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SEISMIC EVALUATION REPORT

Washington Elementary School
2 Story Classroom Building
Alameda, CA 94502

To:	Robbie Lyng
Company Name:	**ALAMEDA UNIFIED SCHOOL DISTRICT**
Date:	April 2012
Regarding:	Seismic Evaluation of Washington Elementary School 2 Story Classroom Building
Project:	11486.00

EXECUTIVE SUMMARY

The 2 story classroom building, located on Washington Elementary School campus in Alameda, CA, has been reviewed as a **Life Safety** performance level building using the ASCE 31-03 Standard for Seismic Evaluations of Existing Buildings. The building was reviewed against the structural Tier 1 checklists.

The Life Safety level building review resulted in the following structural findings and recommendations for improvement in order of significance:

- Vertical discontinuity of the second floor concrete shear wall located at grid line 11 does not meet ASCE 31-03 requirements for continuity to the foundation.
- Openings at shear walls: Large openings exist in the second floor diaphragm at the stair locations that exceed the allowable 25% of the total wall length prescribed by ASCE 31 Tier 1 “Life Safety” checklist.
- Coupling Beam reinforcing location in the roof along grid line 1 does not meet the reinforcing stirrup requirements prescribed by ASCE 31 Tier 1 “Life Safety” checklist.

Overall the building is in good structural condition and shows no apparent signs of damage or degradation, but was designed per previous iterations of the building code and was not evaluated for near-source earthquake design load increases or ductility requirements of more recent building codes.

The following evaluation report details our findings.

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This seismic evaluation report for the 2 story Classroom building on the Washington Elementary School campus is based on the following:

- One site visit for general review of structure (Appendix A - Photographs) performed on 1/6/2012. No destructive testing or removing of finishes was performed.
- Review of original drawings prepared by Warnecke and Warnecke dated 9/6/55.
- The American Society of Civil Engineers/ Structural Engineering Institute (ASCE/SEI) Standard for Seismic Evaluation of Existing Buildings 31-03 Tier 1 Life Safety level structural seismic evaluation criteria. This standard is based on criteria developed from observation of structural damage during actual earthquakes and is meant to identify general deficiencies and potential behavior of this type of building during an earthquake. With the use of Tier 1 checklists specific deficiencies are identified and quantified for further investigation.

This seismic evaluation report includes the following:

- Summary of site, structural materials of construction, structural system, and historical performance.
- ASCE 31-03 Tier 1 Basic, Supplemental Structural, and Geologic Site Hazards Checklists for Life Safety level of performance for the structure (Appendix D).
- ASCE 31-03 Tier 1 Quick Check calculations (Appendix E).
- Findings and recommendations for the structure.

STRUCTURE OVERVIEW

General Site Description
The two story classroom building is located at 825 Taylor St. in Alameda, CA. The south side of the building faces Taylor street 8th street located along the west and 9th street along the east. The site is flat along all areas of the building.

The structure appears in generally good condition with minimal structural damage or deterioration apparent. See Appendix A for building photos.

Structural System and Materials Description
The subject building was designed and built circa 1955 based on the 1949 Uniform Building Code. The building footprint is rectangular shaped in plan with a total building area of approximately 37,000 square feet. See the overall building plan shown in appendix B.

The roof is constructed with a 3" thick cast in place reinforced concrete slab built integrally with 5 5/8"x14" deep concrete pan joists spaced at 3'-0" on center. The roof pan joist system is vertically supported by perimeter reinforced concrete beams and reinforced concrete columns along the north and south exterior walls and by interior cast in place concrete bearing walls along the corridor.

The second floor structure is also constructed with a 3" thick cast in place reinforced concrete slab built integrally with 5 5/8"x6" deep concrete pan joists spaced at 3'-0" on center and supported on 14"x24" reinforced concrete beams spaced at 11'-6" on center. The floor structure is vertically supported by reinforced cast in place concrete bearing walls and beams at all perimeter lines and interior corridor lines.

The foundation at the concrete walls is a continuous reinforced concrete spread footing and the columns are supported on concrete pad footings. The first floor is constructed with a 5" thick reinforced concrete slab on grade.

The vertical lateral force resisting system consists of 9" and 10" thick reinforced cast in place concrete shear walls. The roof and floor diaphragms are 3" thick reinforced concrete slabs.

Building Type
Per ASCE/SEI 31-03 this building can be classified as Building Type C2: Concrete Shear Wall Buildings with Rigid or Stiff Diaphragms. As described by ASCE/SEI 31-03: "*Lateral forces are resisted by cast-in-place concrete shear walls. In older construction, shear walls are lightly reinforced, but often extend throughout the building. In more recent construction, shear walls occur in isolated locations and are more heavily reinforced with boundary elements and closely spaced ties to provide ductile performance. The diaphragms consist of concrete slabs and are stiff relative to the walls. Foundations consist of concrete spread footings or deep pile foundations, or deep foundations.*"

Historical Performance
Concrete slab diaphragm and cast-in-place concrete shear wall systems have traditionally performed relatively well in earthquake events provided adequate shear wall length is maintained without localized stresses in short wall piers and provided there are no significant plan or vertical discontinuities such as a difference in stiffness between floors in a multi-storied structure. Positive wall-to-diaphragm connections are also critical to

performance. While older building of this type are not always ductile and energy dissipative, they do generally provide very stiff and strong structures. Building damage is rarely attributed to a failure of the concrete diaphragms or walls, but rather to failure in related elements in the load path, such as collectors or connections between diaphragms and vertical elements. In redundant buildings with many long walls, such as this structure, stresses in shear walls are usually low and the performance level is good.

Performance Level
For the purposes of this review, the desired level of performance is **Life Safety** for this structure. Life Safety is the building performance level that includes damage to both structural and nonstructural components during a design earthquake, such that: (a) partial or total structural collapse does not occur, and (b) damage to nonstructural components is non-life-threatening.

Region of Seismicity (Earthquake Activity)
Per the earthquake load equations and tables the site is located in a region of HIGH SEISMICITY with a design short-period spectral response acceleration parameter (S_{DS}) of 1.0g and a design spectral response acceleration parameter at a one second period (S_{D1}) of 0.60g (Appendix C). Both of these parameters significantly exceed the lower boundaries for high seismicity classification, 0.5g for S_{DS} and 0.2g for S_{D1}.

FINDINGS & RECOMMENDATIONS

STRUCTURAL:

The ASCE 31-03 Tier 1 Basic Structural and Supplemental Structural Checklists showed the following structural elements are non-compliant for Life Safety Performance.

