KPW
KILAND • PASSAGLIA • WESTPHAL
STRUCTURAL ENGINEERS, INC

ALBANY UNIFIED SCHOOL DISTRICT
SEISMIC EVALUATION

Prepared for WLC Architects and
Albany Unified School District

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Introduction

Recent seismic evaluations of Albany Unified School District Facilities identified several building elements at Ocean View Elementary School and Marin Elementary School which did not meet the Life Safety Performance Level of ASCE 31. Our firm subsequently performed an additional analysis of these suspect buildings as well as a general seismic study of the remainder of the district school buildings.

The buildings in question at Ocean View Elementary School and Marin Elementary School were built in 1975 and 1973, respectively. The buildings at each campus consist of wood-framed roofs supported by masonry and wood bearing and shear walls. Built before the more stringent provisions of later building codes were implemented, buildings of this type and era are regularly found to have several deficiencies, the most common being inadequate wall to roof connections.

The buildings at the balance of the Albany USD campuses are generally of more recent construction, wood frame construction, or have been recently retrofitted.

The previous reports, prepared by R.P. Gallagher Associates, Inc titled "Seismic Evaluation of Ocean View Elementary School" dated October 2012 and "Seismic Evaluation of Marin Elementary School" dated November 2012 detail the complete results of their seismic assessments of these campuses. The report titled "Initial Seismic Study of Albany USD Schools and Facilities" provides an overview of each building in the District's portfolio, site geologic hazards, and a discussion of DSA AB300 issues. Refer to these reports for a complete discussion of their findings as well as building key plans and photographs.

KPW Evaluation Procedure

Our evaluation primarily focused on the buildings at Ocean View and Marin Elementary Schools which were previously found to have to have seismic deficiencies. In addition to studying the results presented in the previously prepared reports, we performed an independent seismic analysis of these structures using the provisions of ASCE 31 “Seismic Evaluation of Buildings” as well as current code, the 2010 California Building Code. Our analysis included reviewing as-built drawings, performing structural calculations, completing the ASCE 31 Tier 1 checklists and visiting the campuses.

Our study of the remaining Albany USD campuses consisted of tabulating the construction type, construction date, and retrofit date of each building for purposes of categorizing the potential seismic hazards to each building. Modular buildings were not reviewed.

This report summarizes the results of our in-depth analysis of Marin and Ocean View Schools and our general district survey.

Ocean View Elementary School

Built in 1975, the main buildings at Ocean View Elementary School consist of three single story structures connected by covered walkways. The roof is generally flat with a sloped, elevated clerestory roof in each classroom. The wood frame roof is supported by masonry and wood stud walls on conventional shallow foundations. Lateral forces are resisted by the plywood roof diaphragm and the interior plywood and exterior masonry shear walls.

A review of the as-built structural drawings found that the lateral force resisting elements were relatively well engineered and the details of construction better than average for the era. Design consideration was given to the primary seismic elements including the roof diaphragm, chords, collectors, shear walls and key connections.

Several modular classroom buildings installed at a later date occupy the rear portion of the campus; these were not part of our seismic evaluation.

The results of our seismic study of Ocean View Elementary School are as follows. Also refer to Table 1 for a summary of our analysis results.

Roof Diaphragm

A building's horizontal diaphragm transfers lateral forces generated by wind or earthquake loads to the perpendicular shear walls through in plane shear. The roof diaphragm at Ocean View Elementary School consists of ½" plywood with edge blocking and relatively tight edge nailing. Our study found that the roof diaphragms have both adequate shear and chord strength to resist current code level forces.

Collectors

Collectors are intended to transfer the horizontal diaphragm forces to the in-plane shear walls. Recognizing the importance of these elements, current codes apply an amplification factor to the calculated seismic forces when designing these components. The collectors at Ocean View consist of wood beams connected to the masonry or plywood shear walls with bolted metal angles. These collector elements often extend across wall or roof openings to connect portions of the roof diaphragm to somewhat distant shear walls.

Our analysis found that in general the collector connections would be significantly overstressed if subjected to current code level seismic forces. Refer to Figure 1 for a typical collector connection.

