

NPS Structural/Seismic Evaluation: Cabrillo National Monument

San Diego, California

Final Report

October 29, 2010



Prepared for:

National Park Service Denver Service Center
NPS Contract Number C2000080100
NPS Task Order T2011101415

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EXECUTIVE SUMMARY

Per National Park Service (NPS) Task Order T2011101415, Tipping Mar (TM) has performed a structural seismic evaluation of 13 Buildings at Cabrillo National Monument, which is located at the tip of the Point Loma Peninsula just west of the city of San Diego, California. Building descriptions, findings, and recommendations have been prepared for the following facilities:

Table 1 - Facilities Included in NPS Task Order T2011101415

Building Number	Building Name
Building No. 71983	Visitor Center View Building
Building No. 71929	Administration Building
Building No. 109735	Visitor Contact and Law Enforcement Support Building
Building No. 71945	Auditorium/Museum/Supply Room/Restrooms Facility
Building No. 71965	Military History Museum Building
Building No. 71952	Point Loma Lighthouse
Building No. 71932	Assistant Lighthouse Keepers Quarters and Restroom
Building No. 71953	Lighthouse Overlook Restrooms Building
Building No. 71941	Entrance Station Building
Building No. 109736	Upper Maintenance
Building No. 71954	Lower Maintenance Facility
Building No. 71974	Curatorial Building
	Pergola

The purpose of the evaluation is to determine the overall configuration and condition of each of the facilities and to identify structural deficiencies, specifically those that represent an earthquake-induced hazard compromising the stability of the structural system or the safety of building occupants. Other lateral loads such as infrequent wind events and explosion hazards are not within the scope of the report. At the request of NPS, general maintenance items that have no immediate impact on structural stability have not been addressed within this report. Where deficiencies are identified, specific recommendations for improvements are provided to reduce the seismic hazard to occupants and minimize the chance of significant structural damage. Identification of deficiencies and recommendations are based upon experience and engineering judgment. Detailed structural seismic calculations and checks for conformance to building code were not performed.

In general, the buildings within the scope of the evaluation are relatively small structures having a low risk level overall. About two-thirds of the buildings are of one-story wood construction. This type of construction typically presents a low life-safety hazard to occupants. The majority of the walls are of typical stick-framed construction consisting of sheathing over 2x studs. This type of wall is expected to perform fairly well in a seismic event. The effectiveness of a wood shearwall in a particular building is dependent on a number of factors: continuous and sufficient load path from the roof to the wall sheathing, adequate panel edge nailing, and appropriate hold-down and shear anchorage to foundations. Structural deficiencies include inadequate anchorage, sheathing or blocking. When applicable, recommendations



include additional investigation and structural improvements such as adding uplift anchorage hardware, sheathing, blocking, clips, and/or foundation anchors. In cases where the lateral-force-resisting system consisted of cantilevered columns, recommendations included the addition of moment frames or the replacement of weak columns with stronger cantilevered columns. Refer to individual building evaluations and recommendations for additional information.

The other third of the buildings consist of masonry wall construction with light-framed floors and/or roofs. In most of these cases original construction documents were not available, and details of existing reinforcement and/or anchorage connections are unknown. Unreinforced masonry walls are prone to sudden and brittle failure in significant seismic events and are not allowed under modern building codes. The risk is even greater when masonry walls are used in combination with wood floor or roof framing. Common deficiencies include a lack of out-of-plane bracing of masonry walls, inadequate connection or load path from the roof or floor diaphragm to the wall, insufficient wall anchorage and possibly inadequate foundations. In cases where wall reinforcement and anchorage is uncertain, recommendations are made to further investigate the nature of the wall and connections. Recommendations generally include blocking roof joists over walls and providing out-of-plane wall anchorage at the roof and floors. Occasionally, investigation of the foundation or strengthening of cross walls are also recommended.

Recommendations are accompanied by rough order-of-magnitude cost-estimates, which include construction estimates for hard costs for materials and labor. These estimates are based on engineering judgment and experience with similar facilities and conditions. They may not represent all costs associated with the recommended work. These estimates should be verified with a detailed evaluation prior to beginning work. The relative importance of each recommendation is also noted as urgent or important based on the severity of the threat of the hazard and the urgency to alleviate the existing condition. Table 2 provides a summary of the total of all cost-estimates broken down by importance. Refer to the individual building recommendations and the Cost-Estimate section for more detailed explanations.

Table 2 - Cost-Estimate Summary

Total Urgent Improvements	\$402,300
Total Important Improvements	\$12,400
Grand Total	\$414,700

INTRODUCTION

TM has performed a structural seismic evaluation of 13 buildings at Cabrillo National Monument in San Diego, California. The purpose of the evaluation is to determine the overall configuration and condition of each of the facilities, identify structural deficiencies relating to seismic hazards, and make specific recommendations to reduce the seismic hazard to occupants and minimize the chance of significant structural damage. The evaluation is based on existing building documentation as provided by NPS, a site visit conducted by TM, and engineering experience and judgment. Detailed seismic calculations and checks for conformance to the building code were not performed.

The site visit took place from August 17 through 18, 2010. There were a number of NPS employees who provided assistance during the site visit:

- Donald Kirby, Chief of Maintenance
- Martin Lane, Law Enforcement Park Ranger
- Bob Munson, Historian

Donald Kirby and Martin Lane coordinated access to the facilities and escorted us during a significant portion of our visit. Donald Kirby and Bob Munson provided us with building and historical information, including estimated dates of construction and renovations.

The building information gathered during the site visit consists of photographic documentation of existing conditions in addition to verbal information provided by NPS employees. Construction documents, when available, were provided by NPS and referenced during the site visit, as discussed in the Documents and Drawings Reviewed section of this report.

The site and its seismicity were also studied to assess the severity of various risks and hazards associated with the building locations. Discussions of the site and site seismicity are discussed in their respective sections of the report.

The primary focus of the building evaluations and recommendations is to address earthquake-induced hazards that compromise the safety of building occupants and/or the stability of the structural system, however the structural performance under gravity-imposed vertical loading is also considered. Lateral loads due to infrequent wind events such as severe storms and winds may govern over the seismic loads at Cabrillo National Monument. Although structural performance under such loading conditions is not explicitly included in the scope of the report, obvious deficiencies that threaten the integrity of the structure or pose significant risk to life safety have been identified and included in the recommendations when appropriate. At the request of NPS, general maintenance items that have no immediate impact on structural stability have not been addressed within this report.

Building improvement recommendations are associated with rough order-of-magnitude cost-estimates to aid park planners in initial budgeting and planning. These are discussed in the recommendations section of each building evaluation, as well as in the Cost-Estimate section at the end of the report.



DOCUMENTS AND DRAWINGS REVIEWED

Existing building documentation was provided for the majority of the buildings. These documents were referenced during the site visit and the subsequent evaluation. Table 3 provides a summary of the documentation that was provided.

The amount of structural framing information found in the provided documentation varies, and in some cases, records do not reflect current field observations. Non-invasive techniques were utilized to verify or approximate existing structural framing in the building evaluations. Methods included measuring the overall depth of wall and roof assemblies and visual observation of exposed and minimally finished structural members. Additional information was provided by NPS employees who were involved with building construction and/or subsequent remodeling. Refer to individual building discussions for a summary of the findings. Summaries of the materials and details of construction are provided in the building assessments. Observed deviations from the available construction documents have also been noted.

Table 3 - Summary of Documents and Drawings Reviewed

Building Number and Description	Documents Available
Building No. 71983, Visitor Center View Building	• "Visitor Center Cabrillo National Monument." Architectural and Structural Drawings Frank L. Hope & Associates - Architects & Engineers. May 1965. Revised March 1966.
Building No. 71929, Administration Building	• "Visitor Center Cabrillo National Monument." Architectural and Structural Drawings Frank L. Hope & Associates - Architects & Engineers. May 1965. Revised March 1966. • "Administration Addition Cabrillo National Monument." Ed Olsen Jr. + Associates, Baker Engineering. 1986.
Building No. 109735, Visitor Contact and Law Enforcement Support Building	• "Resource Management Office Visitor Center Area Cabrillo National Monument." Dwg 342 41,012A PMIS/PKG No. 20190-R. U.S. Dept. of the Interior National Park Service Denver Service Center. 2005.



Building Number and Description	Documents Available
Building No. 71945, Auditorium/Museum/Supply Room/Restrooms Facility	• "Visitor Center Cabrillo National Monument." Architectural and Structural Drawings Frank L. Hope & Associates - Architects & Engineers. May 1965. Revised March 1966. • "Bookstore Storage Expansion Cabrillo National Monument." Hope Architects + Engineers. September 13, 1991.
Building No. 71965, Military History Museum Building	• No documentation provided.
Building No. 71952, Point Loma Lighthouse	• "Historic Structure Preservation Guide for The Old Point Loma Lighthouse Cabrillo National Monument San Diego, California" David E. Snow, Randall A. Conrad et al. September, 1990. • "Cabrillo National Monument Point Loma, San Diego, California Present Condition of Building" U.S. Department of the Interior National Park Service - Branch of Plans & Design. October 1934. Revised December 1934. • "Cabrillo National Monument Repairs to Lighthouse." U.S. Department of the Interior National Park Service - Branch of Plans & Design. March 1935. • "Old Point Loma Lighthouse Inspection, Construction and Final Reports of NPS Restoration Work 1934-1937 Working Copies." • "Viewing Enclosures for Lighthouse Headquarters Area Cabrillo National Monument." U.S. Dept. of the Interior National Park Service San Francisco Planning and Service Center - Design and Construction. June 1968. • "Old Point Loma Lighthouse Preservation." U.S. Dept. of the Interior National Park Service Denver Service Center Branch of Historic Preservation. 1980. • "Emergency Restoration Lighthouse Lantern." U.S. Dept. of the Interior National Park Service Denver Service Center. 1982.

Building Number and Description	Documents Available
Building No. 71932, Assistant Lighthouse Keepers Quarters and Restroom	• "Restore LH Hist Scene Point Loma Cabrillo National Monument." Dwg. No. 342 41,020B Pkg. No. CABR 133 16. U.S. Dept. of the Interior National Park Service Denver Service Center. 2001.
Building No. 71953, Lighthouse Overlook Restrooms Building	• "Old Point Loma Lighthouse Inspection, Construction and Final Reports of NPS Restoration Work 1934-1937 Working Copies."
Building No. 71941, Entrance Station Building	• "Entrance Station Relocation Park Entrance Cabrillo National Monument." Dwg. No. 342 41,015 Pkg. No. CABR 233 16. U.S. Dept. of the Interior National Park Service Denver Service Center. 2002.
Building No. 109736, Upper Maintenance	• No documentation provided.
Building No. 71954, Lower Maintenance Facility	• No documentation provided.
Building No. 71974, Curatorial Building	• "Museum Storage Facility Lower Maintenance Cabrillo National Monument." Dwg. No. 342 41,016A Pkg. No. CABR 268 478. U.S. Dept. of the Interior National Park Service Denver Service Center. 2001.
Pergola	• "Visitor Center Cabrillo National Monument." Architectural and Structural Drawings Frank L. Hope & Associates - Architects & Engineers. May 1965. Revised March 1966.



