3.2 Structural – Garage Structure

EXECUTIVE SUMMARY

An ASCE 31 Tier 1 – Screening Phase has been conducted in order determine if any potential deficiencies exist in the structural lateral force resisting system for a Life Safety (LS) Seismic Performance Level. As outlined in the *Summary of the ASCE Tier 1 – Screening Phase* section of this report, several items have been deemed "non-compliant" and represent potential structural deficiencies thus requiring retrofit in the absence of additional study / analysis. ASCE 31 Tier 1 – Screening Phase is the standard of practice used to provide a rapid structural evaluation in order to quickly identify potential deficiencies. Therefore, direct retrofit from this evaluation could be overly conservative. By conducting a more detailed evaluation through the ASCE 31 Tier 2 – Evaluation Phase (which is beyond the scope of this report), it may be possible that additional analysis may mitigate some of the ASCE 31 Tier 1 deficiencies listed in this report. Although we cannot guarantee this additional study / analysis will eliminate the retrofit requirements, given the extensive nature of the retrofit items, we would strongly recommend that the additional study and analysis be conducted.

SCOPE OF STUDY

The overall purpose of this evaluation is to investigate and identify inherent weaknesses in the design of the structure and any components of the structure. The evaluation will be completed per the guidelines of the ASCE 31-03 *Seismic Evaluation of Existing Buildings* (ASCE 31) Tier 1 Screening Phase in order to determine whether the building's lateral force resisting system meets the Life Safety (LS) Seismic Performance Level. ASCE 31 has evolved from and is intended to replace the *Handbook for Seismic Evaluation of Buildings-a Prestandard* (FEMA 310). ASCE 31 is a standard that provides a three-tiered process for seismic evaluation of existing buildings in any level of seismicity. The Tier 1 Screening Phase is intended to be a rapid seismic investigation of the structural elements of the building with the purpose of screening out buildings that comply with the provisions of this standard or to quickly identify potential deficiencies. The Tier 2 Evaluation Phase (which is beyond the scope of this report) is intended to further investigate potential deficiencies identified in the Tier 1 Screening Phase. The Tier 3 Detailed Evaluation Phase is also beyond the scope of this report.

For this report, the scope of services includes:

1. Review of original parking structure drawings prepared by Leo A Daly Company from 1963 and parking structure modification drawings prepared by Dreyfuss & Blackford (structural drawings by Buehler & Buehler Structural Engineers, Inc.) from 1990.
2. Site visit (February 10, 2009) to establish the general conditions of the buildings and to verify the information on the drawings. This was not a detailed inspection to verify that every structural element was built as shown on the drawings or to identify parts of the structure which may have been damaged.
3. Review of applicable ASCE 31 Tier 1 Checklist including supporting Tier 1 calculations where required.

GENERAL BUILDING DESCRIPTION

The subject building is a three-story parking structure which currently serves the BOE building located at 450 N Street in Sacramento, California. The original parking structure was designed by Leo A Daly Company in 1963. The lateral force resisting system consisted of concrete slab diaphragm that spanned to precast concrete shear walls. In 1990 the structure was modified in order to fit the current BOE building tower. These modifications involved the demolition of an 'L' shaped portion of the garage in the North-East corner. New shotcrete shear walls were added at gridlines D and 7 in order to replace the old precast shear walls that were removed from gridlines D 2/3 and 10 2/3. Also the existing precast shear walls along gridline B and the cast-in-place shear walls at gridline 5 were strengthened.

EVALUATION CRITERIA & SCOPE

Based on the seismicity of the site (S_{DS} = 0.528g and S_{D1} = 0.313g per 2002 USGS data), the building is defined as being in a "high" level of seismicity per ASCE 31 Table 2-1. Therefore, ASCE 31 (per Table 3-2) requires the following checklists to be completed for a "high" level of seismicity and "Life Safety" level of performance:

- Basic Structural
- Supplemental Structural
- Geologic Site Hazard and Foundation
- Basic Nonstructural
- Intermediate Nonstructural

The documents used to conduct this work include original structural drawings from 1963 and the modification drawings from 1990. In general, these drawings formed the basis for the evaluations conducted. The drawings contained general framing information (i.e., framing layout, beam sizes, etc.) about the existing building. A preliminary site visit was also conducted to observe the condition of the existing building. At the time of the visit, access was available to roof, 3rd floor and 2nd floors. Above the ceiling access was not possible on the ground floor which currently contains office spaces, a day care facility, a café...etc.

