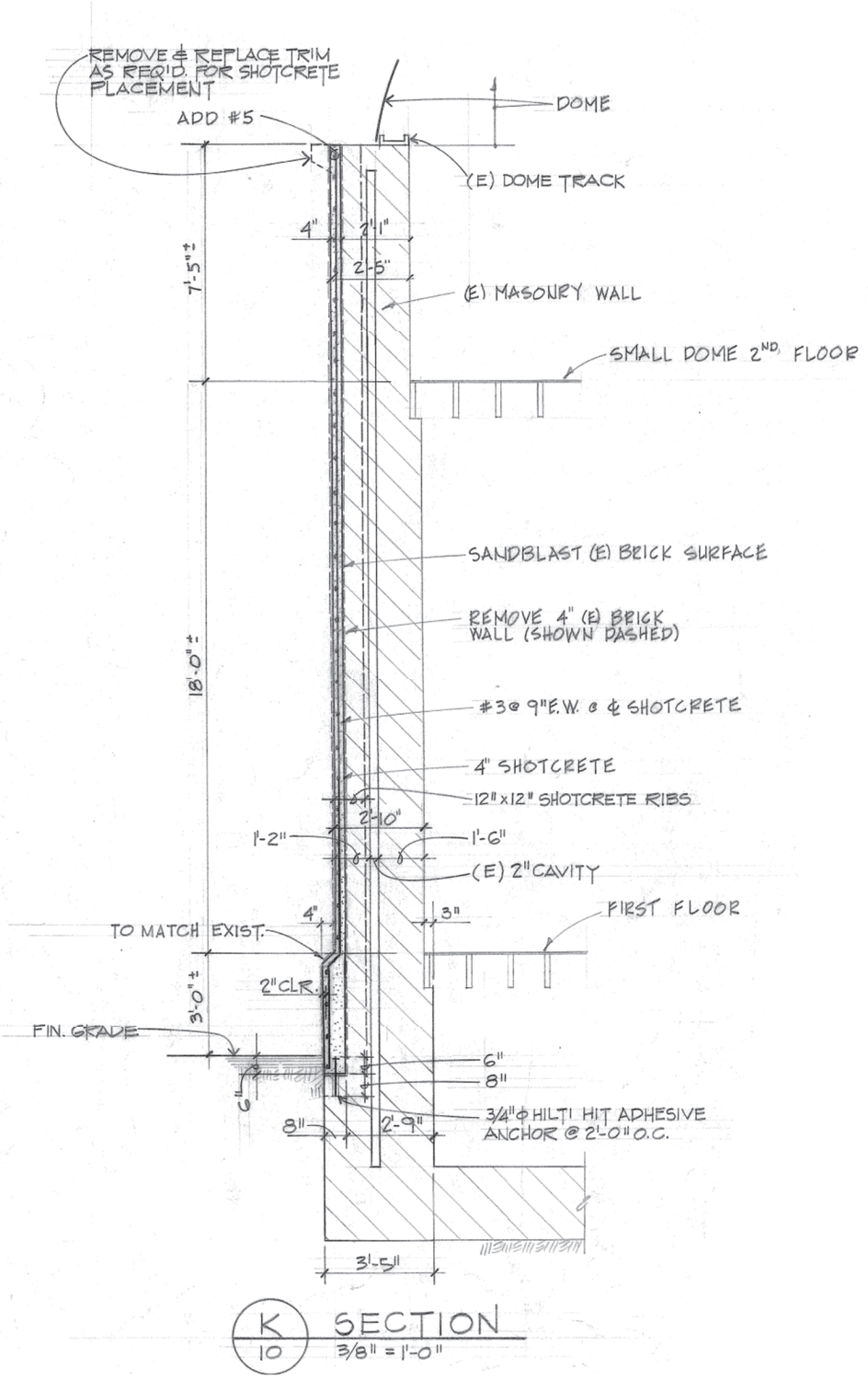
South Dome


I/9
DOME
DOME TRACK
RADIUS = 35'±
SHORE (E) DOME AS REQ'D.
SHOTCRETE WALL
8½"±
2'-5"
(E) MASONRY WALL
2ND FLOOR PLATFORM
5"±
2" CLR.
3" CLR.
#5@12 E.W. E.F.
SANDBLAST (E) BRICK SURFACE
REMOVE (E) BRICK WALL (SHOWN DASHED)
(E) 3" CAVITY
SPLICE INTERIOR CURTAIN OF REINF. @ 1ST FLOOR CABINETS, THUS:
15"
ADD #5
BEND REINF.
1ST FLOOR PLATFORM
MOVEABLE PLATFORM
12'-3"±
1'-8½"±
37'-3"±
16'-6"±
2'-3" LAP
2"
TO MATCH EXISTING
2'-4"±
2"±
FIN. GRADE
16"
8"
2-¾"Φ HILTI HIT ADHESIVE ANCHORS @ 2'-0" O.C.
5"
5"
3'-2"±
C/9 SECTION
3/8" = 1'-0"

