STRUCTURAL EVALUATION OF

HARDING 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 Harding 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 various stages. The original campus consisted of the two-story wood-framed main classroom building that appears to have been constructed in 1926. The single story, wood-framed auditorium building (circa 1927), cafeteria building (1948), and classroom buildings (1943 and 1949) were added to the campus in later construction. It should be noted that two smaller classroom buildings were constructed in the 1940s as temporary structures. In 1954 the main classroom building underwent significant additions including a new second floor at the previously single story areas, new corridors, new utility rooms, and new administration offices. Besides these permanent structures, the campus includes 7 portable buildings (see figure 1). Of the portable structures there is one 1967 unit, one 1969 unit, three 1988 units, and two 1989 units. The total square footage of the permanent structures is about 40,970 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 auditorium and cafeteria buildings have an assembly occupancy (Group A, Division 2 and 3), 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 wood shear walls to resist lateral loads. Each building uses diagonally sheathed shear walls, some in combination with plywood shear walls. The response modification factor for these systems is as follows: 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:

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

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. Main Classroom Building: Louis S. Stone – Architect, Sheets 1, 2, 5 - 7, date indeterminate.
2. Auditorium Building: Louis S. Stone – Architect, W. Adrian Structural Engineer, Sheets 1 - 5, date indeterminate.
3. Additional Classroom Building #1 (temporary): P.L. Dragon, C.R. Schmidts Architects, Sheets A1, 1 - 2, April 13, 1943.
4. Cafeteria Building: Dragon, Schmidts, & Hardman Architects, Sheets 1 - 11, August 2, 1948.
5. Additional Classroom Building #2 (temporary): Dragon, Schmidts, & Hardman Architects, Sheets 1 - 3, June 30, 1949.
6. Toilet Building, Relocation Classroom Building: Charles F. Strothoff A.I.A., Architect, Sheets 1 - 3, October 7, 1953.
7. Additions and Alterations: Charles F. Strothoff A.I.A., Architect, Sheets A1 - A12, May 21, 1954; Adrian, Graham, & Hayes Associated Structural Engineers, Sheets S1 - S16, May 21, 1954.
8. “Measure M” – WCCUSD Elementary School – UBC revised parameters by Jensen- Van Lienden Associates, Inc., Berkeley, California.
9. “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.
10. “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 two-story main classroom building and single story auditorium building are wood-framed structures of similar construction (see figures 2, 3, 4, 6, and 7). Building exteriors are constructed of a combination of brick wainscot veneer, stucco, and wood siding. The auditorium building has a high ceiling with exposed wood trusses, while the classroom building has acoustical tile ceilings that are raised at some locations. The west side of the classroom building facing Ashbury Avenue is almost entirely a window wall (see figure 4). The cafeteria building is another single story wood-framed structure that, unlike the others, uses glue-lam beam construction (figure 5). Two additional single story classroom buildings also are constructed with wood framing and wood siding exteriors (see figures 8, 10, and 11). These buildings typically have extensive window walls at each classroom. It was observed that two of the portable buildings share a common foundation, but appear to be independent structures. Because these buildings have virtually no separation to allow for opposing lateral displacements, they have the potential to "pound" each other during an earthquake. This pounding potential should be investigated further. The additional classroom buildings and portable buildings are linked to each other and the rest of the campus through a system of covered walkways (figure 9), which are of two different construction types: wood post and beam or steel pipe column with wood beams. Electrical conduit was found to be running along the covered walkways between multiple buildings and between portable buildings. Due to the inability of this conduit to withstand these differential movements, this is also identified as a life safety hazard.