SITE DATA

Cabrillo National Monument is located at the tip of the Point Loma Peninsula, west of the city of San Diego, California, as shown in Figure 1. The monument is bounded by the Pacific Ocean to the West, San Diego Bay to the East and NSC San Diego Point Loma Annex to the North. The monument reaches an elevation of 422 feet above sea level.

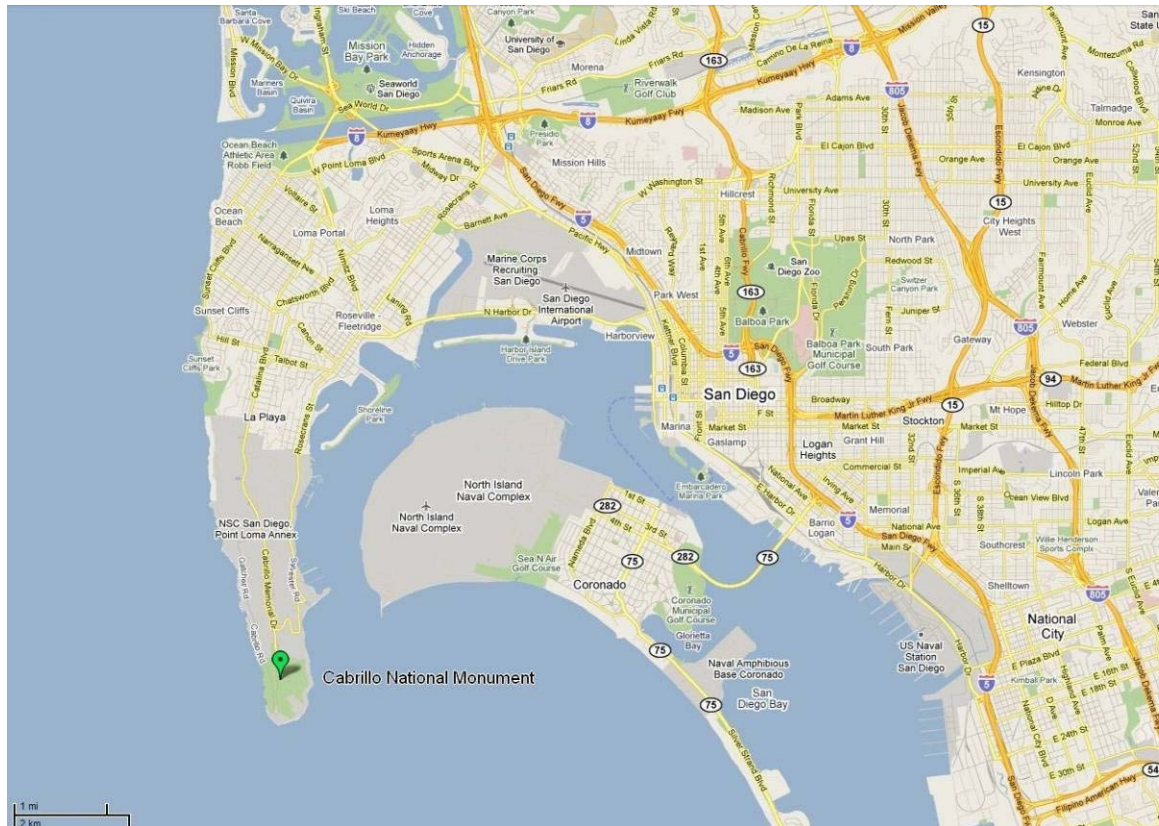


Figure 1: San Diego (www.maps.google.com)



SITE SEISMICITY

Seismic events in Cabrillo National Monument are most likely to be generated by activity on the active faults in the Southern California Region, which are shown in Figure 3. Notable faults from east to west include the San Andreas (30), San Jacinto (16), Elsinore (11), and Rose Canyon (3). These faults have a relatively high probability of generating a significant earthquake and can produce significant ground shaking at Point Loma.

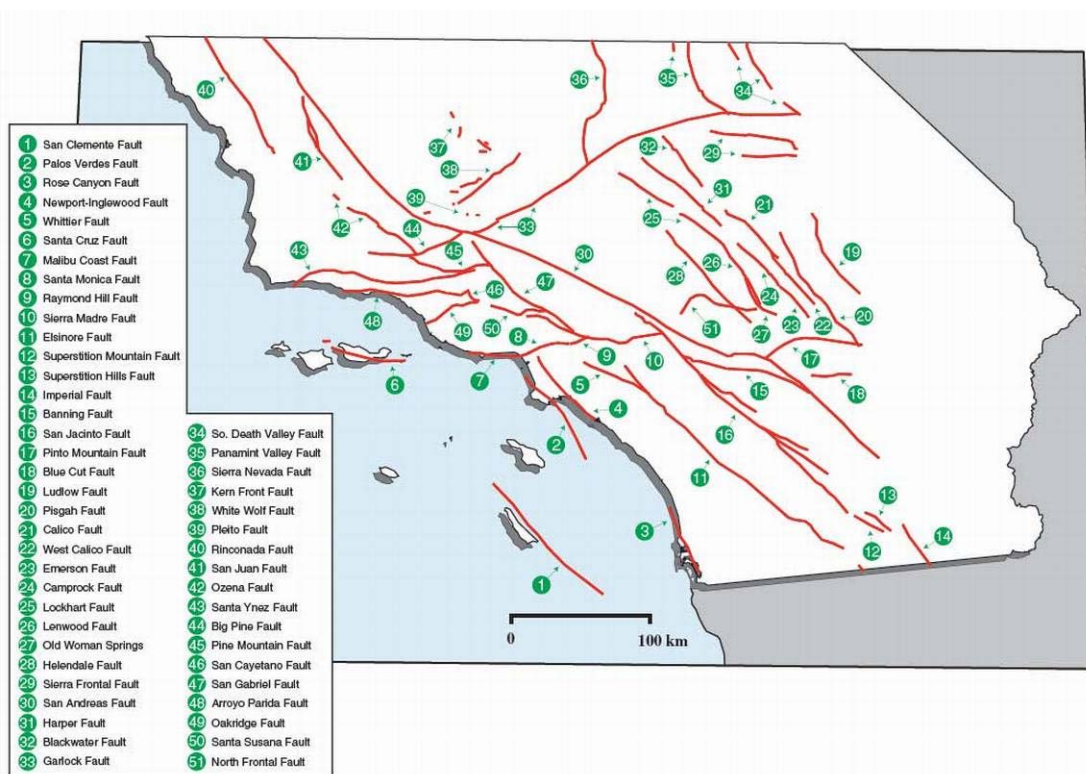


Figure 2: Southern California Faults (www.usgs.gov)

The San Andreas runs the length of California and is capable of magnitude 6.8-8 earthquakes. The most recent large quake in the area was likely the 1992 Joshua Tree Earthquake with a magnitude of 6.1.

The San Jacinto is considered the most seismically active fault in Southern California according to the USGS¹. Recently, a 5.4 magnitude quake erupted from the Coyote Creek section of the San Jacinto fault 13 miles north-west of Borrego Springs on July 7, 2010, and was felt all over San Diego County. It was followed by over 7 aftershocks in the 3.0 magnitude range. The San Jacinto is capable of earthquakes with magnitudes up to 6.5 to 7.5. The last major earthquake was of magnitude 6.5 on April 9, 1968 according to the Southern California Earthquake Data Center².

¹<http://pubs.usgs.gov/of/2004/1455/>

²http://www.data.scec.org/fault_index/sanjacin.html



The Elsinore Fault Zone is one of the largest in Southern California and capable of earthquakes in the 6.5-7.5 magnitude range. The northern end has seen recent earthquakes on the Chino fault and Whittier fault. The most notable recent earthquake would be the April 4, 2010 El Mayor-Cucapah Earthquake (aka the Calexico, Mexicali, Baja or Easter Earthquake) which occurred on the Laguna Salada Fault, a southern extension of the Elsinore Fault. It registered 7.2 on the Moment Magnitude Scale and produced moderate to strong shaking in the city of San Diego (180 miles northwest of epicenter). At least two water mains broke, several leaks occurred, power outages were reported, and cracks appeared in the floors of some downtown buildings. Several foreshocks were reported with magnitudes 3, 4, and 5. There were numerous aftershocks all over Southern California, and three aftershocks had a magnitude of at least 5.

The Rose Canyon Fault runs through the heart of downtown San Diego. It's capable of producing a magnitude 6 – 7.2 earthquake. The last major rupture was in 1862 and damaged much of old town San Diego.

In addition to these faults there are several active offshore faults. Several earthquakes ranging from 3.0 to 4.0 occurred somewhere off the coast of La Jolla. Most recently on July 11, 2009, there was a 3.9 magnitude quake caused by either the San Diego Trough Fault Zone or Coronado Bank Fault Zone, both around 40 km from downtown.

Qualitatively, the site is expected to experience intense ground shaking comparable to other seismic regions in the country. In California, seismic design criteria are established by Code and are expressed quantitatively in terms of design forces based on a design acceleration.

The 2007 California Building Code refers to the 2005 ASCE-7 Minimum Design Loads for Buildings and Other Structures Chapter 11 Seismic Design Criteria. While actual dynamic response to an earthquake is quite complex, the code takes a simple approach by establishing a response spectrum that approximates the maximum response acceleration of a simple structure under the design level earthquake for a certain site.

For Point Loma, the mapped spectral acceleration can be determined visually from maps in ASCE 7-05 or by geo-coordinates: latitude 32°42'6" and longitude -117°14'57". Mapped accelerations are adjusted for local soil conditions through multiplication by site class coefficients. Assuming a Site Class D, which is typically assumed when site soil properties are unknown, the site class coefficients for Point Loma are 1 and 1.5 for the short period (0.2 seconds) and 1-second period respectively. The adjusted Maximum Considered Earthquake (MCE) spectral response accelerations correspond to those expected in the MCE. The MCE is not the largest earthquake that could ever occur, but an earthquake of a magnitude such that there is only a 2% chance in 50 years that a larger earthquake will occur. The design earthquake and spectral acceleration values are two-thirds of this. All accelerations for Point Loma are summarized in Table 4.

Table 4 - Spectral Response Accelerations

Period	Mapped Spectral Response Acceleration, S_A	Adjusted MCE Spectral Response Acceleration, S_M	Design Spectral Response Acceleration, S_D
0.2 sec	1.317 g	1.317 g	0.878 g
1.0 sec	0.519 g	0.778 g	0.519 g



BUILDING EVALUATIONS

Site Description and Introduction

All of the buildings evaluated in this report are located in Cabrillo National Monument and NSC San Diego Point Loma Annex (Fort Rosecrans), on the tip of Point Loma Peninsula, just west of the city of San Diego. Buildings are located in the following areas of the monument and Fort Rosecrans, shown in Figure 3: Visitor Center Complex, Old Point Loma Lighthouse, Upper Maintenance and Lower Maintenance.