Bond Beam at Top of the South Dome Retrofit Supporting Track for Roller Trucks)



North Dome


REMOVE & REPLACE TRIM AS REQ'D. FOR SHOTCRETE PLACEMENT
ADD #5
DOME
(E) DOME TRACK
4"
2'-1"
2'-5"
7'-5"±
(E) MASONRY WALL
SMALL DOME 2ND FLOOR
SANDBLAST (E) BRICK SURFACE
REMOVE 4" (E) BRICK WALL (SHOWN DASHED)
18'-0"±
#3@ 9" E.W. @ ℄ SHOTCRETE
4" SHOTCRETE
12" x 12" SHOTCRETE RIBS
2'-10"
1'-2"
1'-6"
(E) 2" CAVITY
4"
3"
FIRST FLOOR
TO MATCH EXIST.
2" CLR.
3'-0"±
FIN. GRADE
6"
8"
8"
2'-9"
3/4" ℄ HILTI HIT ADHESIVE ANCHOR @ 2'-0" O.C.
3'-5"
K/10 SECTION
3/8" = 1'-0"

Rating form completed by:

RUTHERFORD + CHEKENE
ruthchek.com
Evaluator: JY/WAL/BL
Date: 06/28/2019

APPENDIX A

Additional Photos

West Elevation

(Left: The North Hall and the North Dome; Center: The Central Foyer;
Right: The South Hall and the South Dome)

Partial East Elevation (Looking Southwest)

(Left: The South Dome; Center: The South Hall; Right: The Central Foyer)

Partial East Elevation (Looking Northwest)

(Left: The North Hall; Right: The connection to Lab and Measurement Building)

North Elevation (Looking Southwest)

(Lab and Measurement Building to the Left and the North Dome to the Right)

Oil Container Not Braced in the South Dome

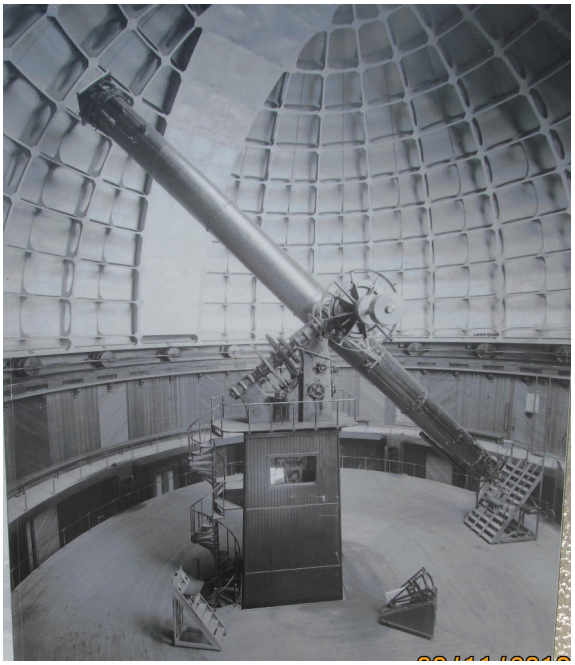
Telescope in South Dome

Grave of James Lick Under the Telescope in the South Dome

Roller Trucks Supporting the North Dome

Rock Substrate Directly Under Brick Footings

Vintage Photo of the Building (Well) Before Retrofitting Showing Exposed Brick



Vintage Photo of the Telescope in the South Dome

APPENDIX B

ASCE 41-17 Tier 1 Checklists (Structural)

UC Campus:	Santa Cruz		Date:	6/28/2019		
Building CAAN:	7240	Auxiliary CAAN:	By Firm:	RUTHERFORD + CHEKENE		
Building Name:	Mt Hamilton Main Building		Initials:	JY	Checked:	WAL/BL
Building Address:	29965 Mt Hamilton Rd, Mt Hamilton, CA 95140		Page:	22	of	41

ASCE 41-17
Collapse Prevention Basic Configuration Checklist

LOW SEISMICITY

BUILDING SYSTEMS - *GENERAL*

	Description
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. (Commentary: Sec. A.2.1.1. Tier 2: Sec. 5.4.1.1) **Comments:** Roof diaphragms deliver loads to the shotcrete shear walls or the unreinforced masonry walls.
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. (Commentary: Sec. A.2.1.2. Tier 2: Sec. 5.4.1.2) **Comments:** There are no adjacent structures.
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. (Commentary: Sec. A.2.1.3. Tier 2: Sec. 5.4.1.3) **Comments:** There are no mezzanines.