10.6 Review of Existing Drawings

Constructed in two phases, the main classroom building is a two story structure in which two thirds of the second floor was added during an addition project. The structure is framed with 2x16 floor joist at 16" on center at both the first and second floors. The roof framing is composed of 2x14 roof joist and 2x6 rafters at 16" on center. Both the floors and roof diaphragms are constructed with diagonal sheathing, which has a plywood overlay at the two center classrooms on the second floor. The joists are supported on wood stud bearing walls. These walls also resist lateral forces where they are sheathed with either diagonal sheathing or plywood to form shear walls. The transverse shear walls (between classrooms and at the building's ends) are not penetrated with openings. In the longitudinal direction the interior corridor wall has minimal door openings, but the exterior walls have extensive window and door openings, particularly at the west face of the building (see figures 4 and 7). At these window openings chord and collector forces are transferred through the headers and steel plate straps. Both the shear wall strength and the collector splice strength at the exterior longitudinal walls are inadequate to resist the prescribed forces. In general, the structure provides continuity for the transfer of chord and collector forces; however, in some locations this continuity is absent or inadequate. Drawings defining the foundation system of the original construction are not available for review, but the construction of the 1954 addition sits on reinforced concrete strip footings varying in width from 1'-2" to 2'-8". During this addition tie-down connections have also been added to some of the wood shear walls in order to transfer uplift forces into the foundation (both original and reconstruction), but this type of positive connection for the resistance of uplift forces is still absent at some critical locations. The life safety hazards identified at the main classroom building are severe and include inadequate shear wall strength, inadequate collector splice strength, and a lack of uplift connection at some critical shear wall locations. The existing roof at the main classroom building is about 24 years old and appears to need replacement.

The auditorium building is framed with large timber trusses spanning the transverse length of the building (47’-6”) and spaced typically at 11’-10”. These trusses support 3x6 rafters and the original 1¼” tongue and groove sheathing, which was overlaid with 3/8” plywood in 1954. The balcony framing includes wood joists carried by steel beams carried by 24” deep steel plate girders. The roof trusses and balcony girders are supported by wood posts and steel columns respectively. Lateral forces are resisted by the exterior wood shear walls, which were sheathed with diagonal sheathing and 1/2” plywood at alternate locations during the 1954 reconstruction. The transverse shear walls are uninterrupted, and the south wall is lengthy, but the north wall has substantial window openings. Double top plates with bolted splice connections provide continuity for the transfer of chord and collector forces; however, these splices are inadequate to transfer the collector forces developed across the window openings at the north wall. The building is founded on its original reinforced concrete footings. There is no evidence of a positive connection between this foundation and the wood shear walls for the purpose of resisting uplift forces, but due to the wall lengths and their position relative to the gravity framing system this does not appear to be critical. While the retrofit work performed on the auditorium building during the 1954 addition has addressed most of the building’s deficiencies, the inadequate collector splice strength at the north wall is identified as a life safety hazard. The existing roof at the auditorium building is about 24 years old and appears to need replacement.

The cafeteria building 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. The glue-lam arches are spaced at 4’-0” and span the 30’ 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 in the longitudinal direction is provided through a wood screw splice. Reinforced concrete strip footings with a typical 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 life safety issues at the cafeteria building. The existing roof at the cafeteria building is about 24 years old and appears to need replacement.

The two additional classroom buildings of similar wood construction were built as temporary structures. Typical roof framing consists of 2x6 rafters at 24" on center and 2x6 ceiling joists at 24" on center. Similar to the roof, the floor framing is made up of 2x6 joists at 16' on center. Diagonal sheathing (1x6) over the roof framing forms the roof diaphragm. The wood stud shear walls at both the perimeter and interior are diagonally sheathed (1x6) to resist lateral forces. Substantial lengths of shear wall occur at both buildings, with the exception of the west wall of the first building where windows inhibit the capacity to resist seismic loads. Double top plates with nailed splice connections provide continuity for the transfer of chord and collector forces, but these splice connections are inadequate at the window wall locations. At the foundation the building is supported on exterior reinforced concrete strip footings (typical 1'-0" width) and interior concrete isolated footings (typical 1'-6" square). There is no positive connection between the foundation and shear walls for the resistance of uplift forces, which is critical at some shear wall locations. Life safety hazards identified at the additional classroom buildings are inadequate shear wall strength, inadequate collector splice strength, and absence of uplift connection at shear walls. The existing roofs at the additional classroom buildings are about 24 years old and appear to need replacement.

