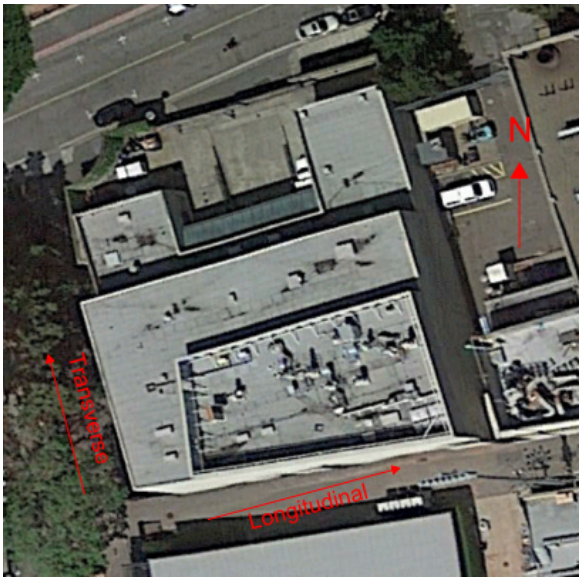
ASCE 41-17 Tier 1 Seismic Evaluation
Building Name: Hazardous Materials Facility
CAAN ID: 1267
Auxiliary Building ID: N/A
Address: Core Campus, Berkeley, CA 94720
Site location coordinates: Latitude 37.8702°, Longitude -122.2640°

Plan Image or Aerial Photo



Exterior Elevation Photo

UCOP *SEISMIC PERFORMANCE LEVEL* (OR "RATING") BASED ON TIER 1 EVALUATION FINDINGS: III

The construction documents indicate that the original design and construction is in accordance with the benchmark design code year (or later) building code seismic design provisions for UBC or IBC listed in Table 1 of the UC Seismic Program Guidebook.

BUILDING DATA
ASCE 41-17 Model Building Type (Governing Building Type bolded for Seismic Risk Model when multiple types exist):

a. Longitudinal Direction: S2/S2A: Steel Eccentrically-Braced Frames
b. Transverse Direction: S2/S2A: Steel Eccentrically-Braced Frames

Square Footage: 24,138sf
Building Length: 124ft
Building Width: 139ft
Building Height: 32ft
Story Height: 16ft (1st – 2nd), 16ft (2nd - Roof)
Number of stories *above* grade: 2
Number of basement stories *below* grade: 0

Year of Original Construction and Code Year: 1999, 1995 CBC (Assumed)
Year of Later Constuction and Code Year: N/A

COST RANGE TO RETROFIT (if applicable): N/A (Benchmark Building)

BUILDING DESCRIPTION

General

The building was built in 1999 and is situated on a nearly-level site on the west side of the UC Berkeley Core campus. The building has two stories above grade and is approximately 32 feet tall. At the north side of the building, the structure is only one story tall and transitions to a two-story structure at the southern portion of the building. The building is essentially rectangular in plan, except for a large rectangular cutout at the north side of the building to faciliate a loading dock. The building footprint measures roughly 124 feet in the east-west (longitudinal) and 139 feet in the north-south (transverse) direction, with a total area of approximately 24,000 square feet. The building primarily is used for storage areas and waste management areas, with some miscellaneous offices and laboratories.

Structural System

The gravity load structural system consists of metal deck over steel beams and girders at the roofs and a composite floor system of metal deck and concrete fill over steel beams and girders at the second level interior suspended floor. Beams and girders frame into wide-flange steel columns at the two-story southern portion of the building and into steel square tube columns at the one-story northern portion of the building. The first floor is a reinforced concrete slab-on-grade. The lateral load system consists of eccentrically-braced steel frames for four bays each in the longitudinal and transverse directions. The bare metal deck at the roofs and the concrete fill on metal deck at the composite floor serve as horizontal diaphragms to transfer load to the eccentrically-braced frames. Several CMU and concrete walls do not act as gravity support, but provide cladding and site privacy at the north and east sides of the building. The columns and walls are founded on spread footings and strip footings.