BUILDING SYSTEMS - *BUILDING CONFIGURATION*

	Description
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. (Commentary: Sec. A2.2.2. Tier 2: Sec. 5.4.2.1) **Comments:** No weak story.
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. (Commentary: Sec. A.2.2.3. Tier 2: Sec. 5.4.2.2) **Comments:** No soft story.
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) **Comments:** All shear walls continue to the strip footing foundation.

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Building CAAN:	7240	Auxiliary CAAN:		By Firm:	RUTHERFORD + CHEKENE		
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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:** Same continuous shear walls from roof to foundation.
●	○	○	○	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:** No major change in story mass.
●	○	○	○	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:** The shear walls distribution in this building is fairly balanced and the roof diaphragm is plywood.

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:** Site is rocky and on top of a mountain. Liquefaction potential is judged by inspection to be negligible.
●	○	○	○	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:** Engineering judgment given the building site is relatively level.
●	○	○	○	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:** The Earthquake Zones of Required Investigation Lick Observatory Quadrangle map has no Earthquake Fault Zones near Mt. Hamilton. The Mt. Hamilton area was "not evaluated for liquefaction or landslides." See http://gmw.conservation.ca.gov/SHP/EZRIM/Maps/LICK_OBSERVATORY_EZRIM.pdf

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

FOUNDATION CONFIGURATION

	Description
C ◉ NC ○ N/A ○ U ○	OVERTURNING: The ratio of the least horizontal dimension of the seismic-force-resisting system at the foundation level to the building height (base/height) is greater than $0.6S_a$. (Commentary: Sec. A.6.2.1. Tier 2: Sec. 5.4.3.3) **Comments:** Building width B = 272', Building average height is H = 22, B/H = 12 Sa = 1.71g per SEAOC at BSE-2E 0.6 x Sa = 1.02 B/H > 0.6 Sa
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) **Comments:** Site Class B.

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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:** The shear walls also provide vertical supports as bearing walls.
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:** There are at least two lines of walls in each direction.
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:** Calculated wall stresses are not less the ASCE 41 limit of 110 psi for f'c = 3,000 psi – wall average shear stresses in the transverse direction (E-W) are 4 and 24 psi respectively (high roof over foyers to attic floor of halls, and foyer second floor to hall first floor)and in the longitudinal direction (N-S) are 22, 48, 44, and 50 psi respectively (foyer high roof to hall attic floor, hall attic to foyer second floor, foyer second floor to hall first floor, and first floor to foundation).
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:** All shotcrete wall section comply. (#3 @ 9" o.c., e.w. in 4" thick walls, #5 @ 12" o.c., e.w., e.f. in 12" thick walls).

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:** Maximum out-of-plane demand Tc = 1.0 x 1.682 x (117pcf x 16"/12+150pcf x 4"/12)x(16.33'/2)x3'=8.5 kips Per Detail C/8 on Sheet 8, one Simpson A35 at alternative joist (38" o.c.) and one A35 at each blocking (4'-0" o.c.) is not sufficient. No anchorage is provided at the two domes to brace the wall from out-of-plane forces.
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:** Plywood or straight sheathing diaphragms are connected to the shear wall with connections of limited shear transfer capacity.

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UC Campus:	Santa Cruz			Date:	6/28/2019			
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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:** Foundations are the original unreinforced masonry or concrete. Reinforcement in the shotcrete are not extended into the foundation. The shotcrete walls are anchored into the foundation with epoxy anchors.

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:** No secondary components.
○	○	◉	○	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:** There are no flat slabs.
○	○	●	○	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:** There are no coupling beams.

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:** There are no split levels.
●	○	○	○	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:** No big openings in the diaphragms adjacent to the shear walls according to drawings.