Shear walls

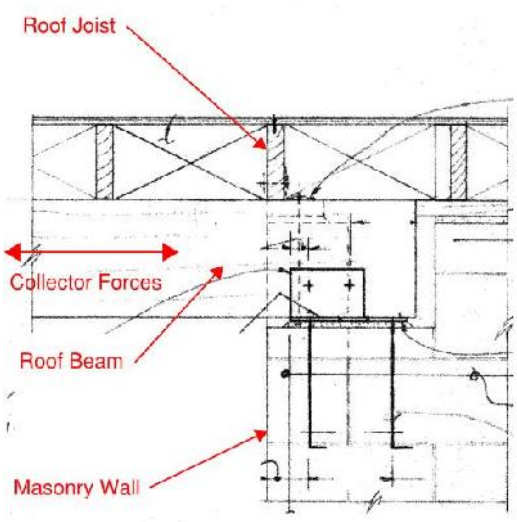
Shear walls transfer building lateral forces to the supporting foundations. At each of the three buildings the exterior masonry walls consist of fluted 8"or 12" concrete masonry. The masonry walls are fully grouted and well-reinforced in a similar manner to what would be required by current standards. Interior plywood shear walls are sheathed on one or both sides with plywood and are connected to the foundation with sill bolts and holdowns. In-plane shear forces are transferred to both wall types with blocking and shear clips.

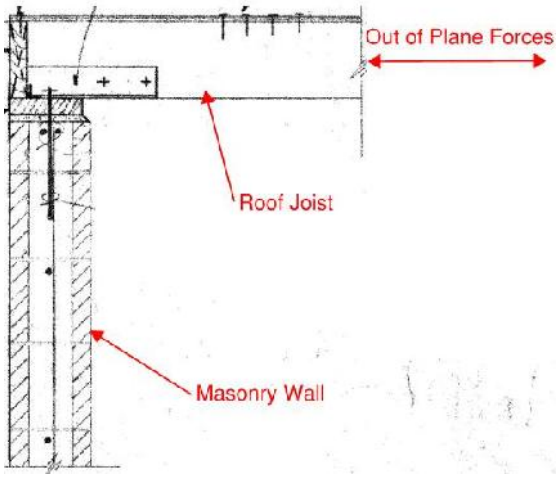
We found that both the masonry and plywood shear walls have adequate strength to resist the applied current code level forces.

Out-of-Plane Wall Anchorage

When subjected to significant earthquake shaking, the connections between the heavy masonry walls and the light, flexible wood roof can be subjected to significant out-of-plane forces. Damage to these connections could result in separation of the walls from the roof and possible loss of support and collapse of the roof framing and walls. Building damage observed as a result of subsequent earthquakes has led to the adoption of stricter anchorage standards in the building code since the time of Ocean View Elementary School's construction.

The out-of-plane wall connections at Ocean View generally consist of a steel angle bolted to the side of a roof joist and the top of the masonry wall as shown in figure 1. Our analysis of these connections found that they would be significantly overstressed if subjected to current code level seismic forces.





Typical Collector Connecion **Typical Out-of-Plane Wall Connection**

Figure 1: Typical Wall-Roof Connections

Marin Elementary School

The Marin Elementary School campus consists primarily of 6 similar hexagonally shaped classroom buildings (Buildings A, B, D, E, F, & G) and a multi-purpose building (Building C) built in 1973. The 1973 buildings consist of a wood frame roof supported by masonry and plywood walls on conventional shallow foundations. Lateral forces are resisted by the plywood roof diaphragm and the interior plywood and exterior masonry shear walls.

A rectangular, wood-framed classroom building (Building H) of unknown date and several modular buildings also exist on the campus. These buildings were not studied as part of our in-depth analysis.

A review of the 1973 as-built structural drawings found that the lateral force resisting elements of the wood/masonry buildings were relatively well engineered and better than average for the era. Consideration was given to the primary elements including the roof diaphragm, chords, collectors, shear walls and key connections.

The results of our seismic study of Marin Elementary School are as follows. Also refer to Table 2 for a summary of our analysis results. Refer to our above discussion of Ocean View Elementary School for a general definition of each lateral force resisting element.

Roof Diaphragm

The roof diaphragm at Marin Elementary School consists of ½" plywood with edge blocking and relatively tight edge nailing. Our study found that the roof diaphragms have both adequate shear and chord strength to resist current code level forces.

Collectors

As the hexagonal buildings are fairly regular in shape with limited wall openings, roof diaphragm collectors are not a major component of these particular buildings lateral force resisting systems. However, in two isolated locations the collector elements would be overstressed if subjected to current code level seismic forces.