Building Condition

Good

Date of Site Visit: 11/08/2018, Russell Berkowitz, Forell/Elsesser Engineers
Limitations of walk-through: None

SITE INFORMATION

Site Class (A-F): C Basis: Geologic Hazards and Site Classification, Geomatrix, Plate 2
Site Specific Ground Motion Study? Yes, 2015 Update to the Site-Specific Seismic Hazard Analyses and Development of Seismic Design Ground Motions
BSE-1N Spectral Accelerations: Basis: 2015 Site Specific Report Table 5 for 36-75ft Soil
S_{DS}: 2.40 S_{D1}: 0.71
BSE-2E Spectral Accelerations: Basis: 2015 Site Specific Report Table 6 for 36-75ft Soil
S_{XS}: 3.15 S_{X1}: 1.05 (Note: S_{XS} taken as 90% of the maximum spectral acceleration, obtained from the site-specific spectrum, at any period within 0.2s to 5s, inclusive, in conformance with ASCE41-17, Section 2.4.2.1 and ASCE7-16, Section 21.4 guidelines)
Level of Seismicity: High

Performance Level: Collapse Prevention Structural Performance
Geologic Hazards:
Fault Rupture: No Basis: California Geological Survey Website
https://maps.conservation.ca.gov/cgs/informationwarehouse/regulatorymaps/

Liquefaction: Low Basis: California Geological Survey Website
https://maps.conservation.ca.gov/cgs/informationwarehouse/regulatorymaps/

Landslide: Low Basis: California Geological Survey Website
https://maps.conservation.ca.gov/cgs/informationwarehouse/regulatorymaps/

PREVIOUS RATINGS SUMMARY

None

DOCUMENTATION

Architectural Drawings: 100% Contract Documents, Environment, Health and Safety Facility, Ehrlich-Rominger Architects, 3/21/97, Sheets A0-A9.2
Structural Drawings: 100% Contract Document, Environment, Health and Safety Facility, Rinne & Peterson Structural Engineers, 3/21/97, Sheets S0.1-S7.5
Seismic Evaluations: N/A
Geotechnical Reports: N/A
Other Documents: N/A
Limitations of available documents: N/A

CONSTRUCTION DATA

Gravity Load Structural System:	Metal deck (roof) or metal deck with concrete fill (interior at second level) on steel beams and girders, framing into steel wide-flange and square tube columns		
Exterior Transverse Walls:	Cement plaster on light gauge metal stud wall (west wall) Cement plaster on CMU wall (east wall)	Opening(s)?	Yes No
Exterior Longitudinal Walls:	Cement plaster on light gauge metal stud wall	Opening(s)?	Yes
Roof Materials/Framing:	1 ½" Metal Deck on steel beams and girders		
Intermediate Floors/Framing:	5 ½" Conc. Over 1 ½" Metal Deck, composite w/ steel beams and girders		
Ground Floor:	6" concrete slab on grade		
Columns:	Square tube steel columns (at 1-story portion), wide-flange steel columns (at 2-story portion)	Foundation:	Spread footings at columns, strip footings at walls
General Condition of Structure:	Good		

Evidence of Settling?:	No
Special Features & Comments:	

LATERAL-FORCE-RESISTING SYSTEM

	Longitudinal	Transverse
ASCE 41-17 Building Type:	S2/S2A: Steel Eccentrically-Braced Frames	S2/S2A: Steel Eccentrically-Braced Frames
Diaphragms:	Metal Deck (Roof), Metal Deck w/ Conc. Fill (Floor)	Metal Deck (Roof), Metal Deck w/ Conc. Fill (Floor)
Vertical Elements:	Wide Flange Columns	Wide Flange Columns
Connections:	Welded Connections	Welded Connections
Details:	Eccentrically Braced Frame Details, Sheet S7.2	Eccentrically Braced Frame Details, Sheet S7.2
Estimated Fundamental Period, T (sec):	0.40 sec	0.40
BSE-2E Spectral Acceleration, S_a:	N/A	N/A
Modification Factor, C:	N/A	N/A
Building Weight, W (kips):	N/A	N/A
Seismic Base Shear, V (kips):	N/A	N/A
System Modification Factor, M_s:	N/A	N/A

