STRUCTURAL EVALUATION OF

LINCOLN ELEMENTARY SCHOOL

WEST CONTRA COSTA UNIFIED SCHOOL DISTRICT (WCCUSD)

For

WLC Architects
Kaiser Building
1300 Potrero Avenue
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By

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10.1 Introduction

The purpose of this report is to perform a seismic assessment of the Lincoln Elementary School in Richmond, CA. The structural assessment includes a site walk through and a limited study of available architectural and structural drawings. The purpose of the structural assessment is to identify decay or weakening of existing structural materials (when visible), to identify seismic deficiencies based on our experience with school buildings, and to identify eminent structural life-safety hazards.

The school campus has had a walk-through site evaluation and a limited study of available architectural and structural drawings. The general structural condition of the buildings and any seismic deficiencies that are apparent during our site visit and review of existing drawings are documented in this report. This report includes a qualitative and quantitative evaluation of the buildings. A limited lateral (seismic) numerical analysis was performed to identify deficient lateral elements which could pose life safety hazards.

The site visits did not include any removal of finishes. Therefore, identification of structural conditions hidden by architectural finishes or existing grade was not performed.

10.2 Description of School

The school is located in the city of Richmond and was built in 1949. The original buildings are a two-story concrete structure (main building) and a one-story wood- and steel-framed structure (cafeteria building) with cement plaster finish on the exterior (see figure 5). There is also a small wood-framed classroom building (rooms 37 and 38) built in 1989. There are three main buildings (permanent structures) and seven portable buildings (see figure 1). There is one 1960 portable, two 1989 portables, one 1996 portable, one 1997 portable, two 1998 portables, and one 2000 portable. The total square footage of the permanent structures is about 38,741 square feet.

10.3 Site Seismicity

The site is a soil classification S_D in accordance with the 1998 California Building Code (CBC) and as per the consultants, Jensen Van Lieden Associates, Inc.

The main building and classroom building have an educational occupancy (Group E, Division 1 and 2 buildings) and the cafeteria building has an assembly occupancy (Group A, Division 3), both of which have an importance factor in the 1998 CBC of 1.15. The campus is located at a distance of about 4.3 kilometers from the Hayward fault. The main building is a concrete structure with non-ductile moment frames in the north-south direction and shear walls in the east-west direction. Non-ductile concrete moment frames are prohibited by the 1998 CBC in seismic zone 4. The concrete shear walls have a response modification factor R=4.5. The cafeteria building and classroom building are wood framed building with shear walls, and have a response modification factor R = 4.5. The 1998 CBC utilizes a code level earthquake, which approximates an earthquake with a 10% chance of exceedance in a 50-year period or an earthquake having a 475-year recurrence period.

The seismic design coefficient in the 1998 CBC is:

$$V = \frac{2.5CaIW}{R} = \frac{2.5(0.44x1.27x1.15)W}{4.5} = 0.357W$$

The site seismicity is used to provide a benchmark basis for the visual identification of deficient elements in the lateral force resisting systems of campus buildings. The calculated base shear was used to perform a limited lateral analysis of the school buildings as described in section 10.7.

10.4 List of Documents

1. Lincoln Elementary School; Dragon, Schmidts, and Hardman Architects; sheets 1-11, S12-S15, P16-P17, H18-H19, E20-E21 (Main Building), 22-26, H27, E28 (Auditorium); June 2, 1948.
2. "Measure M" – WCCUSD Elementary School – UBC revised parameters by Jensen-Van Lienden Associates, Inc., Berkeley, California.
3. "Geological Hazard Study – Recently constructed portable buildings – 24 school sites for Richmond Unified School District," by Jensen-Van Lienden Associates, Inc. dated March 7, 1990.
4. "Measure M" roofing report by "The Garland Company Inc.", Orinda, California.

10.5 Site Visit

DASSE visited the site on October 25th, 2001 and March 7th, 2002. The main purpose of the site visits was to evaluate the physical condition of the structure and in particular focus on the lateral force resisting elements of the building. Following items were evaluated during the site visit:

1. Type and Material of Construction
2. Type of Sheathing at Roof, Floor and Walls
3. Type of Finishes
4. Type of Roof
5. Covered Walkways
6. Presence of Clerestory Windows
7. Presence of Window Walls or High Windows in exterior and interior walls
8. Visible cracks in superstructure, slab on grade and foundation

The main building is a two-story concrete structure (see figures 2 and 4). The east and west faces of the building have multiple large window openings with concrete columns in between. The north and south faces have long segment of shear wall. There are concrete beams and columns along the interior longitudinal corridor with light-framed infill panels (see figure 3).

