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31 October 2014

Seismic Evaluation of the Santa Cruz Downtown Library

224 Church St.
Santa Cruz, California

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Executive Summary

A seismic evaluation was made of the Santa Cruz Downtown Library at 224 Church Street in Santa Cruz in accordance with ASCE/SEI 31-03, Seismic Evaluation of Existing Buildings. This standard was applied as follows:

1. A Tier 1 Screening and Tier 2 Evaluation were made of the primary structural and non-structural elements of the building.
2. The strengths for existing materials are those given on the original drawings or, when not provided, are the default values given in ASCE 31-03 Section 2.2.
3. The level of performance for which the structure was evaluated is Life Safety as indicated in ASCE 31-03 Section 2.4
4. The level of seismicity is High per ASCE-31-03 Table 2-1. The Building Type is C2 – Concrete Shear Wall building above the second floor and RM2 – Masonry Shear Wall building at first floor level.

Significant findings of the ASCE 31-03 Tier 1 Screening are:

Structural Elements:

- The perimeter beams at the low roof level of the main building have significantly high bending moment and shear.
- There is a discontinuity in the main building between the second floor concrete wall bracing and the masonry wall bracing below (there is a 15'-6" horizontal offset on all four sides).
- No other structural issues were found in the main building or service building.

Nonstructural Elements:

- Some interior partitions in the main building appear to be braced at the top by the suspended ceiling grid and are not separately braced to the structure above.
- Some of the free-standing shelving in the main building (shelving not against a wall) are not anchored or braced.
- Fire suppression piping in the lobby of the main building could not be viewed (hidden above a gypsum board ceiling).
- Areas with gypsum board ceilings in the main building could not be viewed from above to determine if these areas are braced to the floor or roof above; however, most areas of gypsum board ceiling are small and are supported by walls on all sides, and are unlikely to represent a life safety hazard.
- In areas where the suspended ceiling grid and acoustic ceiling tiles have been replaced (typically a 2' x 2' grid), the grid is braced and tiles have seismic clips; however, in areas where the grids have not been replaced (typically a 2' x 4'

grid), there is no bracing and no seismic clips. The unbraced areas include smaller rooms within the main building and virtually the entire service building.

- In the service building, light fixtures supported by the suspended ceiling grid do not have independent support to the structure above.

- Large panes of glass in the main building are typically not safety glazing, except where they have been replaced due to breakage (i.e., near main entry).

Conclusions and recommendations from the ASCE 31-03 Tier 2 Evaluation are:

Structural Elements:

Based on the Tier 1 Screening and Tier 2 Evaluation findings, the structural elements of the building are adequate with the exception of:

- Two outer beams on the south side of the building, over windows near the center of each beam, have shear load exceeding their capacity. It is recommended that this deficiency be mitigated. Although it is beyond the scope of this evaluation to further investigate this deficiency or propose specific mitigation measures, it is apparent that one simple solution has the potential of mitigating the above-mentioned deficiency – infill the windows with CMU at the two locations. See Figures 7 and 8 of the evaluation.

Nonstructural Elements:

Based on the Tier 1 Screening and Tier 2 Evaluation findings, the nonstructural elements of the building are adequate with the exception of:

- Original unbraced suspended ceiling grids are not adequately braced and should either be replaced or braced. Additionally, where partitions are presently braced by such ceilings, independent bracing should be provided for those partitions.

- At original suspended ceiling grid locations, ceiling tiles should be provided with seismic retainer clips and light fixtures should be provided within independent vertical support from at least two diagonal corners.

- Unanchored free-standing shelving in the main building should be anchored to the floor.

- Destructive investigation (not included within this evaluation) is recommended for review of bracing for the fire suppression piping in the ceiling cavity of the lobby of the Main Building. If this piping is found to be unbraced, bracing should be added to mitigate damage in an earthquake.

- The large full-height panes of glass in the main building are typically not made from safety glazing, except where these have been replaced due to breakage (i.e., near main entry). The building is relatively stiff; if the as-installed windows have frames that can absorb up to 3/8" of lateral deformation of the surrounding structure, then breakage from a large quake is unlikely; however, if the window panes are tightly fitted in the frames, replacement or modification of the glazing and/or frames should be considered.

Seismic Evaluation of the Santa Cruz Downtown Library

A seismic evaluation was made of the Santa Cruz Downtown Library at 224 Church Street in Santa Cruz in accordance with ASCE/SEI 31-03, Seismic Evaluation of Existing Buildings. This standard was applied as follows:

1. A Tier 1 Screening and a Tier 2 Evaluation were made of the primary structural and non-structural elements of the building.

2. The strengths for existing materials are those given on the original drawings or, when not provided, are the default values given in ASCE 31-03 Section 2.2.

3. The level of performance for which the structure was evaluated is Life Safety as indicated in ASCE 31-03 Section 2.4

4. The level of seismicity is High per ASCE-31-03 Table 2-1. The Building Type is C2 – Concrete Shear Wall building above the second floor and RM2 – Masonry Shear Wall building at first floor level.

The Tier 1 Screening for Life Safety includes the following checklists:

- Basic structural for RM2 and C2 building types
- Supplemental Structural for RM2 and C2 building types
- Geologic Site Hazard and Foundation
- Basic Nonstructural
- Intermediate Nonstructural

The Tier 1 Screening indicates that a full Tier 2 Evaluation is not required for this building (Table 3-3, C2 building less than 6 stories). Any deficiencies found will be reported in this evaluation but will not be further reviewed.

The Tier 1 Analysis was done per ASCE 31-03 Section 3.5. The Tier 2 Analysis was done per ASCE 31-03 Section 4.0.

Building Description

The Main Building is approximately trapezoidal in shape, 145' wide at the north end, 134' wide at the south end and 176' long. It is two stories in height, with the second story set back 15'-6" from the perimeter of the first story on all four sides. A one story Service Building, 36' x 81', is attached to the north half of the east side of the Main Building with a one story connecting link, 18' x 48'.

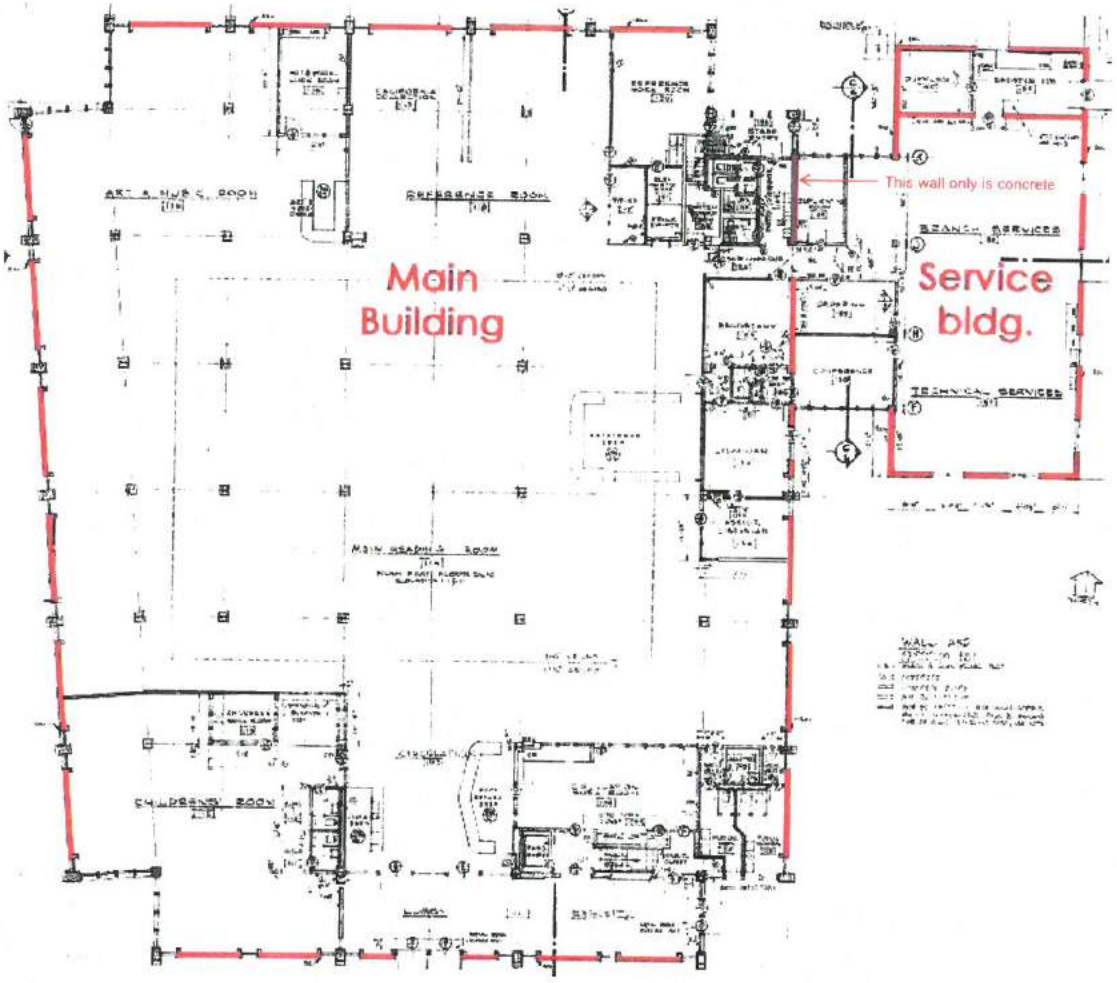


Figure 1. First Floor Plan
First floor bearing and shear walls, consisting of 8" reinforced concrete masonry units, are highlighted in red.

Perimeter columns of the Main Building and interior columns of the Service Building are constructed with reinforced concrete. Interior columns of the Main Building are constructed with steel. Foundations consist of continuous and isolated reinforced concrete footings and the first floor consists of a concrete slab on grade.

The first floor perimeter and interior bearing and shear walls are constructed of 8" nominal concrete masonry units (CMU), fully grouted and reinforced typically with #4 @ 32" vertically and #4 @ 16" horizontally. The walls extend approximately 10' above the floor level and are doweled to the low roof reinforced concrete beam above.

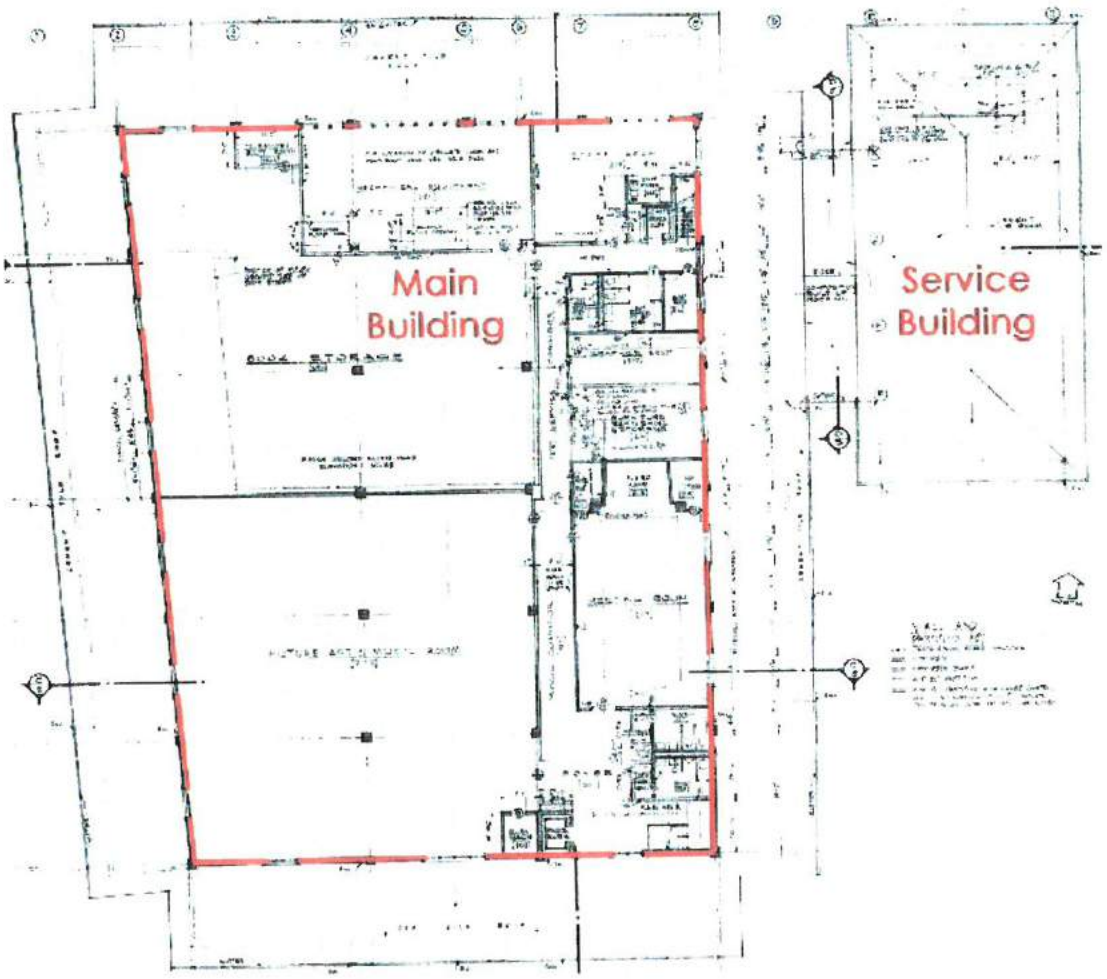


Figure 2. Second Floor / Low Roof Plan
Second floor shear walls, consisting of 8" reinforced concrete, are highlighted in red.

The second floor of the Main Building consists of steel framing composite with a structural reinforced concrete slab. The surrounding low roof area consists of a structural reinforced concrete slab. Large concrete beams span between concrete columns at the perimeter of the Main Building and at the perimeter of the second floor area. Most of the interior steel columns extend from foundation level to the high roof level. Reinforced concrete walls around the perimeter of the second floor area extend to the high roof. These perimeter walls do not align with the first floor perimeter walls but are offset by 15'-6" on all four sides.

The Service Building roof consists of a pan joist concrete "ceiling", with a wood-framed roof above, supported by the pan joist system. The pan joist system forms the flat roof at the connecting link to the Main Building. There are no expansion joints between the Main Building, connecting link and Service Building.

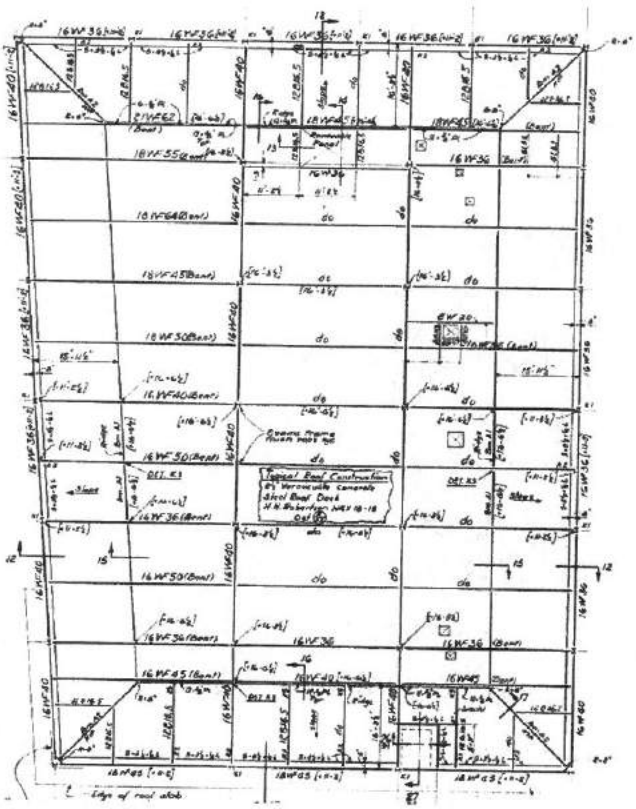
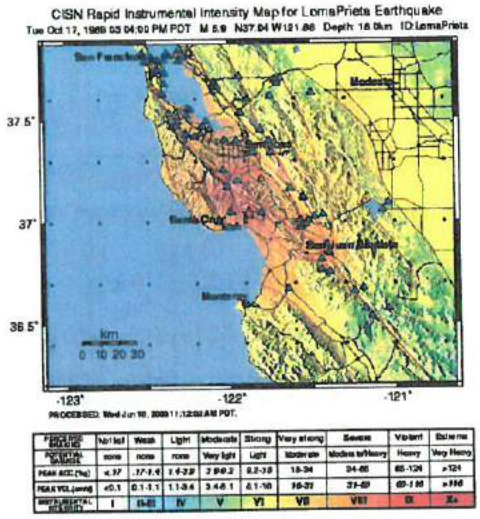


Figure 3. High Roof Framing Plan

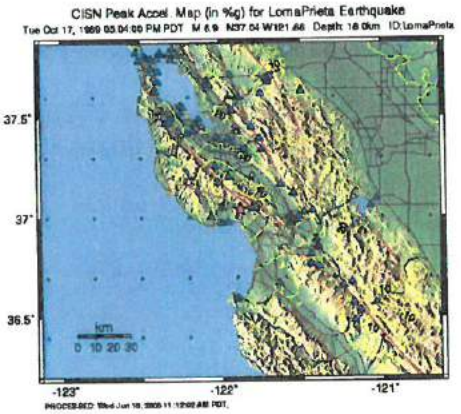
The high roof area of the Main Building above the second floor area consists of steel framing with metal deck and insulating fill at the interior, and a concrete flat slab at the perimeter.

Site Seismicity and Review of 1989 Loma Prieta Earthquake Data

This site can expect severe ground shaking from a major local seismic event. USGS mapped the potential peak ground acceleration (PGA) for this site at .5g. PGA is a reasonably good indicator of expected ground shaking for short buildings (less than 7 stories) and is used in the design of new buildings.



Map 1. Severe Ground Shaking Recorded for Loma Prieta Earthquake



Map 2. PGA at site (red star) was 0.65g for Loma Prieta Earthquake

According to USGS records, the PGA at this site was .65g from the October 17, 1989 Loma Prieta earthquake. As this is higher than the potential PGA used for the design of a new building at this site, the building has experienced at least this one significant test and apparently performed well (no structural damage was reported). However, the peak acceleration was principally in the north-south direction and therefore the seismic load-resisting system for east-west ground shaking was not tested to the same degree as the north-south seismic load resisting elements.

Construction Document Review

The original 1966 drawings were available for review. These include Architectural drawings 1–23, Landscape drawings L1–L2, Structural drawings S1–S7, Electrical drawings E1–E3, and Mechanical drawings M1-M9. Other documents related to the repair of nonstructural damage from the Loma Prieta Earthquake were also available.

In reviewing the original structural drawings, there were certain characteristics in the detailing of concrete beams and columns and the concrete masonry unit (CMU) walls that are worth noting. These include:

- The extensions of dowels from footings into walls or columns is typically 32 bar diameters and lap splices are typically 36 bar diameters. This is OK for small bars, but for lap splices at large bars, #7 and greater, 36 bar diameters may not be enough to fully develop the bar. However, the vast majority of (and the most critical) larger bars for beams and columns have special lap splices called out which generally exceed 36 bar diameters and are generally adequate.

- At CMU walls, all cells are grouted and reinforcing is closely spaced both vertically and horizontally. Horizontal reinforcing is hooked around end-of-wall vertical reinforcing. This detailing meets modern standards for special CMU walls.

- Column ties have cross-lapped 90-degree hooks instead of 135-degree hooks. Beam ties have lap-spliced ties with the lap across the top edge where the slab occurs, or have two-piece ties with lap splices at the top and bottom. Although these are all well-developed as shear reinforcing, they are not great for confinement and ductility; however, there may be little if any ductility demand on concrete members (see Analysis section of evaluation).

Photo 1. View from Church Street

Site Visit

A site visit was made on October 10, 2014 to the currently occupied library facility. The purpose of the site visit was to compare what presently exists with what is shown on the original construction drawings. No significant differences were discovered and the building was found to be in very good condition. Minor differences included:

- A few interior non-bearing non-shear walls have been added and/or modified.
- From documentation found on site, repairs to non-structural elements damaged from the Loma Prieta earthquake included comprehensive asbestos abatement, interior wall repairs, shelving repairs and anchorage, and new suspended ceilings and lights for most of the first floor area. Where new ceiling grids have been placed, they are 2' x 2' instead of the original 2' x 4' grids, and are braced to the structure above. The drop-in acoustic panels within the new ceiling grid area have seismic clips. The original 2' x 4' ceiling grids are not braced and light fixtures within those suspended grids are not independently supported. Acoustic panels in the 2' x 4' original ceiling grids do not have seismic clips.
- An interior stair was added between first and second floor; documentation for this change could not be found.
- A few of the large exterior window panes have been replaced. The replacement glazing is safety glass (the original glazing is not).