The current lateral force resisting system consists of shotcrete shear walls, strengthened cast-in-place shear walls, and strengthened precast shear walls. Therefore, we have reviewed both the Building Type C2 (Concrete Shear Walls with Stiff Diaphragms) and the Building Type PC1A (Precast/Tilt-Up Concrete Shear Walls with Stiff Diaphragms) Tier 1 checklists. It is important to note that this structure exceeds the story limitations for a Building Type PC1A set in ASCE 31 Table 3-3 and a full Tier 2 analysis would be required. As a courtesy, we have reviewed the PC1A Tier 1 checklist for reference.

From the described applicable checklists, several issues were identified as non-compliant (NC). For reference, the structural checklists are included in Appendix A of this report. Supporting structural calculations required for certain Tier 1 "quick checks" are included in Appendix B. The non-compliant issues are summarized and discussed below.

SUMMARY OF ASCE 31-03 TIER 1 SCREENING PHASE

The Tier 1 screening phase identified the structural items below as "non-compliant", thus requiring further investigation and/or more rigorous calculations (which are beyond the scope of this report) in order to determine if the structure is compliant.

Tier 1 Basic Structural Checklist Building Type C2:

- Mezzanines – the mechanical mezzanines are not braced independently from the main structure.
- Concrete Wall Cracks – minor wall cracks were observed during our site visit. These cracks were less than the ASCE 31 allowed 1/8" for Life Safety; however, in a few locations the cracks were in a 'X' pattern.
- Shear Stress Check – the Line 7 and Line 5 shear walls at the 2nd and 1st stories and the line D and B shear walls at the 1st story do not comply with the Tier 1 quick check stresses limitations.
- Reinforcing Steel – the line 5 shear wall horizontal steel does not meet the Tier 1 minimum requirement.

Tier 1 Supplemental Structural Checklist Building Type C2:

- Deflection Compatibility – the Secondary components do not have the shear capacity to develop the flexural strength of the components.
- Openings at Shear Walls – the line 5 shear wall is directly adjacent to the ramp and is therefore non-compliant
- Uplift at Pile Caps – the original drawings do not indicate top reinforcing in the pile cap.

As previously noted, a full ASCE 31 Tier 2 analysis would be required in order to evaluate the structural precast elements (Building Type PC1A). As a courtesy, the Tier 1 evaluation was conducted for reference and in addition to the deficient items noted above, the Girder/Column Connection would be deemed non-compliant since there is no positive connection between the girder and column.

The above listed ASCE 31 Tier 1 deficiencies will require retrofit in the absence of additional study / analysis which is beyond the scope of this report. An ASCE 31 Tier 2 or Tier 3 evaluation may be conducted to determine if the deficiency can be resolved by further analysis or if retrofit will be required

ITEMS REQUIRING ADDITIONAL STUDY AND POTENTIAL SEISMIC RETROFIT

Geologic Site Hazards and Foundation Systems

At the time of this report, no geotechnical report was available. During the ASCE 31 analysis, no calculations were required that necessitated assumptions for the bearing capacity of the existing soil conditions. For determination of the site seismicity, a site class D was assumed as allowed by both ASCE 31 and 2007 CBC.

For the ASCE 31 evaluation to be complete, a licensed geotechnical engineer will be required to evaluate the site for the conditions listed in the Geologic Site Hazards and Foundations checklist. In particular, the potential geologic site hazards such as liquefaction, slope failure, and surface fault rupture must be identified. A complete Tier 1 checklist has been attached in Appendix C for reference only.

Nonstructural Systems and Components

A more thorough evaluation of nonstructural systems (such as M/E/P equipment, piping, fixtures, etc.) and other nonstructural components (such as furnishings, ceilings, partitions, cladding, stairs, canopies, etc.) will need to be conducted. The appropriately licensed professionals will need to participate in evaluating the existing systems for compliance with the Tier 1 checklist attached in Appendix C for reference only.