The Visitor Center View Building, Administration Building, Visitor Contact and Law Enforcement Support Building, Auditorium/Museum/Supply Room/Restrooms Facility, and Pergola form the Visitor Center Complex in the northeastern corner of the park. The Assistant Keepers Quarters, Lighthouse Overlook Restrooms, and the Military History Museum cluster around the Old Point Loma Lighthouse in the center of the monument. The Lower Maintenance Facility and Curatorial Building are in Lower Maintenance, to the east of the park's main entrance. The Entrance Station Building is located at the park entrance road, centered on the northern boundary of the park. To the west of the entrance is the Upper Maintenance building, on land owned by the U.S. Navy as part of NSC San Diego Point Loma Annex.



Figure 3: Cabrillo National Monument
(www.nps.gov/cabr)



The buildings are primarily used for offices, storage, exhibits and visitor space. All buildings are accessible to the public with the exception of the interior of the Entrance Station, the Administration Building, Visitor Contact and Law Enforcement Support Building, Upper Maintenance, Lower Maintenance Facility, and Curatorial Building. According to NPS Park Ranger Martin Lane, of those buildings restricted to NPS employee access, buildings located in Lower Maintenance are supposed to be infrequently used due to their proximity to ammunition storage at NSC San Diego Point Loma Annex; the buildings are in the predicted blast radius should the ammunition ignite. Note that blast and explosion hazards are outside the scope of this evaluation.

Building No. 71983, Visitor Center View Building



Figure 4: Visitor Center View Building East Facade

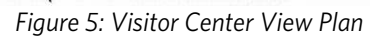
Description

The Visitor Center View Building is a rectangular one-story building with a wood-framed gabled (Dutch gable) roof supported on wood posts. Overall plan dimensions are 77 feet by 44 feet for a total approximate area of 3388 square feet. It is in use as a visitor information center and bookstore. The south facade is shown in Figure 4.

The building was constructed circa 1965, per the date on the architectural and structural drawings by Frank L. Hope & Associates for the original Visitor Center Complex, including drawings for the Visitor Center View Building, Administration Building, Auditorium/Museum Building and Pergola. Building plans and elevations are included for reference as Figure 5 and Figure 6 respectively. No significant deviations from these plans were observed at the building, although the neighboring sunken patios to the north and east are not shown in the original plans.

Roof framing consists of staggered $\frac{3}{8}$ -inch plywood sheathing over decking composed of 3x2s on edge. There are four skylights in the roof diaphragm. The decking spans between 5-inch by 11 $\frac{1}{8}$ -inch glued laminated beams at 11 feet-on-center. The beams are supported by a 9-inch by 19 $\frac{1}{2}$ -inch glued laminated ridge beam at one end and a 12-inch diameter post at the other. There are no walls in the building; the interior has a completely open floor plan, and the exterior consists of large panes of glass between the wood posts.







The floor consists of tile on a 4-inch reinforced concrete slab-on-grade. The foundation system is comprised of 12-inch wide reinforced concrete strip footings around the perimeter and 2-foot square spread footings beneath interior posts. Strip footings along the northern edge may be also be acting as retaining walls as the finished floor can be up to 2 feet 4 inches above adjacent grade. The perimeter strip footings are often either covered in brick or abut brick patio walls, stairs and planters as shown in Figure 7.

The neighboring Pergola roof attaches to the fascia of the Visitor Center eaves by way of a 2x4 ledger nailed to the 3x8 continuous fascia with 16d nails at 16 inches-on-center. A steel

strap connects the plywood on the two structures. There is also an expansion joint in the Pergola roof 11 feet away from the building where it connects to the first set of Pergola columns.

Overall the building was observed to be in good condition. Some hardware connecting the eave fascia to the glued laminated eaves showed signs of rust. A thin crack through the tile was observed running north-south at the eastern end of the building. It could be a sign of differential settlement in the building or hillside, but does not appear to be an indicator of a significant hazard. In general, the structure appears serviceable with no obvious signs of deterioration or distress.

Findings

The primary lateral-force-resisting system consists of the plywood-sheathed roof diaphragm and the cantilevered columns. These columns are highly flexible and offer little in the way of seismic force resistance. Deformations are expected to be quite large and the glass between columns will most likely break under large earthquake induced motion. These columns alone are not a sufficient lateral-force-resisting system. Furthermore, one of the tallest columns holding the ridge beam has a split directly through the bolt plane that holds the ridge beam in place as shown in Figure 8. Although this crack is likely a shrinkage crack, the connection may be vulnerable in a seismic event.

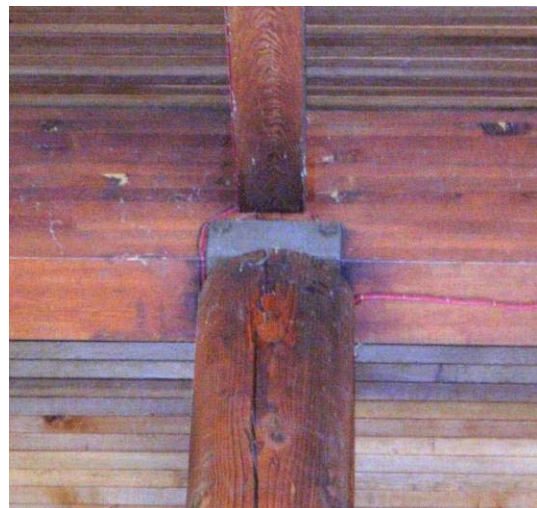


Figure 8: Column Split



The adequacy of the footings under seismic loading is uncertain because their relationship to the brick covered patio walls is unclear. The foundations as shown in the plans are around 3-feet deep, yet in the field the adjacent grade can be well over 2½-feet lower than the top of the finished floor due to the neighboring sunken patio. This implies that the footings are effectively shallowly founded, which is not ideal. However, the patio walls are at least 2 feet away from the edge of the building and we assume there is sufficient material and strength to maintain the integrity of the building footings in a seismic event. As such, the foundations, while not ideal, do not present a life-safety hazard.

We did not observe significant life-safety hazards from nonstructural components; bookshelves are generally around 4½-feet high, and only small lights hang from the ceiling. The portion of the Pergola roof that connects to the building is not likely to be a falling hazard due to its connection to the Visitor Center roof and the expansion joint which should allow for differential movement between the two structures.

Recommendations

Recommendation 71983.1

Construct steel moment frames around the perimeter of the building. Provide a minimum of one frame per elevation, similar to locations shown in Figure 5. Moment frames should consist of single bay frames made of steel wide flange columns, beams, and welded joints. Extend to the underside of the roof framing and attach with a positive connection to the roof framing. Provide new reinforced concrete grade beam foundations where needed to handle the overturning forces expected to be delivered by the moment frames. See Figure 9.

Estimated Cost

We estimate that the cost of construction would be on the order of \$100,000.

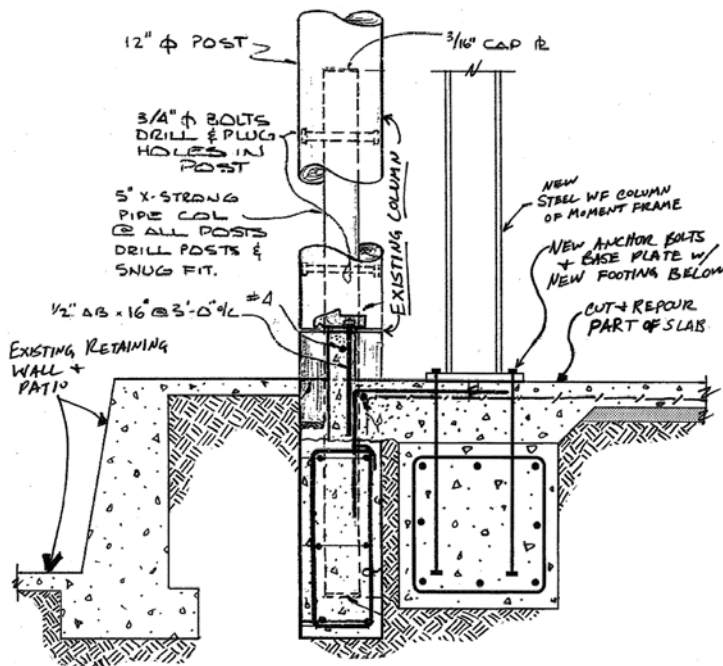


Figure 9: Approx, Location of Moment Frame and Existing Construction

Recommendation 71983.2

Replace rusted hardware at the eaves on the exterior of the building like that shown in Figure 10 with weatherproof (galvanized or painted) hardware.

Estimated Cost

We estimate that the cost of construction would be on the order of \$5,000.

Recommendation 71983.3

Provide two light-gage steel clamps around the top of the column with the split in the top to reinforce the connection.

Estimated Cost

We estimate that the cost of construction would be on the order of \$1,000.



Figure 10: Rusted Hardware at Eave



Building No. 71929, Administration Building



Figure 11: Administration Building East Facade

Description

The Administration Building is a one-story rectangular wood-framed building with hip roof. Approximate overall dimensions are 28 feet by 99 feet for a total square-footage of 3324 square feet. It is in use as the administrative headquarters for the park and houses the staff break room. The east facade can be seen in Figure 11.

The building was constructed in 1965, along with other buildings in the Visitor Center Complex. There have been changes and expansions to the building, notably at the northern end (see the right side of Figure 11) where the building was extended in 1986 per the drawings by Ed Olsen Jr. + Associates and Baker Engineering, and at the library near the center of the building (see the left side of Figure 11) by NPS in the 1990s. In addition, the roof overhang at the kitchen and break room is now enclosed by a wall of windows, most likely constructed by NPS staff in the 1990s.

Roof framing consists of staggered ½-inch plywood sheathing over 2x8 rafters at 24 inches-on-center. Rafters frame to exterior walls and a 2x10 central ridge beam. Every 4 feet, 2-2x6 horizontal ties connect mirrored rafters as shown in Figure 12. Rafters are continuously blocked over walls.



Figure 12: Rafter Ties and Shearwall

Interior and exterior walls are comprised of 2x4 studs at 16 inches-on-center. Interior walls stop at the ceiling, except for the interior walls that were once exterior walls and extend to the roof according to the 1965 plans.

The floor consists of a 4-inch reinforced concrete slab-on-grade. Foundations consist of 12-inch wide reinforced concrete strip footings beneath the original exterior walls and the internal shearwall. The patio has a 6-inch by 6-inch thickened slab edge. According to the 1986 plans for the northern extensions, the floor and foundations are similarly comprised of a 4-inch reinforced concrete slab-on-grade and 12-inch wide reinforced concrete strip footings beneath exterior walls.