Significant Structural Deficiencies, Potentially Affecting *Seismic Performance Level* Designation:

☐ Lateral System Stress Check (wall shear, column shear or flexure, or brace axial as applicable)
☐ Load Path
☐ Adjacent Buildings
☐ Weak Story
☐ Soft Story
☐ Geometry (vertical irregularities)
☐ Torsion
☐ Mass – Vertical Irregularity
☐ Cripple Walls
☐ Wood Sills (bolting)
☐ Diaphragm Continuity
☐ Openings at Shear Walls (concrete or masonry)
☐ Liquefaction
☐ Slope Failure
☐ Surface Fault Rupture
☐ Masonry or Concrete Wall Anchorage at Flexible Diaphragm

☐ URM wall height to thickness ratio
☐ URM Parapets or Cornices
☐ URM Chimney
☐ Heavy Partitions Braced by Ceilings
☐ Appendages

OVERALL SEISMIC DEFICIENCIES & EXPECTED SEISMIC PERFORMANCE

The building is expected to perform well in a major seismic event.

- **UNRESTRAINED CONTENTS ON SHELVING**

There are several areas inside the building where unrestrained contents on shelving could potentially become dislodged and present a falling hazard.

Appendices

A. Additional Photos

B. UCOP Seismic Safety Policy Falling Hazards Assessment Summary

C. Calculations

D. Table 1 of the UC Seismic Program Guidebook

Appendix A – Additional Photos

Exterior View of Loading Dock – Looking Southeast

Typical Interior Condition

Typical Interior Corridor

Typical Eccentrically-Braced Frame Top Connection

Example of Unrestrained Contents on Shelves

Example of Unrestrained Contents on Shelves

Appendix B – UCOP Seismic Safety Policy Falling Hazards Assessment Summary

UC Campus:	Berkeley			Date:	December 27, 2018		
Building CAAN:	1267	Auxiliary CAAN:	N/A	By Firm:	Forell/Elsesser Engineers		
Building Name:	Hazardous Materials Facility			Initials:	*SE*	Checked:	*RB*
Building Address:	Core Campus, Berkeley, CA 94720			Page:	1	of	1

UCOP SEISMIC SAFETY POLICY
Falling Hazard Assessment Summary

	Description
P ☐ N/A ☒	**Heavy ceilings, features or ornamentation above large lecture halls, auditoriums, lobbies, or other areas where large numbers of people congregate (50 ppl or more)** **Comments:**
P ☐ N/A ☒	**Heavy masonry or stone veneer above exit ways or public access areas** **Comments:**
P ☐ N/A ☒	**Unbraced masonry parapets, cornices, or other ornamentation above exit ways or public access areas** **Comments:**
P ☐ N/A ☒	**Unrestrained hazardous material storage** **Comments:**
P ☐ N/A ☒	**Masonry chimneys** **Comments:**
P ☐ N/A ☒	**Unrestrained natural gas-fueled equipment such as water heaters, boilers, emergency generators, etc.** **Comments:**
P ☒ N/A ☐	**Other:** Unrestrained contents on shelving **Comments:** There are several areas inside the building where unrestrained contents on shelving could potentially become dislodged and present a falling hazard.
P ☐ N/A ☒	**Other:** **Comments:**
P ☐ N/A ☒	**Other:** **Comments:**

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

Appendix C – Calculations

Site & Seismicity Information

Environment, Health, and Safety Facility
UC Berkeley
Berkeley, California

Site Parameters		
Site Latitude	37.870238	(Source: Google Earth)
Site Longitude	-122.26404	(Source: Google Earth)

2015 Site-Specific Seismic Hazard Analyses	
Building Code Reference	ASCE 41-17

2015 Site-Specific Seismic Hazard Analyses	
$S_{XS,BSE\text{-}1N}$ =	2.400 g
$S_{X1,BSE\text{-}1N}$ =	0.710 g

Table 2-4. Level of Seismicity Definitions

Level of Seismicity[a]	S_{DS}	S_{D1}
Very low	<0.167 g	<0.067 g
Low	≥0.167 g <0.33 g	≥0.067 g <0.133 g
Moderate	≥0.33 g <0.50 g	≥0.133 g <0.20 g
High	≥0.50 g	≥0.20 g

[a] The higher level of seismicity defined by S_{DS} or S_{D1} shall govern.