The covered walkways have been constructed of two different types. Between the auditorium and the first additional classroom building, the construction used is 2x6 tongue and groove sheathing over 3x8 and 6x8 framing members that are supported by the 3"diameter steel pipe columns. Lateral forces are resisted through these columns, which cantilever from an extensive foundation that includes 1'-0" square pier footings interconnected by 1'-2" deep grade beams in both directions. The remainder of the covered walkway was constructed at an earlier date of 2x6 plank over 4x6, 6x6, and 6x10 framing members that are supported by 6x6 wood posts. This framing system does not provide any resistance to lateral loading and is not adequately tied to the adjacent buildings, which constitutes a life safety concern.

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.	Main Classroom Building: Strength of wood shear walls in the longitudinal direction and at some transverse locations is inadequate to resist prescribed forces.
2.	Main Classroom Building: Strength of chord/collector splices is inadequate to resist prescribed forces. Continuity of chord/collector elements is lacking at some locations.
3.	Main Classroom Building: Positive connection of shear walls to foundation is lacking at the longitudinal and some transverse walls where this connection is critical.
4.	Auditorium Building: Strength of chord/collector splices at the longitudinal walls is inadequate to resist prescribed forces.
5.	Cafeteria Building: Existing wood shear panels are discontinuous between the roof and foundation levels.
6.	Cafeteria Building: Positive tie across three-hinged arch is lacking. Foundation connection of three-hinged arch is unclear.
7.	Additional Classroom Buildings: Strength of wood shear walls at some locations is inadequate to resist prescribed forces.
8.	Additional Classroom Buildings: Strength of chord/collector splices at some locations is inadequate to resist prescribed forces.
9.	Additional Classroom Buildings: Positive connection of shear walls to foundation is lacking at some locations where this connection is critical.
10.	Covered Walkway: Lateral force resisting system is lacking at walkway framed with wood posts.
11.	Portable Buildings/Covered Walkway: Electrical conduits are connected to adjacent buildings with no provision to accommodate differential movement.

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.	Replace existing diagonal sheathing with new plywood sheathing at inadequate locations. Remove some windows and replace with new stud framing and plywood sheathing.	1.0	4, 7
2.	Provide new strapping and blocking at inadequate locations.	1.5	N/A
3.	Provide new holdown anchors into existing foundation and between floors.	1.5	N/A
4.	Provide new strapping and blocking at inadequate locations.	1.5	N/A
5.	Provide new plywood sheathing at longitudinal walls between window locations.	1.1	5
6.	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	N/A
7.	Replace existing diagonal sheathing with new plywood sheathing at inadequate locations.	1.1	11
8.	Provide new strapping and blocking at inadequate locations.	1.5	N/A
9.	Provide new holdown anchors into existing foundation.	1.5	N/A
10.	Provide new knee bracing between existing post and beam in both directions at lacking locations.	1.9	N/A
11.	Provide new flexible electrical conduits between the portable buildings and along the covered walkways.	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 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

