STRUCTURAL EVALUATION OF

CASTRO ELEMENTARY SCHOOL

WEST CONTRA COSTA UNIFIED SCHOOL DISTRICT (WCCUSD)

For

WLC Architects
Kaiser Building
1300 Potrero Avenue
Richmond, CA 94804

By

DASSE Design, Inc.
33 New Montgomery Street #850
San Francisco, CA 94105
(415) 243-8400

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10.1 Introduction

The purpose of this report is to perform a seismic assessment of the Castro Elementary School in El Cerrito, 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 El Cerrito and was built in three main stages. At its inception in 1948, the campus consisted of the wood-framed main classroom building, referred to as Unit A. This building is primarily a single story structure with a partial lower level that results in a two-story facade at its low end. Shortly thereafter (1949), the two single story wood-framed buildings were added to the campus. Now identified as Unit C, this construction included another classroom building and the multipurpose building. A second addition to the campus came in 1954 with the construction of Unit B, another single story, wood-framed classroom building. Along with these buildings two other single story buildings are located on the east side of the playground area. The time of construction for these buildings is unclear, but these structures appear to be older portable buildings (possibly dating back to the 1960s). In addition to these, the campus includes three newer portable structures (see figure 1), including two 1989 units and one 1997 unit. The total square footage of the permanent structures is about 37,365 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 classroom buildings have an educational occupancy (Group E, Division 1 and 2) and the multi-purpose building has an assembly occupancy (Group A, Division 2), both of which have an importance factor in the 1998 CBC of 1.15. The campus is located at a distance of less than 2 kilometers from the Hayward fault. The wood-framed buildings described above utilize diagonally sheathed or plywood shear walls to resist lateral loads. The response modification factor for these systems is as follows: R=4.5 (diagonally sheathing), R=5.5 (plywood sheathing).

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 for diagonally sheathed shear walls is:

$$V = \frac{2.5C_a IW}{R} = \frac{2.5(0.44x1.50x1.15)W}{4.5} = 0.422W$$

The seismic design coefficient in the 1998 CBC for plywood sheathed shear walls is:

$$V = \frac{2.5C_a IW}{R} = \frac{2.5(0.44x1.50x1.15)W}{5.5} = 0.345W$$

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. Unit A, Classroom Building: P.L. Dragon, C.R. Schmidts Architects, Sheets 1 - 11, February 14, 1948.
2. Unit C, Classroom and Multipurpose Buildings: Dragon, Schmidts, & Hardman Architects, Sheets 1 - 21, April 25, 1949.
3. Unit B, Classroom Building: Schmidts & Hardman Architects, Sheets A1 - A10, S1 - S6, December 3, 1954.
4. “Measure M” – WCCUSD Elementary School – UBC revised parameters by Jensen Van Lienden Associates, Inc.
5. “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.
6. “Measure M” roofing report by “The Garland Company Inc.”, Orinda, California.

10.5 Site Visit

DASSE visited the site on November 9th, 2001 and March 8th, 2002. The main purpose of the site visit was to evaluate the physical condition of the structure and in particular focus on the lateral force resisting elements of the building. The 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 classroom building (Unit A) is built into a hillside such that it is partially a two-story structure (see figures 2, 3, 4, and 10). An exterior brick veneer occurs at the lower level, while the exterior finish of the main level is a wainscot brick veneer with stucco above. At the classrooms, the exterior walls are continuous window walls (see figure 3), while the typical corridor walls have a plaster finish. In the basement, a leaking retaining wall was observed, the cause of which should be investigated further. Near the center of the building a brick chimney extends above the roof. Located at the lower end of the campus, the second classroom building (Unit B), which houses the kindergarten classrooms, is a wood-framed single story building (see figures 8 and 9). This structure also has extensive window walls. Around a large skylight over the hallway cracks in the ceiling were observed, indicating that this building is pulling apart. The multipurpose building (Unit C) is another single story, wood framed building (see figures 6 and 7). This structure differs from the others on the campus because it is framed with a series of glue-laminated, 3-pinned arches spaced at 4’-0” on center (see figure 7). The other building of Unit C is the classroom building, which was constructed very similarly to the main classroom building. These two buildings of Unit C are connected by a covered walkway. The roof of this walkway structure is sheathed with straight board sheathing, and is supported by the adjacent buildings. Because the covered walkway is connected to two different structures, it has the potential to pull apart and lose gravity support if the buildings experience opposing displacements during a seismic event. This constitutes a life safety hazard. Additionally, electrical conduit was found to be running along the covered walkways between multiple buildings. Due to the inability of the hard conduit to withstand these differential movements, this is also identified as a life safety hazard. The two portable buildings located at the east side of the playground area appear to have been built on intermittent foundations. This type of discontinuous foundation does not provide for the transfer of lateral loads, and its vulnerability to a toppling type failure is a life safety hazard. At its rear longitudinal wall, the northernmost of these two structures has a continuous window wall, which appears to have insufficient shear strength constituting a life safety hazard.