Shear walls

The exterior masonry walls generally consist of fluted 6" concrete masonry, with thicker block at the taller multi-purpose building wall. The masonry walls are fully grouted and well- reinforced in a similar manner to what would be required by current standards. Interior plywood shear walls are sheathed on one or both sides with plywood and are connected to the foundation with sill bolts and holdowns. In-plane shear forces are transferred to both wall types with blocking and shear clips.

We found that the masonry shear walls have adequate strength to resist the applied current code level forces. The plywood shear walls, which occur in two isolated locations, were found to be overstressed when compared to current code seismic demands.

Out-of-Plane Wall Anchorage

Similar to Ocean View Elementary School, the existing out-of-plane wall connections reflect construction practices common before the adoption of the stricter anchorage criteria found in today's building code. The out-of-plane wall connections at Marin also consist of a steel angle bolted to the side of the roof joists and the top of the masonry wall. Our analysis of these connections found that they would be significantly overstressed if subjected to current code level seismic forces.

District Facilities Overview

Our survey of the remaining Albany Unified School District campuses consisted of determining the general characteristics of each building in order to identify potential seismic issues. We considered type of construction, building age, and whether past retrofits had been performed. Neither structural calculations nor a detailed as-built drawing review was performed for these buildings.

Cornell Elementary School

The main building at Cornell Elementary School consists of the seismically separated south wing, north wing, and admin wing. The south wing and north wing, built in 1948 and 1950 respectively, are two story buildings with wood roofs and floors supported by reinforced concrete walls. The admin wing is a two story wood frame building built in 1974.

The north wing and south wing were seismically retrofitted in 1997 and 2001, with the retrofit consisting of reinforcing the connection between the concrete walls and the wood floor and roof.

Given the type of construction and the past seismic retrofit these three buildings would be considered to have a lower seismic risk than older or more damage prone building types.

Albany Middle School

Albany Middle School was built in 1997, with a lateral force resisting system consisting of steel braced frames. As the building code provisions in effect at this time contained relatively modern seismic design criteria, the school is assumed to have a lower level of seismic risk.

Albany High School

Albany High School was significantly rebuilt in 1999, with the addition of 4 new steel braced frame buildings. A reinforced concrete Fine Arts building with an unknown construction date remained on the site.

Given their relatively recent construction, the 1999 steel frame buildings would be expected to have a lower risk of earthquake damage. The reinforced concrete Fine Arts building has was classified as Category 1 (expected to perform reasonably well in an earthquake) by the DSA AB300 list and the R.P. Gallagher Reports.

Albany Children's Center

The Children's Center consists of 5 wood frame buildings connected by a covered walkway and two modular buildings. The date of construction of the wood buildings is unknown, though based upon our observations we estimated the buildings to be of 1950's or 1960's construction. Single story wood frame buildings such as these are generally found to have a lower risk of earthquake damage.

Macgregor High School

Macgregor High School Consists of 6 wood frame buildings and several modular buildings. The date of construction is unknown. Similar to the Children's Center, Single story wood frame buildings such as these are generally found to have a lower risk of earthquake damage.

Conclusion and Recommendations

Our study found that certain elements at both Ocean View and Marin Elementary schools do not meet the life safety criteria of either ASCE 31 or the current building code. The primary elements found to be deficient, based upon the criteria of these standards, were collector connections and out-of-plane wall anchors. Given the increased demand on these components prescribed by recent building codes, these deficiencies are commonly found in buildings of this type and vintage. The results of our evaluation are also similar to those presented in the reports by R.P. Gallagher Associates Inc.

In our professional opinion, the deficiencies at Ocean View and Marin Schools do not represent immediate concerns that would warrant facility closure. The buildings appear to have been built in accordance with the seismic provisions in place at the time of construction and our review of the as-built drawings found the details of the seismic system were relatively well engineered. Seismic retrofit of these buildings is not required by any current statute.

We would recommend that the deficient elements at Ocean View and Marin Schools be strengthened as part of an overall modernization and seismic retrofit program. Retrofits of this nature are commonly performed and often can be implemented economically and with a minimal impact to the function or appearance of the buildings.

We do not believe that further investigation of the recently built buildings at Albany High School or Albany Middle School would be warranted at this time.