Figure 13: Water Damage

Overall the building was observed to be in good condition. The north-eastern corner of the northern extension showed signs of recent water damage due to a leak and should be repaired. Otherwise, the structure appears serviceable with no obvious signs of significant deterioration or distress.

Findings

The lateral-force-resisting system consists of plywood shearwalls in the east-west direction and 4 let-in wood braces and a shearwall in the north south-direction. The braces occur on the west exterior wall while the shearwall is on the east wall. The east wall consists mostly of windows such that this side is considerably weaker than the others, making the lateral-force-resisting system an essentially 3-sided system. This means that the building will have a tendency to twist in plan under seismic loading and induce greater forces than would normally be expected in the east-west oriented walls.



The plywood and nailing scheme in the east-west direction appears sufficient to resist seismic loads. Blocking between roof joists and nails from the plywood into the blocking and from the blocking to top plates provides a load path from the roof to the walls. Bottom plates are anchored to the foundations to transmit shear, although the north and south walls lack hold-downs or uplift anchorage hardware, limiting their ability to resist overturning forces induced by an earthquake.

The let-in braces are likely insufficient to resist north-south lateral loading. We also observed that the top of the eastern shearwall, shown in Figure 12, has a large opening cut into it to accommodate ethernet and other computer cables, weakening the capacity of the existing shearwall. Roof-to-wall and wall-to-floor connections are similar to those in the east-west direction.

The northern addition is also an essentially three-sided system being bounded by nearly solid wall on the north, west, and south sides. These walls should be sufficient to resist seismic forces given the addition's size and configuration; however, the possible lack of hold-downs could be inadequate in resisting overturning.

There are a number of non-structural falling hazards present at the administration building. Several tall lockers and high bookshelves are not anchored and are at risk of falling and causing injury during an earthquake. The water heater is strapped and fastened to an interior wall and not likely a hazard.

Recommendations

Recommendation 71929.1

Replace let-in braces with plywood sheathing (44 feet minimum). Provide a minimum of 3/8-inch plywood sheathing with 8d nails at 6 inches-on-center at panel edges and 8d nails at 12 inches-on-center as interim nailing. Provide for a load path between the roof diaphragm and the new wall sheathing by adding blocking, nails, and uplift clips as necessary. See Figure 14 and Figure 15 for typical shear wall definitions and configuration.

Estimated Cost

We estimate that the cost of construction would be on the order of \$30,000.

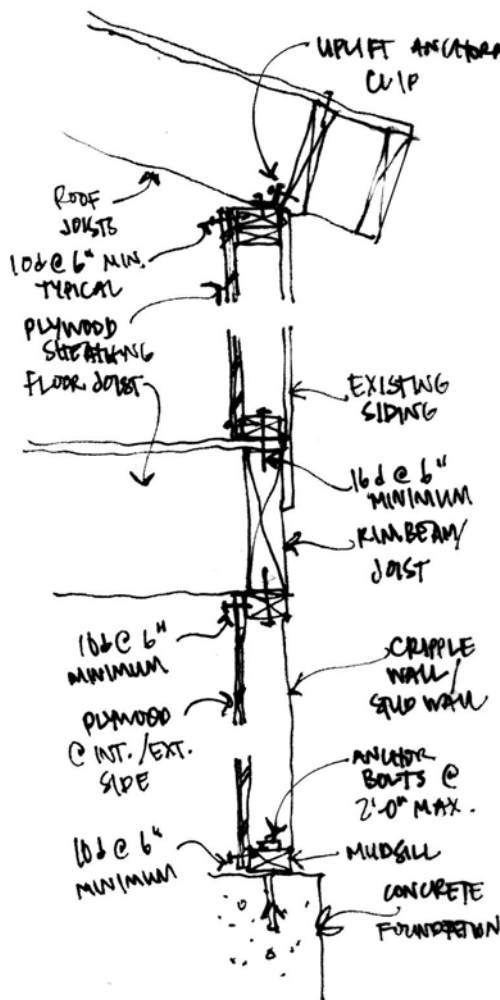


Figure 14: Typical Shear Wall Section

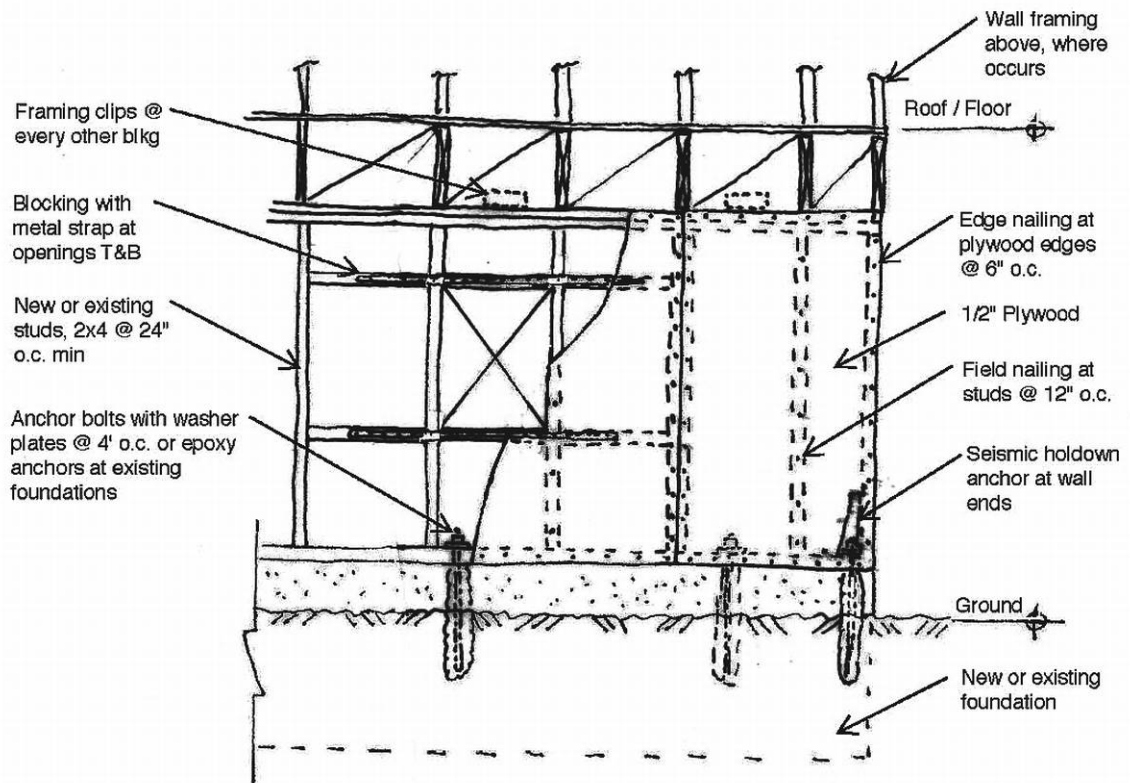


Figure 15: Typical Shear Wall Elevation

Recommendation 71929.2

Install hold-downs at all shear walls, fastening to stud and attaching to the foundation with epoxy anchors. See Figure 14 and Figure 15 for typical shear wall definitions and configuration.

Estimated Cost

We estimate that the cost of construction would be on the order of \$10,000.

Recommendation 71929.3

Secure tall cabinets and shelving that have the potential to become a falling hazard (approximately 14 locations). This is most easily accomplished with small clips fastened to studs or posts. Wall siding alone is not adequate to support lateral loads from tall shelving.

Estimated Cost

We estimate that the cost of construction would be on the order of \$200 per location.



Building No. 109735, Visitor Contact and Law Enforcement Support Building



Figure 16: Visitor Contact and Law Enforcement Support Building East Facade

Description

The Visitor Contact and Law Enforcement Support Building is a rectangular single-story wood framed building with hip roof. It is approximately 40 feet by 20 feet in plan for a total area of 800 square feet. It is used as office and storage space for park law enforcement. The east facade can be seen in Figure 16.

The building was likely constructed in 2005. No significant differences between the plans and the structure itself were observed, though the extension of the pergola included in the same plan set has not been constructed.

The roof structure is composed of plywood sheathing over wooden trusses supported by the exterior walls. The trusses, which are spaced at 24 inches-on-center, are made of 2x4 top and bottom chords with 2x4 diagonals and verticals.

Both the exterior and interior walls are formed by 2x6 studs at 24 inches-on-center.

The floor is a reinforced concrete slab-on-grade. Foundations consist of reinforced concrete strip footings beneath the exterior walls and an east-west shearwall on the interior of the building.

Overall the building appeared to be in excellent condition. The structure looked serviceable with no signs of significant deterioration or distress.

Findings

The primary lateral-force-resisting system consists of the plywood-sheathed roof diaphragm and wood shearwalls. The shearwalls are designated in the plans and appear adequate to resist seismic forces given the size and configuration of the building. Although the east wall consists mostly of windows, two small shearwalls are provided for at each end of the wall of windows. Roof joists are blocked over walls and thus not at risk of rolling in a seismic event. Although no hardware was observed, it is presumed that nailing similar to that in other structures in the Visitor Center Complex provides a continuous load path from the roof to the walls. The plans also specified hold-downs, such that the shearwalls have some overturning capacity and the load path is continuous to the foundation.

Inside the structure, there are many tall, unanchored bookshelves, such as those shown in Figure 17, that are non-structural falling hazards. These should be anchored to the structure to prevent injury and loss of life in an earthquake.

Recommendations

Recommendation 109735.1

Secure tall cabinets and shelving that have the potential to become a falling hazard (5 locations). This is most easily accomplished with small clips fastened to studs or posts. Additional framing may need to be added if appropriate framing does not exist. Wall siding alone is not adequate to support lateral loads from tall shelving.

Estimated Cost

We estimate that the cost of construction would be on the order of \$200 per location.



Figure 17: Free Standing Bookshelves



Building No. 71945, Auditorium/Museum/Supply Room/Restrooms Facility



Figure 18: Auditorium/Museum West Facade and Extension

Description

The Auditorium and Museum building is a rectangular single-story wood framed building with a single-story expansion at the south-western corner. The main building has a hip roof and the extension appears to have a shed roof. The Auditorium/Museum has overall dimensions of about 55 feet by 66 feet for a total area of 3630 square feet. The expansion is approximately 12 feet by 33 feet for 396 square feet of area. The southern half of the building houses the auditorium whereas the northern half serves as a museum. Restrooms are located at the north western corner near a maintenance room along the west wall. The expansion is primarily used for storage. The west facade and expansion are shown in Figure 18.

Main Building

The main building was constructed in 1965 as part of the Visitor Center Complex. The building has been the subject of several alterations:

- The door to the museum was relocated one bay to the south.
- A straight interior partition in the museum exhibits room was replaced by a curved wall near the center of the room.
- Fire doors for the auditorium were relocated from the west facade to the south facade.
- Restroom entrances and walls have been reconfigured. Interior partitions and the entrances along the north side of the building have been moved to transform the janitor's closet and men's vestibule into a changing room and handicap accessible bathroom.