A. VERTICAL DISCONTINUITIES: (ASCE Section 4.3.2.4) – "*All vertical elements in the lateral-force resisting system shall be continuous to the foundation.*" Second floor shear wall line 11 is not continuous to the foundation and is vertically supported on a concrete beam at level 2. The lateral load on this wall will need to transfer either through the floor "collector" beam element to the in-plane shear wall located between grids C and D, or through the floor diaphragm to the lower story shear walls. The lateral shear force vertical overturning forces for this shear wall are resisted by the corridor concrete shear wall on the north end of the wall and by the concrete column on the south end.

   RECOMMENDATION: Although the concrete beam below the 2nd story wall along line 11 is reinforced, the beam horizontal reinforcing will need to be sufficient and develop into the in-plane lower portion of the concrete shear wall to transfer the lateral loads of the wall above. This connection will most likely need to be strengthened with bolted steel channels on each side and a welded rod assembly to transfer the collector shear force to the in plane lower wall between grids C and D. The vertical support elements of the upper story wall along grid lines 11/A and 11/B may also need to be strengthened with exterior steel elements or exterior fiber reinforced polymers to support the added vertical loads from overturning.

B. OPENINGS AT SHEAR WALLS: (ASCE Section 4.5.1.4) – " *Diaphragm openings immediately adjacent to the shear walls shall be less than 25% of the wall length for Life Safety and 15% of the wall length for Immediate Occupancy.*" Stair openings at the second floor along gridlines 1, 11, 12 and 23 in the North/South direction exceed the 25% maximum opening allowed for Life Safety.

RECOMMENDATION: Adhesive reinforcing dowels may need to be installed to strengthen the connections between the diaphragm and the concrete shear wall. Additionally, drag strut or collector elements that are adequately developed into the diaphragm beyond the wall may also be required. Collector elements may be provided by strengthening the existing concrete beams with bolted steel channels and welded rod assemblies as noted in item B above.

C. COUPLING BEAMS: (ASCE Section 4.4.2.2.3) – *"The stirrups in coupling beams over means of egress shall be spaced at or less than d/2 and shall be anchored into the confined core of the beam with hooks of 135º or more for Life Safety."* The coupling beam in the roof between the two long concrete shear walls along grid line 1 does not have stirrups meeting the d/2 spacing and are not anchored with 135 degree hooks as required for Life Safety.

RECOMMENDATION: Although the walls may be adequate to resist the lateral loads as two independent walls, damage to the coupling beam may result in falling debris that is a potential life safety hazard especially in locations of egress. Additionally, the coupling beam supports out-of-plane loading of the exterior storefront system which may be jeopardized by the failure of the beam. The performance of the coupling beam in a seismic event may be improved by applying an external fiber reinforced polymer system, and providing adequate ductile connections at each end to the concrete walls. These connections to the wall may be strengthened with bolted steel channel members.

D. GEOLOGIC SITE HAZARDS – LIQUEFACTION (ASCE Section 4.7.1.1) – "Liquefaction-susceptible, saturated, loose granular soils that could jeopardize the building's seismic performance shall not exist in the foundation soils at depths within 50 feet under the building for Life Safety and Immediate Occupancy." Although a soils report and geologic analysis for this site were not available, a liquefaction hazard study of the San Francisco Bay Area, published by the Association of Bay Area Governments (ABAG) does provide some indication of the liquefaction hazard. The liquefaction hazard map indicates the structure to be in an area of moderate liquefaction hazard (see Liquefaction Map in Appendix B).

RECOMMENDATION: Site specific geotechnical data would be entirely more accurate for determining if the site complies with Tier 1 criteria. Therefore, a comprehensive geotechnical investigation is recommended. The investigation would include exploratory borings to a minimum depth of 50 feet adjacent to the building to determine expected differential settlement of the soil due to seismic event liquefaction. Additional Tier 2 analysis may be required should the Tier 1 criterion not be met. Some significant foundation modifications could be required.

RELIABILITY OF SEISMIC EVALUATIONS

In general, structural engineers do not have the ability to predict the exact damage to a building as a result of an earthquake. There will be a wide variation of damage from building to building due to the variations in ground motion and varying types and quality of construction. In addition, engineers cannot predict the exact ground motions of the earthquake that may strike a given building. Design and evaluation of buildings are performed using standards such as ASCE 31, general guidelines, and information from past earthquakes. However, specific seismic events can differ greatly. The intent of engineers and the codes and standards used for design and evaluation has been to be conservative when attempting to ensure that building design meets minimum standards of life safety. This effort is based on science and technology as well as on observations made from actual seismic events. Building design and evaluation codes are constantly evolving to better meet performance targets based on this information. Continued research will improve predictive methods and facilitate performance-based engineering. It has been estimated that, given design ground motions, approximately five percent of new buildings and a slightly greater percent of retrofit buildings may fail to meet their expected performance.

CLOSING

The engineering checks and analyses associated with this evaluation were based on available original architectural and structural drawings, and the site reviews were based on that which was plainly visible. No attempt was made to uncover hidden conditions or perform any destructive or non-destructive testing. The items discussed in this report are subject to revision should more information become available.

This report is general in nature and does not imply that the recommendations listed above are the only structural requirements that must be made to the existing structure to meet current code criteria.

We understand you may have questions regarding this evaluation and are available for comment and explanations. Please call with any questions you may have. Thank you for choosing ZFA Structural Engineers to assist you with this building seismic review.

Christian S. Botto
Engineer
ZFA Structural Engineers

Chris Warner, SE 4613
Principal
ZFA Structural Engineers

APPENDIX A: Photographs

Photo 1: Exterior Side facing Taylor Street (South Side)

Photo 2: Exterior Side facing 8th Street (West Side)

Photo 3: Partial Interior

Photo 4: West wall cracks

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APPENDIX B:
Location Map, Liquefaction Susceptibility Map, and Building Plan