Flexible Diaphragms

				Description

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Collapse Prevention Structural Checklist For Building Type C2-C2A

C	NC	N/A	U	
●	○	○	○	CROSS TIES: There are continuous cross ties between diaphragm chords. (Commentary: Sec. A.4.1.2. Tier 2: Sec. 5.6.1.2) **Comments:** Every other floor joist and roof joists are continuous between walls and are positively anchored to the wall. No cross ties provided in the two domes.
●	○	○	○	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:** Straight sheathing in the North Foyer area at roof and second level with ratio approximately 1.5.
◉	○	○	○	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:** ¾" plywood is provided where spans greater than 24 ft. Maximum span of straight sheathing is less than 24 ft.
○	○	◉	○	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:** No diagonally sheathed diaphragm and plywood is blocked.
○	○	◉	○	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:** All diaphragms in the building are wood.

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:** There are no pile caps.

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ASCE 41-17
Collapse Prevention Structural Checklist For Building Type URM-URMA

LOW AND MODERATE SEISMICITY

SEISMIC-FORCE-RESISTING SYSTEM

C	NC	N/A	U	Description
●	○	○	○	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:** The number of lines of shear walls is at least two in both orthogonal directions.
○	●	○	○	SHEAR STRESS CHECK: The shear stress in the unreinforced masonry shear walls, calculated using the Quick Check procedure of Section 4.4.3.3, is less than 30 lb/in.^{2} (0.21 MPa) for clay units and 70 lb/in.^{2} (0.48 MPa) for concrete units. (Commentary: Sec. A.3.2.5.1. Tier 2: Sec. 5.5.3.1.1) **Comments:** Calculated wall stresses exceed the ASCE 41 limit of 30 psi for unreinforced masonry shear walls. Wall average shear stresses in the longitudinal direction (N-S) are 40 (attic level to first floor level) and 52 psi (first floor to foundation level) and in the transverse direction (N-S) are 19, 66, 75, and 86 psi between the high roof to North/South Hall attic, North/South Hall attic to Foyer second floor, Foyer second floor to first floor, and first floor to foundation, respectively. The peak D/C ratio is 86/30 = 2.9.

CONNECTIONS

C	NC	N/A	U	Description
○	●	○	○	WALL ANCHORAGE: Exterior concrete or masonry walls that are dependent on the diaphragm 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:** Maximum out-of-plane demand Tc = 1.0 (for CP) x (Sa=1.71) x (117pcf brick x 16”/12+150pcf concrete x 4”/12 = 10 psf for stucco) x (16.33’ height/2) x 38”/(12”/ft) =10.7 kips Per Detail C/8 on Sheet 8, there are Simpson F35s at each connected joist which is every other joists. The joists are at 19” o.c, so the connected joist takes a 38” tributary width. The F35s are insufficient by inspection to take this load, as ASCE 41-17 Section 12.3.3.1 requires hardware in connections to be considered as force-controlled. No anchorage is provided at the two dome areas to brace the wall from out-of-plane forces.
●	○	○	○	WOOD LEDGERS: The connection between the wall panels and the diaphragm does not induce cross-grain bending or tension in the wood ledgers. (Commentary: Sec. A.5.1.2. Tier 2: Sec. 5.7.1.3) **Comments:** No tension is applied perpendicular to the ledger per Detail D/11 and B/11 on Sheet 11 in the North Foyer. In the rest of the building, floor joists seats on top of the wall, no wood ledger is used.

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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:** Plywood or straight sheathing diaphragms are connected to the shear wall with limited shear transfer capacity.
○	○	●	○	GIRDER–COLUMN CONNECTION: There is a positive connection using plates, connection hardware, or straps between the girder and the column support. (Commentary: Sec. A.5.4.1. Tier 2: Sec. 5.7.4.1) **Comments:** No girders or columns.

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	PROPORTIONS: The height-to-thickness ratio of the shear walls at each story is less than the following: (Commentary: Sec. A.3.2.5.2. Tier 2: Sec. 5.5.3.1.2): Top story of multi-story building: 9 First story of multi-story building: 15 All other conditions: 13 **Comments:** For the North Foyer second story 8'9"/13" = 8.1 < 9 OK; 12'-7"/13"=11.6<15 OK. For the two halls 15'-6"/13"=14.3>13. NG, but the walls are braced or shotcreted.
○	●	○	○	MASONRY LAYUP: Filled collar joints of multi-wythe masonry walls have negligible voids. (Commentary: Sec. A.3.2.5.3. Tier 2: Sec. 5.5.3.4.1) **Comments:** The masonry perimeter walls in the North Dome still have the original cavity design per Detail K/10 on Sheet 10.