Other observations were made of both structural and non-structural elements. Findings include:

- A walk through and around the building revealed that the structural concrete and masonry work is in very good condition. No cracking was found.
- At exterior walkways, concrete was in very good condition, although roots from trees at landscaped areas adjacent to exterior slabs on grade have moved the slabs in a few locations; evidence could be found of grinding of slab edges to eliminate offsets between separate slabs.
- A spot check of the shelving anchorage found that most free-standing shelving is anchored at all corners. However, a few random shelving units were found to lack anchorage or bracing (this is readily discerned by attempting to rock the shelving unit by hand or by removing the lowest shelves to directly review the anchorage).
- Fire sprinklers occur only in the entry lobby area. The fire sprinkler piping could not be viewed (there is a gypsum board ceiling in this area with no access to the space above).

Photo 2. Southeast Corner of East Wall
First floor CMU walls (white) are between concrete columns and a concrete beam above (red). The second story is set back 15'-6" from this wall and has concrete perimeter walls (red).

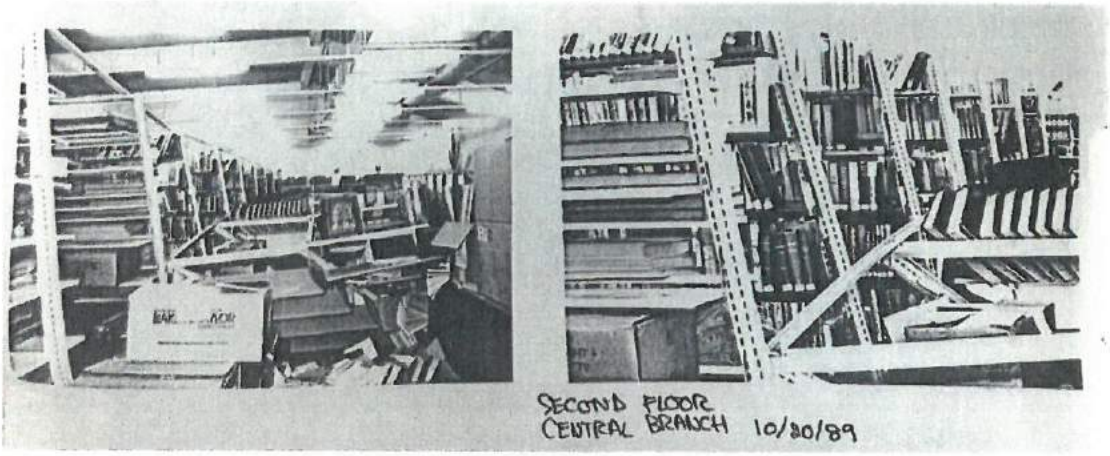


Photo 3. Photo of Document Found on Site
Damage to shelving following the 1989 Loma Prieta earthquake.

Photo 4. Service Building

Photo 5. Connecting Link between Main Building and Service Building

Photo 6. Braced Replacement 2' x 2' Suspended Ceiling Grids in Main Building

Photo 7. Unbraced Original 2' x 4' Suspended Ceiling Grids in Service Building

ASCE 31-03 Tier 1 Screening

In preparing the Tier 1 Screening checklists (see Appendix A) and related structural calculations (see Appendix B), the following apparent deficiencies were noted:

Basic and Supplemental Structural Checklist for Building Type RM2 and C2:

- The perimeter beams at the low roof level of the main building have significantly high bending moment and shear.
- There is a discontinuity in the main building between the second floor concrete wall bracing and the masonry wall bracing below (there is a 15'-6" horizontal offset on all four sides).
- No other structural issues were found in the main building or service building.

Geologic Site Hazards and Foundations Checklist

- There were no non-compliant items from this checklist.

Basic and Intermediate Nonstructural Component Checklist

- Some of the interior partitions in the main building appear to be braced at the top by the suspended ceiling grid and are not separately braced to the structure above.
- Some of the free-standing shelving in the main building (shelving not against a wall) are not anchored to the floor or braced.
- Fire suppression piping in the lobby of the main building could not be viewed (hidden above a gypsum board ceiling).
- Areas with gypsum board ceilings in the main building could not be viewed from above to determine if these areas are braced; however, most areas of gypsum board ceiling are small and supported by walls on all sides, and are unlikely to represent a life hazard.
- In areas where the suspended ceiling grid and acoustic tiles have been replaced (typically a 2' x 2' grid), the grid is braced and tiles have seismic clips; however, in areas where the grids have not been replaced (typically a 2' x 4' grid), there is no bracing and no seismic clips. The unbraced areas include smaller rooms within the main building and virtually the entire service building.
- In the service building, light fixtures supported by the suspended ceiling grid do not have independent support to the structure above.
- Large panes of glass in the main building are typically not safety glazing, except where these have been replaced due to breakage (i.e., near main entry).

Analysis for the Tier 1 Screening

A lateral force analysis was made to review the shear load and shear capacity for the CMU and concrete shear walls (see Appendix B).

There are two unusual characteristics of this building that required a three-dimensional detailed analysis of the building:

1. The 15'-6' offset in plan between shear walls at first and second floor and the resultant discontinuity of the second floor perimeter shear walls, which do not continue to first floor; the second story perimeter walls are supported by concrete-encased steel framing.
2. The gaps (filled by windows) between the CMU shear walls and the concrete columns, coupled with the beam above that spans between columns but is also tied into the CMU wall below (in fact, the CMU walls were constructed before the concrete beams above were cast in place).

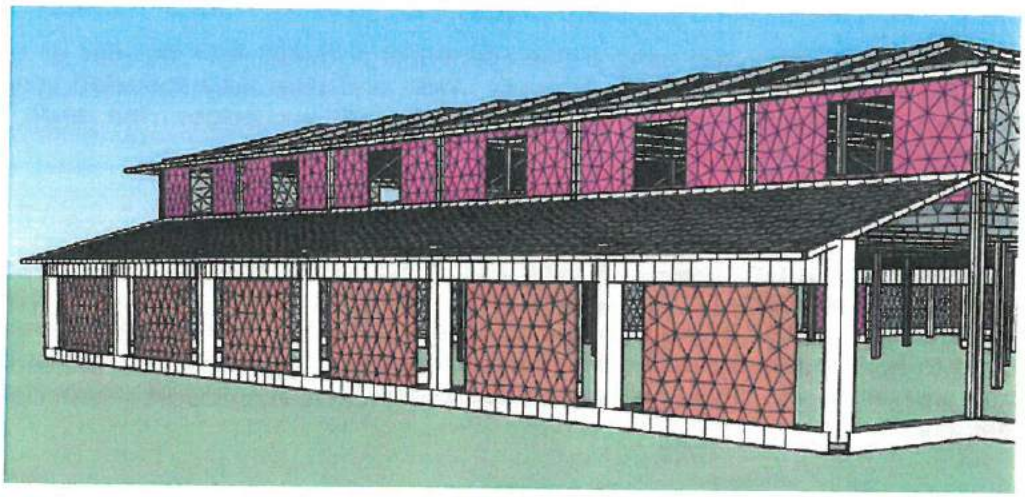


Figure 4. Modeling of perimeter CMU walls (brown) and concrete beams above (white) at low roof of Main Building.

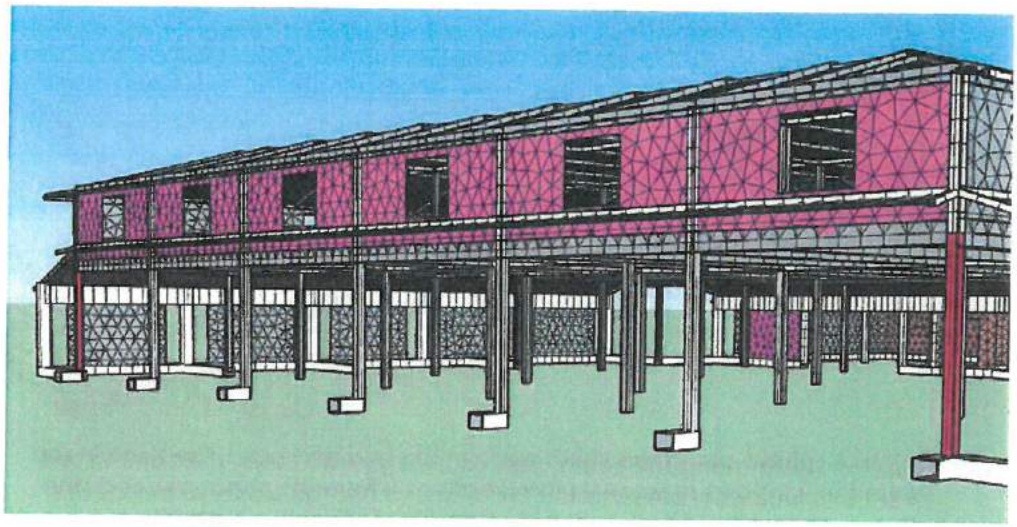


Figure 5. Modeling of second floor perimeter walls (pink) over beams and columns below. Corner columns are shown in red.

The analysis shows that the shear capacities of the CMU and concrete shear walls are adequate. However, an unexpected finding was that there were high shears and moments in the beams over the perimeter CMU walls of the Main Building, and high axial loads in the columns at the four corners of the second floor of the Main Building. Therefore a Tier 2 Evaluation was made for these elements.

ASCE 31-03 Tier 2 Evaluation

A Tier 2 Evaluation was made for those elements of the structure found to have potential deficiencies in the Tier 1 Screening. The elements reviewed in the Tier 2 Evaluation include:

- Perimeter concrete beams at the low roof level of the Main Building
- First floor columns below the four corners of the second floor perimeter walls of the Main Building.

The building was analyzed using a three-dimensional model that includes all beams, footings, slabs, deck/fill, columns and walls. Walls and slabs were modeled using shell elements, with members added at wall and slab ends and edges. The results of this further evaluation are as follows:

Perimeter concrete beams at the low roof level of the Main Building

The perimeter beams were checked for ASCE 31-03 derived loads in various combinations of dead, live and seismic load. An envelope of maximum shears and moments were found for each of the concrete members. Most of the beams were found to have adequate shear and moment capacity. However, two beams on the south wall (either side of the main entry) were found to have inadequate shear capacity. See Figure 6.

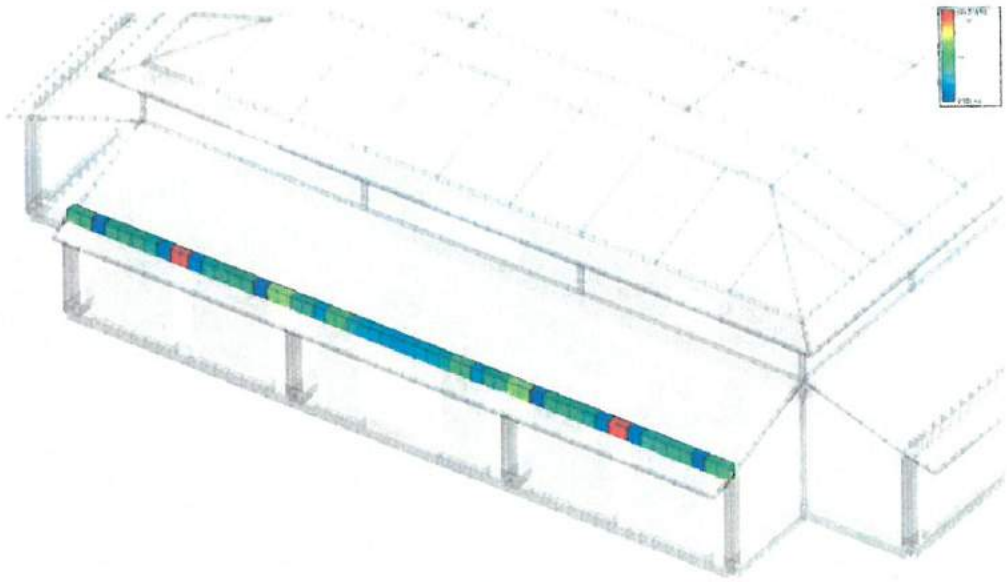


Figure 6. Shear along the south wall. In the two end bays, the zone in red over the windows represents the locations where the shear exceeds the capacity of beam. The demand is 118% of the capacity.

First floor columns below the four corners of the second floor perimeter walls

The four corner columns were checked for ASCE 31-03 derived loads in various combinations of dead, live and seismic load. An envelope of maximum axial loads, shear loads and moments were found for each of the steel members. All of these were found to have adequate shear and moment capacity. No further evaluation is required for these elements.

Summary of Structural Findings

The following is a summary of findings based on the application of the ASCE 31-03 Tier 1 Screening and the Tier 2 Evaluation of potentially deficient structural members:

Structural Elements:

- Existing CMU and concrete shear walls have adequate strength to resist ASCE 31-03 vertical and lateral loads.
- The perimeter concrete beams at the low roof of the main building are adequate with the exception of the end beams on either side of the entry at the south side of the Main Building; these two beams have inadequate shear capacity (the maximum applied load is 118% of the capacity).
- The first floor columns below the four corners of the second floor perimeter shear walls of the Main Building are adequate.

Summary of Structural Conclusions and Recommendations

Based on the Tier 1 Screening and Tier 2 Evaluation findings, the structural elements of the building are adequate with the exception of:

- Two outer beams on the south side of the building, over the windows that are near the center of each beam, have shear load exceeding their capacity. It is recommended that this deficiency be mitigated. Although it is beyond the scope of this evaluation to further investigate this deficiency or propose specific mitigation measures, it is apparent that one simple solution has the potential of mitigating the above-mentioned deficiency – infill the windows with CMU at the two locations. See Figures 7 and 8.

Figure 7. Present Condition with 2 Windows

Figure 8. Mitigated Condition with 2 Infills

Summary of Non-Structural Findings

The following is a summary of findings based on the application of the ASCE 31-03 Tier 1 Screening and the Tier 2 Evaluation of potentially deficient non-structural elements:

- Interior partitions in the main building that stop at the ceiling and braced at the top by the original unbraced suspended ceiling grid are not adequately braced.
- Some free-standing shelving in the main building are not anchored or braded.
- Fire suppression piping in the lobby of the main building could not be viewed (hidden above a gypsum board ceiling) and may or may not be adequately braced within the ceiling cavity.
- Gypsum board ceilings in the main building could not be viewed from above and may or may not be braced; however, most areas of gypsum board ceiling are small and supported by walls on all sides, and are unlikely to represent a life hazard.
- In areas where the suspended ceiling grid and tiles have been replaced (typically a 2' x 2' grid), the grid is braced and tiles have seismic clips; however, in areas where the grids have not been replaced (typically a 2' x 4' grid), there is no bracing and no seismic clips. The unbraced areas include smaller rooms within the main building and virtually the entire service building.
- In the service building, light fixtures supported by the suspended ceiling grid do not have independent support to the structure above.
- Large panes of glass in the main building are typically not safety glazing, except where these have been replaced due to breakage (i.e., near main entry).

Summary of Non-Structural Conclusions and Recommendations

Based on the Tier 1 Screening and Tier 2 Evaluation findings, the non-structural elements of the building are adequate with the exception of:

- Original unbraced suspended ceiling grids are not adequately braced and should either be replaced or braced. Additionally, where partitions are presently braced by such ceilings, independent bracing should be provided for those partitions.
- At original suspended ceiling grid locations, ceiling tiles should be provided with seismic retainer clips and light fixtures should be provided with independent vertical support from at least two diagonal corners.
- Unanchored free-standing shelving in the main building should be anchored to the floor.
- Destructive investigation (not included within this evaluation) is recommended for review of bracing for the fire suppression piping in the ceiling cavity of the lobby of the Main Building. If this piping is found to be unbraced, bracing should be added to mitigate damage in an earthquake.
- The large full-height panes of glass in the main building are typically not safety glazing, except where these have been replaced due to breakage (i.e., near main entry). The building is relatively stiff; if the as-installed windows have frames that can absorb up to 3/8" of lateral deformation of the surrounding structure, then breakage from a large quake is unlikely; however, if window panes are tightly fitted in the frames, replacement or modification of the glazing and/or frames should be considered.

Appendix A

ASCE 31-03 Tier 1 Structural and Nonstructural Checklists

- Basic structural for Type RM2 building
- Supplemental Structural for Type RM2 building
- Basic structural for Type C2 building
- Supplemental Structural for Type C2 building
- Geologic Site Hazard and Foundation
- Basic Nonstructural
- Intermediate Nonstructural

3.7.14 Basic Structural Checklist for Building Type RM2: Reinforced Masonry Bearing Walls with Stiff Diaphragms

This Basic Structural Checklist shall be completed where 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; corresponding section numbers are in parentheses following each evaluation statement.

C3.7.14 Basic Structural Checklist for Building Type RM2

These buildings have bearing walls that consist of reinforced brick or concrete block masonry. Diaphragms consist of metal deck with concrete fill, precast concrete planks, tees, or double-tees, with or without a cast-in-place concrete topping slab, and are stiff relative to the walls. The floor and roof framing is supported on interior steel or concrete frames or interior reinforced masonry walls.

Building System

(C)	NC	N/A	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)
C	NC	(N/A)	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)
(C)	NC	N/A	WEAK STORY: The strength of the lateral-force-resisting system in any story shall not be less than 80 percent of the strength in an adjacent story, above or below, for Life Safety and Immediate Occupancy. (Tier 2: Sec. 4.3.2.1)
(C)	NC	N/A	SOFT STORY: The stiffness of the lateral-force-resisting system in any story shall not be less than 70 percent of the lateral-force-resisting system stiffness in an adjacent story above or below, or less than 80 percent of the average lateral-force-resisting system stiffness of the three stories above or below for Life Safety and Immediate Occupancy. (Tier 2: Sec. 4.3.2.2)
(C)	NC	N/A	GEOMETRY: There shall be no changes in horizontal dimension of the lateral-force-resisting system of more than 30 percent 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)
(C)	NC	N/A	VERTICAL DISCONTINUITIES: All vertical elements in the lateral-force-resisting system shall be continuous to the foundation. (Tier 2: Sec. 4.3.2.4)
(C)	NC	N/A	MASS: There shall be no change in effective mass more than 50 percent 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)
(C)	NC	N/A	TORSION: The estimated distance between the story center of mass and the story center of rigidity shall be less than 20 percent of the building width in either plan dimension for Life Safety and Immediate Occupancy. (Tier 2: Sec. 4.3.2.6)

C NC N/A 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)

C NC N/A MASONRY UNITS: There shall be no visible deterioration of masonry units. (Tier 2: Sec. 4.3.3.7)

C NC N/A MASONRY JOINTS: The mortar shall not be easily scraped away from the joints by hand with a metal tool, and there shall be no areas of eroded mortar. (Tier 2: Sec. 4.3.3.8)

C NC N/A REINFORCED MASONRY WALL CRACKS: All existing diagonal cracks in wall elements shall be less than 1/8 inch for Life Safety and 1/16 inch for Immediate Occupancy, shall not be concentrated in one location, and shall not form an X pattern. (Tier 2: Sec. 4.3.3.10)

Lateral-Force-Resisting System

C NC N/A 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)

C NC N/A SHEAR STRESS CHECK: The shear stress in the reinforced masonry shear walls, calculated using the Quick Check procedure of Section 3.5.3.3, shall be less than 70 psi for Life Safety and Immediate Occupancy. (Tier 2: Sec. 4.4.2.4.1)

C NC N/A REINFORCING STEEL: The total vertical and horizontal reinforcing steel ratio in reinforced masonry walls shall be greater than 0.002 for Life Safety and Immediate Occupancy of the wall with the minimum of 0.0007 for Life Safety and Immediate Occupancy in either of the two directions; the spacing of reinforcing steel shall be less than 48 inches for Life Safety and Immediate Occupancy; and all vertical bars shall extend to the top of the walls. (Tier 2: Sec. 4.4.2.4.2)

Diaphragms

C NC N/A TOPPING SLAB: Precast concrete diaphragm elements shall be interconnected by a continuous reinforced concrete topping slab. (Tier 2: Sec. 4.5.5.1)

Connections

C NC N/A WALL ANCHORAGE: Exterior concrete or masonry walls that are dependent on the diaphragm for lateral support shall be anchored for out-of-plane forces at each diaphragm level with steel anchors, reinforcing dowels, or straps that are developed into the diaphragm. Connections shall have adequate strength to resist the connection force calculated in the Quick Check procedure of Section 3.5.3.7. (Tier 2: Sec. 4.6.1.1)

C NC N/A 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 or diaphragms for Immediate Occupancy. (Tier 2: Sec. 4.6.2.1)

C NC N/A TOPPING SLAB TO WALLS OR FRAMES: Reinforced concrete topping slabs that interconnect the precast concrete diaphragm elements shall be doweled for transfer of forces into the shear wall or frame elements for Life Safety, and the dowels shall be able to develop the lesser of the shear strength of the walls, frames, or slabs for Immediate Occupancy. (Tier 2: Sec. 4.6.2.3)

C NC N/A 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)

C NC N/A GIRDER/COLUMN CONNECTION: There shall be a positive connection utilizing plates, connection hardware, or straps between the girder and the column support. (Tier 2: Sec. 4.6.4.1)

3.7.14S Supplemental Structural Checklist for Building Type RM2: Reinforced Masonry Bearing Walls with Stiff Diaphragms

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

Lateral-Force-Resisting System

C NC (N/A) 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)

C NC (N/A) PROPORTIONS: The height-to-thickness ratio of the shear walls at each story shall be less than 30. This statement shall apply to the Immediate Occupancy Performance Level only. (Tier 2: Sec. 4.4.2.4.4)

Diaphragms

(C) NC N/A OPENINGS AT SHEAR WALLS: Diaphragm openings immediately adjacent to the shear walls shall be less than 25 percent of the wall length for Life Safety and 15 percent of the wall length for Immediate Occupancy. (Tier 2: Sec. 4.5.1.4)

(C) NC N/A OPENINGS AT EXTERIOR MASONRY SHEAR WALLS: Diaphragm openings immediately adjacent to exterior masonry shear walls shall not be greater than 8 feet long for Life Safety and 4 feet long for Immediate Occupancy. (Tier 2: Sec. 4.5.1.6)

C NC (N/A) 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)

C NC (N/A) DIAPHRAGM REINFORCEMENT AT OPENINGS: There shall be reinforcing around all diaphragm openings larger than 50 percent 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)

3.7.14 Basic Structural Checklist for Building Type RM2: Reinforced Masonry Bearing Walls with Stiff Diaphragms

This Basic Structural Checklist shall be completed where 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; corresponding section numbers are in parentheses following each evaluation statement.