LIMITATIONS

The services of Buehler and Buehler performed for this project have been provided at a level that is consistent with the general level of skill and care ordinarily provided by engineers practicing in structural engineering. Work is necessarily done under the constraints of time and budget. Conclusions and information presented in this report are dependent on information provided by others. Conditions that are currently unseen which are exposed during construction may require changes to the conclusions presented here. While skill and care have been used to develop these findings, conclusions, and recommendations, no prediction, level of confidence, or guarantee of future performance of this structure is provided. No warranty is expressed or implied.

Prepared by Buehler & Buehler Structural Engineers, Inc.

BOE INFRASTRUCTURE STUDY – PARKING GARAGE STRUCTURE
450 N STREET
SACRAMENTO, CALIFORNIA

MARCH 27, 2009

APPENDIX A
ASCE 31 TIER 1 CHECKLIST

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)

3.7.11A Basic Structural Checklist for Building Type PC1A: Precast/Tilt-Up 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.

C3.7.11A Basic Structural Checklist for Building Type PC1A

These buildings are one or more stories in height and have precast concrete perimeter wall panels that are cast on-site and tilted into place. The floors and roof consist of precast elements, cast-in-place concrete, or metal deck with concrete fill, and are stiff relative to the walls. Framing is supported on interior steel or concrete columns and perimeter concrete bearing walls. Lateral forces are resisted by the precast concrete perimeter wall panels. Wall panels may be solid or have large window and door openings that cause the panels to behave more as frames than as shear walls. Foundations consist of concrete spread footings or deep pile 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 — 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 — PRECAST CONCRETE WALLS: There shall be no visible deterioration of concrete or reinforcing steel or evidence of distress, especially at the connections. (Tier 2: Sec. 4.3.3.6)

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 precast panels, 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. 4.4.2.3.1)

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. 4.4.2.3.2)

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)
SLAB IS C.I.P.

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) NO EXTERIOR WALLS

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 — PRECAST WALL PANELS: Precast wall panels shall be connected to the foundation for Life Safety and the connections shall be able to develop the strength of the walls for Immediate Occupancy. (Tier 2: Sec. 4.6.3.7)

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)

3.7.11AS Supplemental Structural Checklist for Building Type PC1A: Precast Tilt-Up 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) — 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) — WALL OPENINGS: The total width of openings along any perimeter wall line shall constitute less than 75 percent of the length of any perimeter wall for Life Safety and 50 percent for Immediate Occupancy with the wall piers having aspect ratios of less than 2-to-1 for Life Safety and Immediate Occupancy. (Tier 2: Sec. 4.4.2.3.3)

C NC (N/A) — CORNER OPENINGS: Walls with openings at a building corner larger than the width of a typical panel shall be connected to the remainder of the wall with collector reinforcing. (Tier 2: Sec. 4.4.2.3.4)

C NC (N/A) — PANEL-TO-PANEL CONNECTIONS: Adjacent wall panels shall be interconnected to transfer overturning forces between panels by methods other than welded steel inserts. This statement shall apply to the Immediate Occupancy Performance Level only. (Tier 2: Sec. 4.4.2.3.5)

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. 4.4.2.3.6)

Diaphragms

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 — PRECAST PANEL CONNECTIONS: There shall be at least two anchors from each precast wall panel into the diaphragm elements for Life Safety and the anchors shall be able to develop the strength of the panels for Immediate Occupancy. (Tier 2: Sec. 4.6.1.3)

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)

C NC (N/A) — GIRDERS: Girders supported by walls or pilasters shall have at least two ties securing the anchor bolts for Life Safety and Immediate Occupancy. (Tier 2: Sec. 4.6.4.2)

BOE INFRASTRUCTURE STUDY – PARKING GARAGE STRUCTURE
450 N STREET
SACRAMENTO, CALIFORNIA

MARCH 27, 2009

APPENDIX B
ASCE 31 TIER 1 CALCULATIONS

usgs values BOE.txt 1/26/2009

Conterminous 48 States
2006 International Building Code
Latitude = 38.577379
Longitude = -121.502872
Spectral Response Accelerations Ss and S1
Ss and S1 = Mapped Spectral Acceleration Values
Site Class B - Fa = 1.0 ,Fv = 1.0
Data are based on a 0.01 deg grid spacing