The cafeteria building is a one-story wood and steel structure with cement plaster exterior and some brick veneer (see figures 5 and 7). The ceiling appears to be plaster. There are multiple window openings along the south wall (see figure 6) and large door openings on the east face of the building (see figure 5). The other walls only have minor wall openings. At the east end of the building, there is a low roof area over the entry lobby. There appears to be some deterioration of the wood at the windows on the south side of the building (see figure 8).

Between the main and cafeteria buildings, there is a small covered walkway area (see figures 6 and 7). This covered walkway is supported by the walls of the two buildings, and does not have its own gravity support system. There are electrical conduits between the two buildings that are supported by the covered walkway.

The classroom building is a wood-framed structure with a covered walkway attached to the front of the building (see figure 9). The rear face of the building has multiple window openings (see figure 10). The 4x4 posts that support the covered walkway sit on small concrete pedestals. One of these pedestals has significant cracking that appears to go most of the way through the section (see figure 11). At the top of that same post, there appears to be some rotting of the beam (see figure 12). At the east side of the building, there is electrical conduit that runs across to the cafeteria building near the roof level (see figure 13).

10.6 Review of Existing Drawings

There were no drawings of the classroom building available for review. Although the site map (figure 1) shows the construction date of the building as 1989, it appears to be older. Furthermore, the site map shows classrooms number 37 and number 38 as portable units instead of as a permanent structure.

The main building has pan-joist concrete roof and floor slabs. The second floor slab is 3" thick and has 6" x 14" typical joists. The roof slab is 2½" thick and has 6" x 12" typical joists. These slabs are typically supported by 12" x 18" concrete columns spaced at 12'-10" along the east and west sides of the building and along both sides of the central corridor. There are concrete shear walls, with thicknesses varying from 6" to 12", in the east-west (transverse) direction. Lateral forces are resisted by a moment frame in the north-south (longitudinal) direction. The detailing of these columns is non-ductile and the effective length of the column is shortened by concrete infill above and below the windows (see figure 2). Therefore, these short columns can be expected to fail in a non-ductile shear failure mode. The foundation typically consists of 5'-0" square x 1'-3" deep spread footings under the interior columns and 2'-6" wide x 1'-0" deep strip footings under the exterior columns. The existing roofing at the main building is about 8 years old and appears to be in acceptable condition.

The cafeteria building has a diagonally sheathed roof supported by 2x10 lumber spanning 16'-6" between steel trusses. These trusses span 48' in the building transverse direction between 6" wide-flange steel columns spaced at 16'-6". Lateral forces are resisted by diagonally sheathed shear walls at the building perimeter and at the back of the lobby. Bolted splices are used at the north and south diaphragm chords in the high roof area. These shear walls typically sit on 2'-8" wide x 1'-0" deep concrete strip footings. There are window and door openings in all of the shear walls. At the north wall, there are multiple window openings in the shear wall (see figure 7). The existing roofing at the cafeteria building is about 16 years old and appears to need to be replaced.

Calculations indicated that the roof diaphragm and the transverse walls in the Cafeteria Building need to be reinforced.

The covered walkway that spans between the main building and the cafeteria building does not have its own independent gravity or lateral force resisting systems, and there is no seismic joint between the covering and either building.

10.7 Basis of Evaluation

The document FEMA 310, Federal Emergency Management Agency, *"Handbook for the Seismic Evaluation of Buildings – A Prestandard,"* 1998, is the basis of our qualitative seismic evaluation methods. The seismic performance levels that the FEMA 310 document seeks to achieve are lower than the current Building Code. However, it attempts to identify the potential for building collapse, partial collapses, or building element life safety falling hazards when buildings are subjected to major earthquake ground motion.

The California Building Code (CBC 1998) is the basis of our quantitative seismic evaluation methods. Base shears identified in section 10.3 were used to perform a limited lateral seismic analysis of the school buildings. The scope of the analysis was not to validate every member and detail, but to focus on those elements of the structure determined to be critical and which could pose life safety hazards. Member *strength* values are based on the document FEMA 356, Federal Emergency Management Agency, *"Prestandard and Commentary for the Seismic Rehabilitation of Buildings"* 2000.