Building site location

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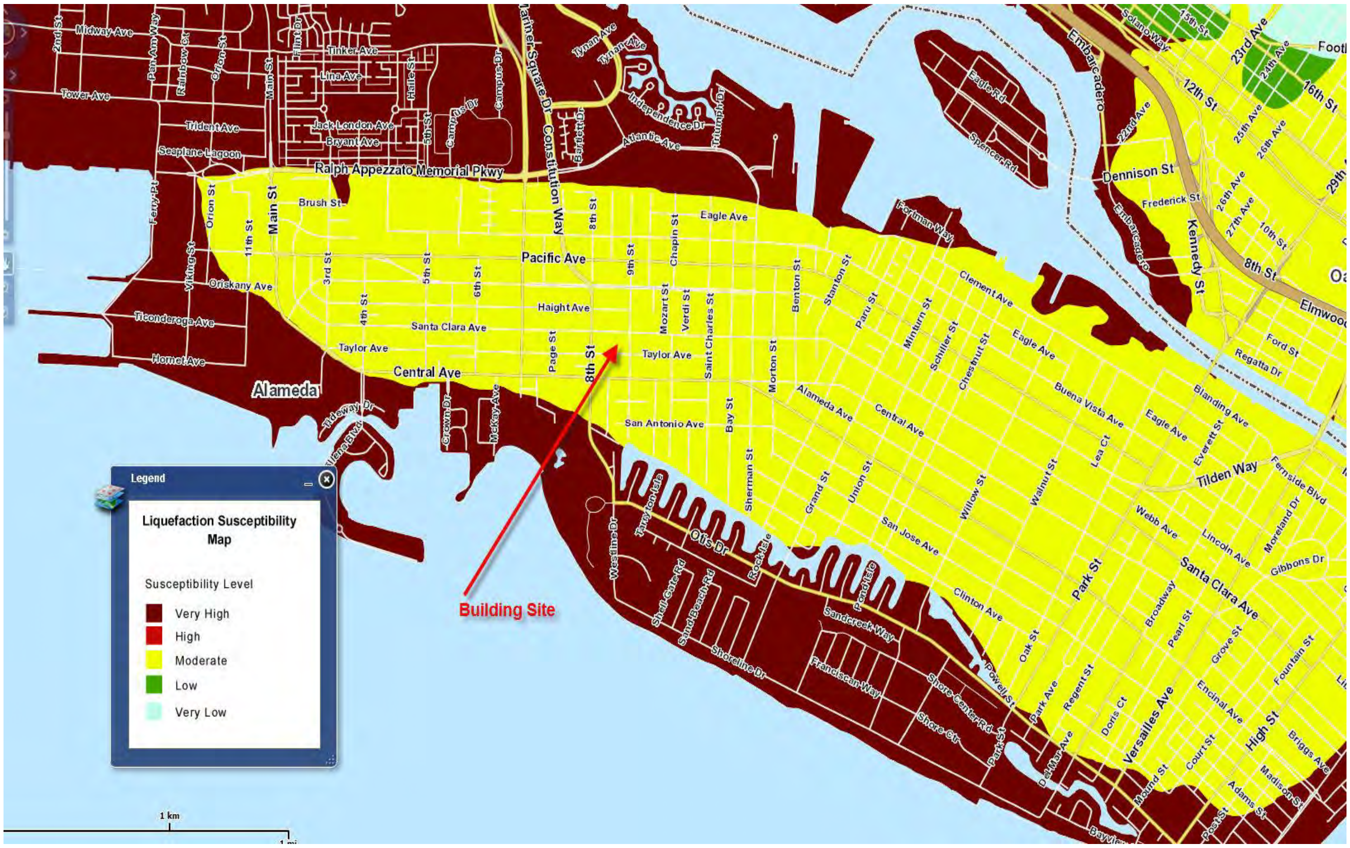

Liquefaction Susceptibility Map

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Alquist-Priolo Earthquake Fault Zone Map

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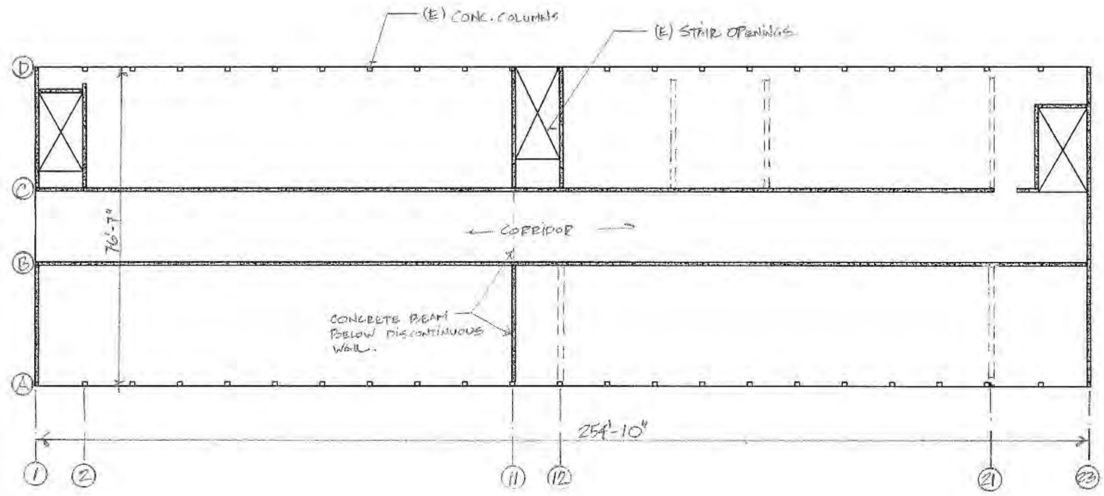
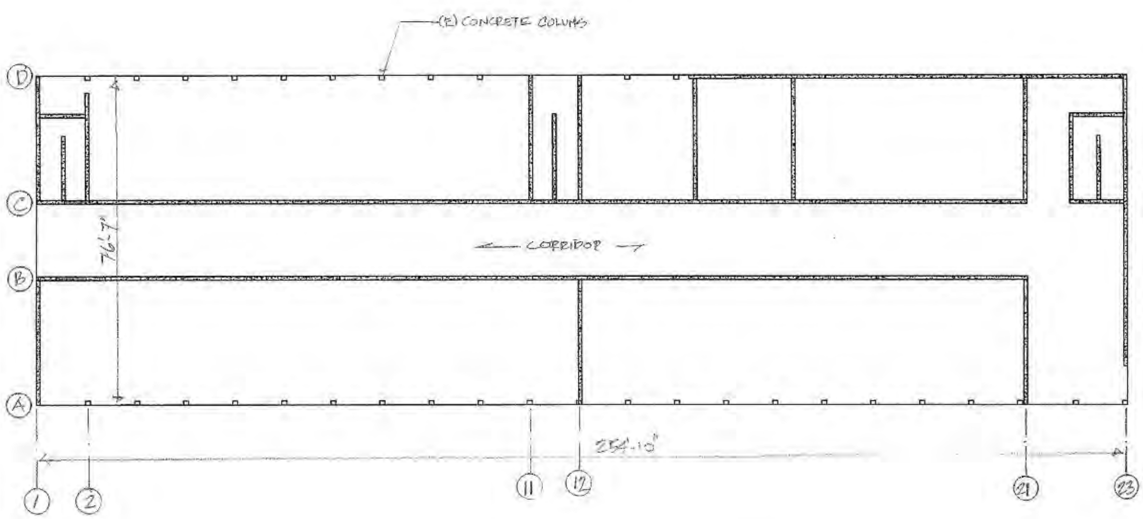


SECOND FLOOR KEY PLAN

Notes:

1. —Indicates reinforced cast in place concrete shear wall.