Period (sec)	Sa (g)	
0.2	0.600	(Ss, Site Class B)
1.0	0.246	(S1, Site Class B)

Conterminous 48 States
2006 International Building Code
Latitude = 38.577379
Longitude = -121.502872
Spectral Response Accelerations SMs and SM1
SMs = Fa x Ss and SM1 = Fv x S1
Site Class D - Fa = 1.32 ,Fv = 1.909

Period (sec)	Sa (g)	
0.2	0.792	(SMs, Site Class D)
1.0	0.469	(SM1, Site Class D)

Conterminous 48 States
2006 International Building Code
Latitude = 38.577379
Longitude = -121.502872
Design Spectral Response Accelerations SDs and SD1
SDs = 2/3 x SMs and SD1 = 2/3 x SM1
Site Class D - Fa = 1.32 ,Fv = 1.909

Period (sec)	Sa (g)	
0.2	0.528	(SDs, Site Class D)
1.0	0.313	(SD1, Site Class D)

$S'_{DS} > 0.5g$
$S'_{D1} > 0.2g$

∴ PER TABLE 2-1, SITE IS AT A HIGH LEVEL OF SEISMICITY.

- PER TABLE 3-2 w/ HIGH LEVEL OF SEISMICITY & @ LS LEVEL OF PERFORMANCE NEED TO GO THRU THE FOLLOWING CHECKLISTS:
  - BASIC & SUPPLAMENTAL STRUCTURAL
  - GEOLOGIC SITE HAZARD & FOUNDATION
  - BASIC & INTERMEDIATE NON-STRUCTURAL.

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STRUCTURAL ENGINEERS, INC.

JOB
JOB NO. DATE 1/27/09
CLIENT BY SDS SHEET NO.

TIER 1 ANALYSIS.

- BUILDING MODEL TYPE ⟶ CONCRETE SHEAR WALLS w/ RIGID DIAPHRAGMS (C 2) & PRECAST CONC. SW w/ STIFF DIA.

- PSEUDO LATERAL FORCE (3.5.2.1)

$V = C S_a W$ (3-1)

$C = 1.1$ PER TABLE 3-4, 3-STORIES.

$S_a = S_{D1}/T$ BUT NOT TO EXCEED S_{DS} (3.5.2.3.1)

↳ $T = C_t h_n^{\beta}$ (3.5.2.4)

$C_t = 0.020$ $h_n = \pm 35'\text{-}2''$

$\beta = 0.75$

$T = 0.289$ SEC.