10.8 List of Deficiencies

Building deficiencies listed below have corresponding recommendations identified and listed in Section 10.9, which follow the same order as the itemized list of deficiencies identified below. The severity of the deficiency is identified by a "structural deficiency hazard priority" system based on a scale between 1.0 and 3.9, which is described in Section 10.11. These priority ratings are listed in section 10.9. Priority ratings between 1.0 to 1.9 could be the causes for building collapses, partial building collapses, or life-safety hazards, if the corresponding buildings are subjected to major earthquake ground motions, which are possible at these sites. It is strongly recommended that these life safety hazards are mitigated by implementing the recommendations listed below.

Item	Building Structural Deficiencies
1.	In the longitudinal direction of the main building there is not an adequate length of shear wall. Much of the lateral resistance is provided by non-ductile concrete columns and gravity concrete beams acting as moment frames. Non-ductile moment frames are prohibited in seismic "Zone 4" area because of their tendency for hazardous brittle failures.
2.	Insufficient shear walls in the transverse direction of the main structure, which

	could allow high wall shear forces and large soil pressures due to wall overturning forces if the building were subjected to major earthquake shaking.
3.	The covered walkway spans between the classroom building and the cafeteria building. These buildings will have different displacements. The walkway may suffer severe damage and is a life safety hazard because it does not have its own gravity support framing and could collapse if it were separated from one of the buildings.
4.	The cafeteria building roof diaphragm is overstressed.
5.	At the transverse walls of the cafeteria building, the diagonal sheathing is overstressed at selected locations. No holdowns are present to resist wall overturning forces.
6.	The wood around the window at the south side of the cafeteria building is deteriorating due to wood decay. This may lead to deterioration of the remainder of the wall.
7.	The rear wall of the classroom building has excessive window openings, resulting in a lack of adequate shear wall.
8.	At the covered walkway at the front of the classroom building, the connection of the post to the roof beam has some rot. This may result in partial collapse of the covered walkway if subjected to major earthquake ground motions.
9.	At the covered walkway at the front of the classroom building, the posts rest on unreinforced concrete pedestals that could fall over and cause the post and supported roof framing to lose vertical support. Also, one of the pedestals has significant cracking, making the failure of the pedestal and subsequent partial collapse of the overhang during an earthquake more likely to occur.
10.	There is conduit running between the classroom building and the cafeteria building. Because the conduit has a rigid connection, it could be severed as the buildings move apart and is a life-safety hazard..

10.9 Recommendations

Items listed below follow the same order as the itemized list of deficiencies identified in section 10.8 above.

Item	Recommended Remediation	Priority	Figure Number
1.	Add new infill shear walls in longitudinal direction to provide adequate seismic resistance. Provide new collectors and holdowns as required.	1.0	2
2.	Add new shear wall panels in transverse direction between classrooms. Provide new collectors and holdowns as required.	1.2	N/A
3.	Provide new beams, columns and footings adjacent to each building so that damage will not lead to the collapse of the walkway.	1.5	6, 7
4.	Cover roof with new plywood sheathing.	1.5	N/A

5.	Add new plywood sheathing to the interior face of the wall. Provide new collectors as required. Add new holdowns at the ends of shear wall panels.	1.4	N/A
6.	Replace damaged wood and paint to protect from weather.	1.9	8
7.	Infill some windows with new framing and shear wall. Provide new collectors and holdowns as required.	1.3	10
8.	Replace damaged members, and paint to protect from weather	1.5	12
9.	Shore existing posts and replace concrete pedestals.	1.5	11
10.	Provide new flexible connection at conduit	1.9	13

10.10 Portable Units

In past earthquakes, the predominant damage displayed by portable buildings has been associated with the buildings moving off of their foundations and suffering damage as a result. The portables observed during our site visits tend to have the floor levels close to the ground, thus the damage resulting from buildings coming off of their foundation is expected to be minimal. The life safety risk of occupants would be posed from the potential of falling 3 feet to the existing grade levels during strong earthquake ground shaking. Falling hazards from tall cabinets or bookshelves could pose a greater life safety hazard than building movement. The foundation piers supporting the portable buildings tend to be short; thus the damage due to the supports punching up through the floor if the portable were to come off of its foundation is not expected to be excessive.