2. — INDICATE REINFORCED CONC. SHEAR WALL BELOW FLOOR.



FOUNDATION / 1ST FLOOR KEY PLAN

Notes:

1. Indicates reinforced cast in place concrete shear wall.

KEY PLANS

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APPENDIX: C
Earthquake Design Parameters

Location: 825 Taylor Ave, Alameda, CA 94501

Latitude: 37.7727

Longitude: -122.271

Site Class: D

Spectral Response Accelerations S_s and S_1 for Maximum Considered Earthquake (MCE) per ASCE 7-05 Standard:

S_s = Short period (0.2 sec) response acceleration
S_1 = Spectral response acceleration at a one second period
F_a = Site coefficient as a function of site class & S_a
F_v = Site coefficient as a function of site class & S_1

S_s = 1.50 g

S_1 = 0.60 g

F_a = 1.00

F_v = 1.50

S_a = Spectral acceleration

$S_a = S_{D1}/T < S_{DS}$

T = Fundamental period of the vibration of the building
$S_{DS} = 2/3 \times F_a \times S_s$
$S_{D1} = 2/3 \times F_v \times S_1$

T = .247 sec

S_{DS} = 1.0 g

S_{D1} = 0.60 g

S_a = 1.00 g

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APPENDIX D:
ASCE 31- 03 Summary Data Sheet
&
Tier 1 Checklists

ASCE 31-03 Seismic Evaluation of Existing Structures

Summary Data Sheet

BUILDING DATA

Building Name: Washington Elementary School: 2 story Classroom Building   Date: April 2012

Building Address: 825 Taylor Street, Alameda, CA 94501

Latitude: 37.7727   Longitude: -122.271   By:

Year Built: 1955   Year(s) Remodeled: 2001-Nonstructural   Original Design Code: 1949

Area (sf): 37,000   Length (ft): 255'   Width (ft): 76'

No. of Stories: 2   Story Height: 14.5   Total Height: 28

USE ☐ Industrial ☐ Office ☐ Warehouse ☐ Hospital ☐ Residential ☒ Educational ☐ Other:

CONSTRUCTION DATA

Gravity Load Structural System: Concrete slab and concrete beams supported on concrete bearing walls and concrete columns

Exterior Transverse Walls: Cast in Place concrete walls   Openings? yes

Exterior Longitudinal Walls: Cast in Place concrete walls and sotefront   Openings? yes

Roof Materials/Framing: Concrete slab supported on cast in place concrete beams

Intermediate Floors/Framing: Cast in place concrete

Ground Floor: concrete slab on grade

Columns: Cast in place concrete   Foundation: concrete spread footings

General Condition of Structure: Good

Levels Below Grade? None

Special Features and Comments

LATERAL-FORCE-RESISTING SYSTEM

	Longitudinal	Transverse
System:	Cast in place reinforced concrete shear walls	Cast in place reinforced concrete shear walls
Vertical Elements:	Conrete shear walls and concrete columns	Conrete shear walls and concrete columns
Diaphragms:	Cast in place reinforced concrete slab	Cast in place reinforced concrete slab
Connections:	Steel reinforcing bars	Steel reinforcing bars

EVALUATION DATA

Spectral Response Accelerations: S_S = 1.50g S_1 = .60g

Soil Factors: Class = D F_a = 1.00 F_v = 1.50

Design Spectral Response Accelerations S_{DS} = 1.0g S_{D1} = .60g

Level of Seismicity: HIGH   Performance Level: Life Safety

Building Period: T = .247

Spectral Acceleration: S_a = 1.0g

Modification Factor: C = 1.20   Building Weight: W= Approx. 7,514 k

Pseudo Lateral Force: $V=C\,S_aW=$ 9,017 k

BUILDING CLASSIFICATION: C2

REQUIRED TIER 1 CHECKLISTS

	Yes	No
Basic Structural Checklist	☒	☐
Supplemental Structural Checklist	☒	☐
Geologic Site Hazards and Foundations Checklist	☐	☒
Basic Nonstructural Component Checklist	☐	☒
Intermediate Nonstructural Checklist	☐	☒
Supplemental Nonstructural Checklist	☐	☒

FURTHER EVALUATION REQUIREMENT:

3.7.9 BASIC STRUCTURAL CHECKLIST FOR BUILDING TYPE C2: CONCRETE SHEAR WALL BUILDINGS WITH RIGID OR STIFF DIAPHRAGMS

This Basic Structural Checklist shall be completed when required by Table 3-2.

Each of the evaluation statements on this checklist shall be marked compliant (C), non-compliant (NC), or not applicable (N/A) for a Tier 1 Evaluation. Compliant statements identify issues that are acceptable according to the criteria of this standard, while non-compliant statements identify issues that require further investigation. Certain statements may not apply to the buildings being evaluated. For non-compliant evaluation statements, the design professional may choose to conduct further investigation using the corresponding Tier 2 evaluation procedure; the section numbers in parentheses following each evaluation statement correspond to Tier 2 evaluation procedures.

C3.7.9 Basic Structural Checklist for Building Type C2

These buildings have floor and roof framing that consists of cast-in-place concrete slabs, concrete beams, one-way joists, two-way waffle joists, or flat slabs. Floors are supported on concrete columns or bearing walls. Lateral forces are resisted by cast-in-place concrete shear walls. In older construction, shear walls are lightly reinforced, but often extend throughout the building. In more recent construction, shear walls occur in isolated locations and are more heavily reinforced with boundary elements and closely spaced ties to provide ductile performance. The diaphragms consist of concrete slabs and are stiff relative to the walls. Foundations consist of concrete spread footings or deep pile foundations, or deep foundations.

C	NC	N/A		COMMENT
			BUILDING SYSTEM	
☒	☐	☐	LOAD PATH: The structure shall contain a minimum of one complete load path for Life Safety and Immediate Occupancy for seismic force effects from any horizontal direction that serves to transfer the inertial forces from the mass to the foundation. (Tier 2: Sec. 4.3.1.1)	
☐	☐	☒	MEZZANINES: Interior mezzanine levels shall be braced independently from the main structure, or shall be anchored to the lateral-force-resisting elements of the main structure. (Tier 2: Sec. 4.3.1.3)	No interior mezzanines present
☒	☐	☐	WEAK STORY: The strength of the lateral-force-resisting system in any story shall not be less than 80% of the strength in an adjacent story, above or below, for Life-Safety and Immediate Occupancy. (Tier 2: Sec. 4.3.2.1)	
☒	☐	☐	SOFT STORY: The stiffness of the lateral-force-resisting system in any story shall not be less than 70% of the lateral-force-resisting system stiffness in an adjacent story above or below, or less than 80% of the average lateral-force-resisting system stiffness off the three stories above or below for Life Safety and Immediate Occupancy. (Tier 2: Sec. 4.3.2.2)	