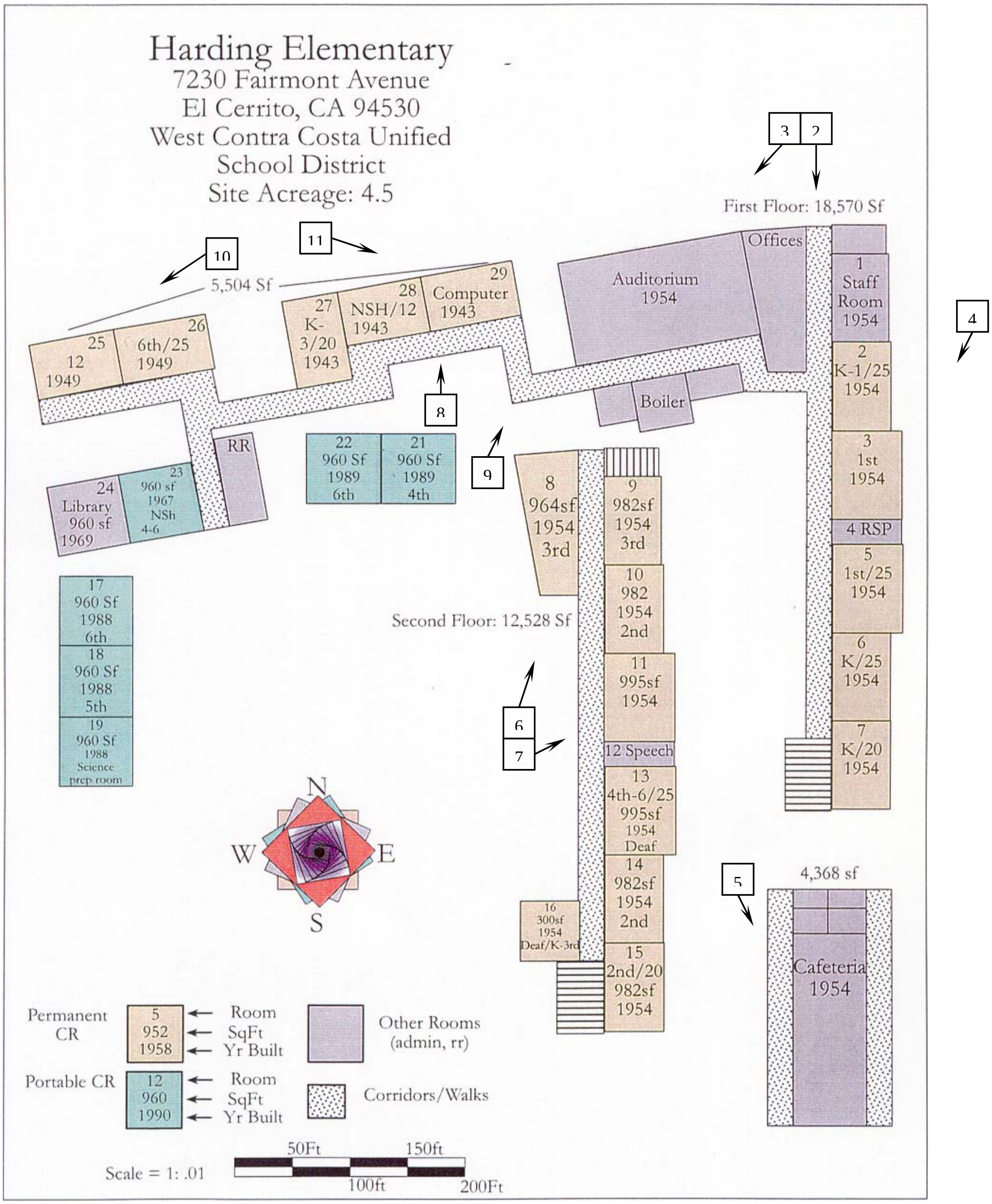

Figure 1: School Layout Plan

Figure 2: Main Entrance

Figure 3: Main Classroom Building/Auditorium Building facing Fairmount Avenue

Figure 4: Main Classroom Building facing Ashbury Avenue

Figure 5: Cafeteria Building east face

Figure 6: Auditorium Building south face

Figure 7: Main Classroom Building east face

Figure 8: Additional Classroom Building 1 south face

Figure 9: Covered Walkway

Figure 10: Additional Classroom Building 1 north face

Figure 11: Additional Classroom Building 2 north face