The older, wood frame buildings at the Albany Children’s Center, Macgregor High School, Cornell Elementary School and Marin Elementary School could be expected to have certain seismic deficiencies given their era of construction. However, based upon our experience with similar structures we do not anticipate that the nature of these deficiencies would warrant immediate action. We recommend that these buildings be investigated further and potentially strengthened as part of any overall modernization program.

The wood frame and partially retrofitted wood and concrete buildings at Cornell Elementary School may also have certain seismic deficiencies given their age and type of construction. Similar to the wood frame buildings discussed above, we would recommend that these buildings also be investigated further as part of any modernization program.

Table 1: Ocean View Elementary School Calculation Summary

Ocean View Elementary School			
Lateral Force Resisting System Calculation Summary			
	Item	**DCR**	**Notes**
Classroom and Library Buildings	Diaphragm	0.18-0.65	Diaphragm has adequate shear capacity
	Collectors	2.00-5.60	Collector connections significantly overstressed.
	Masonry Shear Walls	0.10-0.50	CMU shear walls have adequate in-plane shear capacity
	Wood Shear Walls	0.6-0.80	Plywood shear walls have adequate in-plane shear capacity
	Out-of-Plane Wall Anchorage	3.23-6.10	Roof to wall connection found to be significantly overstressed
Gymnasium Building	Diaphragm	0.46-0.65	Diaphragm has adequate shear capacity
	Collectors	1.52-3.60	Collector connections significantly overstressed.
	Masonry Shear Walls	0.10-0.40	CMU shear walls have adequate in-plane shear capacity
	Wood Shear Walls	0.50-0.70	Plywood shear walls have adequate in-plane shear capacity
	Out-of-Plane Wall Anchorage	7.71	Roof to wall connection found to be significantly overstressed

Note: DCR refers to "Demand to Capacity Ratio." DCR's less than 1.0 are considered acceptable while DCR's over 1.0 are overstressed.

Table 2: Marin Elementary School Calculation Summary

Marin Elementary School			
Lateral Force Resisting System Calculation Summary			
	Item	**DCR**	**Notes**
Buildings A,B,D,E,F,G	Diaphragm	0.94	Diaphragm has adequate shear capacity
	Shear Walls	0.48-0.69	6" CMU Walls have adequate in-plane shear capacity
	Out-of-Plane Wall Anchorage	4.54	Roof to wall connection found to be overstressed
Building C	Diaphragm	0.75	Diaphragm has adequate shear capacity
	Chords	0.5-2.33	Chords acceptable in most cases and overstressed at one location
	Collectors	0.5-3.87	Collectors acceptable in most cases and overstressed at two locations
	Masonry Shear Walls	0.88	CMU Walls have adequate in-plane shear capacity
	Wood Shear Walls	1.18-1.93	Plywood shear walls, which occur in two locations, overstressed
	Out-of-Plane Wall Anchorage	7.54	Roof to wall connection found to be significantly overstressed

Note: DCR refers to "Demand to Capacity Ratio." DCR's less than 1.0 are considered acceptable while DCR's over 1.0 are overstressed.

Table 3: Albany Unified School District Building Summary

School Name	Building Name	Year Built	No. of Stories	Area sf	Structural Description
Ocean View Elementary School	Classroom Bldgs	1975	1	48,569 total	Wood frame roof with masonry and plywood shear walls
	Library Wing	1975	1		
	Multi-Purpose Wing	1975	1		
Marin Elementary School	Bldg A	1973	1	3,455	Wood frame roof with masonry and plywood shear walls
	Bldg B	1973	1	3,215	
	Bldg C	1973	1	4,265	
	Bldg D	1973	1	3,215	
	Bldg E	1973	1	3,215	
	Bldg F	1973	1	3,215	
	Bldg G	1973	1	3,125	
	Bldg H	Unk.	1	Unk.	Wood Frame
Cornell Elementary School	South Wing	1948	2	13,397	Wood frame roof and floors with concrete shear walls. Partial seismic retrofit.
	North Wing	1950	1 & 2	8,688	Wood Frame
	Admin. Wing	1974	2	7,800	Wood frame roof and floors with concrete shear walls. Partial seismic retrofit.
Albany Middle School	Gymnasium	1997	1	9,248	Steel braced frame
	Area "A" Classroom Bldg.	1997	1	8,212	
	Area "B" Classroom Bldg.	1997	2	25,931	
	Area "C" Classroom Bldg.	1997	2	20,515	
	Food Service	1997	1	4,228	