DIAPHRAGMS (STIFF OR FLEXIBLE)

				Description
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:** There are no big openings in the diaphragms adjacent to the shear walls according to drawings, except for the domes.
○	●	○	○	

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C	NC	N/A	U	
○	●	○	○	OPENINGS AT EXTERIOR MASONRY SHEAR WALLS: Diaphragm openings immediately adjacent to exterior masonry shear walls are not greater than 8 ft (2.4 m) long. (Commentary: Sec. A.4.1.6. Tier 2: Sec. 5.6.1.3) **Comments:** There are no big openings in the diaphragms adjacent to the shear walls according to drawings, except for the domes.

FLEXIBLE DIAPHRAGMS

				Description
C	NC	N/A	U	CROSS TIES: There are continuous cross ties between diaphragm chords. (Commentary: Sec. A.4.1.2. Tier 2: Sec. 5.6.1.2) **Comments:** Every other floor joist and roof joist is continuous between walls and positively anchored to the wall.
●	○	○	○	
C	NC	N/A	U	STRAIGHT SHEATHING: All straight-sheathed diaphragms have aspect ratios less than 2-to-1 in the direction being considered. (Commentary: Sec. A.4.2.1. Tier 2: Sec. 5.6.2) **Comments:** Straight sheathing in the North Foyer area at roof and second level with ratio approximately 1.5.
●	○	○	○	
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. (Commentary: Sec. A.4.2.2. Tier 2: Sec. 5.6.2) **Comments:** ¾" plywood is provided where spans greater than 24 ft.
●	○	○	○	
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. (Commentary: Sec. A.4.2.3. Tier 2: Sec. 5.6.2) **Comments:** No diagonally sheathed diaphragm and plywood is blocked.
●	○	○	○	
C	NC	N/A	U	OTHER DIAPHRAGMS: The 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:** All diaphragms in the building are wood.
●	○	○	○	

CONNECTIONS

				Description
C	NC	N/A	U	STIFFNESS OF WALL ANCHORS: Anchors of concrete or masonry walls to wood structural elements are installed taut and are stiff enough to limit the relative movement between the wall and the diaphragm to no greater than 1/8 in. before engagement of the anchors. (Commentary: Sec. A.5.1.4. Tier 2: Sec. 5.7.1.2) **Comments:** Out-of-plane anchors are taut connections to joists running perpendicular to the wall or blocking where joists are parallel to the walls.
●	○	○	○	

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C	NC	N/A	U	
○	○	◉	○	BEAM, GIRDER, AND TRUSS SUPPORTS: Beams, girders, and trusses supported by unreinforced masonry walls or pilasters have independent secondary columns for support of vertical loads. (Commentary: Sec. A.5.4.5. Tier 2: Sec. 5.7.4.4) **Comments:** No secondary components. All roof rafters bear on the walls which are also shear walls.

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

Rating form completed by:

RUTHERFORD + CHEKENE
ruthchek.com
Evaluator: JY/WAL/BL
Date: 06/28/2019

APPENDIX C

UCOP Seismic Safety Policy Falling Hazards Assessment Summary

UC Campus:	Santa Cruz			Date:	06/28/2019		
Building CAAN:	7240	Auxiliary CAAN:		By Firm:	**Rutherford + Chekene**		
Building Name:	Mt Hamilton Observatory Main Building			Initials:	JY	Checked:	WAL/BL
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UCOP SEISMIC SAFETY POLICY
Falling Hazard Assessment Summary

	Description
P ☐ N/A ☒	**Heavy ceilings, features or ornamentation above large lecture halls, auditoriums, lobbies, or other areas where large numbers of people congregate (50 ppl or more)** **Comments:** There is a plaster ceiling over the entrance lobby, but the lobby appear too small to serve 50 people or more.
P ☐ N/A ☒	**Heavy masonry or stone veneer above exit ways or public access areas** **Comments:** Shotcrete was added to the exterior of the building, protecting perimeter and exit ways.
P ☐ N/A ☒	**Unbraced masonry parapets, cornices, or other ornamentation above exit ways or public access areas** **Comments:** There are short parapets at the Central Foyer roof edge, but they are concrete. At the west and east brick perimeter walls, the roof runs over the top of the wall, so there is no parapet.
P ☐ N/A ☒	**Unrestrained hazardous material storage** **Comments:** Facilities staff indicated there is no hazard material storage in the observatory building.
P ☐ N/A ☒	**Masonry chimneys** **Comments:** Masonry chimneys were not observed.
P ☐ N/A ☒	**Unrestrained natural gas-fueled equipment such as water heaters, boilers, emergency generators, etc.** **Comments:** Facilities staff indicated that propane tanks which are stored outside of the building supply boilers that heat hot water for steam radiators.

