Degenkolb

Berkeley
UNIVERSITY OF CALIFORNIA

Evaluator: HK
Date: 03/29/19

ASCE 41-17 Tier 1 Seismic Evaluation

Building Name: Lawrence Hall of Science-Exhibition Halls
CAAN ID: 1800
Auxiliary Building ID: 1800.1
Address: 1 Centennial Drive, Berkeley, CA 94720
Site location coordinates: Latitude 37.8794 Longitudinal -122.2467

REGISTERED PROFESSIONAL ENGINEER
RAYMOND S. PUGLIESI
No. 3968
STRUCTURAL
STATE OF CALIFORNIA

Plan Image or Aerial Photo

North Elevation Photo (Inverted Pendulum Structure)

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

BUILDING DATA

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

a. Longitudinal Direction: **C2**, Concrete Shear Wall – rigid diaphragm
b. Transverse Direction: **C2**, Concrete Shear Wall – rigid diaphragm

Square Footage: 7,600 sf each. 15,200 out of 134,388 sf total.
Building Length: 117 ft overall length
Building Width: 70 ft overall width
Building Height: 35 ft (at tallest point above Level A)
Story Height: 35 ft.
Number of stories *above* grade: 2
Number of basement stories *below* grade: None
Year of Original Construction and Code Year: 1968, 1964 UBC
Year of Later Constuction and Code Year: 1983, 1979 UBC

COST RANGE TO RETROFIT (if applicable): None

BUILDING DESCRIPTION

General

The Lawrence Hall is an unusual building with a combination of precast and cast in place elements that are either light weight or normal weight depending upon the level they have been installed at. It is located on a sloping site and has some partial levels due to the sloped site and tall storey space required at some rooms on Level C. The base structure has an octagonal shape, with another two story part also called the Information Center located at the south end. There are various independent shell structures supported on the building either fully or partially, the Exhibition Halls, the Entrance Foyer and the Memorial Room.

The Exhibition Halls house a children's museum, a planetarium and various exhibits.

Structural System

Exhibition Halls: These are two, two story shell structures located to the East and West of the Base Structure, separated from the surrounding structures with a 2" seismic joint. These are very similar in construction to the Memorial Room, except that they are supported on their own foundation system with concrete piers and tie beams. These are inverted pendulum structures with a larger plan area at the second level than at the base. The Second floor of this structure consists of the waffle slab system similar to the rest of Level A.

The Lateral system of the building consists of 8" concrete walls (or slabs) spanning between concrete frames spanning across the width of the building.

Building Condition

Good, no visible structural or non-structural damage.

Date of Site Visit: 3/26/2019, Ray Pugliesi and Heavenz Kaur, Degenkolb Engineers
Limitations of walk-through:

SITE INFORMATION

Site Class (A-F): D Basis: Default.
Site Specific Ground Motion Study? No
BSE-1N Spectral Accelerations: Basis: USGS Data
S_{DS}: 1.903 S_{D1}: 1.031
BSE-2E Spectral Accelerations: Basis: USGS Data
S_{XS}: 2.473 S_{X1}: 1.29
Level of Seismicity: High
Performance Level: Collapse Prevention Structural Performance (Risk category II, ASCE 41-17 Table 2-1)

Geologic Hazards:
Fault Rupture No Basis: Earthquake Zones of Required Investigation- Briones Valley https://maps.conservation.ca.gov/cgs/informationwarehouse/regulatorymaps/
Liquefaction No Basis: Earthquake Zones of Required Investigation- Briones Valley https://maps.conservation.ca.gov/cgs/informationwarehouse/regulatorymaps/
Landslide No, but surrounded by region prone to landslide Basis: Earthquake Zones of Required Investigation- Briones Valley https://maps.conservation.ca.gov/cgs/informationwarehouse/regulatorymaps/

PREVIOUS RATINGS SUMMARY

1. Good – 1997 Preliminary Seismic Evaluation (SAFER), Forell/Elsesser Engineers Inc.

DOCUMENTATION

Architectural Drawings: Lawrence Memorial Hall of Science, by Anshen & Allen Architects, dated, December 15, 1964.
Lawrence Hall of Science Alterations, Step 1, by ED2 Architects, dated, March 4, 1982.
Structural Drawings: Lawrence Memorial Hall of Science, by Isadore Thompson SE Structural Engineer, dated, December 15, 1964.
Lawrence Hall of Science Alterations, Step 1, by Shapiro, Okino & Hom Structural Engineers, dated, March 4, 1982.
Seismic Evaluations: 1997 Preliminary Seismic Evaluation (SAFER), Forell/Elsesser Engineers Inc., July 8, 1997.
Geotechnical Reports: Not available
Other Documents:

CONSTRUCTION DATA

Gravity Load Structural System:	24” deep waffle slab supported on precast walls at Level A. Concrete frames spanning across the width of the building for the shell structure above.		
Exterior Transverse Walls:	5” thick precast concrete walls above Level 1. 10” thick cast in place walls below Level A.	Opening(s)?	Yes

Exterior Longitudinal Walls:	Similar to Transverse Walls	Opening(s)?	Yes
Roof Materials/Framing:	5” thick concrete slab		
Intermediate Floors/Framing:	24” thick waffle slab		
Ground Floor:	4” slab on grade with #3@15” o.c. each way		
Columns:	None	Foundation:	36” diameter concrete piers
General Condition of Structure:	Good		
Evidence of Settling?:	No		
Special Features & Comments:	The building is located on a sloping site and is highly irregular in plan. Along with the base structure there are four shell structures located on or around the building.		
	The Exhibition halls are inverted pendulum type structures with base area smaller than at Level A.		

LATERAL-FORCE-RESISTING SYSTEM

	Longitudinal	Transverse
ASCE 41-17 Building Type:	C2: Concrete SW	C2: Concrete SW
Diaphragms:	24” thick waffle slab Level A, 5”slab at roof.	24” thick waffle slab Level A, 5”slab at roof.
Vertical Elements:	10” thick cast in place walls below Level A, 5” thick precast walls above Level A. The walls span between concrete frames than span the width of the building.	10” thick cast in place walls below Level A, 5” thick precast walls above Level A. The walls span between concrete frames than span the width of the building.
Connections:	Dowelled in cast in place concrete	Dowelled in cast in place concrete
Details:		
Estimated Fundamental Period, T (sec):	0.288	0.288
BSE-2E Spectral Acceleration, S_a:	2.47g	2.47g
Modification Factor, C:	1.3 (C2 – Table 4-7)	1.3 (C2 – Table 4-7)
Building Weight, W (kips):	1,660	1,660
Seismic Base Shear, V (kips):	4,516	4,516
System Modification Factor, M_s:	4.5 for reinforced concrete shear wall at CP, per Table 4-8 of ASCE 41-17	4.5 for reinforced concrete shear wall at CP, per Table 4-8 of ASCE 41-17

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 major deficiency of this building is related to its overall geometry.

1. Overturning: The base of the structure is smaller than the plan area at Level A. The "inverted pendulum" structure of this building is prone to overturning but is mitigate by the self-weight of the structure that provides a stabilizing force large enough to exceed the overturning moment of the building. Besides, #4@16 EF wall dowels are present throughout the wall along the building perimeter at the foundation, that provide a positive connection between the walls and the foundations.

Seismic Retrofit Concept Sketches/Description (only if above-listed rating is V or greater):

Not applicable

Appendices

A. Additional Photos

B. ASCE 41-17 Tier 1 Checklists (Structural)

C. UCOP Seismic Safety Policy Falling Hazards Assessment Summary

D. Quick Check Calculations

APPENDIX A

Additional Photos

Figure A.1 Roof of Exhibition Hall

Figure A.2 View of Exhibition Hall looking North- grade slopes down from the South end to the North end

APPENDIX B

ASCE 41-17 Tier 1 Checklists (Structural)

UC Campus:	BERKELEY			Date:	03/29/2019		
Building CAAN:	1800.1	Auxiliary CAAN:	N/A	By Firm:	DEGENKOLB ENGINEERS		
Building Name:	LAWRENCE HALL OF SCIENCE-EXHIBITION			Initials:	*HK*	Checked:	
Building Address:	BERKELEY, CA 94720			Page:	1	of	3

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:** Precast shear walls are doweled into cast in place walls that continue to the building foundation.
○	○	○	○	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:** 2" seismic joint at Level A near Exhibition Halls
○	○	●	○	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:** Precast shear walls are doweled into cast in place walls that continue to the building foundation.

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

ASCE 41-17
Collapse Prevention Basic Configuration Checklist

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:** At Level A, the precast walls are longer in the East-West direction by almost 30%
●	○	○	○	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:**
●	○	○	○	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:**

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Building Address:	BERKELEY, CA 94720			Page:	3	of	3

ASCE 41-17
Collapse Prevention Basic Configuration Checklist

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:** Base/Height = 21/24'=0.875<0.6*2.47 (Sa)=1.48
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:** Tie beams are present between foundation piers.