Level of Seismicity = HIGH

Determine BSE-2E Spectral Response Acceleration Parameters

Environment, Health, and Safety Facility
UC Berkeley
Berkeley, California

Site Parameters		
Site Latitude	37.870238	(Source: Google Earth)
Site Longitude	-122.264039	(Source: Google Earth)

Site Data		
Site Soil Classification		(Assumed, Unknown)
Liquefaction Potential	Low	(Assumed, Unknown)

2015 Site-Specific Seismic Hazard Analyses	
Building Code Reference	ASCE 41-17
EQ Hazard Level	BSE-2E

2015 Site-Specific Seismic Hazard Analyses	
$S_{XS,BSE\text{-}2E,\ Max\ 0.2s\ to\ 5s}$ =	3.500 g
% Multiplier	90%
$S_{XS,BSE\text{-}2E}$ =	3.150 g
$S_{X1,BSE\text{-}2E}$ =	1.050 g

Determine Building Period per ASCE 41-17 Section 4.4.2.4

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

Values of Period Parameters C_t and β

Structure Type	C_t	β
Steel moment-resisting frames (S1, S1a)	0.035	0.80
Concrete moment-resisting frames (C1)	0.018	0.90
Steel eccentrically braced frames (S2, S2a)	0.030	0.75
All other framing systems	0.020	0.75

Structure Type	Longitudinal	Transverse
	S2	S2
	Steel Braced Frames - Stiff Diaphragms	Steel Braced Frames - Stiff Diaphragms

Height of Roof Level Above Base 32.0 ft <-- 31'-3" to T.O. metal deck + waterproofing/insulation

Period, T, ASCE 41-17 Equation 4-4

	Longitudinal	Transverse
C_t	0.030	0.030
β	0.750	0.750
h_n	32.0 ft	32.0 ft
$T = C_t h_n^{\beta}$	**0.404 s**	**0.404 s**

Weight of Materials

Roof (1.5" Metal Deck Only)

1.5" Metal Deck =	4.00 psf
Steel Beams =	4.40 psf
Steel Girders =	1.17 psf
Steel Columns =	1.07 psf
Roofing =	5.00 psf
Insulation =	2.00 psf
Distributed MEP =	5.00 psf
Ceiling =	3.00 psf
Misc =	2.00 psf
Partitions =	5.00 psf
Total =	**32.63 psf**

Floor (5.5" NWC over 1.5" Metal Deck)

1.5" Metal Deck =	4.00 psf
5.5" NWC =	78.13 psf
Steel Beams =	8.27 psf
Steel Girders =	5.63 psf
Steel Columns =	2.13 psf
Flooring =	5.00 psf
Insulation =	2.00 psf
Distributed MEP =	5.00 psf
Ceiling =	3.00 psf
Misc =	5.00 psf
Partitions =	10.00 psf
Total =	**128.16 psf**

Weight of Materials

12" CMU Wall (Detail 24/A6.1)

12" CMU, assumed fully grouted =	118.00 psf
Interior Gypsum Board =	2.50 psf
Cement Plaster =	10.00 psf
Metal Lath =	0.50 psf
Total =	**131.00 psf**

6" Metal Stud Wall (Detail 5/A6.1)

6" Metal Stud Wall =	5.00 psf
Interior Gypsum Board =	2.50 psf
Batt Insulation =	2.00 psf
Cement Plaster =	10.00 psf
Metal Lath =	0.50 psf
Total =	**20.00 psf**

Summary of Seismic Weight

Original Building

Flat Weights

	Flat Unit Weight (psf)	Flat Area (sf)	Flat Weight (kips)	
Roof Metal Deck	32.63	10108	330	***330***
2nd Level NWC over Deck	128.16	9860	1264	
2nd Level Metal Deck	32.63	4292	140	***1404***