$S_a = 0.313/0.289 = 1.08 > S_{DS} = 0.528$

$\therefore S_a = 0.528$

$V = C S_a W$

$= 1.1\,(0.528)\,W$

$V = 0.5808\,W$

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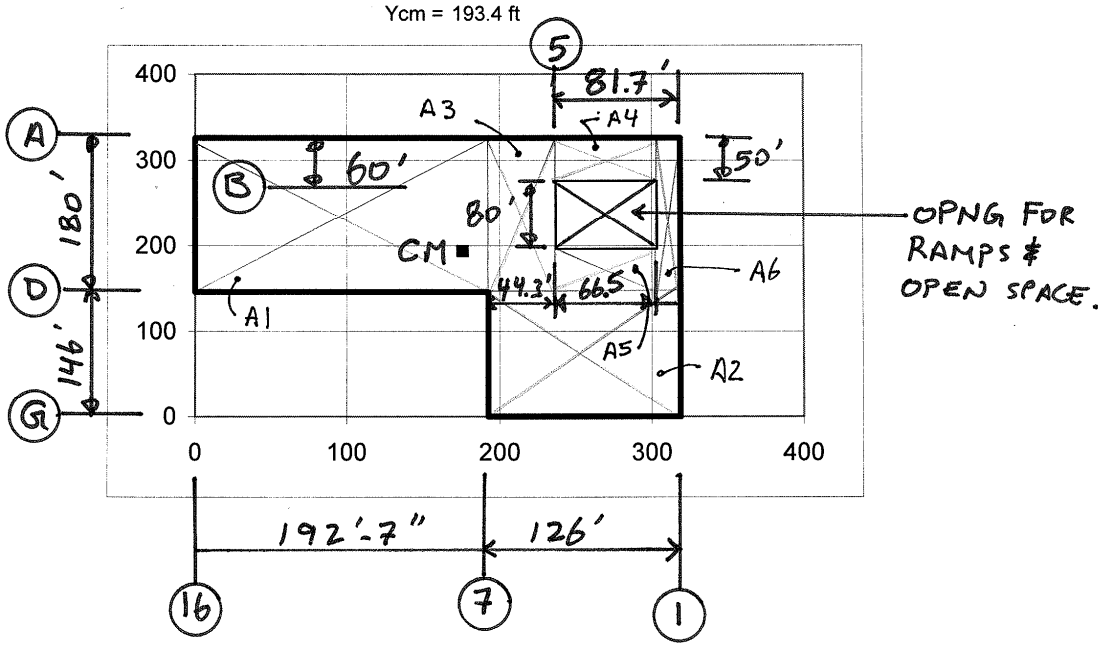
JOB	Capitol Square - Garage Tier 1		
JOB NO.	S08-347.00	DATE	1/29/2009
CLIENT	BY SDS	SHEET NO.	

floor weight = 1.0 psf ← RELATIVELY, FLOOR WT DOESN'T VARY AREA TO AREA ∴ ACTUAL FLR WT WILL NOT AFFECT CM LOC.

Area ID	Area	mass	Xi	Yi	WiXi	WIYi
A1	34686.0 sq ft	34686	96.4 ft	236.0 ft	3341996	8185896
A2	18408.1 sq ft	18408.12	255.7 ft	73.0 ft	4707692	1343793
A3	7979.4 sq ft	7979.4	214.9 ft	236.0 ft	1714506	1883138
A4	3325.0 sq ft	3325	270.3 ft	301.0 ft	898691	1000825
A5	3325.0 sq ft	3325	270.3 ft	171.0 ft	898691	568575
A6	2745.0 sq ft	2745	311.2 ft	236.0 ft	854128.7	647820
		70468.52			12415705	13630047

Xcm = 176.2 ft
Ycm = 193.4 ft



* SHEAR WALLS ON GRIDS 7 & 5, D & B

** ESTIMATED DISTANCE BTWN CM & CR < 20% OF BLDG WIDTH ∴ COMPLIANT

F:\S08-34700_Calc\CM.xls 1/29/2009, 11:47 AM

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JOB _____
JOB NO. _____ DATE 2/12/09
CLIENT _____ BY SDS SHEET NO. _____

TIER I ANALYSIS.

- SHEAR STRESS CHECK

↳ CALCULATED PER SECTION 3.5.3.3 ⟶ MUST BE LESS THAN THE GREATER OF 100psi OR $2\sqrt{f'_c}$.

- PER 3.5.3.3 ⟶ $V_j^{AVE} = \frac{1}{m}\left(\frac{V_j}{A_v}\right)$ (3-12)

  - V_j = STORY SHEAR PER 3.5.2.2

    ↳ $F_x = \frac{w_x h_x^k}{\sum_{i=1}^{n} w_i h_i^k} V$ (3-3a)

  - m-FACTOR PER TABLE 3-7

    ↳ m = 4.0 FOR LS

BLDG Wt's

ROOF = 8765^k, 3rd = 8352^k, 2nd = 11538^k Σ = 28655^k

(SEE REFERENCE CALC's FOR Wt DERIVATION)

$V = C_s S_a W = 0.5808W = \underline{16643^k}$

LEVEL	W_i	h_i	$W_i h_i$	% V	F_x	STORY V
ROOF	8765^k	38.17'	334560 k-ft	42.2	7024^k	7024^k
3rd	8352^k	28.67'	239452 k-ft	30.2	5026^k	12050^k
2nd	11538^k	19'	219222 k-ft	27.6	4594^k	16644^k
			Σ = 793234			

FOR RIGID DIA ⟶ DISTRIBUTION BASED ON RELATIVE RIGIDITY

BUEHLER & BUEHLER STRUCTURAL ENGINEERS, INC.