Falling Hazards Risk: Low

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

Rating form completed by:

RUTHERFORD + CHEKENE
ruthchek.com
Evaluator: JY/WAL/BL
Date: 06/28/2019

APPENDIX D

Quick Check Calculations

Unit Weight

	Seismic Weight	Dead Load	
Main Hallway Corridor Floor	**psf**	**psf**	**Remarks**
floor cover	25	25	Marble and mortar
floor sheathing and floor joists	14	14	1" T&G with 2 1/2 x 9 1/2 @14" o.c.
brick piles below	5	5	9x9 brick piers @ 5'-10" o.c.
Total	44	44	

	Seismic Weight	Dead Load	
Main Hallway Office Rooms Floor	**psf**	**psf**	**Remarks**
floor cover	4	4	Hard wood floor
floor sheathing and floor joists	12	12	1" T&G with 2 1/2 x 9 1/2 @18" o.c.
brick piles below	2.5	3	9x9 brick piers @ 11'-8" o.c.
Total	19	19	

	Seismic Weight	Dead Load	
Main Hallway Roof/Attic	**psf**	**psf**	**Remarks**
Roofing Sheathing	8	8	Standing seam metal roof+3/4" plywood+insulation
Roof Framing	13	13	3x4 purlins @ 16" o.c. + truss @ 7'-0" on average
Plaster Decoration	8	8	Covered by the current ceiling
Ceiling, lighting and MEP	15	15	Plaster Ceiling, Hanging Lights MEP piping above the ceiling
Misc.	2	2	wood walkway and dormers on the roof
Total	46	25	

	Seismic Weight	Dead Load	
North Foyer First Floor	**psf**	**psf**	**Remarks**
floor cover	25	25	Marble and mortar
floor sheathing and floor joists	10	10	1" T&G at top and 5/8" GWB below with 2x12 @16" o.c.
misc.	1	1	Elevator Machine Box attached to the bottom of the floor below
Total	36	35	

	Seismic Weight	Dead Load	
North Foyer Second Floor	**psf**	**psf**	**Remarks**
floor cover	5	5	Capet and Hardwood Floor (estimated, not observed)
floor sheathing and floor joists	10	10	1" T&G with 2x12 @16" o.c.
Ceiling, lighting and MEP	5	5	
Data Room Units	15	15	
Total	35	20	

	Seismic Weight	Dead Load	
Typical Foyer Roof	**psf**	**psf**	**Remarks**
Roofing Sheathing	4	4	1x6 straight sheathing
Roof Framing	3	3	Truss @ 16" o.c.
Ceiling, lighting and MEP	6	6	stripping gyp board ceiling
Total	13	6	

	Seismic Weight	Dead Load	
Central Foyer First Floor	**psf**	**psf**	**Remarks**
floor cover	25	25	Marble and mortar
floor sheathing and floor joists	10	10	1" T&G with 2x12 @16" o.c. (estimated no dwg)
Total	35	35	

	Seismic Weight	Dead Load	
Central Foyer Second Floor	**psf**	**psf**	**Remarks**
floor cover	5	5	Capet and Hardwood Floor (estimated, not observed)
floor sheathing and floor joists	10	10	1" T&G with 2x12 @16" o.c. (estimated no dwg)
Ceiling, lighting and MEP	5	5	
misc.	3	3	Built-up wood stairs
Total	23	23	

South Foyer First Floor	**psf**	**psf**	**Remarks**
floor cover	25	25	Marble and mortar
floor sheathing and floor joists	10	10	1" T&G with 2x12 @16" o.c. (estimated no dwg)
Total	35	35	

	Seismic Weight	Dead Load	
South Foyer Second Floor	**psf**	**psf**	**Remarks**
floor cover	5	5	Capet and Hardwood Floor (estimated, not observed)
floor sheathing and floor joists	10	10	1" T&G with 2x12 @16" o.c. (estimated no dwg)
Ceiling, lighting and MEP	5	5	
misc.	3	3	Built-up wood stairs
Total	23	23	