10.6 Review of Existing Drawings

The lower basement portion of Unit A, the main classroom building, is constructed with concrete walls and a concrete slab-on-grade. The main level floor over this area is supported by concrete system composed of a 2½” slab, 16½” deep joists spaced 36”± on center, 16½” deep beams, and 14” square columns. The roof framing is made up of 2x14 ceiling joists spaced at 16” on center that support 2x4 rafters also spaced at 16” on center at intervals. The roof is sheathed with 1x6 diagonal sheathing. Lateral forces are resisted by 1x6 wood “let-in braces” that occur periodically at the interior walls, and the diagonally sheathed exterior end walls. The lateral resistance provided by these braces is minimal, and in combination with the exterior window walls (figure 3 and 10), very little capacity exists to resist seismic loads. A load path for chord and collector forces is provided through double top plates and/or headers, but the splices of these members are inadequate for the prescribed forces. The building’s foundation is composed of 3’-9” square spread footings at the columns and strip footings of varying widths at the walls, all of which are reinforced concrete. The insufficient “let-in braces” and collector splices represent life safety hazards at the main classroom building. The existing roof of Unit A, the main classroom building, is about 19 years old and appears to need replacement.

Unit B, the classroom building, is a traditionally framed wood structure. Roof joists (2x14 and 2x16 spaced at 24” on center, typical) span between 2x6 wood stud, bearing walls. The roof is sheathed with 3/8” and 1/2” plywood and is discontinuous across 3 different levels (figure 9). At this discontinuity the lower roof framing is susceptible to ripping away from the supporting bearing wall due to differential displacements. Around the hallway skylight, the framing does not provide a continuous diaphragm tie at the ridge. This lack of continuity has resulted in the ceiling cracking observed and poses a concern, as the diaphragm is likely to pull apart in a seismic event. The structure resists seismic loads through both exterior and interior wood shear walls that are sheathed with 3/8” plywood. Some of the exterior walls are window walls or have clerestory windows (figures 8 and 9), but sufficient shear resistance is provided by the plywood shear walls at most locations. Double top plates with well nailed splice connections provide continuity for the transfer of chord and collector forces. At a couple of interior shear walls the shear strength is deficient, and at one critical wall an adequate collector member is not provided. The building is founded on reinforced concrete strip footings varying in width from 1’-0” to 2’-4”. A positive tie down connection between this foundation and the wood shear walls for the purpose of resisting uplift forces is provided at the most critical locations, but not at all necessary locations. The local deficiencies in diaphragm discontinuities, shear wall strength, continuity of collector members, and foundation tie downs represent life safety concerns at Unit B. The existing roof of the classroom building, Unit B, is about 19 years old and appears to need replacement.

The multipurpose building of Unit C has a framing system unique to the other buildings found on this campus. A series of 3-pinned arches constructed out of glue laminated timbers support a panelized roof system (figure 7). The glue-lam arches are spaced at 4’-0” and span the 30’-0” width of the building. The roof diaphragm is composed of 1/2” plywood with intermediate stiffener members. The walls between the glue-lam arches are framed with intermediate horizontal wood members. Diagonally sheathed (1x6) shear panels are intended to resist lateral forces in the longitudinal direction, while lateral forces in the transverse direction are resisted by the glue-lam arches and end shear walls. The longitudinal shear panels do not extend to the roof level, but instead rely on weak axis bending of the glue-lam arches to transfer forces from the roof to the sheathed wall below the windows, which is an inadvisable system. The transverse shear walls have few openings, and the large number of arches provides a redundancy that is advantageous in resisting seismic forces. However, the arches lack a positive tie at the center hinge and have an undefined foundation connection, both of which are important for the resistance of lateral seismic loads. Continuity for the transfer of chord and collector forces is provided through a wood screw splice. Reinforced concrete strip footings with a 1’-2” width support the entire structure. A positive connection between this foundation and the wood shear walls for the purpose of resisting uplift forces does not exist, but this is not deemed critical given the shear wall lengths and tributary gravity loads. The discontinuous longitudinal shear walls and the lack of continuity tie at the glue-lam arch are identified as a life safety issues at the multipurpose building. The existing roof of the multipurpose building at Unit C is about 19 years old and appears to need replacement.