Total Flat Seismic Weight = ***1734***

Wall Weights

	Wall Unit Weight (psf)	Wall Trib Height (ft)	Wall Length (ft)	Overall Wall Area (sq. ft.)	% Solid	Effective Wall Area (sq. ft.)	Wall Weight (kips)
Roof Level Walls							
CMU Parapet (Above)	131	3	90	270	100%	270	35
Metal Stud Wall (Below)	20	8	323	2584	100%	2584	52
CMU Wall (Below)	131	8	90	720	100%	720	94
							181
2nd Level Walls							
Metal Stud Parapet (Above)	20	3	305	915	100%	915	18
Metal Stud Wall (Above)	20	8	321	2568	100%	2568	51
CMU Wall (Above)	131	8	88	704	100%	704	92
Metal Stud Wall (Below)	20	8	450	3600	100%	3600	72
CMU Wall (Below)	131	8	140	1120	100%	1120	147
							381

Building Weight Summary:

Roof	**511**	**kips**
2nd Level	**1784**	**kips**

Total Building Seismic Weight = ***2296*** **kips**

Determine Psuedo Seismic Force per ASCE 41-17 Section 4.4.2.1

$$V = CS_aW \qquad (4\text{-}1)$$

Number of Stories = 2

Table 4-7. Modification Factor, *C*

	Number of Stories			
Building Type[a]	**1**	**2**	**3**	**≥4**
Wood and cold-formed steel shear wall (W1, W1a, W2, CFS1) Moment frame (S1, S3, C1, PC2a)	1.3	1.1	1.0	1.0
Shear wall (S4, S5, C2, C3, PC1a, PC2, RM2, URMa) Braced frame (S2) Cold-formed steel strap-brace wall (CFS2)	1.4	1.2	1.1	1.0
Unreinforced masonry (URM) Flexible diaphragms (S1a, S2a, S5a, C2a, C3a, PC1, RM1)	1.0	1.0	1.0	1.0

[a] Defined in Table 3-1.

Building Type	S2
Period	0.404
S_{XS}	3.15
S_{X1}	1.050
S_{X1} / T	2.601
S_a	2.601
C	1.2
W	2296 kips
V	**7166 kips**

Story Shear Forces per ASCE 41-17 Section 4.4.2.2

$$F_x = \frac{w_x h_x^k}{\sum_{i=1}^{n} w_i h_i^k} V \qquad (4\text{-}2a)$$

$$V_j = \sum_{x=j}^{n} F_x \qquad (4\text{-}2b)$$

Original Building

V = 7166 kips

Level	Weight (kips)	Height (ft)	w x h	F_x (kips)	C_{vx}	V_j (kips)
Roof	511	32	16359	2610	5.11	2610
L2	1784	16	28549	4555	2.55	7166
	2296		44908	7166		

Quick Check - Brace Axial Stress Check

Fy	ksi	50
Roof Trib Area	ft2	660
Roof DL	psf	24
Roof LL	psf	5
L2 Trib Area	ft2	660
L2 DL	psf	124
L2 LL	psf	62.5
DL Multiplier	---	1.1
LL Multiplier	---	1.1
Axial Load	k	156.453
A (W14X109)	in2	32
Axial Stress	k	4.889
0.1Fy	ksi	5
Acceptable?	---	OK

Quick Check - Brace Axial Stress Check

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

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

Table 4-9. M_s Factors for Diagonal Braces

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

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

		Level 2	Roof	
Fy	ksi	46	46	
Fye Multiplier	---	1.25	1.25	
Fye	ksi	57.5	57.5	
d	in	14	7	
t	in	0.5	0.5	
d/t	---	28	14	<-- b/t or d/t?
90/(Fye)^(1/2)	---	11.869	11.869	
190/(Fye)^(1/2)	---	25.056	25.056	
Ms	---	3.500	6.434	
V	k	7166	2610	
s	ft	30	30	<-- What is this?
Nbr	---	4	4	
Lbr	ft	20.827	20.827	
Abr	in2	24.6	11.6	
favg	ksi	14.445	6.070	
0.5Fy	ksi	23	23	
Acceptable?	---	OK	OK	