3.7.9 BASIC STRUCTURAL CHECKLIST FOR BUILDING TYPE C2: CONCRETE SHEAR WALL BUILDINGS WITH RIGID OR STIFF DIAPHRAGMS

C	NC	N/A		COMMENT
☒	☐	☐	GEOMETRY: There shall be no changes in horizontal dimension of the lateral-force-resisting system of more than 30% in a story relative to adjacent stories for Life Safety and Immediate Occupancy, excluding one-story penthouses and mezzanines. (Tier 2: Sec. 4.3.2.3)	
☐	☒	☐	VERTICAL DISCONTINUITIES: All vertical elements in the lateral-force-resisting system shall be continuous to the foundation. (Tier 2: Sec. 4.3.2.4)	
☒	☐	☐	MASS: There shall be no change in effective mass more than 50% from one story to the next for Life Safety and Immediate Occupancy. Light roofs, penthouses and mezzanines need not be considered. (Tier 2: Sec. 4.3.2.5)	
☒	☐	☐	TORSION: The estimated distance between the story center of mass and the story center of rigidity shall be less than 20% of the building width in either plan dimension for Life Safety and Immediate Occupancy. (Tier 2: Sec. 4.3.2.6)	
☒	☐	☐	DETERIORATION OF CONCRETE: There shall be no visible deterioration of concrete or reinforcing steel in any of the vertical- or lateral-force-resisting elements. (Tier 2: Sec. 4.3.3.4)	
☐	☐	☒	POST-TENSIONING ANCHORS: There shall be no evidence of corrosion or spalling in the vicinity of post-tensioning or end fittings. Coil anchors shall not have been used. (Tier 2: Sec. 4.3.3.5)	No Post-tensioning anchors
☒	☐	☐	CONCRETE WALL CRACKS: All existing diagonal cracks in wall elements shall be less than 1/8" for Life Safety and 1/16" for Immediate Occupancy, shall not be concentrated in one location, and shall not form an X pattern. (Tier 2: Sec. 4.3.3.9)	Small cracks were observed at the west exterior concrete wall, however, the cracks appear to be less than 1/8" in width. See photo 4 in App A.

3.7.9 BASIC STRUCTURAL CHECKLIST FOR BUILDING TYPE C2: CONCRETE SHEAR WALL BUILDINGS WITH RIGID OR STIFF DIAPHRAGMS

C	NC	N/A		COMMENT
			LATERAL FORCE RESISTING SYSTEM	
☒	☐	☐	COMPLETE FRAMES: Steel or concrete frames classified as secondary components shall form a complete vertical load carrying system. (Tier 2: Sec. 4.4.1.6.1)	
☒	☐	☐	REDUNDANCY: The number of lines of shear walls in each principal direction shall be greater than or equal to 2 for Life Safety and Immediate Occupancy. (Tier 2: Sec. 4.4.2.1.1)	
☒	☐	☐	SHEAR STRESS CHECK: The shear stress in the concrete shear walls, calculated using the Quick Check procedure of Section 3.5.3.3, shall be less than the greater of 100 psi or $2\sqrt{f'c}$ for Life Safety and Immediate Occupancy. (Tier 2: Sec. 4.4.2.2.1)	
☒	☐	☐	REINFORCING STEEL: The ratio of reinforcing steel area to gross concrete area shall be not less than 0.0015 in the vertical direction and 0.0025 in the horizontal direction for Life Safety and Immediate Occupancy. The spacing of reinforcing steel shall be equal to or less than 18” for Life Safety and Immediate Occupancy. (Tier 2: Sec. 4.4.2.2.2)	
			CONNECTIONS	
☒	☐	☐	TRANSFER TO SHEAR WALLS: Diaphragms shall be connected for transfer of loads to the shear walls for Life Safety and the connections shall be able to develop the lesser of the shear strength of the walls for Immediate Occupancy. (Tier 2: Sec. 4.6.2.1)	
☒	☐	☐	FOUNDATION DOWELS: Wall reinforcement shall be doweled into the foundation for Life Safety and the dowels shall be able to develop the lesser of the strength of the walls or the uplift capacity of the foundation for Immediate Occupancy. (Tier 2: Sec. 4.6.3.5)	

3.7.9S SUPPLEMENTAL STRUCTURAL CHECKLIST FOR BUILDING TYPE C2: CONCRETE SHEAR WALL BUILDINGS WITH RIGID OR STIFF DIAPHRAGMS

This Supplemental Structural Checklist shall be completed when required by Table 3-2. The Basic Structural Checklist shall be completed prior to completing this Supplemental Structural Checklist.

C	NC	N/A		COMMENT
			LATERAL FORCE RESISTING SYSTEM	
☒	☐	☐	DEFLECTION COMPATIBILITY: Secondary components shall have the shear capacity to develop the flexural strength of the components for Life Safety and shall meet the requirements of 4.4.1.4.9, 4.4.1.4.10, 4.4.1.4.11, 4.4.1.4.12, and 4.4.1.4.15 for Immediate Occupancy. (Tier 2: Sec. 4.4.1.6.2)	Due to the number and long lengths of the concrete shear walls, the building drift is expected to be small, therefore secondary component deflections are in compliance with this check.
☐	☐	☒	FLAT SLABS: Flat slabs/plates not part of lateral-force-resisting system shall have continuous bottom steel through the column joints for Life Safety and Immediate Occupancy. (Tier 2: Sec. 4.4.1.6.3)	Slabs are part of the lateral force resisting system.
☐	☒	☐	COUPLING BEAMS: The stirrups in coupling beams over means of egress shall be spaced at or less than d/2 and shall be anchored into the confined core of the beam with hooks of 135º or more for Life Safety. All coupling beams shall comply with the requirements above and shall have the capacity in shear to develop the uplift capacity of the adjacent wall for Immediate Occupancy. (Tier 2: Sec. 4.4.2.2.3)	Coupling beam at roof along grid line 1 does not have stirrups meeting the d/2 spacing and are not anchored with 135 degree hooks as required for Life Safety.
☐	☐	☒	OVERTURNING: All shear walls shall have aspect ratios less than 4 to 1. Wall piers need not be considered. This statement shall apply to the Immediate Occupancy Performance Level only. (Tier 2: Sec. 4.4.2.2.4)	NA- Limited to Life Safety
☐	☐	☒	CONFINEMENT REINFORCING: For shear walls with aspect ratios greater than 2 to 1, the boundary elements shall be confined with spirals or ties with spacing less than $8d_b$. This statement shall apply to the Immediate Occupancy Performance Level only. (Tier 2: Sec. 4.4.2.2.5)	NA- Limited to Life Safety
☐	☐	☒	REINFORCING AT OPENINGS: There shall be added trim reinforcement around all wall openings with a dimension greater than three times the thickness of the wall. This statement shall apply to the Immediate Occupancy Performance Level only. (Tier 2: Sec. 4.4.2.2.6)	NA- Limited to Life Safety