C3.7.14 Basic Structural Checklist for Building Type RM2

These buildings have bearing walls that consist of reinforced brick or concrete block masonry. Diaphragms consist of metal deck with concrete fill, precast concrete planks, tees, or double-tees, with or without a cast-in-place concrete topping slab, and are stiff relative to the walls. The floor and roof framing is supported on interior steel or concrete frames or interior reinforced masonry walls.

Building System

(C)	NC	N/A	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)
C	NC	(N/A)	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)
(C)	NC	N/A	WEAK STORY: The strength of the lateral-force-resisting system in any story shall not be less than 80 percent of the strength in an adjacent story, above or below, for Life Safety and Immediate Occupancy. (Tier 2: Sec. 4.3.2.1)
(C)	NC	N/A	SOFT STORY: The stiffness of the lateral-force-resisting system in any story shall not be less than 70 percent of the lateral-force-resisting system stiffness in an adjacent story above or below, or less than 80 percent of the average lateral-force-resisting system stiffness of the three stories above or below for Life Safety and Immediate Occupancy. (Tier 2: Sec. 4.3.2.2)
(C)	NC	N/A	GEOMETRY: There shall be no changes in horizontal dimension of the lateral-force-resisting system of more than 30 percent 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)
(C)	NC	N/A	VERTICAL DISCONTINUITIES: All vertical elements in the lateral-force-resisting system shall be continuous to the foundation. (Tier 2: Sec. 4.3.2.4)
(C)	NC	N/A	MASS: There shall be no change in effective mass more than 50 percent 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)
(C)	NC	N/A	TORSION: The estimated distance between the story center of mass and the story center of rigidity shall be less than 20 percent of the building width in either plan dimension for Life Safety and Immediate Occupancy. (Tier 2: Sec. 4.3.2.6)

C NC N/A 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)

C NC N/A MASONRY UNITS: There shall be no visible deterioration of masonry units. (Tier 2: Sec. 4.3.3.7)

C NC N/A MASONRY JOINTS: The mortar shall not be easily scraped away from the joints by hand with a metal tool, and there shall be no areas of eroded mortar. (Tier 2: Sec. 4.3.3.8)

C NC N/A REINFORCED MASONRY WALL CRACKS: All existing diagonal cracks in wall elements shall be less than 1/8 inch for Life Safety and 1/16 inch for Immediate Occupancy, shall not be concentrated in one location, and shall not form an X pattern. (Tier 2: Sec. 4.3.3.10)

Lateral-Force-Resisting System

C NC N/A 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)

C NC N/A SHEAR STRESS CHECK: The shear stress in the reinforced masonry shear walls, calculated using the Quick Check procedure of Section 3.5.3.3, shall be less than 70 psi for Life Safety and Immediate Occupancy. (Tier 2: Sec. 4.4.2.4.1)

C NC N/A REINFORCING STEEL: The total vertical and horizontal reinforcing steel ratio in reinforced masonry walls shall be greater than 0.002 for Life Safety and Immediate Occupancy of the wall with the minimum of 0.0007 for Life Safety and Immediate Occupancy in either of the two directions; the spacing of reinforcing steel shall be less than 48 inches for Life Safety and Immediate Occupancy; and all vertical bars shall extend to the top of the walls. (Tier 2: Sec. 4.4.2.4.2)

Diaphragms

C NC N/A TOPPING SLAB: Precast concrete diaphragm elements shall be interconnected by a continuous reinforced concrete topping slab. (Tier 2: Sec. 4.5.5.1)

Connections

C NC N/A WALL ANCHORAGE: Exterior concrete or masonry walls that are dependent on the diaphragm for lateral support shall be anchored for out-of-plane forces at each diaphragm level with steel anchors, reinforcing dowels, or straps that are developed into the diaphragm. Connections shall have adequate strength to resist the connection force calculated in the Quick Check procedure of Section 3.5.3.7. (Tier 2: Sec. 4.6.1.1)

C NC N/A 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 or diaphragms for Immediate Occupancy. (Tier 2: Sec. 4.6.2.1)

C NC N/A TOPPING SLAB TO WALLS OR FRAMES: Reinforced concrete topping slabs that interconnect the precast concrete diaphragm elements shall be doweled for transfer of forces into the shear wall or frame elements for Life Safety, and the dowels shall be able to develop the lesser of the shear strength of the walls, frames, or slabs for Immediate Occupancy. (Tier 2: Sec. 4.6.2.3)

C NC N/A 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)

C NC N/A GIRDER/COLUMN CONNECTION: There shall be a positive connection utilizing plates, connection hardware, or straps between the girder and the column support. (Tier 2: Sec. 4.6.4.1)

3.7.14S Supplemental Structural Checklist for Building Type RM2: Reinforced Masonry Bearing Walls with Stiff Diaphragms

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

Lateral-Force-Resisting System

C NC (N/A) 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)

C NC (N/A) PROPORTIONS: The height-to-thickness ratio of the shear walls at each story shall be less than 30. This statement shall apply to the Immediate Occupancy Performance Level only. (Tier 2: Sec. 4.4.2.4.4)

Diaphragms

(C) NC N/A OPENINGS AT SHEAR WALLS: Diaphragm openings immediately adjacent to the shear walls shall be less than 25 percent of the wall length for Life Safety and 15 percent of the wall length for Immediate Occupancy. (Tier 2: Sec. 4.5.1.4)

(C) NC N/A OPENINGS AT EXTERIOR MASONRY SHEAR WALLS: Diaphragm openings immediately adjacent to exterior masonry shear walls shall not be greater than 8 feet long for Life Safety and 4 feet long for Immediate Occupancy. (Tier 2: Sec. 4.5.1.6)

C NC (N/A) 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)

C NC (N/A) DIAPHRAGM REINFORCEMENT AT OPENINGS: There shall be reinforcing around all diaphragm openings larger than 50 percent 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)

3.7.9 Basic Structural Checklist for Building Type C2: Concrete Shear Walls with Stiff Diaphragms

This Basic Structural Checklist shall be completed where 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; corresponding section numbers are in parentheses following each evaluation statement.

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, mat foundations, or deep foundations.

Building System

(C)	NC	N/A	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)
C	NC	(N/A)	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)
(C)	NC	N/A	WEAK STORY: The strength of the lateral-force-resisting system in any story shall not be less than 80 percent of the strength in an adjacent story, above or below, for Life Safety and Immediate Occupancy. (Tier 2: Sec. 4.3.2.1)
(C)	NC	N/A	SOFT STORY: The stiffness of the lateral-force-resisting system in any story shall not be less than 70 percent of the lateral-force-resisting system stiffness in an adjacent story above or below, or less than 80 percent of the average lateral-force-resisting system stiffness of the three stories above or below for Life Safety and Immediate Occupancy. (Tier 2: Sec. 4.3.2.2)
(C)	NC	N/A	GEOMETRY: There shall be no changes in horizontal dimension of the lateral-force-resisting system of more than 30 percent 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)
(C)	NC	N/A	VERTICAL DISCONTINUITIES: All vertical elements in the lateral-force-resisting system shall be continuous to the foundation. (Tier 2: Sec. 4.3.2.4)
(C)	NC	N/A	MASS: There shall be no change in effective mass more than 50 percent 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)

C NC N/A TORSION: The estimated distance between the story center of mass and the story center of rigidity shall be less than 20 percent of the building width in either plan dimension for Life Safety and Immediate Occupancy. (Tier 2: Sec. 4.3.2.6)

C NC N/A 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)

C NC N/A 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)

C NC N/A CONCRETE WALL CRACKS: All existing diagonal cracks in wall elements shall be less than 1/8 inch for Life Safety and 1/16 inch for Immediate Occupancy, shall not be concentrated in one location, and shall not form an X pattern. (Tier 2: Sec. 4.3.3.9)

Lateral-Force-Resisting System

C NC N/A 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)

C NC N/A 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)

C NC N/A 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)

C NC N/A 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 inches for Life Safety and Immediate Occupancy. (Tier 2: Sec. 4.4.2.2.2)

Connections

C NC N/A 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 or diaphragms for Immediate Occupancy. (Tier 2: Sec. 4.6.2.1)

C NC N/A 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 Walls with Stiff Diaphragms

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

Lateral-Force-Resisting System

(C) NC N/A 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 Sections 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)

C NC (N/A) 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)

C NC (N/A) 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 135° 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)

C NC (N/A) 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)

C NC (N/A) 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)

C NC (N/A) 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)

(C) NC N/A 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 inches. This statement shall apply to the Immediate Occupancy Performance Level only. (Tier 2: Sec. 4.4.2.2.7)

Diaphragms

(C) NC N/A DIAPHRAGM CONTINUITY: The diaphragms shall not be composed of split-level floors and shall not have expansion joints. (Tier 2: Sec. 4.5.1.1)

(C) NC N/A OPENINGS AT SHEAR WALLS: Diaphragm openings immediately adjacent to the shear walls shall be less than 25 percent of the wall length for Life Safety and 15 percent of the wall length for Immediate Occupancy. (Tier 2: Sec. 4.5.1.4)

C NC (N/A) 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)

C NC (N/A) DIAPHRAGM REINFORCEMENT AT OPENINGS: There shall be reinforcing around all diaphragm openings larger than 50 percent 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)

Connections

C NC (N/A) 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)

3.8 Geologic Site Hazards and Foundations Checklist

This Geologic Site Hazards and Foundations Checklist shall be completed where 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; corresponding section numbers are in parentheses following each evaluation statement.

Geologic Site Hazards

The following statements shall be completed for buildings in levels of high or moderate seismicity.

(C) NC N/A LIQUEFACTION: 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. (Tier 2: Sec. 4.7.1.1)

(C) NC N/A SLOPE FAILURE: The building site shall be sufficiently remote from potential earthquake-induced slope failures or rockfalls to be unaffected by such failures or shall be capable of accommodating any predicted movements without failure. (Tier 2: Sec. 4.7.1.2)

(C) NC N/A SURFACE FAULT RUPTURE: Surface fault rupture and surface displacement at the building site is not anticipated. (Tier 2: Sec. 4.7.1.3)

Condition of Foundations

The following statement shall be completed for all Tier 1 building evaluations.

(C) NC N/A FOUNDATION PERFORMANCE: There shall be no evidence of excessive foundation movement such as settlement or heave that would affect the integrity or strength of the structure. (Tier 2: Sec. 4.7.2.1)

The following statement shall be completed for buildings in levels of high or moderate seismicity being evaluated to the Immediate Occupancy Performance Level.

(C) NC N/A DETERIORATION: There shall not be evidence that foundation elements have deteriorated due to corrosion, sulfate attack, material breakdown, or other reasons in a manner that would affect the integrity or strength of the structure. (Tier 2: Sec. 4.7.2.2)

Capacity of Foundations

The following statement shall be completed for all Tier 1 building evaluations.

C NC (N/A) POLE FOUNDATIONS: Pole foundations shall have a minimum embedment depth of 4 feet for Life Safety and Immediate Occupancy. (Tier 2: Sec. 4.7.3.1)

The following statements shall be completed for buildings in levels of moderate seismicity being evaluated to the Immediate Occupancy Performance Level and for buildings in levels of high seismicity.

C NC (N/A) OVERTURNING: The ratio of the horizontal dimension of the lateral-force-resisting system at the foundation level to the building height (base/height) shall be greater than $0.6S_a$. (Tier 2: Sec. 4.7.3.2)

C NC N/A TIES BETWEEN FOUNDATION ELEMENTS: The foundation shall have ties adequate to resist seismic forces where footings, piles, and piers are not restrained by beams, slabs, or soils classified as Class A, B, or C. (Section 3.5.2.3.1, Tier 2: Sec. 4.7.3.3)

C NC N/A DEEP FOUNDATIONS: Piles and piers shall be capable of transferring the lateral forces between the structure and the soil. This statement shall apply to the Immediate Occupancy Performance Level only. (Tier 2: Sec. 4.7.3.4)

C NC N/A SLOPING SITES: The difference in foundation embedment depth from one side of the building to another shall not exceed one story in height. This statement shall apply to the Immediate Occupancy Performance Level only. (Tier 2: Sec. 4.7.3.5)

3.9.1 Basic Nonstructural Component Checklist

This Basic Nonstructural Component Checklist shall be completed where 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; corresponding section numbers are in parentheses following each evaluation statement.

Partitions

C NC (N/A) UNREINFORCED MASONRY: Unreinforced masonry or hollow clay tile partitions shall be braced at a spacing equal to or less than 10 feet in levels of low or moderate seismicity and 6 feet in levels of high seismicity. (Tier 2: Sec. 4.8.1.1)

A few partitions are laterally bracing by suspended ceilings.

Ceiling Systems

C (NC) N/A SUPPORT: The integrated suspended ceiling system shall not be used to laterally support the tops of gypsum board, masonry, or hollow clay tile partitions. Gypsum board partitions need not be evaluated where only the Basic Nonstructural Component Checklist is required by Table 3-2. (Tier 2: Sec. 4.8.2.1)

Light Fixtures

(C) NC N/A EMERGENCY LIGHTING: Emergency lighting shall be anchored or braced to prevent falling during an earthquake. (Tier 2: Sec. 4.8.3.1)

Cladding and Glazing

C NC (N/A) CLADDING ANCHORS: Cladding components weighing more than 10 psf shall be mechanically anchored to the exterior wall framing at a spacing equal to or less than 4 feet. A spacing of up to 6 feet is permitted where only the Basic Nonstructural Component Checklist is required by Table 3-2. (Tier 2: Sec. 4.8.4.1)

C NC (N/A) DETERIORATION: There shall be no evidence of deterioration, damage or corrosion in any of the connection elements. (Tier 2: Sec. 4.8.4.2)

C NC (N/A) CLADDING ISOLATION: For moment frame buildings of steel or concrete, panel connections shall be detailed to accommodate a story drift ratio of 0.02. Panel connection detailing for a story drift ratio of 0.01 is permitted where only the Basic Nonstructural Component Checklist is required by Table 3-2. (Tier 2: Sec. 4.8.4.3)

C NC (N/A) MULTI-STORY PANELS: For multi-story panels attached at each floor level, panel connections shall be detailed to accommodate a story drift ratio of 0.02. Panel connection detailing for a story drift ratio of 0.01 is permitted where only the Basic Nonstructural Component Checklist is required by Table 3-2. (Tier 2: Sec. 4.8.4.4)

C NC (N/A) BEARING CONNECTIONS: Where bearing connections are required, there shall be a minimum of two bearing connections for each wall panel. (Tier 2: Sec. 4.8.4.5)

C NC (N/A) INSERTS: Where inserts are used in concrete connections, the inserts shall be anchored to reinforcing steel or other positive anchorage. (Tier 2: Sec. 4.8.4.6)

C NC (N/A) PANEL CONNECTIONS: Exterior cladding panels shall be anchored out-of-plane with a minimum of 4 connections for each wall panel. Two connections per wall panel are permitted where only the Basic Nonstructural Component Checklist is required by Table 3-2. (Tier 2: Sec. 4.8.4.7)

Masonry Veneer

C NC (N/A) SHELF ANGLES: Masonry veneer shall be supported by shelf angles or other elements at each floor 30 feet or more above ground for Life Safety and at each floor above the first floor for Immediate Occupancy. (Tier 2: Sec. 4.8.5.1)

C NC (N/A) TIES: Masonry veneer shall be connected to the back-up with corrosion-resistant ties. The ties shall have a spacing equal to or less than 24 inches with a minimum of one tie for every 2-2/3 square feet. A spacing of up to 36 inches is permitted where only the Basic Nonstructural Component Checklist is required by Table 3-2. (Tier 2: Sec. 4.8.5.2)

C NC (N/A) WEAKENED PLANES: Masonry veneer shall be anchored to the back-up adjacent to weakened planes, such as at the locations of flashing. (Tier 2: Sec. 4.8.5.3)

C NC (N/A) DETERIORATION: There shall be no evidence of deterioration, damage, or corrosion in any of the connection elements. (Tier 2: Sec. 4.8.5.4)

Parapets, Cornices, Ornamentation, and Appendages

C NC (N/A) URM PARAPETS: There shall be no laterally unsupported unreinforced masonry parapets or cornices with height-to-thickness ratios greater than 1.5. A height-to-thickness ratio of up to 2.5 is permitted where only the Basic Nonstructural Component Checklist is required by Table 3-2. (Tier 2: Sec. 4.8.8.1)

C NC (N/A) CANOPIES: Canopies located at building exits shall be anchored to the structural framing at a spacing of 6 feet or less. An anchorage spacing of up to 10 feet is permitted where only the Basic Nonstructural Component Checklist is required by Table 3-2. (Tier 2: Sec. 4.8.8.2)

Masonry Chimneys

C NC (N/A) URM CHIMNEYS: No unreinforced masonry chimney shall extend above the roof surface more than twice the least dimension of the chimney. A height above the roof surface of up to three times the least dimension of the chimney is permitted where only the Basic Nonstructural Component Checklist is required by Table 3-2. (Tier 2: Sec. 4.8.9.1)

Stairs

C NC (N/A) URM WALLS: Walls around stair enclosures shall not consist of unbraced hollow clay tile or unreinforced masonry with a height-to-thickness ratio greater than 12-to-1. A height-to-thickness ratio of up to 15-to-1 is permitted where only the Basic Nonstructural Component Checklist is required by Table 3-2. (Tier 2: Sec. 4.8.10.1)

C NC (N/A) STAIR DETAILS: In moment frame structures, the connection between the stairs and the structure shall not rely on shallow anchors in concrete. Alternatively, the stair details shall be capable of accommodating the drift calculated using the Quick Check procedure of Section 3.5.3.1 without including tension in the anchors. (Tier 2: Sec. 4.8.10.2)

Building Contents and Furnishing

C (NC) N/A TALL NARROW CONTENTS: Contents over 4 feet in height with a height-to-depth or height-to-width ratio greater than 3-to-1 shall be anchored to the floor slab or adjacent structural walls. A height-to-depth or height-to-width ratio of up to 4-to-1 is permitted where only the Basic Nonstructural Component Checklist is required by Table 3-2. (Tier 2: Sec. 4.8.11.1)

Most shelving is anchored but a small percentage is not anchored.