- The men's toilet entrance has been moved to the west facade.
- The boiler and air handling unit have been removed from the maintenance rooms.

These changes are shown graphically in Figure 19. Red clouds represent an area that has changed. Red lines also represent the curved partition and beginning of the walls for the expansion.

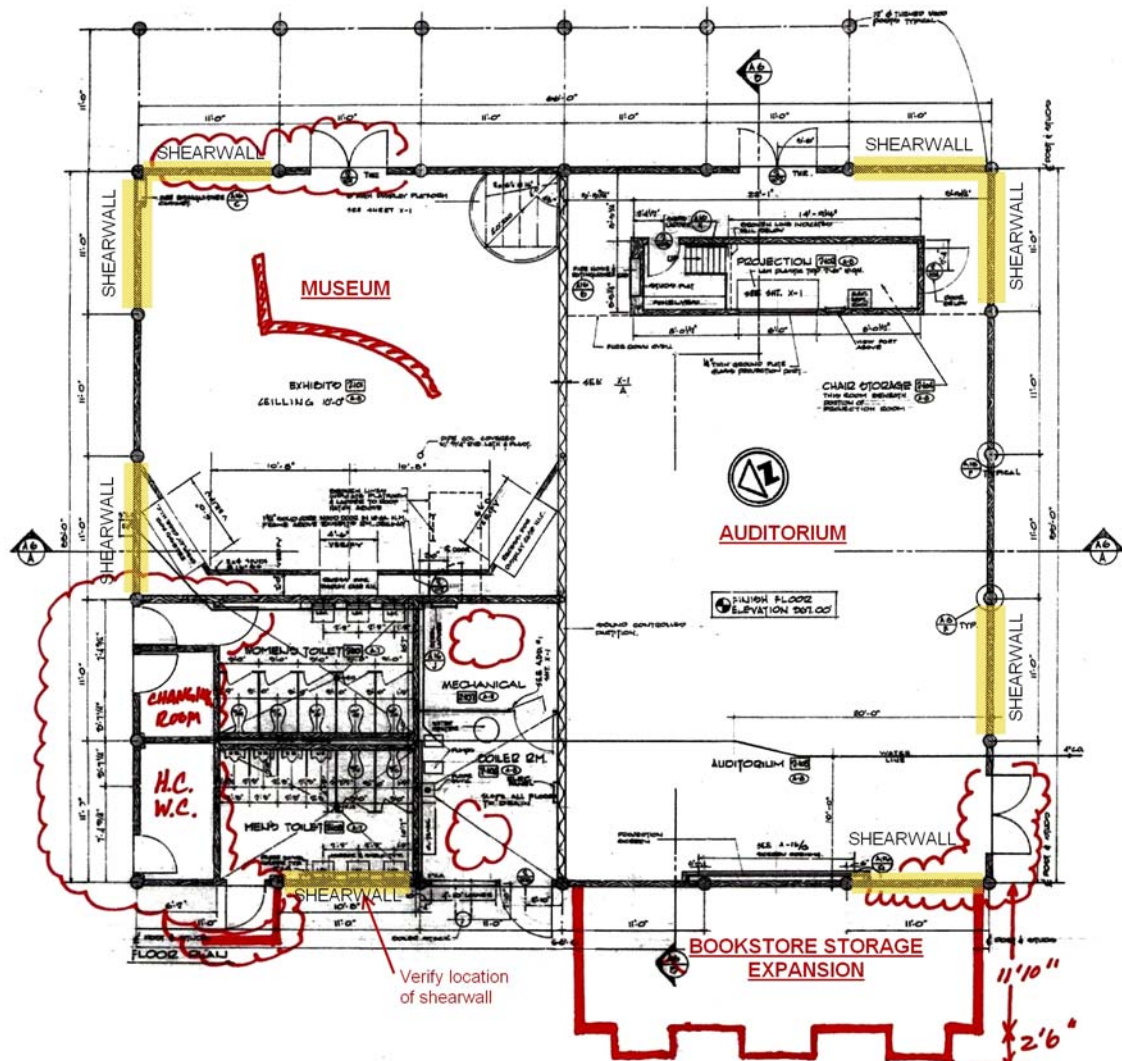


Figure 19: Auditorium/Museum Changes and Alterations Plan

The main roof construction consists of ½-inch thick plywood with staggered joints over 2x12 joists at 24 inches-on-center. Joists frame to outside walls at one end and glued laminated hip beams or beams surrounding the central flat part of the roof at the other. The central flat portion of the roof, a mechanical equipment platform, is bounded by 11-inch by 19 ½-inch glued



laminated beams and 6x12 beams. Framing between the beams consists of 3x12 joists at 24 inches-on-center covered by $\frac{3}{4}$ -inch plywood. The ceiling framing hangs from the roof rafters with double 2x3 hangers attached to alternating rafters.

The exterior walls are comprised of 12-inch diameter wood posts at 11 feet-on-center with stud walls made of 2x4s at 16 inches-on-center between. Some of the walls are sheathed in $\frac{5}{8}$ -inch plywood on both sides and can provide lateral resistance. The parapet surrounding the mechanical equipment platform on the roof is made of 2x4 studs at 16 inches-on-center.

The majority of interior partition walls consist of 2x4 studs at 16 inches-on-center. The interior wall running east-west through the center of the building and separating the auditorium from the museum consists of staggered 2x6s at 16 inches-on-center. In addition to the interior walls, there are four steel pipe columns that support the beams beneath the mechanical equipment platform on the roof. The northern pair are 3½-inch diameter X-strong steel pipes; the southern pair are 5-inch diameter X-strong steel pipes that are hidden in the central staggered 6x wall.

A 4-inch reinforced concrete slab-on-grade forms the floor of the Auditorium/Museum. The foundation system is comprised of 1-foot wide reinforced concrete strip footings beneath the exterior walls and the central interior wall, 3-foot square reinforced concrete spread footings beneath the 3½-inch diameter pipe columns, and 3½-foot square footings beneath the 5-inch diameter pipe columns.



Figure 20: Cantilevered Bays

Bookstore Storage Expansion

The Bookstore Storage Expansion was built in 1991 and appeared to be relatively unchanged from the plans. Its general shape and dimensions are sketched in Figure 19.

The bookstore storage expansion roof consists of $\frac{1}{2}$ -inch plywood on 2x8 joists at 24 inches-on-center spanning between exterior walls and 4x12 girders. Girders are supported at one end by the main building's foot-diameter exterior wall posts and 4x4 posts at the other. The exterior and interior walls consist of 2x4 studs at 16 inches-on-center. These are supported on a 4-inch thick concrete slab. For the most part, the floor is a slab-on-grade, except at the bays between windows which cantilever 2½ feet from the retaining wall and foundation as shown in

Figure 20. At these locations, the slab measured almost 7 inches thick. Foot-wide reinforced concrete strip footings form the majority of the foundation, except at the west side where an 8-inch thick reinforced concrete retaining wall extends down to the foot-wide strip footing.

Overall, both the main building and expansion were observed to be in good condition. Some ceiling tiles at the Auditorium entrance were sagging. In the extension a few ceiling tiles had been removed to patch a leak, but no signs of significant damage were observed. The structure in both sections appears serviceable with no obvious signs of deterioration or distress.

Findings

Main Building

The lateral-force-resisting system in the main building consists of the plywood-sheathed roof diaphragm and wood shearwalls. We were unable to directly observe the locations of the shearwalls and noted discrepancies in the plans in that door openings exist where shearwalls are shown in the plans at 3 locations. In fact, the auditorium fire doors are shown in the architectural drawings where a shearwall is shown in the structural drawings. Since the plans were clearly engineered with the intent to provide 2 bays of shearwall on each side, we presume that the changes to the design accounted for this and simply swapped door and shear wall positions such that shear walls are located where hatched in yellow in Figure 19. The only area that was obviously renovated and not considered part of the original design intent is the restroom area. This area has been drastically altered after the building was constructed and the men's bathroom door may have effectively removed a shearwall depending on which bay it is located in. Finishes should be removed in this area to verify the presence of the shearwall.

Rafters are blocked to prevent rolling and to transmit seismic forces in the roof to the shearwalls. The 12-inch diameter wood columns act as hold-downs for the shearwalls; the edge posts in the shear walls are heavily nailed to the wood columns which are positively attached to the foundation via a steel pipe and bolts as shown in Figure 21.

We noticed sagging ceiling tiles at the entrance to the auditorium. This area should be checked to ensure that the framing is not somehow damaged or under-performing. Ceiling tiles should be resecured if framing appears to be in good order.

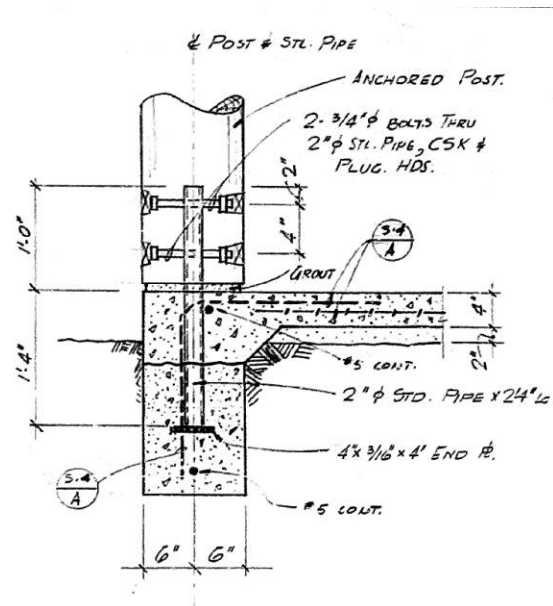


Figure 21: Column Connection

Bookstore Storage Expansion

The Bookstore Storage Expansion to the Auditorium/Museum also has a plywood-sheathed diaphragm and wood shearwalls as its lateral-force-resisting system. Shearwalls are provided for on three sides of the building. The roof of the expansion is also tied to the main building by 4x8s parallel and attached to the auditorium wall. The walls appear to be sufficient given the



size and configuration of the expansion. Details call out for blocking and clips over the shear walls which allow for lateral forces in the roof to be transmitted to the walls. Shearwalls are able to transmit shear to the foundation via anchor bolts in the sill plate and to resist overturning moment by hold-downs at each of the shear walls.

Non Structural

There are several non-structural items that could pose a dangerous falling hazard in the event of an earthquake. These include bookshelves in the projection room and extension as well as storage cases in the maintenance room. Such items should be anchored to the structure to minimize the chance of injury or loss of life in a seismic event.

Recommendations

Recommendation 71945.1

Remove finishes by the men's restroom to verify the location of the shearwall by the bathroom as shown in Figure 19. Engineering recommendations and remediation will be necessary if the shearwall is not located in the bay.

Estimated Cost

We estimate that the cost of investigation would be on the order of \$1,500.