3.7.9S SUPPLEMENTAL STRUCTURAL CHECKLIST FOR BUILDING TYPE C2: CONCRETE SHEAR WALL BUILDINGS WITH RIGID OR STIFF DIAPHRAGMS

C	NC	N/A		COMMENT
☐	☐	☒	WALL THICKNESS: Thickness of bearing walls shall not be less than 1/25 the unsupported height or length, whichever is shorter, nor less than 4". This statement shall apply to the Immediate Occupancy Performance Level only. (Tier 2: Sec. 4.4.2.2.7)	NA- Limited to Life Safety
			DIAPHRAGMS	
☒	☐	☐	DIAPHRAGM CONTINUITY: The diaphragm shall not be composed of split-level floors and shall not have expansion joints. (Tier 2: Sec. 4.5.1.1)	
☐	☒	☐	OPENINGS AT SHEAR WALLS: Diaphragm openings immediately adjacent to the shear walls shall be less than 25% of the wall length for Life Safety and 15% of the wall length for Immediate Occupancy. (Tier 2: Sec. 4.5.1.4)	Stair openings at the second floor along gridlines 1, 11,12 and 23 in the North/South direction exceed the 25% maximum opening allowed for Life Safety.
☐	☐	☒	PLAN IRREGULARITIES: There shall be tensile capacity to develop the strength of the diaphragm at re-entrant corners or other locations of plan irregularities. This statement shall apply to the Immediate Occupancy Performance Level only. (Tier 2: Sec. 4.5.1.7)	NA- Limited to Life Safety
☐	☐	☒	DIAPHRAGM REINFORCEMENT AT OPENINGS: There shall be reinforcing around all diaphragm openings larger than 50% of the building width in either major plan dimension. This statement shall apply to the Immediate Occupancy Performance Level only. (Tier 2: Sec. 4.5.1.8)	NA- Limited to Life Safety
			CONNECTIONS	
☐	☐	☒	UPLIFT AT PILE CAPS: Pile caps shall have top reinforcement and piles shall be anchored to the pile caps for Life Safety, and the pile cap reinforcement and pile anchorage shall be able to develop the tensile capacity of the piles for Immediate Occupancy. (Tier 2: Sec. 4.6.3.10)	Not Applicable

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APPENDIX E:
ASCE 31- 03 Tier 1 Quick Checks

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ROOF DEAD LOADS.

ROOF'G (COMP ROOF)	6 PSF.
3" THICK CONC. SLAB	37.5
5⅝ x 14 RJ's @ 3'-0" o/c	27.3
ACOUST. TILE CLG + SUSP. SYS.	2.0
MEP (ASSUMED)	2.5
CONC. BRIDGING (4x14) @ 12' o/c.	5.0
MISC + PART	4.7
TRDL =	85 PSF

TYP. COL LOAD 2ND to ROOF:

$(1'-0")(1'-2")(150)(12.5/2) = 1094^{\#}$

ROOF SPANDREL

$(2')(1')(150)(2) = 600^{\#/'}$ LINE A & D.

TYP. 9" THICK CONC. WALL $= (\frac{9}{12})(150)(14.5/2) = 816^{\#/'}$ 10" WALL = $906.3^{\#/'}$

TYP. STOREFRONT $= (20 \text{ PSF})(14.5/2) = 145^{\#/'}$

SECOND FLR DEAD LOADS:

FLOOR'G (ASSUME LINOLEUM)	1.5 PSF
3" THICK CONC. SLAB	37.5
5⅝x6" JOISTS @ 3'-0" o/c.	12
14x24" CONC. BMS @ 11.5' o/c.	30.4
ACOUST. TILE + SUSP SYS.	2.0
MISC + PART.	6.6
T2DL =	90 PSF

TYP COL. LOAD (2-R & 1-2)

$1094^{\#} + (1.0)(1.17)(150)(14/2) = 2319^{\#}$

2ND FLOOR SPANDREL

$(\frac{10 \times 25}{144})(150)(2) = 521^{\#/'}$ LINES A & D 10" CONC = $1781^{\#/'}$

9" CONC. $= (9/12)(150)(28.5/2) = 1603.1^{\#/'}$; TYP. STOREFRONT $= (20)(28.5/2) = 285^{\#/'}$

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DETERMINE CENTER OF MASS @ ROOF

$$\bar{X} = \frac{\Sigma W_i x_i}{\Sigma W_i}$$

$W_R = (.085)(254.83)(76.58') = 1659^k$

$W_{CA's} = (1.094^k)(42\ CA's) = 46^k$

$W_{PT.\text{-}SPANDREL} = (.60)(253' \times 2) = 303.6^k$

$W_{\perp\ CONC.\ WALLS} = (.906)(253' \times 2) = 458^k$

$W_{\perp\ STOREFRONT\ WALLS} = (.145)(253' \times 2) = 73.4^k$

$W_{ROOF} = 1659 + 46 + 303.6 + 458 + 73.4 = \underline{\underline{2540^k}}$

$W_1 = (.906)(33' \times 2) = 60k$

$W_2 = (.816)(26') = 21.2^k$

$W_3 = (.816)(30 \times 2) = 49^k$

$W_4 = (.816)(30') = 24.5^k$

$W_5 = (.816)(30') = 24.5^k$

$W_6 = (.906)(78') = 70.7^k$

$W_7 = (.816)(11.5) = 9.4^k$

$W_8 = (.816)(11.5) = 9.4^k$

$$\Sigma W_i x_i = \underbrace{(2540)(127.4')}_{W_R} + \underbrace{(21.2)(12)}_{W_2} + \underbrace{(49)(116.5)}_{W_3} + \underbrace{(24.5)(12.7')}_{W_4} + \underbrace{(24.5)(243.5)}_{W_5} +$$
$$+ \underbrace{(70.7)(254.5')}_{W_6} + \underbrace{(9.4)(6')}_{W_7} + \underbrace{(9.4)(249)}_{W_8} + \underbrace{(60)(0)}_{W_1} = 359{,}0263^{k'}$$

$\Sigma W_i = 2809^k$

$$\bar{X} = \frac{359{,}0263}{2809} = 128'$$

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CENTER OF MASS @ ROOF, CONT'D.

$$\Sigma W_i y_i = (2540)(38') + \underbrace{(30)(59.5) + (30)(15.5)}_{W_1} + \underbrace{(21.2)(58')}_{W_2} + \underbrace{(24.5)(59.5) + (24.5)(15.5)}_{W_3}$$

$$\underbrace{(24.5)(61)}_{W_4} + \underbrace{(24.5)(61)}_{W_5} + \underbrace{(70.7)(38')}_{W_6} + \underbrace{(9.4)(68)}_{W_7} + \underbrace{(9.4)(68)}_{W_8} = 108,762.9^{\#}$$

$$\bar{Y} = \frac{108,762.9}{2809} = \underline{\underline{38.72'}}$$

TYP. WALL RIGIDITY CALC.