Mechanical and Electrical Equipment

C NC (N/A) EMERGENCY POWER: Equipment used as part of an emergency power system shall be mounted to maintain continued operation after an earthquake. (Tier 2: Sec. 4.8.12.1)

C NC (N/A) HAZARDOUS MATERIAL EQUIPMENT: HVAC or other equipment containing hazardous material shall not have damaged supply lines or unbraced isolation supports. (Tier 2: Sec. 4.8.12.2)

(C) NC N/A DETERIORATION: There shall be no evidence of deterioration, damage, or corrosion in any of the anchorage or supports of mechanical or electrical equipment. (Tier 2: Sec. 4.8.12.3)

(C) NC N/A ATTACHED EQUIPMENT: Equipment weighing over 20 lb that is attached to ceilings, walls, or other supports 4 feet above the floor level shall be braced. (Tier 2: Sec. 4.8.12.4)

Could not be viewed.

Piping

C NC N/A FIRE SUPPRESSION PIPING: Fire suppression piping shall be anchored and braced in accordance with NFPA-13 (NFPA, 1996). (Tier 2: Sec. 4.8.13.1)

C NC N/A FLEXIBLE COUPLINGS: Fluid, gas, and fire suppression piping shall have flexible couplings. (Tier 2: Sec. 4.8.13.2)

Hazardous Materials Storage and Distribution

C NC (N/A) TOXIC SUBSTANCES: Toxic and hazardous substances stored in breakable containers shall be restrained from falling by latched doors, shelf lips, wires, or other methods. (Tier 2: Sec. 4.8.15.1)

3.9.1 Basic Nonstructural Component Checklist

This Basic Nonstructural Component Checklist shall be completed where 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; corresponding section numbers are in parentheses following each evaluation statement.

Partitions

C NC (N/A) UNREINFORCED MASONRY: Unreinforced masonry or hollow clay tile partitions shall be braced at a spacing equal to or less than 10 feet in levels of low or moderate seismicity and 6 feet in levels of high seismicity. (Tier 2: Sec. 4.8.1.1)

Some partitions are braced at the top by ceiling system.

Ceiling Systems

C (NC) N/A SUPPORT: The integrated suspended ceiling system shall not be used to laterally support the tops of gypsum board, masonry, or hollow clay tile partitions. Gypsum board partitions need not be evaluated where only the Basic Nonstructural Component Checklist is required by Table 3-2. (Tier 2: Sec. 4.8.2.1)

Light Fixtures

(C) NC N/A EMERGENCY LIGHTING: Emergency lighting shall be anchored or braced to prevent falling during an earthquake. (Tier 2: Sec. 4.8.3.1)

Cladding and Glazing

C NC (N/A) CLADDING ANCHORS: Cladding components weighing more than 10 psf shall be mechanically anchored to the exterior wall framing at a spacing equal to or less than 4 feet. A spacing of up to 6 feet is permitted where only the Basic Nonstructural Component Checklist is required by Table 3-2. (Tier 2: Sec. 4.8.4.1)

C NC (N/A) DETERIORATION: There shall be no evidence of deterioration, damage or corrosion in any of the connection elements. (Tier 2: Sec. 4.8.4.2)

C NC (N/A) CLADDING ISOLATION: For moment frame buildings of steel or concrete, panel connections shall be detailed to accommodate a story drift ratio of 0.02. Panel connection detailing for a story drift ratio of 0.01 is permitted where only the Basic Nonstructural Component Checklist is required by Table 3-2. (Tier 2: Sec. 4.8.4.3)

C NC (N/A) MULTI-STORY PANELS: For multi-story panels attached at each floor level, panel connections shall be detailed to accommodate a story drift ratio of 0.02. Panel connection detailing for a story drift ratio of 0.01 is permitted where only the Basic Nonstructural Component Checklist is required by Table 3-2. (Tier 2: Sec. 4.8.4.4)

C NC (N/A) BEARING CONNECTIONS: Where bearing connections are required, there shall be a minimum of two bearing connections for each wall panel. (Tier 2: Sec. 4.8.4.5)

C NC N/A INSERTS: Where inserts are used in concrete connections, the inserts shall be anchored to reinforcing steel or other positive anchorage. (Tier 2: Sec. 4.8.4.6)

C NC N/A PANEL CONNECTIONS: Exterior cladding panels shall be anchored out-of-plane with a minimum of 4 connections for each wall panel. Two connections per wall panel are permitted where only the Basic Nonstructural Component Checklist is required by Table 3-2. (Tier 2: Sec. 4.8.4.7)

Masonry Veneer

C NC N/A SHELF ANGLES: Masonry veneer shall be supported by shelf angles or other elements at each floor 30 feet or more above ground for Life Safety and at each floor above the first floor for Immediate Occupancy. (Tier 2: Sec. 4.8.5.1)

C NC N/A TIES: Masonry veneer shall be connected to the back-up with corrosion-resistant ties. The ties shall have a spacing equal to or less than 24 inches with a minimum of one tie for every 2-2/3 square feet. A spacing of up to 36 inches is permitted where only the Basic Nonstructural Component Checklist is required by Table 3-2. (Tier 2: Sec. 4.8.5.2)

C NC N/A WEAKENED PLANES: Masonry veneer shall be anchored to the back-up adjacent to weakened planes, such as at the locations of flashing. (Tier 2: Sec. 4.8.5.3)

C NC N/A DETERIORATION: There shall be no evidence of deterioration, damage, or corrosion in any of the connection elements. (Tier 2: Sec. 4.8.5.4)

Parapets, Cornices, Ornamentation, and Appendages

C NC N/A URM PARAPETS: There shall be no laterally unsupported unreinforced masonry parapets or cornices with height-to-thickness ratios greater than 1.5. A height-to-thickness ratio of up to 2.5 is permitted where only the Basic Nonstructural Component Checklist is required by Table 3-2. (Tier 2: Sec. 4.8.8.1)

C NC N/A CANOPIES: Canopies located at building exits shall be anchored to the structural framing at a spacing of 6 feet or less. An anchorage spacing of up to 10 feet is permitted where only the Basic Nonstructural Component Checklist is required by Table 3-2. (Tier 2: Sec. 4.8.8.2)

Masonry Chimneys

C NC N/A URM CHIMNEYS: No unreinforced masonry chimney shall extend above the roof surface more than twice the least dimension of the chimney. A height above the roof surface of up to three times the least dimension of the chimney is permitted where only the Basic Nonstructural Component Checklist is required by Table 3-2. (Tier 2: Sec. 4.8.9.1)

Stairs

C NC N/A URM WALLS: Walls around stair enclosures shall not consist of unbraced hollow clay tile or unreinforced masonry with a height-to-thickness ratio greater than 12-to-1. A height-to-thickness ratio of up to 15-to-1 is permitted where only the Basic Nonstructural Component Checklist is required by Table 3-2. (Tier 2: Sec. 4.8.10.1)

C NC N/A STAIR DETAILS: In moment frame structures, the connection between the stairs and the structure shall not rely on shallow anchors in concrete. Alternatively, the stair details shall be capable of accommodating the drift calculated using the Quick Check procedure of Section 3.5.3.1 without including tension in the anchors. (Tier 2: Sec. 4.8.10.2)

Building Contents and Furnishing

(C) NC N/A TALL NARROW CONTENTS: Contents over 4 feet in height with a height-to-depth or height-to-width ratio greater than 3-to-1 shall be anchored to the floor slab or adjacent structural walls. A height-to-depth or height-to-width ratio of up to 4-to-1 is permitted where only the Basic Nonstructural Component Checklist is required by Table 3-2. (Tier 2: Sec. 4.8.11.1)

Mechanical and Electrical Equipment

C NC (N/A) EMERGENCY POWER: Equipment used as part of an emergency power system shall be mounted to maintain continued operation after an earthquake. (Tier 2: Sec. 4.8.12.1)

C NC (N/A) HAZARDOUS MATERIAL EQUIPMENT: HVAC or other equipment containing hazardous material shall not have damaged supply lines or unbraced isolation supports. (Tier 2: Sec. 4.8.12.2)

(C) NC N/A DETERIORATION: There shall be no evidence of deterioration, damage, or corrosion in any of the anchorage or supports of mechanical or electrical equipment. (Tier 2: Sec. 4.8.12.3)

(C) NC N/A ATTACHED EQUIPMENT: Equipment weighing over 20 lb that is attached to ceilings, walls, or other supports 4 feet above the floor level shall be braced. (Tier 2: Sec. 4.8.12.4)

Piping

C NC (N/A) FIRE SUPPRESSION PIPING: Fire suppression piping shall be anchored and braced in accordance with NFPA-13 (NFPA, 1996). (Tier 2: Sec. 4.8.13.1)

C NC (N/A) FLEXIBLE COUPLINGS: Fluid, gas, and fire suppression piping shall have flexible couplings. (Tier 2: Sec. 4.8.13.2)

Hazardous Materials Storage and Distribution

C NC (N/A) TOXIC SUBSTANCES: Toxic and hazardous substances stored in breakable containers shall be restrained from falling by latched doors, shelf lips, wires, or other methods. (Tier 2: Sec. 4.8.15.1)

3.9.2 Intermediate Nonstructural Component Checklist

This Intermediate Nonstructural Component Checklist shall be completed where required by Table 3-2. The Basic Nonstructural Component Checklist shall be completed prior to completing this Intermediate Nonstructural Component Checklist.

Ceiling Systems

C NC N/A — LAY-IN TILES: Lay-in tiles used in ceiling panels located at exits and corridors shall be secured with clips. (Tier 2: Sec. 4.8.2.2)

C NC N/A — INTEGRATED CEILINGS: Integrated suspended ceilings at exits and corridors or weighing more than 2 pounds per square foot shall be laterally restrained with a minimum of four diagonal wires or rigid members attached to the structure above at a spacing equal to or less than 12 feet. (Tier 2: Sec. 4.8.2.3)

Although gypsum board ceilings are not braced, areas are typically small.

C NC N/A — SUSPENDED LATH AND PLASTER: Ceilings consisting of suspended lath and plaster or gypsum board shall be attached to resist seismic forces for every ~~12~~ 144 square feet of area. (Tier 2: Sec. 4.8.2.4)

In newer ceilings with 2' x 2' grid.

Light Fixtures

C NC N/A — INDEPENDENT SUPPORT: Light fixtures in suspended grid ceilings shall be supported independently of the ceiling suspension system by a minimum of two wires at diagonally opposite corners of the fixtures. (Tier 2: Sec. 4.8.3.2)

In older ceilings with 2' x 4' grid

Cladding and Glazing

C NC N/A — GLAZING: Glazing in curtain walls and individual panes over 16 square feet in area, located up to a height of 10 feet above an exterior walking surface, shall have safety glazing. Such glazing located over 10 feet above an exterior walking surface shall be laminated annealed or laminated heat-strengthened safety glass or other glazing system that will remain in the frame when glass is cracked. (Tier 2: Sec. 4.8.4.8)

Most large panes not compliant, except where previously broken and replaced.

Parapets, Cornices, Ornamentation, and Appendages

C NC N/A — CONCRETE PARAPETS: Concrete parapets with height-to-thickness ratios greater than 2.5 shall have vertical reinforcement. (Tier 2: Sec. 4.8.8.3)

C NC N/A — APPENDAGES: Cornices, parapets, signs, and other appendages that extend above the highest point of anchorage to the structure or cantilever from exterior wall faces and other exterior wall ornamentation shall be reinforced and anchored to the structural system at a spacing equal to or less than 10 feet for Life Safety and 6 feet for Immediate Occupancy. This requirement need not apply to parapets or cornices compliant with Section 4.8.8.1 or 4.8.8.3. (Tier 2: Sec. 4.8.8.4)

Masonry Chimneys

C NC N/A — ANCHORAGE: Masonry chimneys shall be anchored at each floor level and the roof. (Tier 2: Sec. 4.8.9.2)

Mechanical and Electrical Equipment

C NC N/A VIBRATION ISOLATORS: Equipment mounted on vibration isolators shall be equipped with restraints or snubbers. (Tier 2: Sec. 4.8.12.5)

Ducts

C NC N/A STAIR AND SMOKE DUCTS: Stair pressurization and smoke control ducts shall be braced and shall have flexible connections at seismic joints. (Tier 2: Sec. 4.8.14.1)

3.9.2 Intermediate Nonstructural Component Checklist

This Intermediate Nonstructural Component Checklist shall be completed where required by Table 3-2. The Basic Nonstructural Component Checklist shall be completed prior to completing this Intermediate Nonstructural Component Checklist.

Main ceiling area is not braced.

Ceiling Systems

C (NC) N/A — LAY-IN TILES: Lay-in tiles used in ceiling panels located at exits and corridors shall be secured with clips. (Tier 2: Sec. 4.8.2.2)

C (NC) N/A — INTEGRATED CEILINGS: Integrated suspended ceilings at exits and corridors or weighing more than 2 pounds per square foot shall be laterally restrained with a minimum of four diagonal wires or rigid members attached to the structure above at a spacing equal to or less than 12 feet. (Tier 2: Sec. 4.8.2.3)

C NC (N/A) — SUSPENDED LATH AND PLASTER: Ceilings consisting of suspended lath and plaster or gypsum board shall be attached to resist seismic forces for every 12 square feet of area. (Tier 2: Sec. 4.8.2.4)

Light Fixtures

C (NC) N/A — INDEPENDENT SUPPORT: Light fixtures in suspended grid ceilings shall be supported independently of the ceiling suspension system by a minimum of two wires at diagonally opposite corners of the fixtures. (Tier 2: Sec. 4.8.3.2)

Cladding and Glazing

C NC (N/A) — GLAZING: Glazing in curtain walls and individual panes over 16 square feet in area, located up to a height of 10 feet above an exterior walking surface, shall have safety glazing. Such glazing located over 10 feet above an exterior walking surface shall be laminated annealed or laminated heat-strengthened safety glass or other glazing system that will remain in the frame when glass is cracked. (Tier 2: Sec. 4.8.4.8)

Parapets, Cornices, Ornamentation, and Appendages

C NC (N/A) — CONCRETE PARAPETS: Concrete parapets with height-to-thickness ratios greater than 2.5 shall have vertical reinforcement. (Tier 2: Sec. 4.8.8.3)

C NC (N/A) — APPENDAGES: Cornices, parapets, signs, and other appendages that extend above the highest point of anchorage to the structure or cantilever from exterior wall faces and other exterior wall ornamentation shall be reinforced and anchored to the structural system at a spacing equal to or less than 10 feet for Life Safety and 6 feet for Immediate Occupancy. This requirement need not apply to parapets or cornices compliant with Section 4.8.8.1 or 4.8.8.3. (Tier 2: Sec. 4.8.8.4)

Masonry Chimneys

C NC (N/A) — ANCHORAGE: Masonry chimneys shall be anchored at each floor level and the roof. (Tier 2: Sec. 4.8.9.2)

Mechanical and Electrical Equipment

C NC (N/A) VIBRATION ISOLATORS: Equipment mounted on vibration isolators shall be equipped with restraints or snubbers. (Tier 2: Sec. 4.8.12.5)

Ducts

C NC (N/A) STAIR AND SMOKE DUCTS: Stair pressurization and smoke control ducts shall be braced and shall have flexible connections at seismic joints. (Tier 2: Sec. 4.8.14.1)

Appendix B

ASCE 31-03 Tier 1 & Tier 2 Structural Calculations

- Tier 1 Structural Calculations
- Tier 2 Structural Calculations

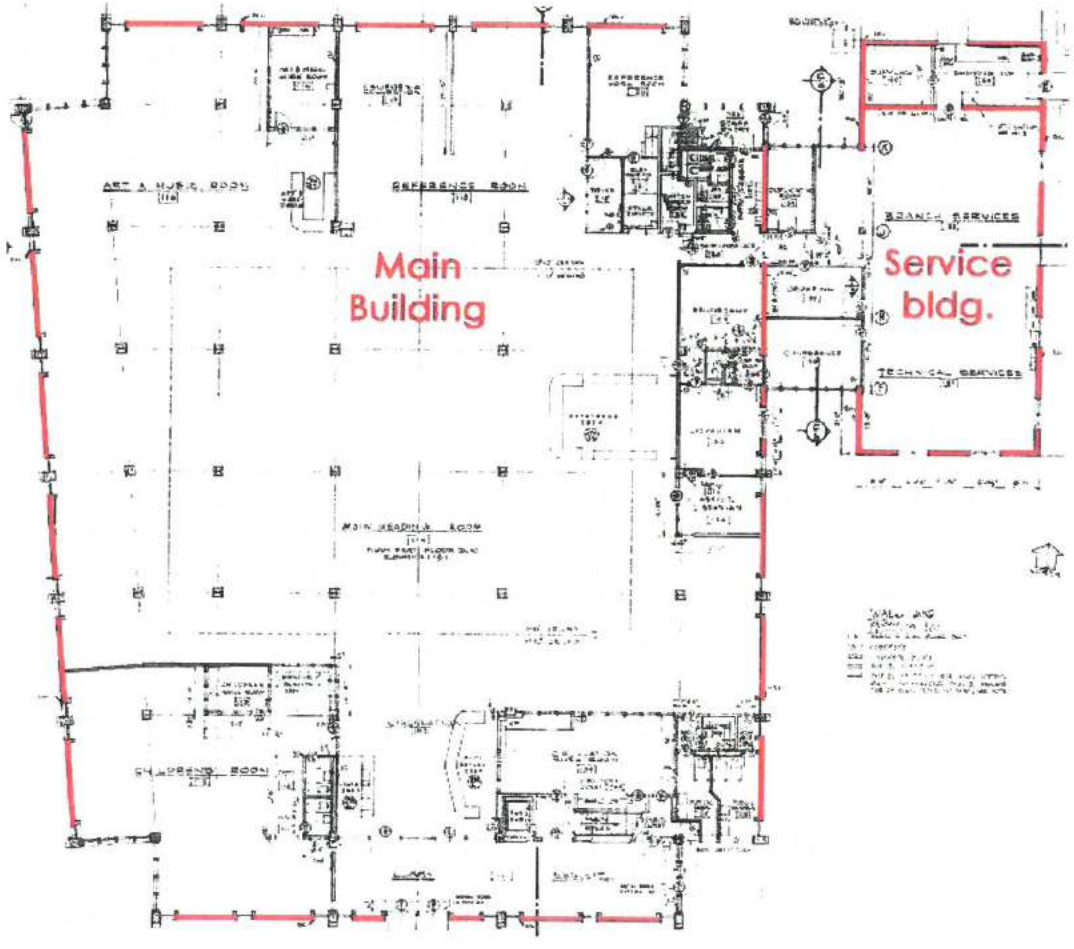
Tier 1 Analysis of Building

As part of the Tier 1 Screening, analysis is required for the following:

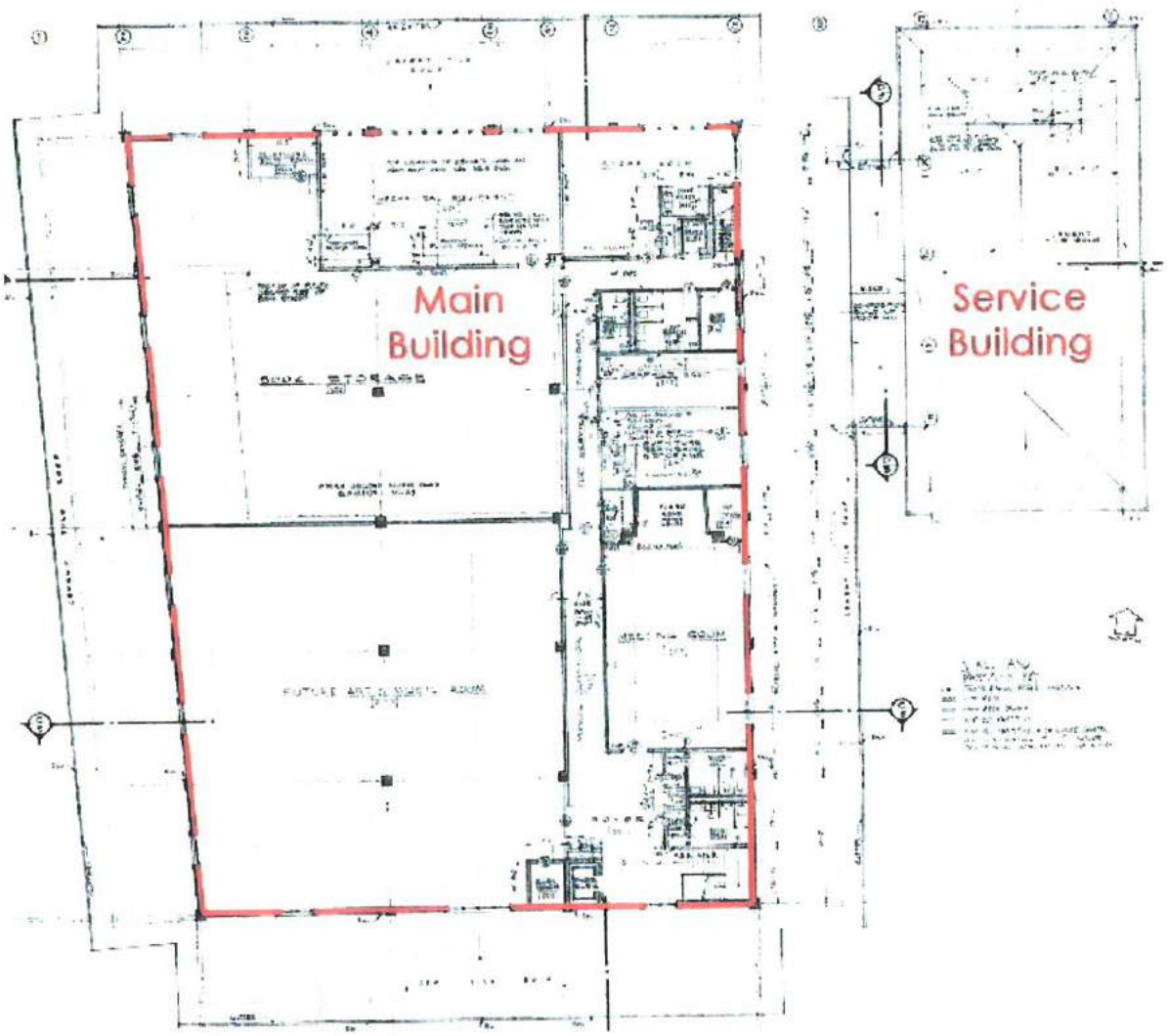
- Shear stress check of CMU walls for the first floor level (Type RM2 structure)
- Shear stress check of concrete walls for the second floor level of the Main Building (Type C2 structure).