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

UC Campus:	BERKELEY			Date:	03/29/2019		
Building CAAN:	1800.1	Auxiliary CAAN:	N/A	By Firm:	DEGENKOLB ENGINEERS		
Building Name:	LAWRENCE HALL OF SCIENCE-EXHIBITION			Initials:	HK	Checked:	
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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:**
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:** Typically 5" thick walls w/#3@11 (H) EF, 10" thick shear walls w/$4@16 (H) EF and #5@16 (V) EF.

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:**

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

C	NC	N/A	U	
◉	○	○	○	FOUNDATION DOWELS: Wall reinforcement is doweled into the foundation with vertical bars equal in size and spacing to the vertical wall reinforcing directly above the foundation. (Commentary: Sec. A.5.3.5. Tier 2: Sec. 5.7.3.4) **Comments:**

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:**
○	○	◉	○	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:**
○	○	◉	○	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:**
◉	○	○	○	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:**

Flexible Diaphragms

				Description

ASCE 41-17
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:**
○	○	◉	○	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

				Description
C	NC	N/A	U	
○	○	◉	○	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:** Wall rebar has been directly developed into the piles. No pile caps are present in the building.

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

APPENDIX C

UCOP Seismic Safety Policy Falling Hazards Assessment Summary

UC Campus:	BERKELEY			Date:	3/29/2019		
Building CAAN:	1800.1	Auxiliary CAAN:	N/A	By Firm:	DEGENKOLB ENGINEERS		
Building Name:	LAWRENCE HALL OD SCIENCE-EXHIBITION			Initials:	*HK*	Checked:	
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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:**
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:** **Comments:**
P ☐ N/A ☐	**Other:** **Comments:**
P ☐ N/A ☐	**Other:** **Comments:**

Falling Hazards Risk: Low

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

APPENDIX D
Quick Check Calculations

Degenkolb Engineers
1300 Clay St, 9th Floor
Oakland, CA 94612-2047
Phone: 510.272.9040
Fax: 510.272.9526

Degenkolb

Subject:	Weight Take Off	**Job Number:** B8114004.00	**Date:** 3/29/2019
Job:	UCB, LAWRENCE HALL	**By:** HK	**Section:**
		Checked By:	**Page/of:**

Level C

Effective Flat Dead Load+Misc				188	psf
Floor weight				1663	kips

Level B Mezz

Effective Flat Dead Load				127	psf
Floor Weight				2212	kips

Level A

Effective Flat Dead Load+ Floor Paving (50 psf overall)				393	psf
Floor Weight+Entry Foyer+Library Roof+Memorial Hall				30665	kips

Information Center Roof

Effective Flat Dead Load				104	psf
Floor Weight+Memorial Hall				1266	kips

	Area (ft2)	Thickness (in)	Weight (pcf)	Flat Load (psf)	Weight (kips)
Entry Foyer, Memorial Room Exhibition Halls					
8" Shells					
Entry Foyer	29000	8	150	150	4350
Memorial Hall	1950	8	110	103	200.2
2x Exhibition Halls	13740	8	150	150	3320.5

Total Building Weight	35806	kips	

Exhibition Halls

C	1.1	
Sa	2.47	
W	1660	
Base Shear V	**4516**	kips
k	1	
Ms	4.5 for RC wall, Collapse Prevention	

x	w_x	h_x	$w_x h_x^k$	F_x	V_i
Roof					4516

Level	Wall Length		Wall Thickness		f'c	2sqrt(f'cE) (psi	Demand (psi)		D/C- Tier 1	
	N/S	E/W	N/S	E/W			N/S	E/W	N/S	E/W
x	182.00	93.00	10.00	10.00	4000.00	141.42	45.95	89.93	0.32	0.44

Overturning Check

OT Moment:

Force:	4106 kips	Tier 2: C1C2CmSaW
Hx:	47.5 ft	
Base Width	29 ft	
Total length of wall resisting OT	90 ft	
Mot	195025.42 ft-kips	
Mst	24073.625 ft-kips	
	kips /ft	
0.9Mst	21666.263	ASCE 41-17 (7-6)
Mot/C1C2uot	19502.542 **OK**	

Wall bottom dowels: #4@16V(EF)