– ASSUME

E = 1097.7 ksi (f'_c = 3000 psi w/ .35 CRACKED PROP. FACTOR)

G = 1357.4

- ASSUME 1k OF LOAD

Ht = 14'-0"

t = 9"

L = 30'

$$I = \left(\frac{9 \times 360^3}{12}\right) = 34,992,000 \text{ in}^4$$

$$A = (9)(360") = 3240 \text{ in}^2$$

$$\Delta = \frac{h^3}{3EI} + \frac{1.2h}{AG} = \frac{(14 \times 12)^3}{(3)(1098)(34,992,000)} + \frac{(1.2)(168)}{(3240)(1357)} = 0.0000870$$

RIGIDITY = $1/\Delta$ = 11,496

ROOF CENTER OF RIGIDITY

CRY (WALLS IN THE **X DIRECTION**)

WALL	Description	Rx	Y	Rx*Y
7		136.40	68.00	9275.20
8		136.40	65.00	8866.00
9		85830.00	45.00	3862350.00
10		85830.00	33.50	2875305.00
				0.00
				0.00
				0.00
				0.00
				0.00
				0.00
SUM		171932.80		6755796.20
			CRY=	39.3 ft.

CRX (WALLS IN THE **Y DIRECTION**)

WALL	Description	Ry	X	Ry*X
1.1		3202.00	0.00	0.00
1.2		3202.00	0.00	0.00
2		1554.30	12.00	18651.60
3.1		2262.20	116.50	263546.30
3.2		2262.20	116.50	263546.30
4		2262.20	127.00	287299.40
5		1554.30	243.50	378472.05
6		19064.00	254.50	4851788.00
				0.00
				0.00
SUM		35363.20		6063303.65
			CRX=	171.5 ft.

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Floor CENTER OF MASS

Building Overall Dimensions	X=	254.8 ft.
	Y=	76.0 ft.

ITEM	WEIGHT	cmx	cmy	W*cmx	W*cmy
Floor	2921	127	38	372097	110987
W1.1	59	0	61	0	3570
W1.2	59	0	15	0	885
W2	21	6	55	125	1144
W3	42	12	58	499	2413
W4	48	117	60	5592	2880
W4.1	25	117	15	2854	368
W5	35	122	57	4287	2006
W6.1	48	127	61	6096	2904
W6.2	25	127	15	3112	368
W7	25	154	61	3773	1482
W8	25	177	61	4337	1482
W9.1	25	231	61	5660	1482
W9.2	27	231	15	6283	408
W10	35	243	56	8536	1954
W11	13	249	55	3255	721
W12	119	255	43	30401	5070
W13	18	6	68	106	1197
W14	18	249	66	4374	1162
W15	411	116	45	47494	18298
W16	19	249	45	4781	854
W17	411	116	32	47494	12953
W18	82	205	76	16714	6202
W north col + storefront	74	77	76	5698	5624
W South col + storefront	123	127	0	15683	0
				0	0
				0	0
				0	0
				0	0
	4705			599249	186412

$$\bar{X}_{CM} = \frac{599,249}{4705} = 127.4'$$

$$\bar{Y}_{CM} = \frac{186,412}{4705} = 39.6'$$

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SECOND FLOOR CENTER OF RIGIDITY

CRY (WALLS IN THE **X DIRECTION**)

WALL	Description	Rx	Y	Rx*Y
W1.1		0.00	61	0.00
W1.2		0.00	15	0.00
W2		0.00	55	0.00
W3		0.00	58	0.00
W4		0.00	60	0.00
W4.1		0.00	15	0.00
W5		0.00	57	0.00
W6.1		0.00	61	0.00
W6.2		0.00	15	0.00
W7		0.00	61	0.00
W8		0.00	61	0.00
W9.1		0.00	61	0.00
W9.2		0.00	15	0.00
W10		0.00	56	0.00
W11		0.00	55	0.00
W12		0.00	43	0.00
W13		1038.00	68	70584.00
W14		1038.00	66	68508.00
W15		183846.00	45	8181147.00
W16		1315.00	45	58517.50
W17		183846.00	32	5791149.00
W18		67259.00	76	5111684.00
				0.00
				0.00
				0.00
				0.00
				0.00
				0.00
				0.00
SUM		438342.00		19281589.50
			CRY=	**44.0 ft.**

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CRX (WALLS IN THE **Y DIRECTION**)

WALL	Description	Ry	X	Ry*X
W1.1		15278.00	0	0
W1.2		15278.00	0	0
W2		1629.00	6	9774
W3		8592.00	12	103104
W4		11471.00	117	1336371.5
W4.1		0.00	117	0
W5		5976.00	122	727876.8
W6.1		11471.00	127	1456817
W6.2		11471.00	127	1456817
W7		11471.00	154	1766534
W8		11471.00	177	2030367
W9.1		11471.00	231	2649801
W9.2		11471.00	231	2649801
W10		5976.00	243	1449180
W11		2790.00	249	693315
W12		45846.00	255	11682936.18
W13		0.00	6	0
W14		0.00	249	0
W15		0.00	116	0
W16		0.00	249	0
W17		0.00	116	0
W18		0.00	205	0
				0
				0
				0
				0
				0
				0
				0
				0
				0
SUM		181662.00		28012694.48
			CRX=	**154.2 ft.**