Story Weight

wconcrete = 150 pcf wmasonry= 117 pcf

Floor Levels	Floor Area (ft²) [1]					Floor Weight (psf)					Wall Weight						Floor Weight (kips) [2]	Additional weight (kips)[3]	Total Seismic Weight (kips)	
	Main Hallway-Corridor	Main Hallway-Offices	North Foyer	Central Foyer	South Foyer	Main Hallway-Corridor	Main Hallway-Offices	North Foyer	Central Foyer	South Foyer	Wall height below floor level (ft)	Wall height tributary to each level (ft)	Wall Area below-Concrete (ft²)	Wall Area below-Masonry (ft²)	Wall Seismic Weight-Concrete (kips)	Wall Seismic Weight-Masonry (kips)				
Foyer High Roof	0	0	622	1,167	360			13	13	13	7.50	3.75	60	61	34	27	27		87	
Hall Attic Low Roof	2,231	3,499	0	0	0	46	46				16.25	8.13	139	471	169	448	263	304	1,184	
Foyer Second Floor	0	0	622	1,167	360			35	23	23	12.58	10.04	60	61	90	72	57		219	
Foyer & Hall First Floor	2,231	3,499	622	1,167	360	44	19	36	35	35	3.00	7.79	139	471	162	430	239	291	1,122	
															455	976			**2,611**	**Total Weight**

Notes:
1 & 2- Shear force in the foyer area are assumed to be taken by the walls around the foyer areas only.
3 - Only the shotcrete portions are considered as lateral force resisting system at the east and west elevation; the seismic weight of the remaining unreinforced masonry walls are calculated as below:

Attic:	wall length	239.58	ft
	wall height trib to attic	8.13	ft
	wall thickness (in):	16	in
	wall weight	**303.7**	kip
First Floor:	wall length	239.58	ft
	wall height trib to attic	7.79	ft
	wall thickness (in):	16	in
	wall weight	**291.1**	kip

Period

C_t=	0.02
h_n (ft)=	22.00
B=	0.75

T=	0.20	sec

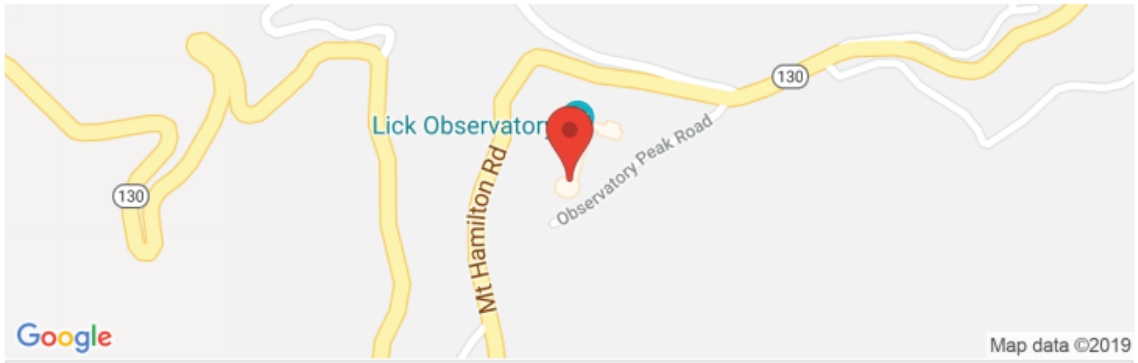
Notes:
1- The period calculated per ASCE 41-17 Equation 4-4.

$$T = C_t \cdot h_n^{B}$$

2- Ct and B are for "all other framing system" per ASCE 41-17 Section 4.4.2.4.
3- The building height is taken from the 1st floor to the roof.

BSE-2E Response Spectrum

Latitude, Longitude: 37.341138, -121.643012



Date	6/24/2019, 4:53:13 PM
Design Code Reference Document	ASCE41-17
Custom Probability	
Site Class	B - Rock

Type	Description	Value
Hazard Level		BSE-2E
S_S	spectral response (0.2 s)	2.244
S_1	spectral response (1.0 s)	0.789
S_{XS}	site-modified spectral response (0.2 s)	1.708
S_{X1}	site-modified spectral response (1.0 s)	0.558
f_a	site amplification factor (0.2 s)	0.9
f_v	site amplification factor (1.0 s)	0.8

Story Shears

Sa=	1.71	
W=	2,611	kips
C=	1.2	Per ASCE 41-17 Table 4-7[3]

V=	5,352	kips

k= 1.00

Per ASCE 41-17 Section 4.4.2.2, K = 1.0 for periods less than 0.5 sec and K = 2.0 for T >2.5 sec. It varies linearly in between 0.5 sec and 2.5 sec period.