Recommendation 71945.2

Secure tall cabinets and shelving that have the potential to become a falling hazard (approximately 5 locations). This is most easily accomplished with small clips fastened to studs or posts. Additional framing may need to be added if appropriate framing does not exist. Wall siding alone is not adequate to support lateral loads from tall shelving.

Estimated Cost

We estimate that the cost of construction would be on the order of \$200 per location.

Building No. 71965, Military History Museum Building



Figure 22: Military History Museum (Radio Room) North Facade

Description

The Military History Museum is a rectangular single-story concrete building with a wood framed shed roof. It measures approximately 20 feet by 14 feet in plan for a total area of 280 square feet. The Military History Museum, once a radio room for the U.S. Navy, houses exhibits detailing the defenses at Fort Rosecrans and Point Loma during World War II. The entrance on the north facade can be seen in Figure 22.

According to Bob Munson, NPS Historian, the building was constructed in the 1920s. No documentation was provided for the building. The structure showed no signs of significant retrofit or change. A sketch of the building plan is provided in Figure 23. Note that the windows are covered by exhibits on the inside of the building and can only be observed from the exterior.

There was no attic access to the tar-and-paper roof. It is presumed that the roof structure is similar to that of the eaves which are straight-sheathed in wood, with 2x6 joists at about 24 inches-on-center. The joists frame onto the exterior walls. No hardware or positive connection between the wood joists and the concrete walls was observed.

Exterior walls are cast-in-place concrete, approximately 8-inches thick. Interior walls consist of 4-inch thick cast-in-place concrete. The walls support a wood straight-sheathed ceiling.

The floor is a concrete slab-on-grade. Foundations are presumably concrete.

Overall, the building appeared to be in good condition. The structure appeared serviceable with no signs of significant deterioration or distress.



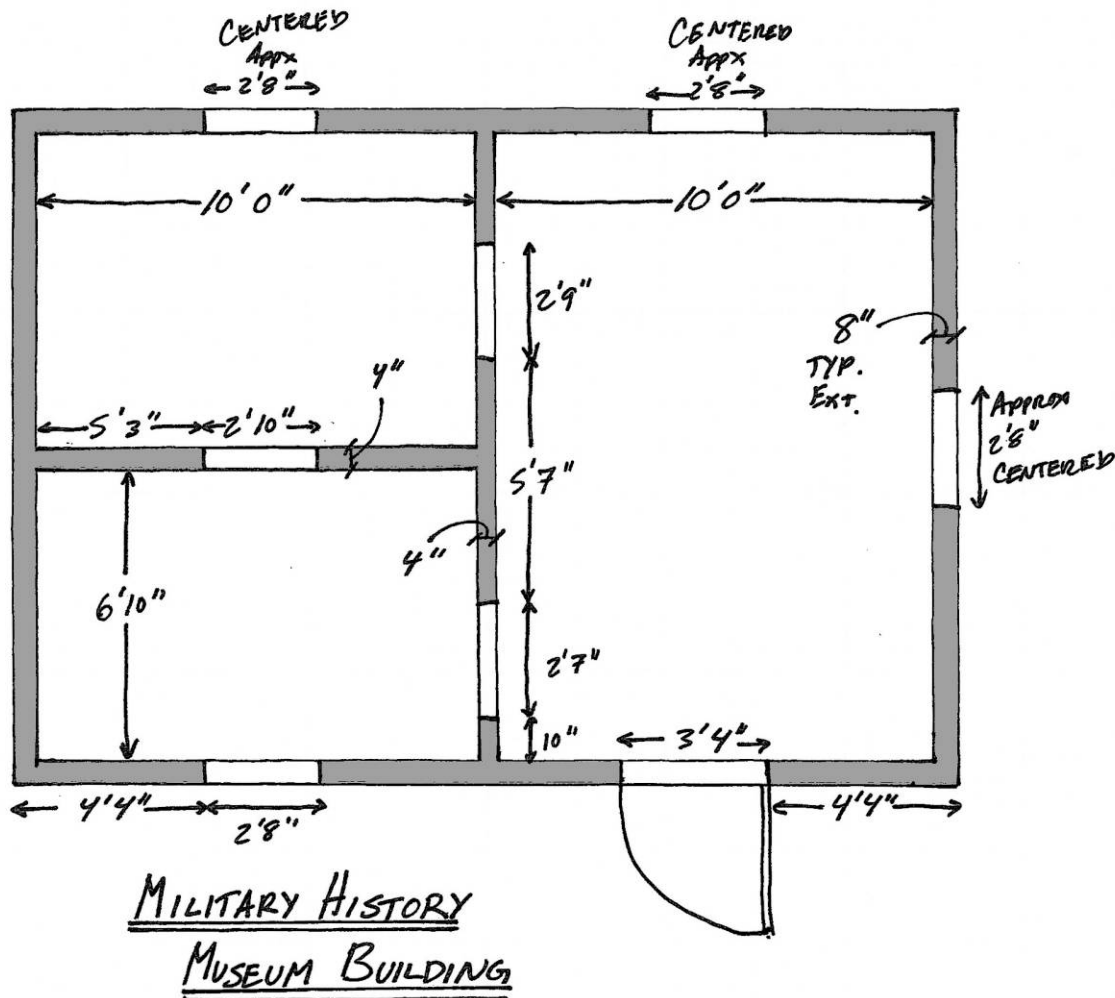


Figure 23: Plan of Military History Museum Building

Findings

The primary lateral-force-resisting system consists of the wood roof diaphragm and the concrete walls, which are possibly unreinforced. Unreinforced concrete walls are brittle and prone to unexpected failure, a risk that is increased when such walls are inadequately connected to light-framed diaphragms. In such cases, there are three important aspects of the system to consider when evaluating the structure's ability to resist seismic induced forces:

- The strength and continuity of the diaphragm and it's connection to the walls.
- In-plane wall strength based on extent of solid wall and aspect ratio.
- Out-of-plane wall bracing and sufficient thickness to resist out-of-plane forces on the wall.

The adequacy of the roof-to-wall connections is critical to maintaining a load path for lateral forces in an earthquake. Based on the age of the structure, and assuming the walls are

reinforced, there is probably some minimal amount of anchorage from the sill plate to the concrete wall. At a minimum, there should be anchorage at 48 inches-on-center. However, it is unlikely that roof joists are blocked over the walls and connected to a sill plate to transmit lateral forces.

Based on the approximate decade of construction, it is likely that there is some minimal reinforcing. Given the size and configuration of the building, in-plane wall failure is not likely a life-safety issue. The walls appear adequate to resist seismic forces; there are substantial sections of solid walls with low height-to-length aspect ratios.

Similarly, out-of-plane failure is not a large concern due to the height-to-width ratio of the walls provided the connection to the diaphragm is fixed. Furthermore, the internal walls aid in bracing the walls out-of-plane.

Assuming there is some minimal reinforcement in the walls and that this extends to the foundation, it is unlikely that the wall-to-floor connection is a life-safety issue.

Non-structural elements in the building include the exhibits. Few of these constitute a dangerous falling hazard, though there is one tall cabinet on the west wall holding a television and speaker that could potentially be a danger. This should be anchored to the structure to minimize the chance of injury or loss of life in an earthquake.

Recommendations

Recommendation 71965.1

Install blocking between joists over the walls with fasteners between the sheathing, blocking and wood nailer.

Estimated Cost

We estimate that the cost of construction would be on the order of \$8,000.

Recommendation 71965.2

Secure tall cabinets and shelving that have the potential to become a falling hazard (1 instance). This is most easily accomplished with small clips fastened to studs or posts. Additional framing may need to be added if appropriate framing does not exist. Wall siding alone is not adequate to support lateral loads from tall shelving.

Estimated Cost

We estimate that the cost of construction would be on the order of \$200 per location.



Building No. 71952, Point Loma Lighthouse



Figure 24: Old Point Loma Lighthouse North-East Corner

Description

The Old Point Loma Lighthouse is a three-story (including basement) rectangular stone building or dwelling with a brick lighthouse tower protruding two stories above the roof and a single-story lean-to on the west wall. The overall plan dimensions are approximately 20 feet 6 inches by 28 feet 6 inches. The total area, including tower and lean-to is 2602 square feet. The building, no longer in operation as a lighthouse, is listed on the National Register of Historic Places (since 1974) and serves as an historic attraction that is open to the public. The lighthouse is shown on the right of Figure 24.

The Old Point Loma Lighthouse was constructed in 1854. In 1935, a variety of repairs and changes occurred including:

- Reconstruction of the lean-to
- Repair of exterior walls
- Reconstruction of the chimneys
- Excavation of the basement an additional 6 inches
- New lath and plaster on walls and ceilings
- Installation of new floor joists and replacing flooring
- Replacement of wooden tower stairs with metal stairs
- Installation of a new gallery deck, railing and glass in lantern sash
- Replacement of the dome roof with a copper roof
- And replacement of the main building roof and lean-to roof with standing seam roofing.

A concrete foundation drain was installed in 1937. The dwelling and lean-to were reroofed again in 1981, and the painted copper roof was replaced with cedar shingles. A new foundation drainage system was installed, and the walls and ceilings were re-plastered. In 1983 the upper part of the tower was rebuilt and the lantern and gallery were restored. Plans are difficult to read but generally match the building as it is now.

Dwelling

According to the plans, the current roof consists of wood shingles over gapped wood straight sheathing supported by 3-inch by 6-inch rafters. Rafters span to the external walls.

External walls above and below ground are made of sandstone masonry. Historic stones were quarried on Point Loma, probably near Ballast Point according to reports cited in the Historic Preservation Guide. The west and south walls have a coating of portland cement mortar circa 1879. The Historic Preservation Guide states that the walls are 18 inches thick, though the total out-to-out dimension measured in the field is around 2 feet. Wall openings include windows, a door on the east wall, a door to the kitchen in the lean-to, and a basement access hatch as seen on the left of Figure 25. Notable hardware on the walls includes two vertical metal plates that can be seen above and on either side of the door on the east facade. There is an additional metal plate on the west facade as well. These are presumed to be wrought iron anchor plates.

Most internal walls consist of wood studs with metal lathe and plaster, though walls that form the tower are unreinforced brick masonry. The fireplaces and chimney stacks are also constructed of unreinforced brick masonry.



Figure 25: Lean-To Entrance on North Wall

The second and first floor construction consists of oak boards installed in 1935, possibly over a sub-floor consisting of 1-inch boards laid diagonally. It is unclear from the reports if this sub-floor still exists beneath the 1x5 hardwood floor boards. The floor assemblies are supported by original 3-inch by 8-inch wood joists at 16 inches-on-center and floor joist sisters installed in 1935. Original fasteners were square nails, though the specifications included in the Historical Preservation Guide stated that any kind of nail or screw could be used during the repairs and rehabilitation in the 30s through possibly the 80s.