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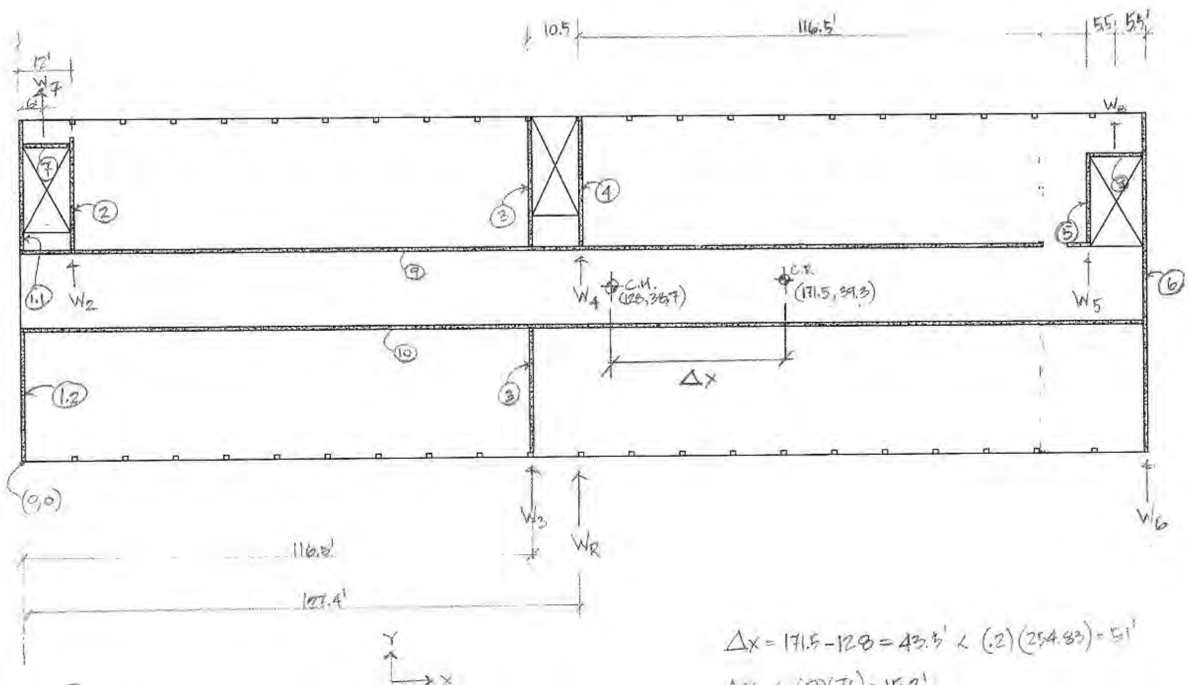
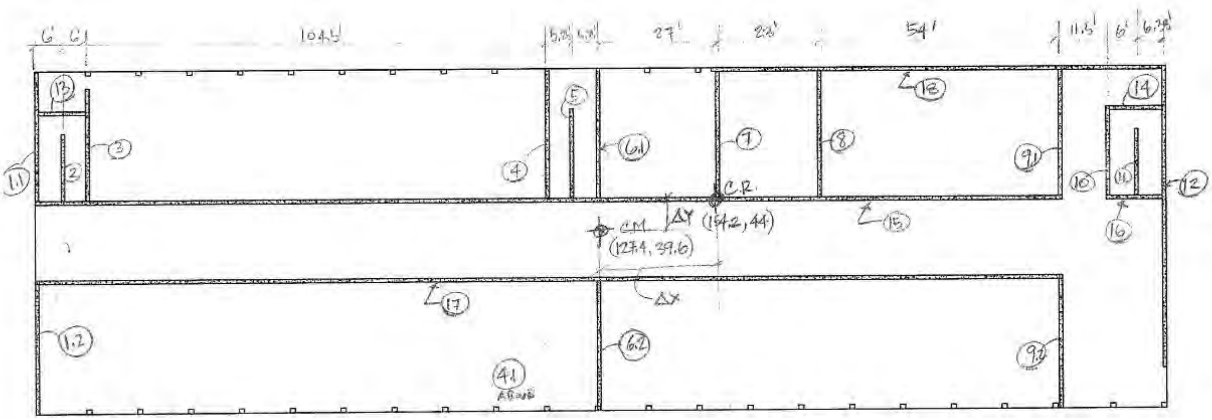


$\Delta x = 171.5 - 128 = 43.5' < (.2)(254.83) = 51'$

$\Delta Y < (.2)(76) = 15.2'$

Roof Diaph



2nd Floor Diaph.

$\Delta Y = 44 - 39.6 = 4.4' < (.20)(76) = 15.2'$

$\Delta x = 154.2 - 127.4 = 26.8' < (.2)(254.83) = 51'$

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SHEAR STRESS CHECK PER § 3.5.3.3 :

PER VERT. DISTRIBUTION ROOF = 55% OF LOAD
FLOOR = 45% OF TOTAL BASE SHEAR

$S_a = S_{DS} = 1.0$

$C = 1.2$ (C2 TYPE BLDG)

$T = 0.020(28.5)^{.75} = 0.247$ s

$V = (1.2)(1.0)(2809 + 4705) = 9{,}017^k$

$V_R = (9{,}017)(.55) = 4959^k$

$V_2 = (9017)(.45) = 4058^k$

$m = 4.0$

ROOF SHEARWALLS N/S-DIRECTION (MOST CRITICAL)

$A_w = (10)(35 \times 2)(12) + (9)(26 \times 12) + (9)(60 \times 12) + (9)(30 \times 12) + (9)(30 \times 12) +$
$(10)(78 \times 12) = 32{,}808$ in²

$v_j = \frac{1}{4}\left(\frac{4959}{32{,}808}\right) = 0.038 = 38$ psi < 100 psi
OR $2\sqrt{3000} = 109$ psi

LOWER WALLS N/S DIRECTION:

$A_w = (10)(66)(12) + (9)(13 \times 12) + (9)(36 \times 12) + (9)(30)(12)(7\text{ walls})$
$+ (9)(22 \times 12) + (9)(22 \times 12) + (9)(16 \times 12) + (10)(67 \times 12) = 49{,}332$ in²

$v_j = \frac{1}{4}\left(\frac{4059^k}{49{,}332}\right) = 0.046 = 46$ psi < 100 psi ∴ OK

LOWER WALLS E/W DIRECTION

$A_w = (10)(231 \times 12)(2) + (9)(100 \times 12) = 66{,}240$ in² > 49,332 in²
∴ OK

CHECK STL REINF. RATIOS:

10" THICK CONC. VERT #4 @ 16" o/c EA. FACE
HORIZ #4 @ 16" o/c EA. FACE

$$\rho_V = \frac{(0.15 \text{ in}^2)(2)}{(10)(12)} = 0.0025 > \rho_{min} = .0015$$

$$\rho_H = 0.0025 = \rho_{min} = 0.0025 \quad \text{ok}$$

MAX SPCG = 16" < 18" ok

9" THICK CONC. VERT & HORIZ #4 @ 16" o/c EA FACE

$$\rho_V = \rho_H = \frac{(.2)(12/16)(2)}{(9")(12)} = 0.0025 \quad \therefore \text{ok}$$

MAX SPCG = 16" ok

11" THICK VERT & HORIZ #4 @ 14" o/c EA FACE

$$\rho_V = \rho_H = \frac{(.2)(12/14)(2)}{(11)(12)} = 0.0026 \quad \text{ok}$$

12" THICK VERT & HORIZ #4 @ 12" o/c

$$\rho_V = \rho_H = \frac{(.2)(2)}{(12)(12)} = 0.0028 \quad \text{ok}$$