Quick Check - Brace Slenderness/Compactness

Slenderness

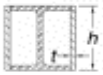
		Level 2	Roof
K	---	1	1
Lv	ft	16	16
Lh	ft	13.333	13.333
L	ft	20.827	20.827
r	in	5.49	2.63
KL/r	---	45.524	95.030
KL/r limit	---	200	200
Acceptable?	---	OK	OK

Compactness per AISC 360, Table B4.1

		Level 2	Roof
Flange b/t	---	27.1	12.1
Web h/t	---	27.1	12.1
E	ksi	29000	29000
Fy	ksi	46	46
Limiting λp, flange 1.12*sqrt(E/Fy)	---	28.12148	28.12148
Limiting λp, web 2.42*sqrt(E/Fy)	---	60.76247	60.76247
Flange Compact?	---	OK	OK
Web Compact?	---	OK	OK
Compact?	---	OK	OK

Moderately Ductile per AISC 341, Table D1.1

		Level 2	Roof
b/t	---	27.1	12.1
E	ksi	29000	29000
Fy	ksi	46	46
Limiting λmd 0.64*sqrt(E/Fy)	---	16.06941	16.06941
Moderately Ductile?	---	FAILS	OK

Description of Element	Width-to-Thickness Ratio	Limiting Width-to-Thickness Ratio		Example
		λ_{hd} Highly Ductile Members	λ_{md} Moderately Ductile Members	
Walls of rectangular HSS	b/t	$0.55\sqrt{E/F_y}$[b]	$0.64\sqrt{E/F_y}$[c]	
Flanges of boxed I-shaped sections and built-up box sections	b/t			
Side plates of boxed I-shaped sections and walls of built-up box shapes used as diagonal braces	h/t			

Appendix D – Table 1 of the UC Seismic Program Guidebook

Table 1: Benchmark Building Codes and Standards

Building Type[a,b]	Building Seismic Design Provisions	
	UBC	IBC
Wood frame, wood shear panels (Types W1 and W2)	1976	2000
Wood frame, wood shear panels (Type W1a)	1976	2000
Steel moment-resisting frame (Types S1 and S1a)	1997	2000
Steel concentrically braced frame (Types S2 and S2a)	1997	2000
Steel eccentrically braced frame (Types S2 and S2a)	1988[g]	2000
Buckling-restrained braced frame (Types S2 and S2a)	[f]	2006
Metal building frames (Type S3)	[f]	2000
Steel frame with concrete shear walls (Type S4)	1994	2000
Steel frame with URM infill (Types S5 and S5a)	[f]	2000
Steel plate shear wall (Type S6)	[f]	2006
Cold-formed steel light-frame construction—shear wall system (Type CFS1)	1997[h]	2000
Cold-formed steel light-frame construction—strap-braced wall system (Type CFS2)	[f]	2003
Reinforced concrete moment-resisting frame (Type C1)[i]	1994	2000
Reinforced concrete shear walls (Types C2 and C2a)	1994	2000
Concrete frame with URM infill (Types C3 and C3a)	[f]	[f]
Tilt-up concrete (Types PC1 and PC1a)	1997	2000
Precast concrete frame (Types PC2 and PC2a)	[f]	2000
Reinforced masonry (Type RM1)	1997	2000
Reinforced masonry (Type RM2)	1994	2000
Unreinforced masonry (Type URM)	[f]	[f]
Unreinforced masonry (Type URMa)	[f]	[f]
Seismic isolation or passive dissipation	1991	2000

Note: This table has been adapted from ASCE 41-17 Table 3-2. Benchmark Building Codes and Standards for Life Safety Structural Performed at BSE-1E.

Note: UBC = *Uniform Building Code*. IBC = *International Building Code*.

[a] Building type refers to one of the common building types defined in Table 3-1 of ASCE 41-17.

[b] Buildings on hillside sites shall not be considered Benchmark Buildings.

[c] not used

[d] not used

[e] not used

[f] No benchmark year; buildings shall be evaluated in accordance with Section III.J.

[g] Steel eccentrically braced frames with links adjacent to columns shall comply with the 1994 UBC Emergency Provisions, published September/October 1994, or subsequent requirements.

[h] Cold-formed steel shear walls with wood structural panels only.

[i] Flat slab concrete moment frames shall not be considered Benchmark Buildings.