The basement floor, according to NPS Historian Bob Munson, was originally just tile on grade that was simply covered in concrete as the new basement floor. The Historic Preservation Guide verified that the original floor consisted of Mexican tile from a nearby fort, but that this was removed to museum archives and a new monolithic concrete floor was poured. The foundation of the dwelling is likely concrete or sandstone.





Figure 26: Crack at top of Basement Wall

For its age, the building is in good condition. The reports state that fire damaged members were repaired or replaced and that all wood, historical wood included, was chemically treated against termites. Minor water damage was observed in the plaster in the basement. Minor cracks in the northern part of the basement appear to be superficial cracks in the paint. There are some larger cracks at the top of the basement wall in the southwestern corner as shown in Figure 26. They are less than an eighth of an inch wide and are not likely an indication of a serious hazard. In the external walls, mortar and sandstone appear to be thinning in several places, specifically the south-east corner, the south elevation, and south-west corner. This is likely due to corrosion from sea-air. Overall, the structure appeared serviceable with no signs of significant damage or distress.

Tower

The tower extends two stories above the dwelling roof and extends down through the center of the dwelling to the basement. Its roof consists of a metal dome over the gallery level. The tower has a compression ring just below the gallery level that was originally wrought iron. It was replaced with stainless steel reinforcing in 1983.

The tower walls themselves consist of approximately 12-inch thick brick masonry, which is likely unreinforced. There are floor openings in the wall at every floor to allow access to those floors of the dwelling. There is also one window above the roof of the dwelling. These openings are all located on the east side of the round tower.

There are no floors within the tower itself, but a metal staircase extends up through the center of the tower. The gallery floor or observation floor of the lighthouse is a metal floor.

The foundation of tower is likely concrete or sandstone, similar to the dwelling.

Overall, the tower appeared to be in good condition with no obvious signs of significant damage or distress.

Lean-To

The lean-to shown in Figure 25 is a one story wood structure on the west wall of the dwelling. The roof appears to be wood-framed and is covered in wood shingles. Photos in the Historical Preservation Guide reveal that the lean-to roof is supported by a wood ledger fastened to the external walls of the dwelling.

The lean-to walls are probably composed of lath and plaster on wood studs.

The floor consists of sheet linoleum over oak flooring according to the Historic Preservation Guide. From a vent on the west wall, one can see that the floor is diagonally sheathed and supported on 2x6 joists spaced at least 16 inches-on-center with bridging between joists.

The foundation consists of concrete strip footings beneath the walls. Their depth is uncertain.

Overall the lean-to appeared to be in good condition. There was evidence of minor insect damage in the ceiling straight sheathing in the lean-to. The structure appeared serviceable with no significant signs of damage or distress.

Findings

Dwelling

The primary lateral-force-resisting system consists of the wood roof and floor diaphragms and the exterior sandstone walls. The walls are most likely unreinforced and thus prone to brittle failure in a seismic event. The risk of failure is increased when masonry walls are inadequately connected to light-framed roof and floor diaphragms. The structure's ability to resist seismic induced forces depends on the following factors:

- In-plane wall strength based on extent of solid wall and aspect ratio.
- Out-of-plane wall bracing and sufficient thickness to resist out-of-plane forces on the wall.
- The strength and continuity of the diaphragm and it's connection to the walls.

The walls appear sufficient in the east-west direction, being mostly solid wall with a height-to-length ratio close to 1. The walls in the north-south direction on the west wall appear sufficient. The east wall has many window openings and thus, more slender wall elements vulnerable to concentrated damage and cracking in an earthquake.

Out-of-plane strength of the dwelling walls is less of a concern. The 2007 California Building Code Title 24 Part 10 Existing Building Code contains criteria for acceptable height-to-thickness ratios of unreinforced stone masonry. Lighthouse dwelling walls have height-to-thickness ratios less than the maximum allowed by that code as shown in Table 5.

Table 5- Lighthouse Height-to-Thickness Ratios

Location	Height-to-Thickness Ratio	Max Accepted Limit
Top Story	2.6	8
First Floor	6.7	9

The walls need to be adequately braced out-of-plane at both the roof and floors. Anchorage could not directly be observed at the time of the site visit. It is assumed that anchorage is minimal or non-existent. The floor diaphragms, consisting of diagonal sheathing plus finished wood floors appear sufficient. The roof diaphragm, on the other hand, does not appear to be sufficient, being of gapped straight-sheathing. Furthermore, the joists are most likely not blocked and have a minimal connection to the top of the masonry walls.



Tower

The tower that extends two stories above the dwelling is an unreinforced brick masonry structure similarly prone to failure under seismic loading. This particular configuration has the added risk associated with a vertical geometric irregularity in that damage is likely to be concentrated where the tower meets the main dwelling roof.

In-plane failure is not really a concern due to the round configuration of the tower and relatively small number of openings.

Walls appear adequate in the out-of-plane direction because their height-to-thickness ratios are sufficiently low as summarized in Table 6.

Table 6- Lighthouse Tower Height-to-Thickness Ratios

Location	Height-to-Thickness Ratio	Max Accepted Limit
Top Story	8	9
First Floor	10	15

It is critical that the tower be properly braced at each level. The tower roof was recently reconstructed with new masonry, a stainless steel ring of reinforcement and metal gallery floor. These elements should be adequate to tie the top of the tower together. At lower levels, the floor diaphragm of the dwelling will need to be used to brace the tower. Currently, the connection of the tower to the floors appears inadequate.

Lean-To

The lean-to functions more or less as a separate structure. Wood-framed roof and floor diaphragms and wood-framed walls on three sides comprise the lateral-force-resisting system. The lean-to is attached to the main structure stone walls by a ledger, such that the wood walls and the connection to the dwelling form a four-sided lateral-force-resisting system. These walls appear sufficient to resist seismic forces. The primary areas of concern are roof joist blocking and attachment to the walls, as well as the wall-to-floor and cripple wall-to-foundation connections. No uplift anchorage hardware was observed in either location.

Recommendations

The proposed recommendations are based on a rudimentary observation of the building and expected performance based on experience with similar structures. Due to the unique nature of this building and its historical importance, it may be advisable to perform a more detailed evaluation to verify the quality of mortar, masonry and other materials as well as obtain a more in-depth understanding of the construction and seismic performance.

Recommendation 71952.1

Install anchorage hardware consisting of anchor bolts at 4 feet-on-center epoxy grouted into the masonry walls fastened to joists beneath the first and second floors as well as the roof in order to brace the dwelling exterior walls in the out-of-plane direction. Anchor bolts should be fastened to the joist approximately 4 feet back from the wall. When floor joists are parallel to the wall, install blocking between joists and fasten to the floor sheathing. Blocking should extend a minimum of 4 feet from the wall, attaching the anchor bolt to the last block. Install anchor bolts around the tower walls in a similar fashion, epoxying into the tower walls and fastening to joists a minimum of 2 feet from the walls, at every level, including the dwelling roof.

Estimated Cost

We estimate that the cost of construction would be on the order of \$25,000.

Recommendation 71952.2

Sheath the roof of the dwelling in plywood. Provide full-depth blocking between roof joists with fasteners between roof sheathing, blocking and the sill below.

Estimated Cost

We estimate that the cost of construction would be on the order of \$75,000.

Recommendation 71952.3

Provide full-depth blocking between roof joists over the walls at the lean-to, with fasteners between roof sheathing, blocking and the support below. Provide positive anchorage from the bottom sill to the foundation.

Estimated Cost

We estimate that the cost of construction would be on the order of \$10,000.

Recommendation 71952.3

Perform a survey to determine the extent of damage in the existing sandstone wall. Provide new concrete or grout to patch all damaged areas.

Estimated Cost

We estimate that the cost of construction would be on the order of \$5,000.



Building No. 71932, Assistant Lighthouse Keepers Quarters and Restroom



Figure 27: Assistant Lighthouse Keepers Quarters South Facade

Description

The Assistant Lighthouse Keepers Quarters is a single-story wood-framed structure with gable roof, though the restroom on the south facade has a shed roof. Outside dimensions are 30 feet by 30 feet for a total area of 900 square feet. It is used as museum exhibition space with cultural interpretations pertaining to life at the lighthouse. The south facade and restroom can be seen in Figure 27.

The building was constructed in 2000 according to the date on the architectural and structural plans. The Assistant Lighthouse Keepers Quarters closely matches the construction documents provided.

Roof framing consists of $\frac{5}{8}$ -inch plywood sheathing on prefabricated wood scissor trusses at 24 inches-on-center. The ridge is blocked, and there are several 2x4 wood braces extending from the north and south walls to the roof.

Exterior walls are made of 2x4 wood studs at 16 inches-on-center with $\frac{5}{8}$ -inch plywood sheathing. Interior walls are of the same construction, though the closet is additionally lined on

the interior with ½-inch plywood. Modern light-gage metal fasteners are used throughout the building to connect the roof and walls.

The floor consists of a 5-inch reinforced concrete slab-on-grade. The foundation is a 1-foot wide reinforced concrete strip footing beneath the building perimeter.

Overall, the building is in excellent condition and the structure appears serviceable. No signs of significant distress or deterioration were observed.

Findings

The primary lateral-force-resisting system consists of the plywood-sheathed roof diaphragm and exterior wood shearwalls. Although wall sheathing nails could not be observed at the time of the site visit, edge nailing most likely consists of 8d nails at 6 inches-on-center similar to the roof plywood nailing. In this case, the walls appear adequate for seismic loads given the size and configuration of the building. According to the plans, roof trusses are blocked over supports and anchored to the walls with seismic ties and light-gage framing clips, providing a load path from the roof diaphragm to the walls. The load path from the walls to the foundation appears sufficient for shear with anchor bolts at 4 feet-on-center. However, hold-downs are notably lacking from the plans. Anchorage hardware, such as hold-downs, is necessary for the structure to be able to resist overturning forces due to a seismic event.

Recommendations

Recommendation 71932.1

Provide hold-downs between posts at the ends of shear wall segments and the foundation.

Estimated Cost

We estimate that the cost of construction would be on the order of \$5,000.



Building No. 71953, Lighthouse Overlook Restrooms Building



Figure 28: Lighthouse Overlook Restrooms

Description

The Lighthouse Overlook Restrooms Building, also known as the Comfort Station, is a rectangular single-story stone masonry building with gable roof. It is approximately 27 feet by 19 feet in plan for a total area of 513 square feet. It is used as a public Men's and Women's restroom facility. The women's entrance along the north facade is shown in Figure 28.

According to the reports referenced in the Historic Preservation Guide for the Old Lighthouse, the structure was built in 1935. NPS historian Bob Munson stated that it was built by the Civilian Conservation Corps (CCC). No detailed documentation was available for this building, though the Historic Preservation Guide included a few construction photos. The building does not appear to have been through any significant retrofits and mostly matches the photos from the 1930s. A sketch of the building plan can be seen in Figure 29. Note that the building beyond the neighboring masonry site walls and the entire western facade were inaccessible during the site visit due to the severity of the slope at the site.