Table 3: Albany Unified School District Building Summary

School Name	Building Name	Year Built	No. of Stories	Area sf	Structural Description
Albany High School	Gymnasium	1999	1	14,800	Steel braced frame
	Locker Rooms	1999	2	13,154	
	Middle Lobby	1999	2	2,272	
	Classroom Bldg.	1999	3	86,974	
	Fine Arts Bldg	Unk.	2	17,185	Reinforced Concrete
	Multi-Purpose Bldg.	Unk.	1	11,333	Wood Frame
Albany children's Center	Admin/Classrooms	Unk.	1	Unk.	Wood Frame
MacGregor High School	Admin/Classrooms	Unk.	1	Unk.	Wood Frame

3.7.13 Basic Structural Checklist for Building Type RM1: Reinforced Masonry Bearing Walls with Flexible 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.

C3.7.13 Basic Structural Checklist for Building Type RM I

These buildings have bearing walls that consist of reinforced brick or concrete block masonry. Wood floor and roof framing consists of wood joists, glulam beams, and wood posts or small steel columns. Steel floor and roof framing consists of steel beams or open web joists, steel girders, and steel columns. Lateral forces are resisted by the reinforced brick or concrete block masonry shear walls. Diaphragms consist of straight or diagonal wood sheathing, plywood, or untopped metal deck, and are flexible relative to the walls. Foundations consist of brick or concrete spread footings or deep foundations.

Building System

C 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 ADJACENT BUILDINGS: The clear distance between the building being evaluated and any adjacent building shall be greater than 4 percent of the height of the shorter building for Life Safety and Immediate Occupancy. (Tier 2: Sec. 4.3.1.2)

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)

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)

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)

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)

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)

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 DETERIORATION OF WOOD: There shall be no signs of decay, shrinkage, splitting, fire damage, or sagging in any of the wood members, and none of the metal connection hardware shall be deteriorated, broken, or loose. (Tier 2: Sec. 4.3.3.1)

MASONRY UNITS: There shall be no visible deterioration of masonry units. (Tier 2: Sec. 4.3.3.7)

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)

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 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 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 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)

Connections

NC 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 WOOD LEDGERS: The connection between the wall panels and the diaphragm shall not induce cross-grain bending or tension in the wood ledgers. (Tier 2: Sec. 4.6.1.2)

C 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 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 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)

3.7.13S Supplemental Structural Checklist for Building Type RM1: Reinforced Masonry Bearing Walls with Flexible 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 REINFORCING AT OPENINGS: All wall openings that interrupt rebar shall have trim reinforcing on all sides. This statement shall apply to the Immediate Occupancy Performance Level only. (Tier 2: Sec. 4.4.2.4.3)

C 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

NC CROSS TIES: There shall be continuous cross ties between diaphragm chords. (Tier 2: Sec. 4.5.1.2)

NC 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)

NC 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 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 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)

N/A STRAIGHT SHEATHING: All straight sheathed diaphragms shall have aspect ratios less than 2to-1 for Life Safety and I-to-1 for Immediate Occupancy in the direction being considered. (Tier 2: Sec. 4.5.2.1)

C SPANS: All wood diaphragms with spans greater than 24 feet for Life Safety and 12 feet for Immediate Occupancy shall consist of wood structural panels or diagonal sheathing. (Tier 2: Sec. 4.5.2.2)

N/A UNBLOCKED DIAPHRAGMS: All diagonally sheathed or unblocked wood structural panel diaphragms shall have horizontal spans less than 40 feet for Life Safety and 30 feet for Immediate Occupancy and shall have aspect ratios less than or equal to 4-to-I for Life Safety and 3-to-1 for Immediate Occupancy. (Tier 2: Sec. 4.5.2.3)

N/A NON-CONCRETE FILLED DIAPHRAGMS: Untopped metal deck diaphragms or metal deck diaphragms with fill other than concrete shall consist of horizontal spans of less than 40 feet and shall have span/depth ratios less than 4-to-1. This statement shall apply to the Immediate Occupancy Performance Level only. (Tier 2: Sec. 4.5.3.1)

C OTHER DIAPHRAGMS: The diaphragm shall not consist of a system other than wood, metal deck, concrete, or horizontal bracing. (Tier 2: Sec. 4.5.7.1)

Connections

C STIFFNESS OF WALL ANCHORS: Anchors of concrete or masonry walls to wood structural elements shall be installed taut and shall be stiff enough to limit the relative movement between the wall and the diaphragm to no greater than 1/8 inch prior to engagement of the anchors. (Tier 2: Sec. 4.6.1.4)

3.7.13 Basic Structural Checklist for Building Type RM1: Reinforced Masonry Bearing Walls with Flexible 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.