Calculations include:

- Calculation of lateral loading per ASCE 31-03 criteria
- Load takeoff for building to determine lateral loads and lateral load distribution
- Check of CMU wall stress
- Check of CMU reinforcing detailing
- Check of Concrete wall stress
- Check of concrete reinforcing detailing



Above: First floor plan. CMU bracing walls are shown in red.



Above: 2nd floor plan. Concrete bracing walls are shown in red.

A 3-dimensional analysis was done using MultiFrame. All beams and columns were modeled based on information provided in the original construction documents. All walls and slabs were modeled as shell elements with thicknesses as noted in the original construction documents.

Loading combinations included:

D +/- 0.30Ex +/- 0.09Ez (four combinations)
D +/- 0.09Ex +/- 0.30Ez (four combinations)

Where D = dead load, Ex = seismic load in the X-direction at 1.0g and Ez = seismic load in the Z-direction at 1.0g

ASCE 31-03 Tier 1 Analysis

V = C*Sa*W where

V =	Pseudo lateral force
C =	Modification factor per Table 3-4
Sa =	Response spectral acceleration
W =	Effective seismic weight

C =	1.2	for 2-story reinforced masonry building
SD1 =	0.6	from USGS mapping
T =	0.217	estimated building period, T
Sa 1 =	2.76	= SD1/T
Sa 2 =	1.00	= SDS
Sa =	1.00	= min(SD1/T,SDS)
V =	1.20*W	= C*Sa*W
m =	4	m-factor for reinforced masonry
Vm =	0.30*W	for evaluation of masonry

v ave = = Vm/Aw where Aw = total wall cross-sectional area

Alternatively,

V = 0.75*W for Life Safety evaluation where foundation is less than 3' below exterior grade with slab or tie beams, and m-factor = 1.0 to be used.
Vm = 0.75*W using this alternative - too conservative; use computed value instead.

Tier 1 Analysis - Load Takeoff

High Roof	W	H	L	A or V	Unit Wt.	Unit	Total Wt.
Main Roof + Ceiling	106.75		144	15372	14	PSF	215208
Overhang	3.5	0.54	515.5	974.295	150	PCF	146144
Perim. Beams	1.33	3	496	1979.04	150	PCF	296856
Perm. Walls	0.67	2.665	499	890.9895	150	PCF	133648
Partitions		5	576	2880	7.5	PSF	21600
Structural Steel					490	PCF	97444
						Total	910901

2nd Floor/Low Roof	W	H	L	A or V	Unit Wt.	Unit	Total Wt.
Main Floor	106.75	0.375	144	5764.5	150	PCF	864675
Fl. finishes, Ceiling	106.75		144	15372	8	PSF	122976
Partitions above		5	576	2880	7.5	PSF	21600
Partitions below		5	576	2880	7.5	PSF	21600
Structural Steel					490	PCF	161589
Fixtures	106.75		144	15372	2	PSF	30744
Roofing/ceiling	15.5		501.5	7773.25	9	PSF	69959
Roof slab	20	0.54	501.5	5416.2	150	PCF	812430
Perim. Beams outer	1.33	3	496	1979.04	150	PCF	296856
Perim. Beams inner	1.33	5.67	496	3740.386	150	PCF	561058
Perim. Walls outer	0.635	9.67	304.5	1869.767	126	PCF	235591
Perim. Walls inner	0.67	2.665	499	890.9895	150	PCF	133648
Perim. Cols. outer	1.5	106.37	2	319.11	150	PCF	47867
						Total	3380593

Annex Roof	W	H	L	A or V	Unit Wt.	Unit	Total Wt.
Main roof - wood	36		81.17	2922.12	8	PSF	23377
Overhang - wood	3		246	738	16	PSF	11808
Main roof - conc	36		81.17	2922.12	78	PSF	227925
	18		47.67	858.06	73	PSF	62638
Ceiling	36		81.17	2922.12	5	PSF	14611
	18		47.67	858.06	6	PSF	5148
Partitions		5	156	780	7.5	PSF	5850
CMU Walls	0.635	4.84	186	571.6524	126	PCF	72028
Columns	1	38.72	1	38.72	126	PCF	4879
						Total	428265

Level	W (k)	H (ft)	WH	WH/sum	.3W	
High Roof	911	30	27327	0.33	470	k
2nd Floor/LR/Annex	3809	14.42	54924	0.67	945	k
	4720		82251		1416	k

Apply 1416k each direction, plus 30% of this in opposite direction for non-orthogonal effects
Use 3-D analysis with shell elements for all CMU and concrete walls, beams and slabs

Main Building
Load to CMU Walls (From 3D analysis of building using 0.3W lateral load)

	Line 1	Line 9	Line A	Line M
V walls (k)	-562.211	-443.856	-393.223	-428.764
L walls (ft - total)	100	75.67	61.33	76.67
V/ft (k/ft)	5.62	5.87	6.41	5.59
v (psi)	61	64	70	61

Annex
Load to CMU Walls (From 3D analysis of building using 0.3W lateral load)

	Line 10	Line 11	Line E.3	Line L	Line L.8
V walls (k)	-113.192	-146.28	-157.142	-170.842	-67.927
L walls (ft - total)	32.58	81.17	36	33	36
V/ft (k/ft)	3.47	1.80	4.37	5.18	1.89
v (psi)	38	20	48	57	21

v max = 70 psi

Note: Loads above are to CMU loads and do not include loads taken by concrete

Limitation is 70 psi for Tier 1 Screening - all are OK, with maximum at line A at 70 psi
Total vertical + horizontal reinforcing:

#5 @ 16" o.c. vertical	rho =	0.0026	
#4 @ 24" horizontal	rho =	0.0011	
Minimum combined required	rho =	0.002	OK
Minimum either direction req	rho =	0.0007	OK
Maximum spacing		48 in. o.c.	OK

No Tier 2 analysis req'd for CMU walls between 1st & 2nd floor/low roof in either the Main Building or the Annex.

Main Building
Load to Concrete Walls (from 3D analysis of building using 0.3W lateral load)

	Line 2	Line 8	Line B	Line L
V walls (k)	-501	-410	-514	-397
L walls (ft - total)	97	96	77	61
V/ft (k/ft)	5.16	4.27	6.68	6.51
v (psi)	54	44	70	68

v max = 70 psi

Limitation is 100 psi for Tier 1 Screening - all are OK, with maximum at line B at 70 psi
Reinforcing is #4 @ 10" o.c. each way in 8" concrete wall
Spacing is < 18", OK
Ratio to gross area = 0.2/10/8 = 0.0025, OK (minimum is 0.0025)

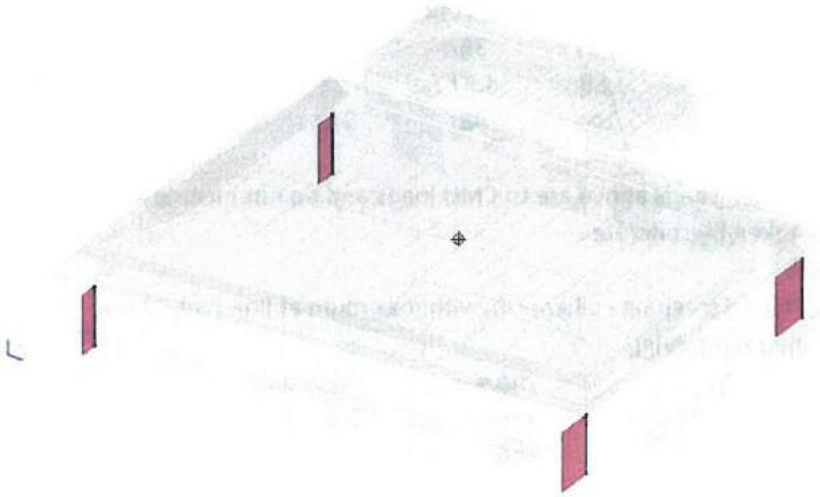
No Tier 2 analysis req'd for concrete shear walls between 2nd floor and high roof

Tier 2 Analysis of Building

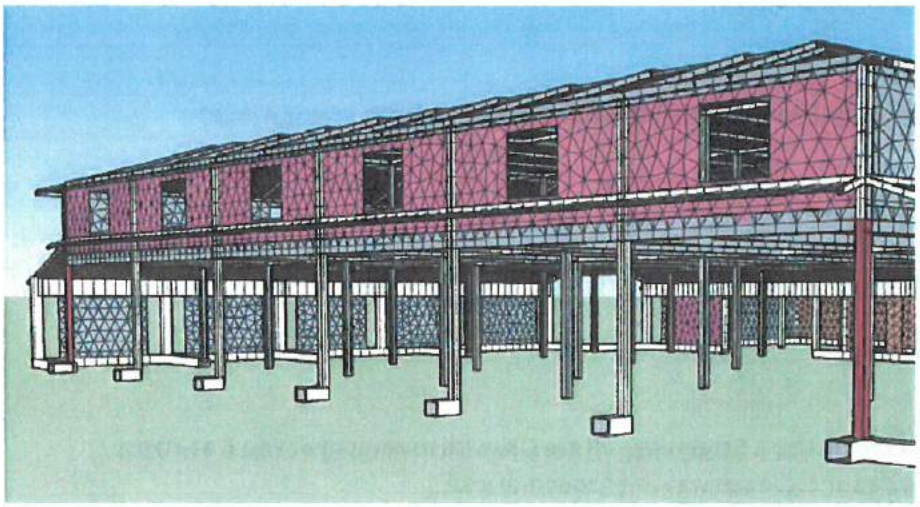
Further analysis of the building was made to review the following:

- Axial loads in the four corner columns under the perimeter of the second floor walls where there is a discontinuity of these walls (they do not continue to the first floor)
- Moments and shears in the beams at the perimeter of the low roof area of the main building where CMU walls occur below.

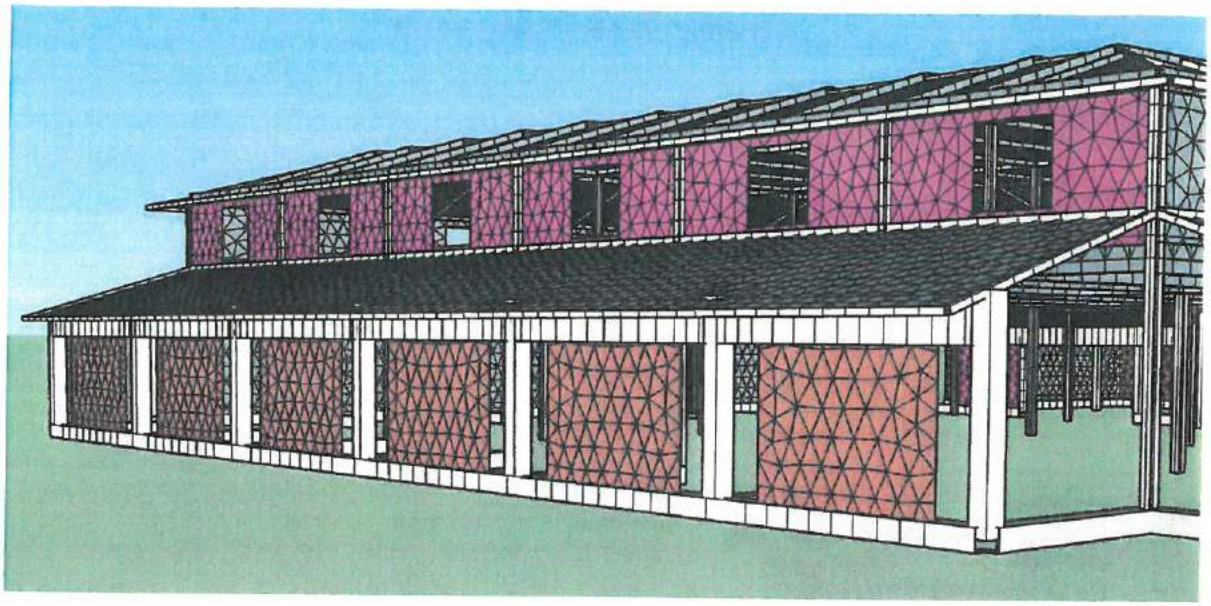
Axial Loads at Corner Columns:



Above: These are the four affected columns. Axial load varied depending on load combination applied.



Above: The affected columns are shown in red under wall corners above them.



Above: This shows the typical discontinuity between the walls above (pink) and the walls below (brown) due to the 15'-6" offset in plan.

The steel columns at the four corners were checked using the following load combinations:

D + L + Lr

D + 0.5L +/- Ex +/- 0.3Ez (four combinations)

D + 0.5L +/- 0.3Ex +/- Ez (four combinations)

Where:

D = dead load

L = floor live load

Lr = roof live load

Ex = seismic load in the X-direction at 1.0g

Ez = seismic load in the Z-direction at 1.0g

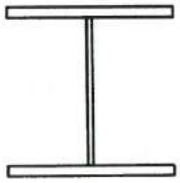
The details of the design check are shown on the pages that follow for each of the affected members. The conclusion is that all four columns are adequate; one of the four was 2% over for one load combination, which is less than 5% and thus considered adequate.

Steel Design Report

Checking C:\Users\r2d2\Documents\Santa Cruz Main Library.mfd to AISC ASD 2010 code
Thursday, October 30, 2014 3:57 PM

Checking design member 504

Members: 585
Group: W
Section: W10x60



Design Constraints

$Kl/r = Max(K_x l_{cx}/r_x, K_y l_{cy}/r_y) = Max(46.469, 79.377) = 79.377$

$Kl/r \le 200$, $79.377 \le 200$, OK OK 60% under

$l/r = Max(l_{cx}/r_x, l_{cy}/r_y) = Max(46.469, 79.377) = 79.377$

$l/r \le 300$, $79.377 \le 300$ OK 74% under

All constraints PASSED

Load Case: SWy+SWx+0.3SWz+0.5L (Strength Limit State)

Design Checks

$M_{ux} \le M_{nx}/\Omega_b$, $30.112 \le 310.833 / 1.67$, $30.112 \le 186.128$ OK 84% under

$M_{uy} \le M_{ny}/\Omega_b$, $4.131 \le 145.833 / 1.67$, $4.131 \le 87.325$ OK 95% under

$P_u \le P_n/\Omega_t$, $0.0 \le 880.056 / 1.67$, $0.0 \le 526.979$ OK 100% under

$P_u \le P_n/\Omega_c$, $264.254 \le 555.179 / 1.67$, $264.254 \le 332.442$ OK 21% under

$\Rightarrow P_r/2P_c + (M_{rx}/M_{cx} + M_{ry}/M_{cy}) \le 1.0$, $0.0 + (0.162 + 0.047) \le 1.0$, $0.209 \le 1.0$ OK 79% under

$\Rightarrow P_r/P_c + 8/9(M_{rx}/M_{cx}) \le 1.0$, $0.795 + 8/9(0.162) \le 1.0$, $0.939 \le 1.0$ OK 6% under

$P_r/P_{cy}(1.5 - 0.5P_r/P_{cy}) + (M_{rx}/CbM_{cx})^2 \le 1.0$, $264.254/332.442(1.5 - 0.5*264.254/332.442) + (30.112/(2.211*186.128))^2 \le 1.0$, $0.882 \le 1.0$ OK 12% under

Load Case: SWy+SWx-0.3SWz+0.5L (Strength Limit State)

Design Checks

$M_{ux} \le M_{nx}/\Omega_b$, $28.878 \le 310.833 / 1.67$, $28.878 \le 186.128$ OK 84% under

$M_{uy} \le M_{ny}/\Omega_b$, $3.375 \le 145.833 / 1.67$, $3.375 \le 87.325$ OK 96% under

$P_u \le P_n/\Omega_t$, $0.0 \le 880.056 / 1.67$, $0.0 \le 526.979$ OK 100% under

$P_u \le P_n/\Omega_c$, $209.638 \le 555.179 / 1.67$, $209.638 \le 332.442$ OK 37% under

$\Rightarrow P_r/2P_c + (M_{rx}/M_{cx} + M_{ry}/M_{cy}) \le 1.0$, $0.0 + (0.155 + 0.039) \le 1.0$, $0.194 \le 1.0$ OK 81% under

$\Rightarrow P_r/P_c + 8/9(M_{rx}/M_{cx}) \le 1.0$, $0.631 + 8/9(0.155) \le 1.0$, $0.769 \le 1.0$ OK 23% under

$P_r/P_{cy}(1.5 - 0.5P_r/P_{cy}) + (M_{rx}/CbM_{cx})^2 \le 1.0$, $209.638/332.442(1.5 - 0.5*209.638/332.442) + (28.878/(2.178*186.128))^2 \le 1.0$, $0.752 \le 1.0$ OK 25% under

Load Case: SWy-SWx-0.3SWz+0.5L (Strength Limit State)

Design Checks

$M_{ux} \le M_{nx}/\Omega_b$, $27.359 \le 310.833 / 1.67$, $27.359 \le 186.128$ OK 85% under

$M_{uy} \le M_{ny}/\Omega_b$, $3.123 \le 145.833 / 1.67$, $3.123 \le 87.325$ OK 96% under

$P_u \le P_n/\Omega_t$, $16.847 \le 880.056 / 1.67$, $16.847 \le 526.979$ OK 97% under

$P_u \le P_n/\Omega_c$, $0.0 \le 555.179 / 1.67$, $0.0 \le 332.442$ OK 100% under

$\Rightarrow P_r/2P_c + (M_{rx}/M_{cx} + M_{ry}/M_{cy}) \le 1.0$, $0.016 + (0.145 + 0.035) \le 1.0$, $0.196 \le 1.0$ OK 80% under

$\Rightarrow P_r/2P_c + M_{rx}/M_{cx} \le 1.0$, $0.0 + 0.147 \le 1.0$, $0.147 \le 1.0$ OK 85% under

$P_r/P_{cy}(1.5 - 0.5P_r/P_{cy}) + (M_{rx}/CbM_{cx})^2 \le 1.0$, $0.0/332.442(1.5 - 0.5*0.0/332.442) + (27.359/(2.33*186.128))^2 \le 1.0$, $0.004 \le 1.0$ OK 100% under

Load Case: SWy-SWx+0.3SWz+0.5L (Strength Limit State)

Design Checks

$M_{ux} \le M_{nx}/\Omega_b$, $27.39 \le 310.833 / 1.67$, $27.39 \le 186.128$ OK 85% under

$M_{uy} \le M_{ny}/\Omega_b$, $2.424 \le 145.833 / 1.67$, $2.424 \le 87.325$ OK 97% under

$P_u \le P_n/\Omega_t$, $0.0 \le 880.056 / 1.67$, $0.0 \le 526.979$ OK 100% under

$P_u \le P_n/\Omega_c$, $38.789 \le 555.179 / 1.67$, $38.789 \le 332.442$ OK 88% under

$\Rightarrow P_r/2P_c + (M_{rx}/M_{cx} + M_{ry}/M_{cy}) \leq 1.0$, 0.0 + (0.147 + 0.028) ≤ 1.0, 0.175 ≤ 1.0 OK 83% under