Because of their light frame wood construction and the fact that they were constructed to be transported, the portable classrooms are not in general expected to be life safety collapse hazards. In some cases the portables rest directly on the ground and though not anchored to the ground or a foundation system could only slide a small amount. In these instances the building could slide horizontally, but we do not expect excessive damage or life safety hazards posed by structural collapse of roofs.

The regulatory status of portables is not always clear given that portables constructed prior to 1982 will likely have not been reviewed by DSA and thus will likely not comply with the state regulations for school buildings. Portables constructed after about 1982 should have been permitted by DSA. The permits are either issued as temporary structures to be used for not more than 24 months or as permanent structures.

10.11 Structural Deficiency Prioritization

This report hazard rating system is based on a scale of 1.0 to 3.9 with 1.0 being the most severe and 3.9 being the least severe. Based on FEMA 310 requirements, building elements have been prioritized with a low rating of 1.0 to 1.9 if the elements of the building's seismic force resisting systems are woefully inadequate. Priority 1.0 to 1.9 elements could be the causes for building collapses, partial building collapses, or life-safety falling hazards if the buildings were subjected to major earthquake ground motion.

If elements of the building’s seismic force resisting system seem to be inadequate based on visual observations, FEMA 310 requirements and limited lateral (seismic) calculations, but DASSE believes that these element deficiencies will not cause life-safety hazards, these building elements have been prioritized between a rating low of 2.0 to 3.9. These elements could experience and / or cause severe building damage if the buildings were subjected to major earthquake ground motion. The degree of structural damage experienced by buildings could cause them not to be fit for occupancy following a major seismic event or even not repairable.

The following criteria was used for establishing campus-phasing priority:

First, the individual element deficiencies which were identified during site visit and review of existing drawings were prioritized with a rating between 1.0 to 3.9 and as described in this section.

The next step was to arrive at a structural deficiency rating between 1 and 10, with a rating of 1 representing a school campus in which the building’s seismic force resisting systems are woefully inadequate.

Based on the school district’s budgetary constraints and scheduling requirements, each school campus was given a phasing number between one and three. Phase I represents a school campus with severe seismic deficiencies, Phase II represents a school campus with significant seismic deficiencies and Phase III represents a school campus with fewer seismic deficiencies.

10.12 Conclusions

1. Given the vintage of the building(s), some elements of the construction will not meet the provisions of the current building code. However, in our opinion, based on the qualitative and limited quantitative evaluations, the building(s) will not pose serious life safety hazards if the seismic deficiencies identified in section 10.8 are corrected in accordance with the recommendations presented in section 10.9.

2. Any proposed expansion and renovation of the buildings should include the recommended seismic strengthening presented in section 10.9. Expansion and renovation schemes that include removal of any portion of the lateral force resisting system will require additional seismic strengthening at those locations. It is reasonable to assume that where new construction connects to the existing building(s), local seismic strengthening work in addition to that described above will be required. All new construction should be supported on new footings.

3. Overall, this school campus has a seismic priority of 1 and we recommend that seismic retrofit work be performed in Phase I.

10.13 Limitations and Disclaimer

This report includes a qualitative (visual) evaluation and a limited quantitative seismic evaluation of each school building. Obvious gravity or seismic deficiencies that are identified visually during site visits or on available drawings are identified and documented in this report. Elements of the structure determined to be critical and which could pose life safety hazards are identified and documented during limited quantitative seismic evaluation of the buildings.

Users of this report must accept the fact that deficiencies may exist in the structure that were not observed in this limited evaluation. Our services have consisted of providing professional opinions, conclusions, and recommendations based on generally accepted structural engineering principles and practices.

DASSE's review of portable buildings has been limited to identifying clearly visible seismic deficiencies observed during our site visit and these have been documented in the report. Portable buildings pose several issues with regard to assessing their life safety hazards. First, drawings are often not available and when they are, it is not easy to associate specific drawings with specific portable buildings. Second, portable buildings are small one story wood or metal frame buildings and have demonstrated fairly safe performance in past earthquakes. Third, there is a likelihood that portable buildings (especially those constructed prior to 1982) are not in compliance with state regulations, either because they were not permitted or because the permit was for temporary occupancy and has expired.