Floor Levels[1,2]	Story Height (ft)	Total Height, H (ft)	Weight, W (kips)	W x H^k	coeff	Fx (kips)	Story Shear, V (kips)
Foyer High Roof	7.50	23.75	87	2,077	0.08	405	405
Hall Attic Low Roof	16.25	16.25	1,184	19,236	0.70	3,754	4,159
Foyer Second Floor	12.58	12.58	219	2,750	0.10	537	4,696
Foyer & Hall First Floor	3.00	3.00	1,122	3,365	0.12	657	5,352
				27,428	1	5,352	

Notes:
1- The base of building is assumed to be at the foundation level.
2- The foyer roofs are higher than the attic roof at the halls; The second floor of the foyer is between the hall attic level and first floor.
3- Modification Factor, C, per ASCE 41-17, Table 4-7.

Average Masonry Wall Stress Check:

Average Stresses

Ms = 1.75

Transverse-Direction (E-W direction)						
Story	Story Shear	Masonry Shear[1]	Wall Area	Average Shear Stress	Tier 1 Shear Stress Limit	Wall OK?
	(kips)	(kips)	(in^2)	(psi)	(psi)	
Foyer High Roof - Hall Attic Low Roof	442	372	11,493	19	30	OK
Hall Attic Low Roof - Foyer Second Floor	4,296	4,296	37,025	66	30	NG
Foyer Second Floor - Foyer & Hall First Floor	4,885	4,885	37,025	75	30	NG
Foyer & Hall First Floor -	5,559	5,559	37,025	86	30	NG

Longitudinal Direction (N-S direction)						
Story	Story Shear	Masonry Shear	Wall Area	Average Shear Stress	Tier 1 Shear Stress Limit	Wall OK?
	(kips)	(kips)	(in^2)	(psi)	(psi)	
Foyer High Roof - Hall Attic Low Roof	442	0	0		30	
Hall Attic Low Roof - Foyer Second Floor	4,296	2,564	36,270	40	30	NG
Foyer Second Floor - Foyer & Hall First Floor	4,885	0	0		30	
Foyer & Hall First Floor -	5,559	3,317	36,270	52	30	NG

Note:
1- Masonry shear is reduced at the foyer roof level since the north foyer has concrete shear wall; Shear demand on the masonry wall is calculated based on the flexible diaphragm tributary area.

Table 4-8. M_s Factors for Shear Walls

	Level of Performance		
Wall Type	**CP[a]**	**LS[a]**	**IO[a]**
Reinforced concrete, precast concrete, wood, reinforced masonry, and cold-formed steel	4.5	3.0	1.5
Unreinforced masonry	1.75	1.25	1.0

[a] CP = Collapse Prevention, LS = Life Safety, IO = Immediate Occupancy.

Average Reinforced Concrete Wall Stress Check:

Average Stresses

Ms = 4.5
f'c = 3000 psi

Based upon General Structural Notes on Sheet S-4

Transverse (E-W direction)						
Story	Story Shear	Concrete Shear[1]	Wall Area	Average Shear Stress	Tier 1 Shear Stress Limit	Wall OK?
	(kips)	(kips)	(in^2)	(psi)	(psi)	
Foyer High Roof - Hall Attic Low Roof	442	70	4,152	4	110	OK
Hall Attic Low Roof - Foyer Second Floor	4,296		0		110	
Foyer Second Floor - Foyer & Hall First Floor	4,885	379	4,152	20	110	OK
Foyer & Hall First Floor -	5,559		0		110	

Longitudinal (N-S direction)						
Story	Story Shear	Concrete Shear[1]	Wall Area	Average Shear Stress	Tier 1 Shear Stress Limit	Wall OK?
	(kips)	(kips)	(in^2)	(psi)	(psi)	
Foyer High Roof - Hall Attic Low Roof	442	442	4,518	22	110	OK
Hall Attic Low Roof - Foyer Second Floor	4,296	4,296	19,986	48	110	OK
Foyer Second Floor - Foyer & Hall First Floor	4,885	4,885	24,504	44	110	OK
Foyer & Hall First Floor -	5,559	5,559	24,504	50	110	OK

Note:
1- Concrete shear in the transverse direction is reduced based on the flexible diaphragm distribution;
In the longitudinal direction, all shear force are assumed to be taken by the concrete walls, i.e. the shear capacity of the masonry walls are ignored.
1 - Ms factor per ASCE 41-17 Table 4-8.

Table 4-8. M_s Factors for Shear Walls

	Level of Performance		
Wall Type	CP[a]	LS[a]	IO[a]
Reinforced concrete, precast concrete, wood, reinforced masonry, and cold-formed steel	4.5	3.0	1.5
Unreinforced masonry	1.75	1.25	1.0

[a] CP = Collapse Prevention, LS = Life Safety, IO = Immediate Occupancy.