$\Rightarrow P_r/2P_c + M_{rx}/M_{cx} \leq 1.0$, 0.058 + 0.147 ≤ 1.0, 0.205 ≤ 1.0 OK 79% under

$P_r/P_{cy}(1.5 - 0.5P_r/P_{cy}) + (M_{rx}/CbM_{cx})^2 \leq 1.0$, 38.789/332.442(1.5 - 0.5*38.789/332.442) + (27.39/(2.336*186.128))^2 ≤ 1.0, 0.172 ≤ 1.0 OK 83% under

Load Case: SWy+SWz+0.3SWx+0.5L (Strength Limit State)

Design Checks

$M_{ux} \leq M_{nx}/\Omega_b$, 9.671 ≤ 310.833 / 1.67, 9.671 ≤ 186.128 OK 95% under

$M_{uy} \leq M_{ny}/\Omega_b$, 12.601 ≤ 145.833 / 1.67, 12.601 ≤ 87.325 OK 86% under

$P_u \leq P_n/\Omega_t$, 0.0 ≤ 880.056 / 1.67, 0.0 ≤ 526.979 OK 100% under

$P_u \leq P_n/\Omega_c$, 249.06 ≤ 555.179 / 1.67, 249.06 ≤ 332.442 OK 25% under

$\Rightarrow P_r/2P_c + (M_{rx}/M_{cx} + M_{ry}/M_{cy}) \leq 1.0$, 0.0 + (0.052 + 0.144) ≤ 1.0, 0.196 ≤ 1.0 OK 80% under

$\Rightarrow P_r/P_c + 8/9(M_{rx}/M_{cx} + M_{ry}/M_{cy}) \leq 1.0$, 0.749 + 8/9(0.052 + 0.144) ≤ 1.0, 0.924 ≤ 1.0 OK 8% under

Load Case: SWy+SWz-0.3SWx+0.5L (Strength Limit State)

Design Checks

$M_{ux} \leq M_{nx}/\Omega_b$, 8.308 ≤ 310.833 / 1.67, 8.308 ≤ 186.128 OK 96% under

$M_{uy} \leq M_{ny}/\Omega_b$, 10.971 ≤ 145.833 / 1.67, 10.971 ≤ 87.325 OK 87% under

$P_u \leq P_n/\Omega_t$, 0.0 ≤ 880.056 / 1.67, 0.0 ≤ 526.979 OK 100% under

$P_u \leq P_n/\Omega_c$, 181.421 ≤ 555.179 / 1.67, 181.421 ≤ 332.442 OK 45% under

$\Rightarrow P_r/2P_c + (M_{rx}/M_{cx} + M_{ry}/M_{cy}) \leq 1.0$, 0.0 + (0.045 + 0.126) ≤ 1.0, 0.17 ≤ 1.0 OK 83% under

$\Rightarrow P_r/P_c + 8/9(M_{rx}/M_{cx} + M_{ry}/M_{cy}) \leq 1.0$, 0.546 + 8/9(0.045 + 0.126) ≤ 1.0, 0.697 ≤ 1.0 OK 30% under

Load Case: SWy-SWz-0.3SWx+0.5L (Strength Limit State)

Design Checks

$M_{ux} \leq M_{nx}/\Omega_b$, 9.072 ≤ 310.833 / 1.67, 9.072 ≤ 186.128 OK 95% under

$M_{uy} \leq M_{ny}/\Omega_b$, 9.027 ≤ 145.833 / 1.67, 9.027 ≤ 87.325 OK 90% under

$P_u \leq P_n/\Omega_t$, 1.653 ≤ 880.056 / 1.67, 1.653 ≤ 526.979 OK 100% under

$P_u \leq P_n/\Omega_c$, 0.0 ≤ 555.179 / 1.67, 0.0 ≤ 332.442 OK 100% under

$\Rightarrow P_r/2P_c + (M_{rx}/M_{cx} + M_{ry}/M_{cy}) \leq 1.0$, 0.002 + (0.049 + 0.103) ≤ 1.0, 0.153 ≤ 1.0 OK 85% under

$\Rightarrow P_r/2P_c + M_{rx}/M_{cx} \leq 1.0$, 0.0 + 0.049 ≤ 1.0, 0.049 ≤ 1.0 OK 95% under

$P_r/P_{cy}(1.5 - 0.5P_r/P_{cy}) + (M_{rx}/CbM_{cx})^2 \leq 1.0$, 0.0/332.442(1.5 - 0.5*0.0/332.442) + (9.072/(2.263*186.128))^2 ≤ 1.0, 0.0 ≤ 1.0 OK 100% under

Load Case: SWy-SWz+0.3SWx+0.5L (Strength Limit State)

Design Checks

$M_{ux} \leq M_{nx}/\Omega_b$, 9.556 ≤ 310.833 / 1.67, 9.556 ≤ 186.128 OK 95% under

$M_{uy} \leq M_{ny}/\Omega_b$, 9.647 ≤ 145.833 / 1.67, 9.647 ≤ 87.325 OK 89% under

$P_u \leq P_n/\Omega_t$, 0.0 ≤ 880.056 / 1.67, 0.0 ≤ 526.979 OK 100% under

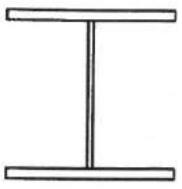
$P_u \leq P_n/\Omega_c$, 67.006 ≤ 555.179 / 1.67, 67.006 ≤ 332.442 OK 80% under

$\Rightarrow P_r/2P_c + (M_{rx}/M_{cx} + M_{ry}/M_{cy}) \leq 1.0$, 0.0 + (0.051 + 0.11) ≤ 1.0, 0.162 ≤ 1.0 OK 84% under

$\Rightarrow P_r/P_c + 8/9(M_{rx}/M_{cx} + M_{ry}/M_{cy}) \leq 1.0$, 0.202 + 8/9(0.051 + 0.11) ≤ 1.0, 0.345 ≤ 1.0 OK 65% under

Checking design member 510

Members: 591
Group: W
Section: W10x60



Design Constraints

$Kl/r = \text{Max}(K_x l_{cx}/r_x, K_y l_{cy}/r_y) = \text{Max}(46.469, 79.377) = 79.377$

$Kl/r \leq 200$, 79.377 ≤ 200, OK OK 60% under

$l/r = \text{Max}(l_{cx}/r_x, l_{cy}/r_y) = \text{Max}(46.469, 79.377) = 79.377$

$l/r \leq 300$, 79.377 ≤ 300 OK 74% under

All constraints PASSED

Load Case: SWy+SWx+0.3SWz+0.5L (Strength Limit State)

Design Checks

$M_{ux} \le M_{nx}/\Omega_b$, 20.56 ≤ 310.833 / 1.67, 20.56 ≤ 186.128 OK 89% under

$M_{uy} \le M_{ny}/\Omega_b$, 2.15 ≤ 145.833 / 1.67, 2.15 ≤ 87.325 OK 98% under

$P_u \le P_n/\Omega_t$, 0.0 ≤ 880.056 / 1.67, 0.0 ≤ 526.979 OK 100% under

$P_u \le P_n/\Omega_c$, 143.949 ≤ 555.179 / 1.67, 143.949 ≤ 332.442 OK 57% under

$\Rightarrow P_r/2P_c + (M_{rx}/M_{cx} + M_{ry}/M_{cy}) \le 1.0$, 0.0 + (0.11 + 0.025) ≤ 1.0, 0.135 ≤ 1.0 OK 86% under

$\Rightarrow P_r/P_c + 8/9(M_{rx}/M_{cx}) \le 1.0$, 0.433 + 8/9(0.11) ≤ 1.0, 0.531 ≤ 1.0 OK 47% under

$P_r/P_{cy}(1.5 - 0.5P_r/P_{cy}) + (M_{rx}/CbM_{cx})^2 \le 1.0$, 143.949/332.442(1.5 - 0.5*143.949/332.442) + (20.56/(2.08*186.128))^2 ≤ 1.0, 0.559 ≤ 1.0 OK 44% under

Load Case: SWy+SWx-0.3SWz+0.5L (Strength Limit State)

Design Checks

$M_{ux} \le M_{nx}/\Omega_b$, 21.695 ≤ 310.833 / 1.67, 21.695 ≤ 186.128 OK 88% under

$M_{uy} \le M_{ny}/\Omega_b$, 4.414 ≤ 145.833 / 1.67, 4.414 ≤ 87.325 OK 95% under

$P_u \le P_n/\Omega_t$, 0.0 ≤ 880.056 / 1.67, 0.0 ≤ 526.979 OK 100% under

$P_u \le P_n/\Omega_c$, 201.704 ≤ 555.179 / 1.67, 201.704 ≤ 332.442 OK 39% under

$\Rightarrow P_r/2P_c + (M_{rx}/M_{cx} + M_{ry}/M_{cy}) \le 1.0$, 0.0 + (0.117 + 0.051) ≤ 1.0, 0.167 ≤ 1.0 OK 83% under

$\Rightarrow P_r/P_c + 8/9(M_{rx}/M_{cx} + M_{ry}/M_{cy}) \le 1.0$, 0.607 + 8/9(0.117 + 0.051) ≤ 1.0, 0.755 ≤ 1.0 OK 24% under

Load Case: SWy-SWx-0.3SWz+0.5L (Strength Limit State)

Design Checks

$M_{ux} \le M_{nx}/\Omega_b$, 20.452 ≤ 310.833 / 1.67, 20.452 ≤ 186.128 OK 89% under

$M_{uy} \le M_{ny}/\Omega_b$, 2.87 ≤ 145.833 / 1.67, 2.87 ≤ 87.325 OK 97% under

$P_u \le P_n/\Omega_t$, 0.0 ≤ 880.056 / 1.67, 0.0 ≤ 526.979 OK 100% under

$P_u \le P_n/\Omega_c$, 61.463 ≤ 555.179 / 1.67, 61.463 ≤ 332.442 OK 82% under

$\Rightarrow P_r/2P_c + (M_{rx}/M_{cx} + M_{ry}/M_{cy}) \le 1.0$, 0.0 + (0.11 + 0.033) ≤ 1.0, 0.143 ≤ 1.0 OK 86% under

$\Rightarrow P_r/2P_c + M_{rx}/M_{cx} \le 1.0$, 0.092 + 0.11 ≤ 1.0, 0.202 ≤ 1.0 OK 80% under

$P_r/P_{cy}(1.5 - 0.5P_r/P_{cy}) + (M_{rx}/CbM_{cx})^2 \le 1.0$, 61.463/332.442(1.5 - 0.5*61.463/332.442) + (20.452/(2.383*186.128))^2 ≤ 1.0, 0.262 ≤ 1.0 OK 74% under

Load Case: SWy-SWx+0.3SWz+0.5L (Strength Limit State)

Design Checks

$M_{ux} \le M_{nx}/\Omega_b$, 20.775 ≤ 310.833 / 1.67, 20.775 ≤ 186.128 OK 89% under

$M_{uy} \le M_{ny}/\Omega_b$, 3.395 ≤ 145.833 / 1.67, 3.395 ≤ 87.325 OK 96% under

$P_u \le P_n/\Omega_t$, 0.0 ≤ 880.056 / 1.67, 0.0 ≤ 526.979 OK 100% under

$P_u \le P_n/\Omega_c$, 3.708 ≤ 555.179 / 1.67, 3.708 ≤ 332.442 OK 99% under

$\Rightarrow P_r/2P_c + (M_{rx}/M_{cx} + M_{ry}/M_{cy}) \le 1.0$, 0.0 + (0.112 + 0.039) ≤ 1.0, 0.15 ≤ 1.0 OK 85% under

$\Rightarrow P_r/2P_c + M_{rx}/M_{cx} \le 1.0$, 0.006 + 0.112 ≤ 1.0, 0.117 ≤ 1.0 OK 88% under

$P_r/P_{cy}(1.5 - 0.5P_r/P_{cy}) + (M_{rx}/CbM_{cx})^2 \le 1.0$, 3.708/332.442(1.5 - 0.5*3.708/332.442) + (20.775/(2.369*186.128))^2 ≤ 1.0, 0.019 ≤ 1.0 OK 98% under

Load Case: SWy+SWz+0.3SWx+0.5L (Strength Limit State)

Design Checks

$M_{ux} \le M_{nx}/\Omega_b$, 7.35 ≤ 310.833 / 1.67, 7.35 ≤ 186.128 OK 96% under

$M_{uy} \le M_{ny}/\Omega_b$, 8.525 ≤ 145.833 / 1.67, 8.525 ≤ 87.325 OK 90% under

$P_u \le P_n/\Omega_t$, 0.0 ≤ 880.056 / 1.67, 0.0 ≤ 526.979 OK 100% under

$P_u \le P_n/\Omega_c$, 27.483 ≤ 555.179 / 1.67, 27.483 ≤ 332.442 OK 92% under

$\Rightarrow P_r/2P_c + (M_{rx}/M_{cx} + M_{ry}/M_{cy}) \le 1.0$, 0.0 + (0.039 + 0.098) ≤ 1.0, 0.137 ≤ 1.0 OK 86% under

$\Rightarrow P_r/2P_c + (M_{rx}/M_{cx} + M_{ry}/M_{cy}) \le 1.0$, 0.041 + (0.039 + 0.098) ≤ 1.0, 0.178 ≤ 1.0 OK 82% under

Load Case: SWy+SWz-0.3SWx+0.5L (Strength Limit State)

Design Checks

$M_{ux} \le M_{nx}/\Omega_b$, 7.795 ≤ 310.833 / 1.67, 7.795 ≤ 186.128 OK 96% under

$M_{uy} \le M_{ny}/\Omega_b$, 8.716 ≤ 145.833 / 1.67, 8.716 ≤ 87.325 OK 90% under

$P_u \le P_n/\Omega_t$, 15.609 ≤ 880.056 / 1.67, 15.609 ≤ 526.979 OK 97% under

$P_u \le P_n/\Omega_c$, 0.0 ≤ 555.179 / 1.67, 0.0 ≤ 332.442 OK 100% under

$\Rightarrow P_r/2P_c + (M_{rx}/M_{cx} + M_{ry}/M_{cy}) \le 1.0$, 0.015 + (0.041 + 0.098) ≤ 1.0, 0.154 ≤ 1.0 OK 85% under

$\Rightarrow P_r/2P_c + (M_{rx}/M_{cx} + M_{ry}/M_{cy}) \le 1.0$, 0.0 + (0.042 + 0.1) ≤ 1.0, 0.142 ≤ 1.0 OK 86% under

Load Case: SWy-SWz-0.3SWx+0.5L (Strength Limit State)

Design Checks

$M_{ux} \le M_{nx}/\Omega_b$, 5.456 ≤ 310.833 / 1.67, 5.456 ≤ 186.128 OK 97% under

$M_{uy} \le M_{ny}/\Omega_b$, 10.49 ≤ 145.833 / 1.67, 10.49 ≤ 87.325 OK 88% under

$P_u \le P_n/\Omega_t$, 0.0 ≤ 880.056 / 1.67, 0.0 ≤ 526.979 OK 100% under

$P_u \le P_n/\Omega_c$, 177.929 ≤ 555.179 / 1.67, 177.929 ≤ 332.442 OK 46% under

$\Rightarrow P_r/2P_c + (M_{rx}/M_{cx} + M_{ry}/M_{cy}) \le 1.0$, 0.0 + (0.029 + 0.12) ≤ 1.0, 0.149 ≤ 1.0 OK 85% under

$\Rightarrow P_r/P_c + 8/9(M_{rx}/M_{cx} + M_{ry}/M_{cy}) \leq 1.0, 0.535 + 8/9(0.029 + 0.12) \leq 1.0, 0.668 \leq 1.0$ OK 33% under

Load Case: SWy-SWz+0.3SWx+0.5L (Strength Limit State)

Design Checks

$M_{ux} \leq M_{nx}/\Omega_b$, 8.002 ≤ 310.833 / 1.67, 8.002 ≤ 186.128 OK 96% under

$M_{uy} \leq M_{ny}/\Omega_b$, 11.924 ≤ 145.833 / 1.67, 11.924 ≤ 87.325 OK 86% under

$P_u \leq P_n/\Omega_t$, 0.0 ≤ 880.056 / 1.67, 0.0 ≤ 526.979 OK 100% under

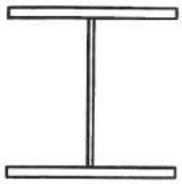
$P_u \leq P_n/\Omega_c$, 220.001 ≤ 555.179 / 1.67, 220.001 ≤ 332.442 OK 34% under

$\Rightarrow P_r/2P_c + (M_{rx}/M_{cx} + M_{ry}/M_{cy}) \leq 1.0, 0.0 + (0.043 + 0.137) \leq 1.0, 0.18 \leq 1.0$ OK 82% under

$\Rightarrow P_r/P_c + 8/9(M_{rx}/M_{cx} + M_{ry}/M_{cy}) \leq 1.0, 0.662 + 8/9(0.043 + 0.137) \leq 1.0, 0.821 \leq 1.0$ OK 18% under

Checking design member 511

Members: 592
Group: W
Section: W10x60



Design Constraints

$Kl/r = \text{Max}(K_x l_{cx}/r_x, K_y l_{cy}/r_y) = \text{Max}(46.469, 79.377) = 79.377$

$Kl/r \leq 200$, 79.377 ≤ 200, OK OK 60% under

$l/r = \text{Max}(l_{cx}/r_x, l_{cy}/r_y) = \text{Max}(46.469, 79.377) = 79.377$

$l/r \leq 300$, 79.377 ≤ 300 OK 74% under

All constraints PASSED

Load Case: SWy+SWx+0.3SWz+0.5L (Strength Limit State)

Design Checks

$M_{ux} \leq M_{nx}/\Omega_b$, 26.664 ≤ 310.833 / 1.67, 26.664 ≤ 186.128 OK 86% under

$M_{uy} \leq M_{ny}/\Omega_b$, 2.005 ≤ 145.833 / 1.67, 2.005 ≤ 87.325 OK 98% under

$P_u \leq P_n/\Omega_t$, 0.0 ≤ 880.056 / 1.67, 0.0 ≤ 526.979 OK 100% under

$P_u \leq P_n/\Omega_c$, 45.153 ≤ 555.179 / 1.67, 45.153 ≤ 332.442 OK 86% under

$\Rightarrow P_r/2P_c + (M_{rx}/M_{cx} + M_{ry}/M_{cy}) \leq 1.0, 0.0 + (0.143 + 0.023) \leq 1.0, 0.166 \leq 1.0$ OK 83% under

$\Rightarrow P_r/2P_c + M_{rx}/M_{cx} \leq 1.0, 0.068 + 0.143 \leq 1.0, 0.211 \leq 1.0$ OK 79% under

$P_r/P_{cy}(1.5 - 0.5P_r/P_{cy}) + (M_{rx}/CbM_{cx})^2 \leq 1.0, 45.153/332.442(1.5 - 0.5*45.153/332.442) + (26.664/(2.341*186.128))^2 \leq 1.0, 0.198 \leq 1.0$ OK 80% under

Load Case: SWy+SWx-0.3SWz+0.5L (Strength Limit State)

Design Checks

$M_{ux} \leq M_{nx}/\Omega_b$, 27.189 ≤ 310.833 / 1.67, 27.189 ≤ 186.128 OK 85% under

$M_{uy} \leq M_{ny}/\Omega_b$, 3.571 ≤ 145.833 / 1.67, 3.571 ≤ 87.325 OK 96% under

$P_u \leq P_n/\Omega_t$, 11.789 ≤ 880.056 / 1.67, 11.789 ≤ 526.979 OK 98% under

$P_u \leq P_n/\Omega_c$, 0.0 ≤ 555.179 / 1.67, 0.0 ≤ 332.442 OK 100% under

$\Rightarrow P_r/2P_c + (M_{rx}/M_{cx} + M_{ry}/M_{cy}) \leq 1.0, 0.011 + (0.144 + 0.04) \leq 1.0, 0.196 \leq 1.0$ OK 80% under

$\Rightarrow P_r/2P_c + M_{rx}/M_{cx} \leq 1.0, 0.0 + 0.146 \leq 1.0, 0.146 \leq 1.0$ OK 85% under

$P_r/P_{cy}(1.5 - 0.5P_r/P_{cy}) + (M_{rx}/CbM_{cx})^2 \leq 1.0, 0.0/332.442(1.5 - 0.5*0.0/332.442) + (27.189/(2.332*186.128))^2 \leq 1.0, 0.004 \leq 1.0$ OK 100% under

Load Case: SWy-SWx-0.3SWz+0.5L (Strength Limit State)