Figures

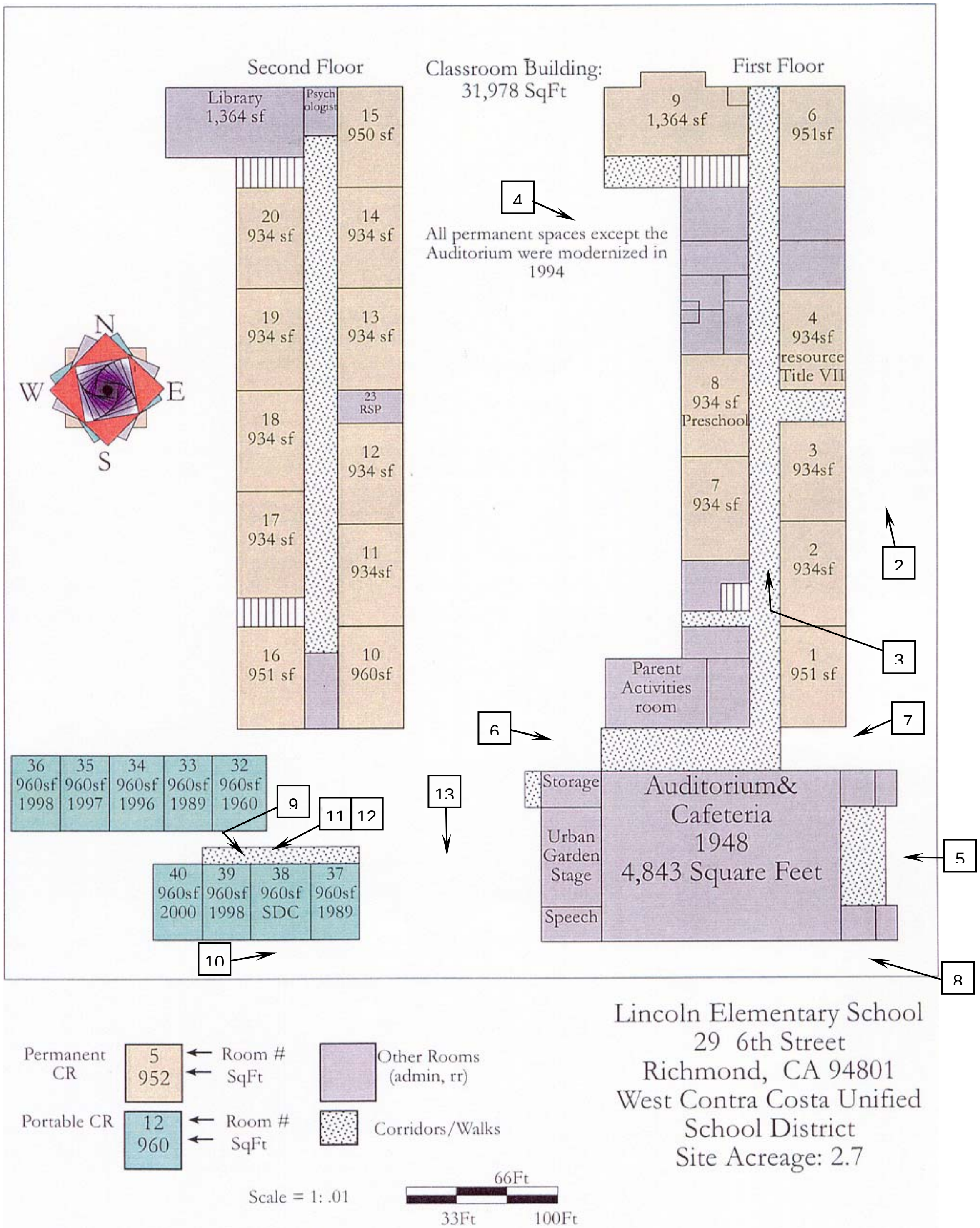

Figure 1: School Layout Plan

Figure 2: Main Entrance

Figure 3: Main building interior corridor

Figure 4: Main building east face

Figure 5: Cafeteria building east entrance

Figure 6: Covered walkway

Figure 7: Covered walkway and cafeteria building north face

Figure 8: South face of cafeteria building

Figure 9: Front view of classroom building

Figure 10: Rear face of classroom building

Figure 11: Concrete pedestal at classroom building covered walkway

Figure 12: Deterioration of beam at classroom building covered walkway

Figure 13: Conduit between cafeteria and classroom buildings