C3.7.13 Basic Structural Checklist for Building Type RM I

These buildings have bearing walls that consist of reinforced brick or concrete block masonry. Wood floor and roof framing consists of wood joists, glulam beams, and wood posts or small steel columns. Steel floor and roof framing consists of steel beams or open web joists, steel girders, and steel columns. Lateral forces are resisted by the reinforced brick or concrete block masonry shear walls. Diaphragms consist of straight or diagonal wood sheathing, plywood, or untopped metal deck, and are flexible relative to the walls. Foundations consist of brick or concrete spread footings or deep foundations.

Building System

C 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 ADJACENT BUILDINGS: The clear distance between the building being evaluated and any adjacent building shall be greater than 4 percent of the height of the shorter building for Life Safety and Immediate Occupancy. (Tier 2: Sec. 4.3.1.2)

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)

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)

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)

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)

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)

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 DETERIORATION OF WOOD: There shall be no signs of decay, shrinkage, splitting, fire damage, or sagging in any of the wood members, and none of the metal connection hardware shall be deteriorated, broken, or loose. (Tier 2: Sec. 4.3.3.1)

MASONRY UNITS: There shall be no visible deterioration of masonry units. (Tier 2: Sec. 4.3.3.7)

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)

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 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 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 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)

Connections

NC 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 WOOD LEDGERS: The connection between the wall panels and the diaphragm shall not induce cross-grain bending or tension in the wood ledgers. (Tier 2: Sec. 4.6.1.2)

C 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 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 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)

3.7.13S Supplemental Structural Checklist for Building Type RM1: Reinforced Masonry Bearing Walls with Flexible 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 REINFORCING AT OPENINGS: All wall openings that interrupt rebar shall have trim reinforcing on all sides. This statement shall apply to the Immediate Occupancy Performance Level only. (Tier 2: Sec. 4.4.2.4.3)

C 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

NC CROSS TIES: There shall be continuous cross ties between diaphragm chords. (Tier 2: Sec. 4.5.1.2)

NC 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)

NC 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 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 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)

N/A STRAIGHT SHEATHING: All straight sheathed diaphragms shall have aspect ratios less than 2to-1 for Life Safety and I-to-1 for Immediate Occupancy in the direction being considered. (Tier 2: Sec. 4.5.2.1)

C SPANS: All wood diaphragms with spans greater than 24 feet for Life Safety and 12 feet for Immediate Occupancy shall consist of wood structural panels or diagonal sheathing. (Tier 2: Sec. 4.5.2.2)

N/A UNBLOCKED DIAPHRAGMS: All diagonally sheathed or unblocked wood structural panel diaphragms shall have horizontal spans less than 40 feet for Life Safety and 30 feet for Immediate Occupancy and shall have aspect ratios less than or equal to 4-to-I for Life Safety and 3-to-1 for Immediate Occupancy. (Tier 2: Sec. 4.5.2.3)

N/A NON-CONCRETE FILLED DIAPHRAGMS: Untopped metal deck diaphragms or metal deck diaphragms with fill other than concrete shall consist of horizontal spans of less than 40 feet and shall have span/depth ratios less than 4-to-1. This statement shall apply to the Immediate Occupancy Performance Level only. (Tier 2: Sec. 4.5.3.1)

C OTHER DIAPHRAGMS: The diaphragm shall not consist of a system other than wood, metal deck, concrete, or horizontal bracing. (Tier 2: Sec. 4.5.7.1)

Connections

C STIFFNESS OF WALL ANCHORS: Anchors of concrete or masonry walls to wood structural elements shall be installed taut and shall be stiff enough to limit the relative movement between the wall and the diaphragm to no greater than 1/8 inch prior to engagement of the anchors. (Tier 2: Sec. 4.6.1.4)