Design Checks

$M_{ux} \leq M_{nx}/\Omega_b$, 28.03 ≤ 310.833 / 1.67, 28.03 ≤ 186.128 OK 85% under

$M_{uy} \leq M_{ny}/\Omega_b$, 3.027 ≤ 145.833 / 1.67, 3.027 ≤ 87.325 OK 97% under

$P_u \leq P_n/\Omega_t$, 0.0 ≤ 880.056 / 1.67, 0.0 ≤ 526.979 OK 100% under

$P_u \leq P_n/\Omega_c$, 219.833 ≤ 555.179 / 1.67, 219.833 ≤ 332.442 OK 34% under

$\Rightarrow P_r/2P_c + (M_{rx}/M_{cx} + M_{ry}/M_{cy}) \leq 1.0, 0.0 + (0.151 + 0.035) \leq 1.0, 0.185 \leq 1.0$ OK 81% under

$\Rightarrow P_r/P_c + 8/9(M_{rx}/M_{cx}) \leq 1.0, 0.661 + 8/9(0.151) \leq 1.0, 0.795 \leq 1.0$ OK 20% under

$P_r/P_{cy}(1.5 - 0.5P_r/P_{cy}) + (M_{rx}/CbM_{cx})^2 \leq 1.0, 219.833/332.442(1.5 - 0.5*219.833/332.442) + (28.03/(2.166*186.128))^2 \leq 1.0, 0.778 \leq 1.0$ OK 22% under

Load Case: SWy-SWx+0.3SWz+0.5L (Strength Limit State)

Design Checks

$M_{ux} \le M_{nx}/\Omega_b$, 29.964 ≤ 310.833 / 1.67, 29.964 ≤ 186.128 OK 84% under

$M_{uy} \le M_{ny}/\Omega_b$, 4.666 ≤ 145.833 / 1.67, 4.666 ≤ 87.325 OK 95% under

$P_u \le P_n/\Omega_t$, 0.0 ≤ 880.056 / 1.67, 0.0 ≤ 526.979 OK 100% under

$P_u \le P_n/\Omega_c$, 275.756 ≤ 555.179 / 1.67, 275.756 ≤ 332.442 OK 17% under

$\Rightarrow P_r/2P_c + (M_{rx}/M_{cx} + M_{ry}/M_{cy}) \le 1.0$, 0.0 + (0.161 + 0.053) ≤ 1.0, 0.214 ≤ 1.0 OK 79% under

$\Rightarrow P_r/P_c + 8/9(M_{rx}/M_{cx} + M_{ry}/M_{cy}) > 1.0$, 0.829 + 8/9(0.161 + 0.053) > 1.0, 1.02 > 1.0 2% over - within 5% - OK

Load Case: SWy+SWz+0.3SWx+0.5L (Strength Limit State)

Design Checks

$M_{ux} \le M_{nx}/\Omega_b$, 7.111 ≤ 310.833 / 1.67, 7.111 ≤ 186.128 OK 96% under

$M_{uy} \le M_{ny}/\Omega_b$, 10.885 ≤ 145.833 / 1.67, 10.885 ≤ 87.325 OK 88% under

$P_u \le P_n/\Omega_t$, 0.0 ≤ 880.056 / 1.67, 0.0 ≤ 526.979 OK 100% under

$P_u \le P_n/\Omega_c$, 191.107 ≤ 555.179 / 1.67, 191.107 ≤ 332.442 OK 43% under

$\Rightarrow P_r/2P_c + (M_{rx}/M_{cx} + M_{ry}/M_{cy}) \le 1.0$, 0.0 + (0.038 + 0.125) ≤ 1.0, 0.163 ≤ 1.0 OK 84% under

$\Rightarrow P_r/P_c + 8/9(M_{rx}/M_{cx} + M_{ry}/M_{cy}) \le 1.0$, 0.575 + 8/9(0.038 + 0.125) ≤ 1.0, 0.72 ≤ 1.0 OK 28% under

Load Case: SWy+SWz-0.3SWx+0.5L (Strength Limit State)

Design Checks

$M_{ux} \le M_{nx}/\Omega_b$, 10.4 ≤ 310.833 / 1.67, 10.4 ≤ 186.128 OK 94% under

$M_{uy} \le M_{ny}/\Omega_b$, 12.9 ≤ 145.833 / 1.67, 12.9 ≤ 87.325 OK 85% under

$P_u \le P_n/\Omega_t$, 0.0 ≤ 880.056 / 1.67, 0.0 ≤ 526.979 OK 100% under

$P_u \le P_n/\Omega_c$, 260.288 ≤ 555.179 / 1.67, 260.288 ≤ 332.442 OK 22% under

$\Rightarrow P_r/2P_c + (M_{rx}/M_{cx} + M_{ry}/M_{cy}) \le 1.0$, 0.0 + (0.056 + 0.148) ≤ 1.0, 0.204 ≤ 1.0 OK 80% under

$\Rightarrow P_r/P_c + 8/9(M_{rx}/M_{cx} + M_{ry}/M_{cy}) \le 1.0$, 0.783 + 8/9(0.056 + 0.148) ≤ 1.0, 0.964 ≤ 1.0 OK 4% under

Load Case: SWy-SWz-0.3SWx+0.5L (Strength Limit State)

Design Checks

$M_{ux} \le M_{nx}/\Omega_b$, 8.541 ≤ 310.833 / 1.67, 8.541 ≤ 186.128 OK 95% under

$M_{uy} \le M_{ny}/\Omega_b$, 9.693 ≤ 145.833 / 1.67, 9.693 ≤ 87.325 OK 89% under

$P_u \le P_n/\Omega_t$, 0.0 ≤ 880.056 / 1.67, 0.0 ≤ 526.979 OK 100% under

$P_u \le P_n/\Omega_c$, 73.88 ≤ 555.179 / 1.67, 73.88 ≤ 332.442 OK 78% under

$\Rightarrow P_r/2P_c + (M_{rx}/M_{cx} + M_{ry}/M_{cy}) \le 1.0$, 0.0 + (0.046 + 0.111) ≤ 1.0, 0.157 ≤ 1.0 OK 84% under

$\Rightarrow P_r/P_c + 8/9(M_{rx}/M_{cx} + M_{ry}/M_{cy}) \le 1.0$, 0.222 + 8/9(0.046 + 0.111) ≤ 1.0, 0.362 ≤ 1.0 OK 64% under

Load Case: SWy-SWz+0.3SWx+0.5L (Strength Limit State)

Design Checks

$M_{ux} \le M_{nx}/\Omega_b$, 10.014 ≤ 310.833 / 1.67, 10.014 ≤ 186.128 OK 95% under

$M_{uy} \le M_{ny}/\Omega_b$, 9.263 ≤ 145.833 / 1.67, 9.263 ≤ 87.325 OK 89% under

$P_u \le P_n/\Omega_t$, 0.0 ≤ 880.056 / 1.67, 0.0 ≤ 526.979 OK 100% under

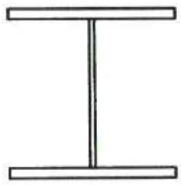
$P_u \le P_n/\Omega_c$, 4.699 ≤ 555.179 / 1.67, 4.699 ≤ 332.442 OK 99% under

$\Rightarrow P_r/2P_c + (M_{rx}/M_{cx} + M_{ry}/M_{cy}) \le 1.0$, 0.0 + (0.054 + 0.106) ≤ 1.0, 0.16 ≤ 1.0 OK 84% under

$\Rightarrow P_r/2P_c + (M_{rx}/M_{cx} + M_{ry}/M_{cy}) \le 1.0$, 0.007 + (0.054 + 0.106) ≤ 1.0, 0.167 ≤ 1.0 OK 83% under

Checking design member 519

Members: 600
Group: W
Section: W10x60



Design Constraints

$Kl/r = \text{Max}(K_x l_{cx}/r_x, K_y l_{cy}/r_y) = \text{Max}(46.469, 79.377) = 79.377$

$Kl/r \le 200$, 79.377 ≤ 200, OK OK 60% under

$l/r = \text{Max}(l_{cx}/r_x, l_{cy}/r_y) = \text{Max}(46.469, 79.377) = 79.377$

$l/r \le 300$, 79.377 ≤ 300 OK 74% under

All constraints PASSED

Load Case: SWy+SWx+0.3SWz+0.5L (Strength Limit State)

Design Checks

$M_{ux} \le M_{nx}/\Omega_b$, 22.947 ≤ 310.833 / 1.67, 22.947 ≤ 186.128 OK 88% under

$M_{uy} \le M_{ny}/\Omega_b$, 3.8 ≤ 145.833 / 1.67, 3.8 ≤ 87.325 OK 96% under

$P_u \le P_n/\Omega_t$, 65.916 ≤ 880.056 / 1.67, 65.916 ≤ 526.979 OK 87% under

$P_u \le P_n/\Omega_c$, 0.0 ≤ 555.179 / 1.67, 0.0 ≤ 332.442 OK 100% under

$\Rightarrow P_r/2P_c + (M_{rx}/M_{cx} + M_{ry}/M_{cy}) \le 1.0$, 0.063 + (0.116 + 0.041) ≤ 1.0, 0.219 ≤ 1.0 OK 78% under

$\Rightarrow P_r/2P_c + M_{rx}/M_{cx} \le 1.0$, 0.0 + 0.123 ≤ 1.0, 0.123 ≤ 1.0 OK 88% under

$P_r/P_{cy}(1.5 - 0.5P_r/P_{cy}) + (M_{rx}/CbM_{cx})^2 \le 1.0$, 0.0/332.442(1.5 - 0.5*0.0/332.442) + (22.947/(2.342*186.128))^2 ≤ 1.0, 0.003 ≤ 1.0 OK 100% under

Load Case: SWy+SWx-0.3SWz+0.5L (Strength Limit State)

Design Checks

$M_{ux} \le M_{nx}/\Omega_b$, 22.737 ≤ 310.833 / 1.67, 22.737 ≤ 186.128 OK 88% under

$M_{uy} \le M_{ny}/\Omega_b$, 1.285 ≤ 145.833 / 1.67, 1.285 ≤ 87.325 OK 99% under

$P_u \le P_n/\Omega_t$, 16.016 ≤ 880.056 / 1.67, 16.016 ≤ 526.979 OK 97% under

$P_u \le P_n/\Omega_c$, 0.0 ≤ 555.179 / 1.67, 0.0 ≤ 332.442 OK 100% under

$\Rightarrow P_r/2P_c + (M_{rx}/M_{cx} + M_{ry}/M_{cy}) \le 1.0$, 0.015 + (0.12 + 0.014) ≤ 1.0, 0.15 ≤ 1.0 OK 85% under

$\Rightarrow P_r/2P_c + M_{rx}/M_{cx} \le 1.0$, 0.0 + 0.122 ≤ 1.0, 0.122 ≤ 1.0 OK 88% under

$P_r/P_{cy}(1.5 - 0.5P_r/P_{cy}) + (M_{rx}/CbM_{cx})^2 \le 1.0$, 0.0/332.442(1.5 - 0.5*0.0/332.442) + (22.737/(2.349*186.128))^2 ≤ 1.0, 0.003 ≤ 1.0 OK 100% under

Load Case: SWy-SWx-0.3SWz+0.5L (Strength Limit State)

Design Checks

$M_{ux} \le M_{nx}/\Omega_b$, 23.813 ≤ 310.833 / 1.67, 23.813 ≤ 186.128 OK 87% under

$M_{uy} \le M_{ny}/\Omega_b$, 4.351 ≤ 145.833 / 1.67, 4.351 ≤ 87.325 OK 95% under

$P_u \le P_n/\Omega_t$, 0.0 ≤ 880.056 / 1.67, 0.0 ≤ 526.979 OK 100% under

$P_u \le P_n/\Omega_c$, 278.805 ≤ 555.179 / 1.67, 278.805 ≤ 332.442 OK 16% under

$\Rightarrow P_r/2P_c + (M_{rx}/M_{cx} + M_{ry}/M_{cy}) \le 1.0$, 0.0 + (0.128 + 0.05) ≤ 1.0, 0.178 ≤ 1.0 OK 82% under

$\Rightarrow P_r/P_c + 8/9(M_{rx}/M_{cx}) \le 1.0$, 0.839 + 8/9(0.128) ≤ 1.0, 0.952 ≤ 1.0 OK 5% under

$P_r/P_{cy}(1.5 - 0.5P_r/P_{cy}) + (M_{rx}/CbM_{cx})^2 \le 1.0$, 278.805/332.442(1.5 - 0.5*278.805/332.442) + (23.813/(2.33*186.128))^2 ≤ 1.0, 0.909 ≤ 1.0 OK 9% under

Load Case: SWy-SWx+0.3SWz+0.5L (Strength Limit State)

Design Checks

$M_{ux} \le M_{nx}/\Omega_b$, 23.018 ≤ 310.833 / 1.67, 23.018 ≤ 186.128 OK 88% under

$M_{uy} \le M_{ny}/\Omega_b$, 3.162 ≤ 145.833 / 1.67, 3.162 ≤ 87.325 OK 96% under

$P_u \le P_n/\Omega_t$, 0.0 ≤ 880.056 / 1.67, 0.0 ≤ 526.979 OK 100% under

$P_u \le P_n/\Omega_c$, 228.905 ≤ 555.179 / 1.67, 228.905 ≤ 332.442 OK 31% under

$\Rightarrow P_r/2P_c + (M_{rx}/M_{cx} + M_{ry}/M_{cy}) \le 1.0$, 0.0 + (0.124 + 0.036) ≤ 1.0, 0.16 ≤ 1.0 OK 84% under

$\Rightarrow P_r/P_c + 8/9(M_{rx}/M_{cx}) \le 1.0$, 0.689 + 8/9(0.124) ≤ 1.0, 0.798 ≤ 1.0 OK 20% under

$P_r/P_{cy}(1.5 - 0.5P_r/P_{cy}) + (M_{rx}/CbM_{cx})^2 \le 1.0$, 228.905/332.442(1.5 - 0.5*228.905/332.442) + (23.018/(2.282*186.128))^2 ≤ 1.0, 0.799 ≤ 1.0 OK 20% under

Load Case: SWy+SWz+0.3SWx+0.5L (Strength Limit State)

Design Checks

$M_{ux} \le M_{nx}/\Omega_b$, 7.891 ≤ 310.833 / 1.67, 7.891 ≤ 186.128 OK 96% under

$M_{uy} \le M_{ny}/\Omega_b$, 9.191 ≤ 145.833 / 1.67, 9.191 ≤ 87.325 OK 89% under

$P_u \le P_n/\Omega_t$, 21.303 ≤ 880.056 / 1.67, 21.303 ≤ 526.979 OK 96% under

$P_u \le P_n/\Omega_c$, 0.0 ≤ 555.179 / 1.67, 0.0 ≤ 332.442 OK 100% under

$\Rightarrow P_r/2P_c + (M_{rx}/M_{cx} + M_{ry}/M_{cy}) \le 1.0$, 0.02 + (0.042 + 0.103) ≤ 1.0, 0.165 ≤ 1.0 OK 84% under

$\Rightarrow P_r/2P_c + (M_{rx}/M_{cx} + M_{ry}/M_{cy}) \le 1.0$, 0.0 + (0.042 + 0.105) ≤ 1.0, 0.148 ≤ 1.0 OK 85% under

Load Case: SWy+SWz-0.3SWx+0.5L (Strength Limit State)

Design Checks

$M_{ux} \le M_{nx}/\Omega_b$, 6.759 ≤ 310.833 / 1.67, 6.759 ≤ 186.128 OK 96% under

$M_{uy} \le M_{ny}/\Omega_b$, 9.539 ≤ 145.833 / 1.67, 9.539 ≤ 87.325 OK 89% under

$P_u \le P_n/\Omega_t$, 0.0 ≤ 880.056 / 1.67, 0.0 ≤ 526.979 OK 100% under

$P_u \le P_n/\Omega_c$, 67.858 ≤ 555.179 / 1.67, 67.858 ≤ 332.442 OK 80% under

$\Rightarrow P_r/2P_c + (M_{rx}/M_{cx} + M_{ry}/M_{cy}) \le 1.0$, 0.0 + (0.036 + 0.109) ≤ 1.0, 0.146 ≤ 1.0 OK 85% under

$\Rightarrow P_r/P_c + 8/9(M_{rx}/M_{cx} + M_{ry}/M_{cy}) \le 1.0$, 0.204 + 8/9(0.036 + 0.109) ≤ 1.0, 0.333 ≤ 1.0 OK 67% under

Load Case: SWy-SWz-0.3SWx+0.5L (Strength Limit State)

Design Checks

$M_{ux} \le M_{nx}/\Omega_b$, 6.583 ≤ 310.833 / 1.67, 6.583 ≤ 186.128 OK 96% under

$M_{uy} \le M_{ny}/\Omega_b$, 11.639 ≤ 145.833 / 1.67, 11.639 ≤ 87.325 OK 87% under

$P_u \le P_n/\Omega_t$, 0.0 ≤ 880.056 / 1.67, 0.0 ≤ 526.979 OK 100% under

$P_u \leq P_n/\Omega_c$, 234.192 ≤ 555.179 / 1.67, 234.192 ≤ 332.442 OK 30% under

$\Rightarrow P_r/2P_c + (M_{rx}/M_{cx} + M_{ry}/M_{cy}) \leq 1.0$, 0.0 + (0.035 + 0.133) ≤ 1.0, 0.169 ≤ 1.0 OK 83% under

$\Rightarrow P_r/P_c + 8/9(M_{rx}/M_{cx} + M_{ry}/M_{cy}) \leq 1.0$, 0.704 + 8/9(0.035 + 0.133) ≤ 1.0, 0.854 ≤ 1.0 OK 15% under

Load Case: SWy-SWz+0.3SWx+0.5L (Strength Limit State)

Design Checks

$M_{ux} \leq M_{nx}/\Omega_b$, 7.667 ≤ 310.833 / 1.67, 7.667 ≤ 186.128 OK 96% under

$M_{uy} \leq M_{ny}/\Omega_b$, 9.497 ≤ 145.833 / 1.67, 9.497 ≤ 87.325 OK 89% under

$P_u \leq P_n/\Omega_t$, 0.0 ≤ 880.056 / 1.67, 0.0 ≤ 526.979 OK 100% under

$P_u \leq P_n/\Omega_c$, 146.051 ≤ 555.179 / 1.67, 146.051 ≤ 332.442 OK 56% under

$\Rightarrow P_r/2P_c + (M_{rx}/M_{cx} + M_{ry}/M_{cy}) \leq 1.0$, 0.0 + (0.041 + 0.109) ≤ 1.0, 0.15 ≤ 1.0 OK 85% under

$\Rightarrow P_r/P_c + 8/9(M_{rx}/M_{cx} + M_{ry}/M_{cy}) \leq 1.0$, 0.439 + 8/9(0.041 + 0.109) ≤ 1.0, 0.573 ≤ 1.0 OK 43% under

End of check of C:\Users\r2d2\Documents\Santa Cruz Main Library.mfd to AISC ASD 2010 code

Review of Perimeter Beams at Low Roof of Main Building

A detailed analysis was made for the concrete beams at the perimeter of the low roof area. These were checked using the following load combinations:

D + L + Lr

D + 0.5L +/- Ex +/- 0.3Ez (four combinations)

D + 0.5L +/- 0.3Ex +/- Ez (four combinations)

Where:

D = dead load

L = floor live load

Lr = roof live load

Ex = seismic load in the X-direction at 1.0g

Ez = seismic load in the Z-direction at 1.0g

The resulting shears and moments were evaluated as follows:

For beam moment, values of C=1 and m=2.5 were used.

For beam shear, values of C=1 and m=2.0 were used.