The second structure included in Unit C is a classroom building that was constructed to match the main classroom building. This single story wood building is framed with a combination of ceiling joists and roof rafters spaced at 24” on center and ranging in size from 2x4 to 2x14. Like the main classroom building, the roof is sheathed with diagonal sheathing and the primary lateral force resisting elements are 1x6 wood “let-in braces”. As stated previously, the minimal capacity of these braces combined with the large amount of exterior window walls results in an insufficient capacity to resist lateral loads. Double top plates and/or headers provide a load path for chord and collector forces, but the splices of these members are inadequate. The building foundation is composed reinforced concrete strip footings with widths varying from 1’-0” to 2’-0”. Like Unit A, the life safety hazards at this classroom building are the insufficient “let-in braces” and collector splices. The existing roof of the classroom building at Unit A, is about 19 years old and appears to need replacement.

Construction drawings for the additional buildings at the east side of the playground are not available for review at this time. The existing roofs of these buildings are about 19 years old and appear to need replacement.

Covered walkways exist on the campus connecting the two buildings of Unit C and the classroom building of Unit C with Unit A. These walkways are tied at their ends to the classroom building of Unit C, and to a lesser extent, the multipurpose building. They are framed with 3x6 and 6x6 members, covered with diagonal sheathing and supported by 3” diameter steel pipes. These steel pipes have base plate connections with only two anchor bolts, which is insufficient to provide a fixed connection that is required to resist seismic loads where the adjacent buildings do not provide lateral restraint. This lack of lateral load resisting system is identified as a life safety hazard.

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.	Unit A (main classroom building): Strength of 1x6 wood "let-in braces" is inadequate to resist prescribed forces.
2.	Unit A (main classroom building): Strength of chord/collector splices is inadequate to resist prescribed forces.
3.	Unit B (classroom building): Plywood diaphragm is discontinuous at a common bearing wall with no provision to accommodate differential movement. Plywood diaphragm is discontinuous at the ridge around the large skylight opening.
4.	Unit B (classroom building): Strength of plywood shear walls at some locations is inadequate to resist prescribed forces.
5.	Unit B (classroom building): Continuity of chord/collector elements is lacking at some locations.
6.	Unit B (classroom building): Positive connection of shear walls to foundation is lacking at some locations.
7.	Unit C (multipurpose building): Existing wood shear panels are discontinuous between the roof and foundation levels.
8.	Unit C (multipurpose building): Positive tie across three-hinged arch is lacking. Foundation connection of three-hinged arch is unclear.
9.	Unit C (classroom building): Strength of 1x6 wood "let-in braces" is inadequate to resist prescribed forces.
10.	Unit C (classroom building): Strength of chord/collector splices is inadequate to resist prescribed forces.
11.	Covered Walkway: Structure is tied to two adjacent buildings with no provision to accommodate differential movement.
12.	Covered Walkway: At distances from the supporting buildings a lateral force resisting system is lacking.
13.	Covered Walkway: Electrical conduits are connected to adjacent buildings with no provision to accommodate differential movement.
14.	Portable Buildings: Strength of shear wall at the rear longitudinal wall is likely to be inadequate to resist prescribed forces.
15.	Portable Buildings: Discontinuous foundation lacks the ability to transfer lateral forces to the ground.

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.	Remove existing, interior wall finish and add new plywood sheathing at inadequate locations. Remove some windows and replace with new stud framing and plywood sheathing. Provide new holdowns at new shear wall locations.	1.0	N/A
2.	Provide new strapping at inadequate locations.	1.5	N/A
3.	Provide new post and beam support at lower roof framing at discontinuous location. Provide new strapping across ridge.	1.5	9
4.	Remove existing, interior wall finish and add new plywood sheathing at inadequate locations.	1.1	N/A
5.	Provide new strapping and blocking at inadequate locations.	1.5	N/A
6.	Provide new holdown anchors into existing foundation at lacking locations.	1.5	N/A
7.	Provide new plywood sheathing at longitudinal walls between window locations.	1.1	6
8.	Provide new strap across center of each glue-lam arch. Investigate the existing foundation connection of the glue-lam arches to determine if strengthening of connection is required.	1.2	7
9.	Remove existing, interior wall finish and add new plywood sheathing at inadequate locations. Remove some windows and replace with new stud framing and plywood sheathing. Provide new holdowns at new shear wall locations.	1.1	N/A
10.	Provide new strapping at inadequate locations.	1.5	N/A
11.	Provide new beams and columns near multipurpose and classroom buildings of Unit C.	1.9	N/A
12.	Provide new epoxy anchor bolts at base plate connections of steel pipe columns.	1.9	N/A
13.	Provide new flexible electrical conduits between adjacent buildings.	1.9	N/A
14.	Remove some windows and replace with new stud framing and plywood sheathing.	1.1	N/A
15.	Provide new reinforced concrete spread footings between existing, intermittent footings at discontinuous foundation.	1.9	N/A