JOB ____
JOB NO. ____ DATE 2/12/09
CLIENT ____ BY SDS SHEET NO. ____

TIER 1 ANALYSIS.

• WALL AREAS.

LINE 7 = 9¼" × 86' (SHOTCRETE) = 9546 # → 47.5% V

LINE 5 = 11" × 80' (8" PC + 3" SC) = 10560 # → 52.5% V

Σ = 20106

LINE D = 9¼" × 166' (SHOTCRETE) = 18426 # → 56% V

LINE B = 9" × 134' (6" PC + 3" SC) = 14472 # → 44% V

Σ = 32898

• WALL SHEAR STRESS

Gridline	wall type	Wall Area	% V
Line 7	SC	9546 sq in.	47.5%
Line 5	CIP	10560 sq in.	52.5%
Line D	SC	18426 sq in.	56.0%
Line B	PC	14472 sq in.	44.0%

	Story Shear		
	Roof	3rd	2nd
Line	7024 k	12050 k	16644 k
Line 7	349.5 k	599.6 k	828.2 k
Line 5	349.2 k	599.1 k	827.5 k
Line D	213.5 k	366.2 k	505.8 k
Line B	213.6 k	366.4 k	506.0 k

	V_j^{ave}		
Line	Roof	3rd	2nd
Line 7	87.4 psi	149.9 psi	207.0 psi
Line 5	87.3 psi	149.8 psi	206.9 psi
Line D	53.4 psi	91.6 psi	126.5 psi
Line B	53.4 psi	91.6 psi	126.5 psi

m = 4.0

	Tier 1 check		
Line	Roof	3rd	2nd
Line 7	Compliant	Non-Compliant	Non-Compliant
Line 5	Compliant	Non-Compliant	Non-Compliant
Line D	Compliant	Compliant	Non-Compliant
Line B	Compliant	Compliant	Non-Compliant

	√f'c =	2*√f'c =
CIP/PC	3000 psi	109.5 psi
SC	4000 psi	126.5 psi

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JOB ____
JOB NO. ____ DATE 2/12/09
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TIER I ANALYSIS.

- REINFORCING STEEL CHECK (0.0015 VERT, 0.0025 HORIZ, 18" cc MAX)

- LINE B → 6" PC WALL w/ 3" SC.
  #4 @ 12" cc EA WAY 6x6/W4xW4 WWF

  $A_s = 0.08 + 0.2 = 0.28^{\#} \rightarrow 0.0026$ EA WAY ∴ OK

- LINE 5 → 8" CIP WALL w/ 3" SC
  #4 @ 10" cc HORIZ 6x6/W4xW4
  #4 @ 12" cc VERT.

  $A_s = 0.08 + 0.24 = 0.32^{\#}$ HORIZ → 0.0024 ∴ NC

  $A_s = 0.08 + 0.2 = 0.28^{\#}$ VERT. → 0.0021 ∴ OK

- LINE D → 9¼" SHOTCRETE WALL
  #4 @ 16" cc EWEF

  $A_s = 0.3^{\#} \rightarrow 0.0027$ EA WAY ∴ OK

- LINE 7 → 9¼" SHOTCRETE WALL
  #4 @ 16" cc EWEF 3rd STORY
  #4 @ 10" cc EF HORIZ } 2nd STORY
  #4 @ 16" cc EF VERT }
  #4 @ 5" cc EF HORIZ } 1st STORY.
  #4 @ 16" cc EF VERT }
  } OK

BOE INFRASTRUCTURE STUDY – PARKING GARAGE STRUCTURE
450 N STREET
SACRAMENTO, CALIFORNIA

MARCH 27, 2009

APPENDIX C

ASCE 31 TIER 1 GEOLOGIC SITE HAZARDS AND FOUNDATIONS CHECKLIST AND NON-STRUCTURAL CHECKLISTS (FOR REFERENCE ONLY)

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)

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)

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)