At the east, west and north sides:

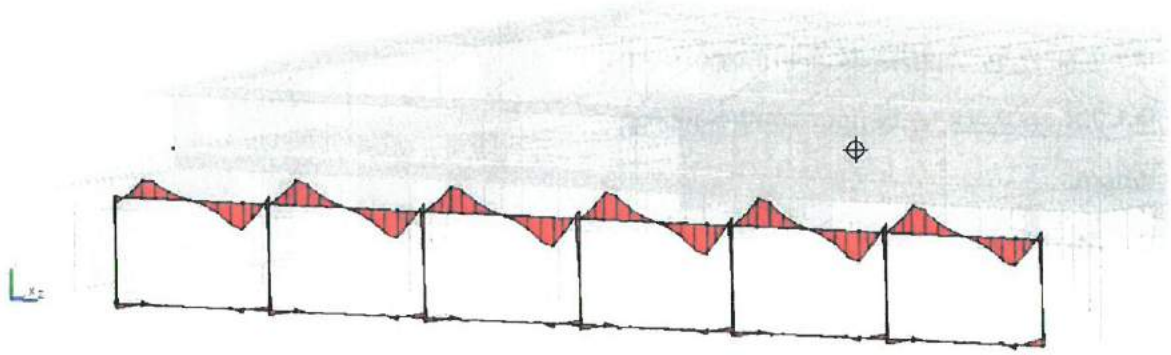
M max (negative or positive) = 279k-ft.	Mu = 279/2.5 = 112k-ft	As = 2.0 in^2
V max = 72k	Vu = 72/2.0 = 36k	As = 0.2 in^2 at 12"

At the south side:

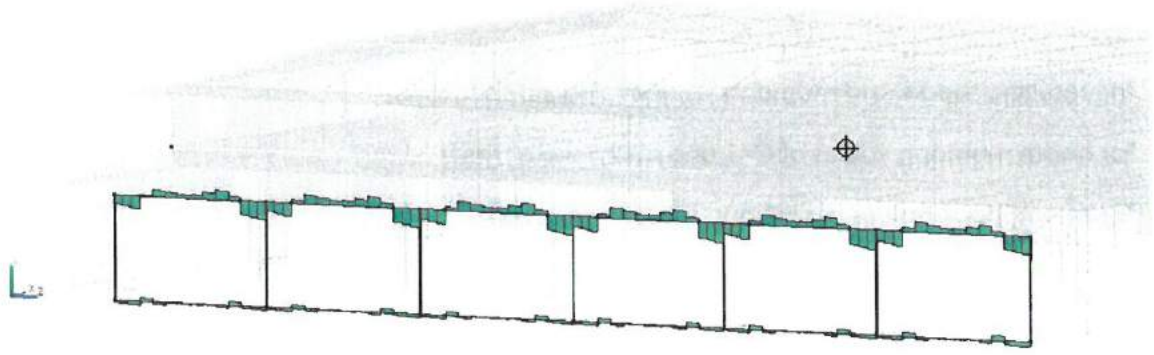
M max (negative or positive) = 279k-ft.	Mu = 279/2.5 = 112k-ft	As = 4.0 in^2
V max = 150k at center of B2 beams	Vu = 150/2.0 = 75k	As = 0.2 in^2 at 18"

f'c = 3,000 psi and fy = 60,000 psi (from original construction documents)

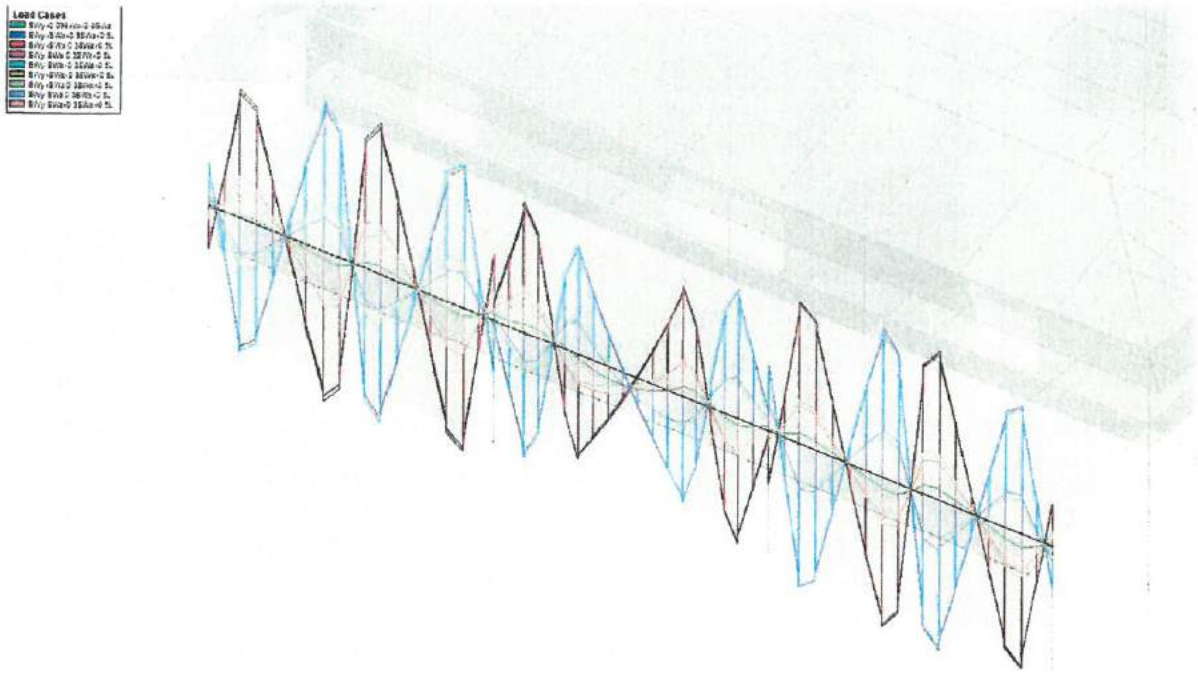
The shear and moment capacity was found to be adequate at all locations except the high shear zone on the B2 beams. If the opening in the CMU wall below is infilled at each of these locations, the V max becomes 88k instead of 150k, and Vu becomes 44k. Under this modification, the beams are adequate.



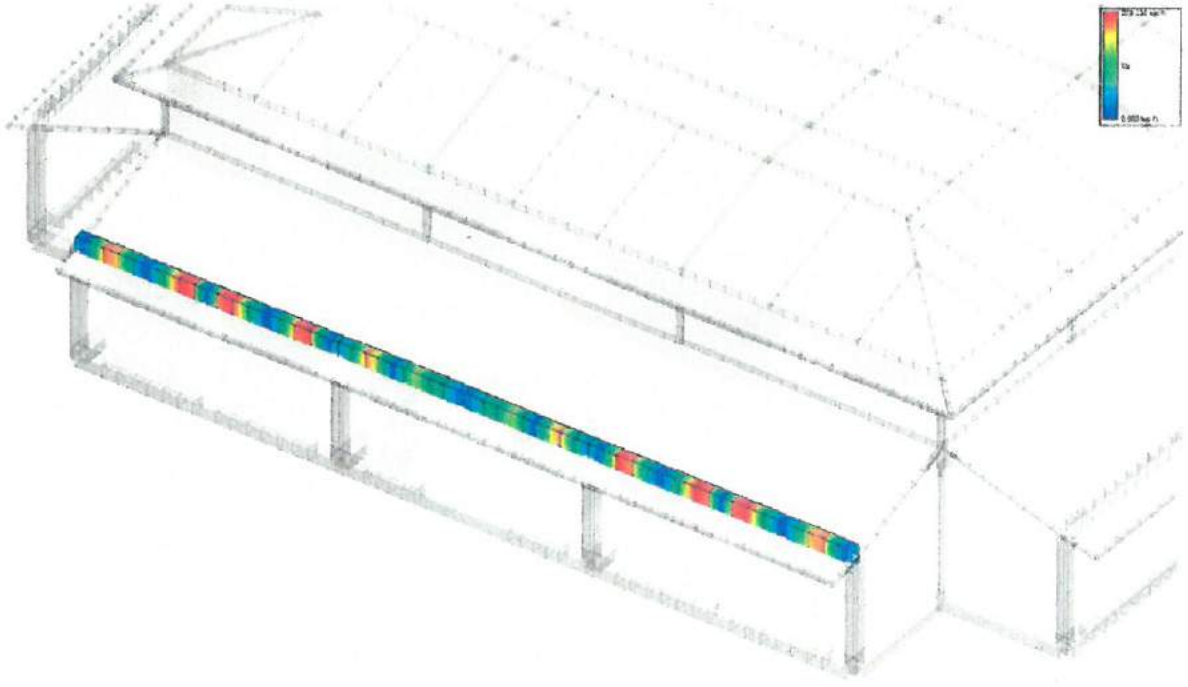
Above: Typical distribution of moment under lateral load condition for perimeter low roof beam.



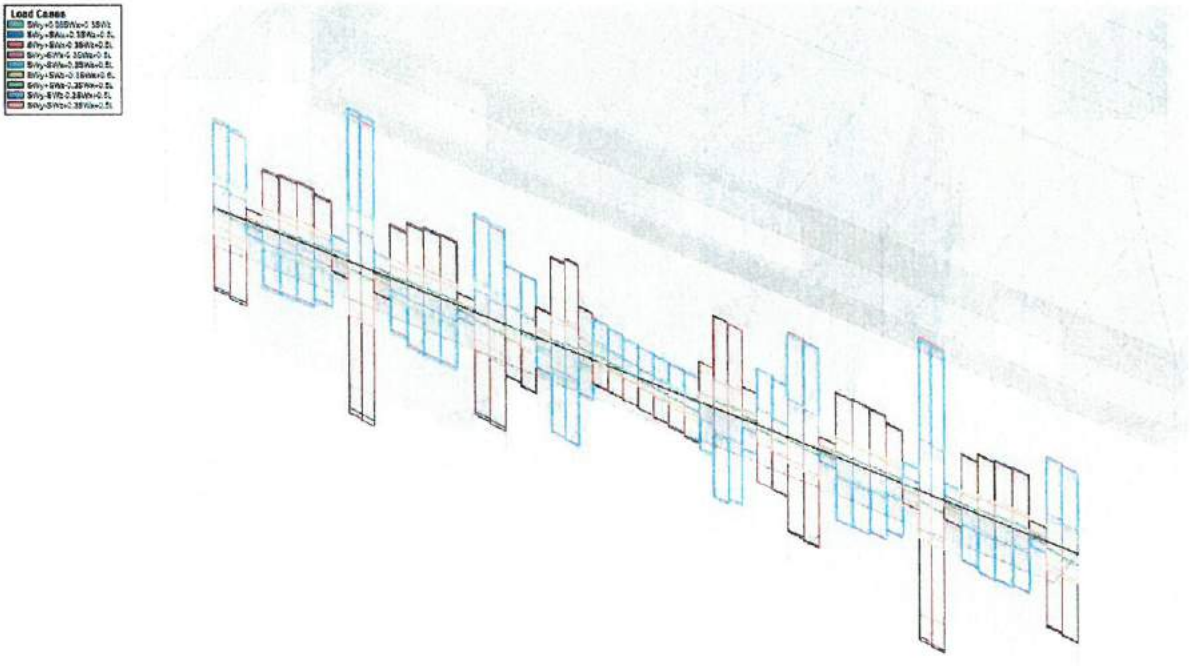
Above: Typical distribution of shear under lateral load condition for perimeter low roof beam.



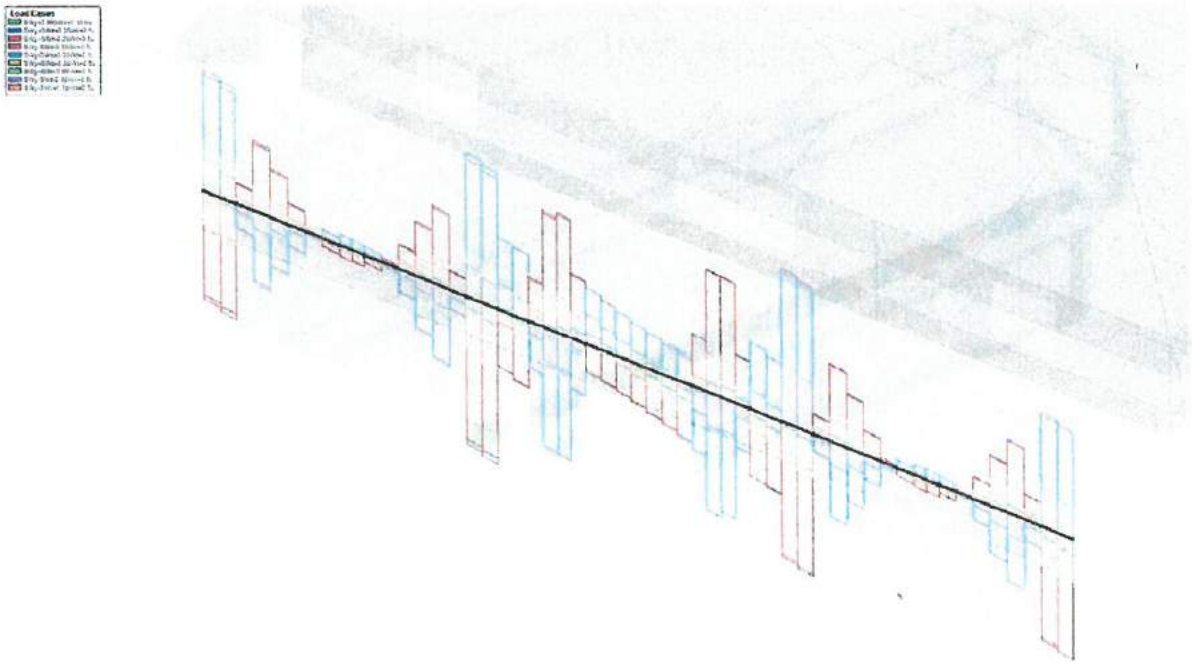
Above: Envelope of moments in south beam line under various load combinations.



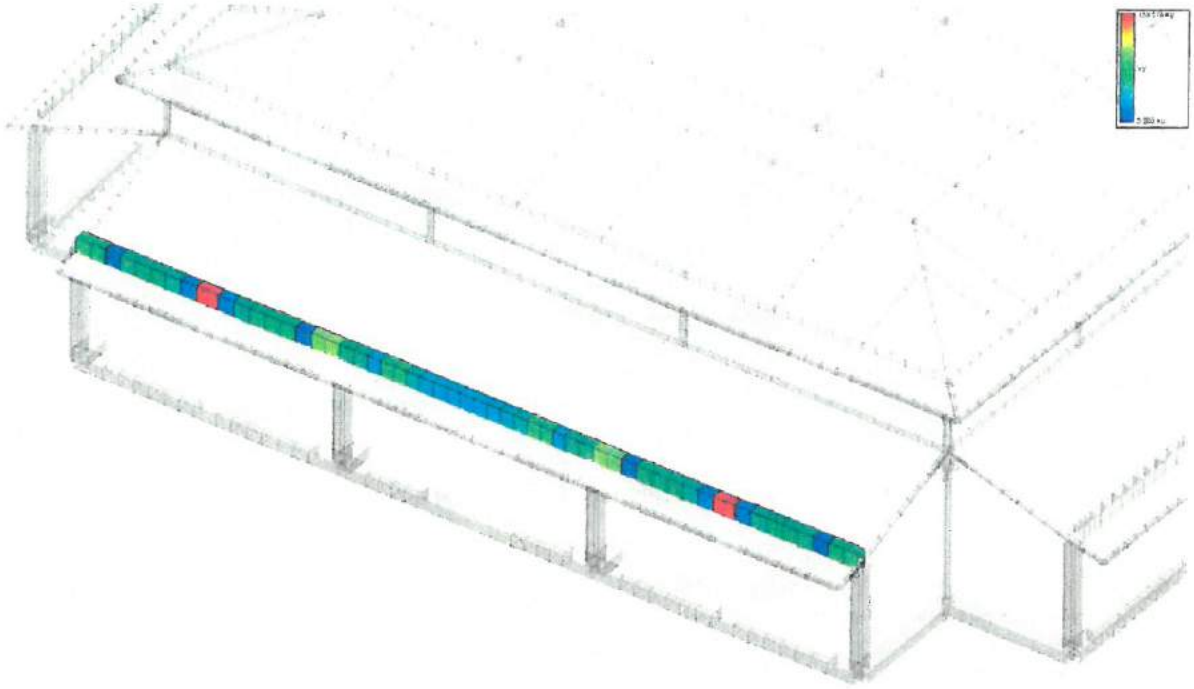
Above: Envelope of intensity of moment along the south beam line. M max = 279k-ft



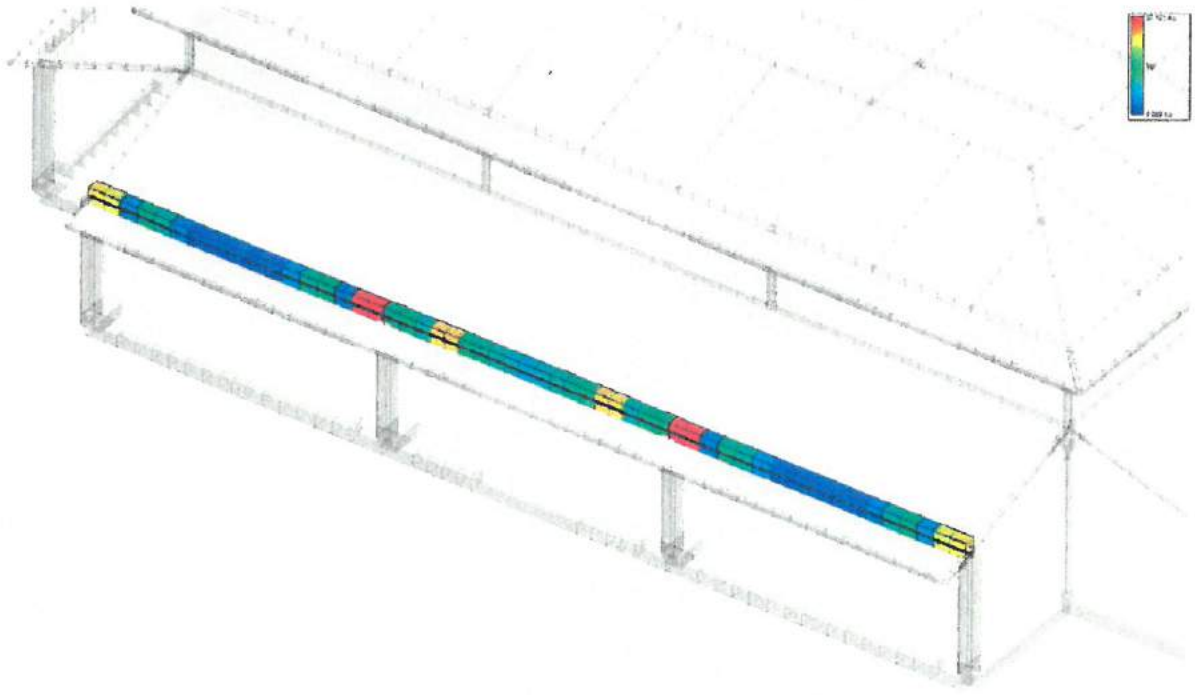
Above: Envelope of shear load along south beam line. Note spikes at mid-span of end beams. V max = 150k and Vu = 75k



Above: Envelope of shear load along south beam line if infilling of CMU is done. V max = 87k and Vu = 44k



Above: Envelope of intensity of shear along south beam line with openings remaining in CMU walls below the red zones. V max in red zones = 150k, Vu=75k



Above: Envelope of intensity of shear over the length of the south beam line if the CMU walls below are infilled. Red zone represent s V max = 87k and Vu = 44k.

f'c = 3 ksi
fy = 60 ksi

b in	d in	As sq.in.	Av sq.in.	s in.	ØVc kips	ØVs kips	ØVn kips	a in.	ØMn 'k	Asmin sq.in.	Asmax sq.in.	Vu(max) k	Mu(max) 'k	Check (D/C<=1?)
B2 at location of high shear zone*														
16	31	2	0.2	18	46.2	17.6	**63.8**	2.94	**265.8**	1.65	7.95	75.0	112.0	NG
B1 or B2														
16	31	4	0.2	12	46.2	26.4	**72.5**	5.88	**505.1**	1.65	7.95	44.0	112.0	**OK**
B3, B4, B5, B11, B13														
16	31	2.4	0.2	12	46.2	26.4	**72.5**	3.53	**315.7**	1.65	7.95	36.0	112.0	**OK**

Formula:
ØVc = IF(b<>'',0.85*2*SQRT(f'c*1000)/1000*b*d,'')
ØVs = IF(b<>'',0.85*Av*fy*d/s,'')
a = IF(b<>'',As*fy/0.85/fc/b,'')
ØMn = IF(b<>'',0.9*As*fy*(d-a/2)/12,'')
Asmin = IF(b<>'',0.2/fy*b*d,'')
Asmax = IF(b<>'',0.75*0.85*0.85*87*fc/fy/(87+fy)*b*d,'')

*The B2 beams at the south wall at mid-span do not have adequate shear capacity. The high shear occurs betw the two CMU shear wall ends below; for east-west seismic load, one wall end pushes up while the other end pulls down, creating the high shear in the beam above. The also creates high axial load in the ends of the relatec CMU walls.

A straighforward mitigation would be to infill between the two 12' section of CMU wall, which eliminates the high shears at these locations. This reduces the shear to 44k and the beams would be adequate.