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 2 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

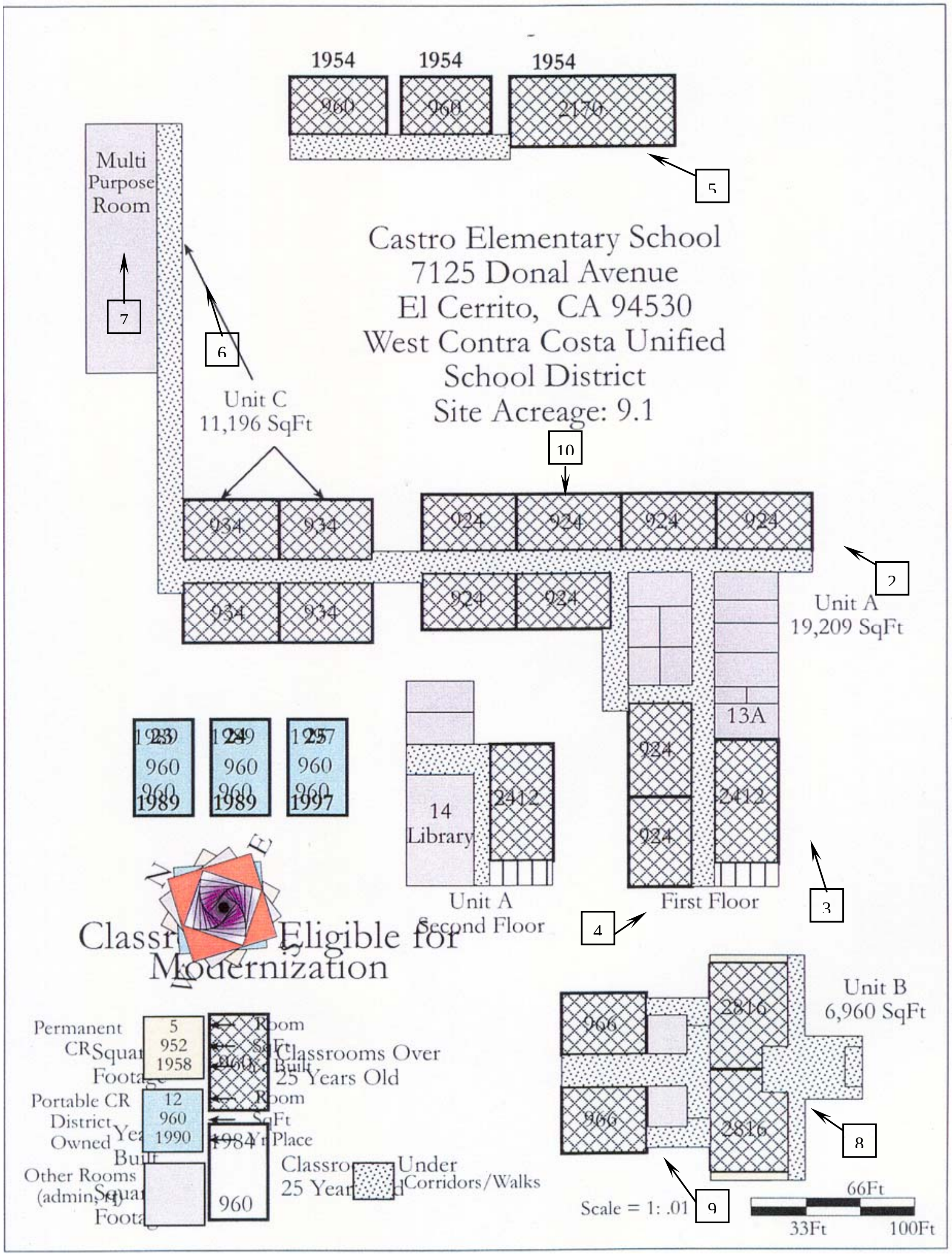

Figure 1: School Layout Plan

Figure 2: Unit A (main classroom building), entrance

Figure 3: Unit A (main classroom building), south face

Figure 4: Unit A (main classroom building), west face

Figure 5: Classroom building, west face

Figure 6: Unit C (multipurpose building), south face

Figure 7: Unit C (multipurpose building), interior

Figure 8: Unit B (classroom building), south face

Figure 9: Unit B (classroom building), west face

Figure 10: Unit A (main classroom building), east face