The roof is a metal standing seam roof over wood straight-sheathing. The roof is supported by full-sawn 2-inch by 6-inch joists that frame to a ridge beam and a sill plate, which is anchored with occasional metal fasteners to the top of the stone and mortar walls. The bathrooms have wood framed ceilings.

Exterior walls consist of stone masonry approximately 2-feet thick. Full-sawn 2-inch by 4-inch wood studs at 16 inches-on-center covered in metal lath and plaster comprise the interior walls.

The floor is a concrete slab-on-grade, and the foundation is also most likely made of concrete.

Overall, the building appeared to be in good condition. The mortar between stones at the base of the east facade had occasionally disintegrated such that there were large, deep gaps around stones. A masonry wall that abuts the building on the north side is separated from it by a large crack in the mortar attaching it to the building, but this does not represent a hazard to the building itself. Otherwise, the structure appeared serviceable with no significant signs of damage or distress.

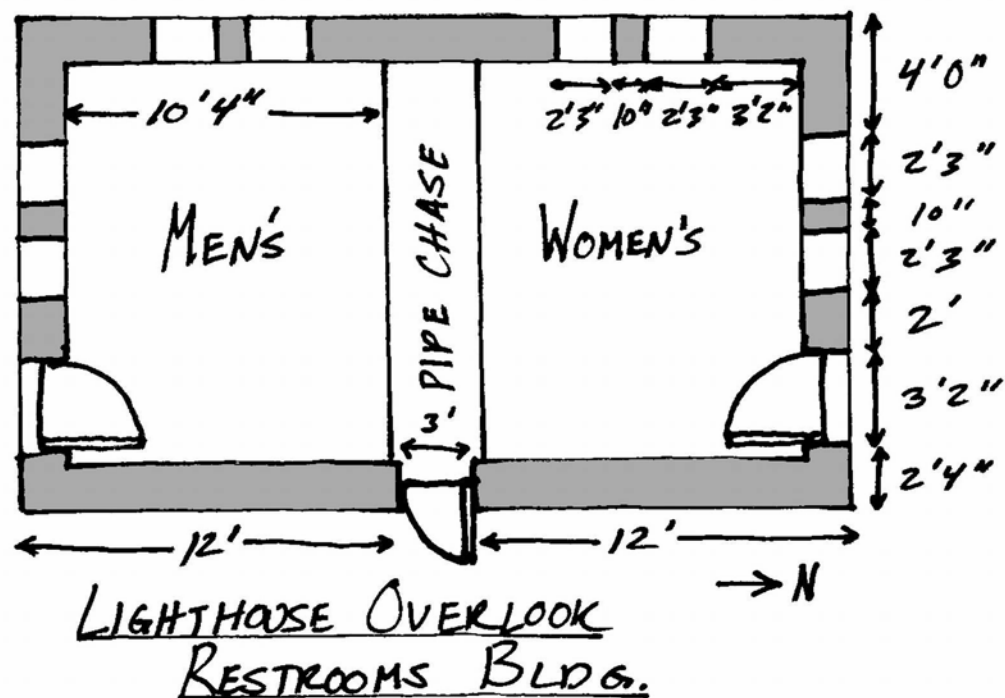


Figure 29: Lighthouse Overlook Restrooms Plan Sketch



Findings

The primary lateral-force-resisting system consists of the wood-straight-sheathed roof diaphragm and masonry walls. Being of rough stone construction, the walls are most likely unreinforced. Unreinforced masonry walls are prone to brittle and sudden failure in seismic events and are explicitly prohibited in modern building codes. The stability of the structural system under seismic loading depends on the following items:

- In-plane wall strength based on extent of solid wall and aspect ratio.
- Out-of-plane wall bracing and sufficient thickness to resist out-of-plane forces on the wall.
- The strength and continuity of the diaphragm and its connection to the walls.

Despite the walls being unreinforced, there is a substantial amount of solid wall that appears adequate for in-plane loads in the north-south direction. The east-west direction appears insufficient to withstand seismic forces due to the number of openings and slender pieces of wall. The slender wall portions will be subject to heavy cracking and damage in an earthquake. Additional walls will be needed to provide more lateral load resistance in the east-west direction.

The out-of-plane wall strength is less of a concern because the height-to-thickness ratio is estimated to be around 6. A height-to-thickness ratio of 8 is considered acceptable for a single-story stone masonry building according to the 2007 California Building Code Title 24 Part 10. However, the walls still need to be braced for out-of-plane loads at the top. Currently there is not enough strength in the ceiling or roof to accomplish this.



Figure 30: Roof Rafter, Top Plate, and Ceiling Framing

At the roof eave, there was no indication of uplift anchorage hardware, and only one anchor bolt was observed at the wood sill, as shown in Figure 30. Rafters were not blocked over their supports and vulnerable to rolling in an earthquake. There did not appear to be a direct lateral load path from the rafters to the stone walls. The walls along the pipe chase do not extend to the roof and cannot take any seismic force generated in the roof. Furthermore, the pipe chase walls are covered in lath and plaster, which provides little to no shear resistance, and cannot effectively brace the stone walls out-of-plane.



Figure 31: Mortar Deterioration

In addition to the roof-to-wall connections, the wall-to-floor and foundation connections are critical to a functioning lateral-force-resisting system. The building beyond the site walls and specifically the west wall were not accessible due to the site slope. The condition of the footings on the downhill slope side could not be observed to see if they are in good condition and bear on competent material. In addition, the east wall showed signs of mortar deterioration, as well as some concrete deterioration as seen in Figure 31.

Recommendations

Recommendation 71953.1

Install plywood sheathing over interior wall framing at the pipe chase. Extending pipe chase wall framing and plywood to the roof. Fasten roof sheathing to the newly sheathed wall. Provide epoxy anchor bolts from the sill plates to the foundation such that anchor bolts are spaced at 48 inches-on-center. See Figure 14 and Figure 15 for typical shearwall construction.

Estimated Cost

We estimate that the cost of construction would be on the order of \$9,800.

Recommendation 71953.2

Provide uplift anchorage hardware at all roof rafters. Ties should be installed at all exterior supports. Provide full-depth blocking between roof joists with fasteners between roof sheathing, blocking and the support below. Provide additional epoxy anchor bolts from the sill plate to the top of wall such that anchor bolts are spaced at 48 inches-on-center.

Provide plywood-sheathing over the tops of the ceiling joists along each wall as shown in Figure 32. Plywood should extend at least 4 feet out from the wall. At the gabled ends, provide a wood ledger connected to the wall via epoxy dowels at 48 inches-on-center for the plywood to connect to.

Estimated Cost

We estimate that the cost of construction would be on the order of \$15,000.

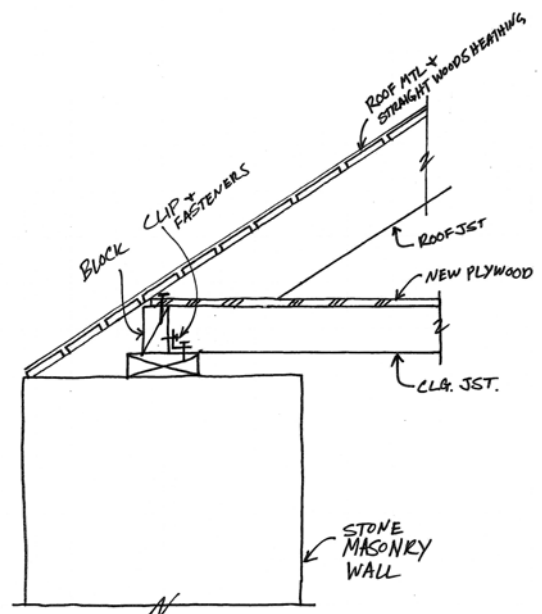


Figure 32: Recommendation 71953.2



Recommendation 71953.3

Patch and repair all deteriorated mortar and concrete.

Estimated Cost

We estimate that the cost of construction would be on the order of \$1,500.

Recommendation 71953.4

Perform a condition assessment of the foundation on the down-slope side of the building to verify the depth and condition of footings and to ensure that the footings are founded on competent material.

Estimated Cost

We estimate that the cost of the investigation would be on the order of \$1,500.

Building No. 71941, Entrance Station Building



Figure 33: Entrance Station Building

Description

The Entrance Station Building is a rectangular single-story wood-framed structure with hip roof. Plan dimensions are 16 feet 7 inches by 20 feet 9 inches for a total area of 344 square feet. It is the park entrance office for remittance and fees; vehicles and people entering the park must stop here to pay the entrance fee. The ticketing window on the west facade can be seen in Figure 33.

The building was constructed in 2002 and appears to conform to the architectural and structural plans.

The roof consists of asphalt shingles over $\frac{5}{8}$ -inch plywood sheathing on prefabricated wood trusses at 24 inches-on-center. The trusses are blocked at the ridge and are supported by the exterior walls and beams framing to 10-inch diameter wood columns at the north-east and south-west corners.

The exterior walls are comprised of 2x6 wood studs at 16 inches-on-center, as are the interior walls. The exterior walls are also sheathed with $\frac{1}{2}$ inch plywood.

The floor is a 6-inch reinforced concrete slab-on-grade. The foundation consists of 1-foot wide reinforced concrete strip footings around the perimeter of the slab and a 2-foot wide 13-inch deep thickened slab beneath walls not at the edge of the slab.

The building appeared to be in good condition. Minor insect damage in the siding was observed at the south-east corner on the southern facade. Overall, the structure appeared to be serviceable with no signs of significant deterioration or distress.



Findings

The primary lateral-force-resisting system consists of the exterior wood walls. Only the walls at the perimeter meet the roof and act as shear walls; other exterior walls stop at the ceiling and cannot transmit lateral forces in the roof to the foundation. The majority of the north facade is taken up by large window and does not contribute to the lateral-force-resisting system. It is thus a three-sided lateral-force-resisting system with a tendency to twist in plan. The remaining three walls appear to be adequate to resist expected seismic loads, although the lateral load path is interrupted at the foundation: no hold-downs were provided. Given the aspect ratio of these walls, hold-downs would be especially advisable to transmit uplift forces to the foundation. The roof-to-wall connection appears sufficient; joists are blocked and seismic ties have been provided for.

Recommendations

Recommendation 71941.1

Install hold-downs at shearwalls at the south, east and west facades. Install straps across the top and bottom of windows in the shearwalls along with the requisite blocking between studs. See Figure 14 and Figure 15 for typical shearwall construction.

Estimated Cost

We estimate that the cost of construction would be on the order of \$5,000.

Building No. 109736, Upper Maintenance



Figure 34: Upper Maintenance (Note other Photo Option)

Description

The Upper Maintenance Building is a rectangular single-story wood-framed building with hip roof. It is approximately 50 feet by 36 feet 6 inches in plan with a total area of 1825 square feet. The facility is used by NPS Park maintenance as office, storage, and work space. The south facade is shown in Figure 34.

No documentation was available for the building. A sketch of the building plan is provided in Figure 35.



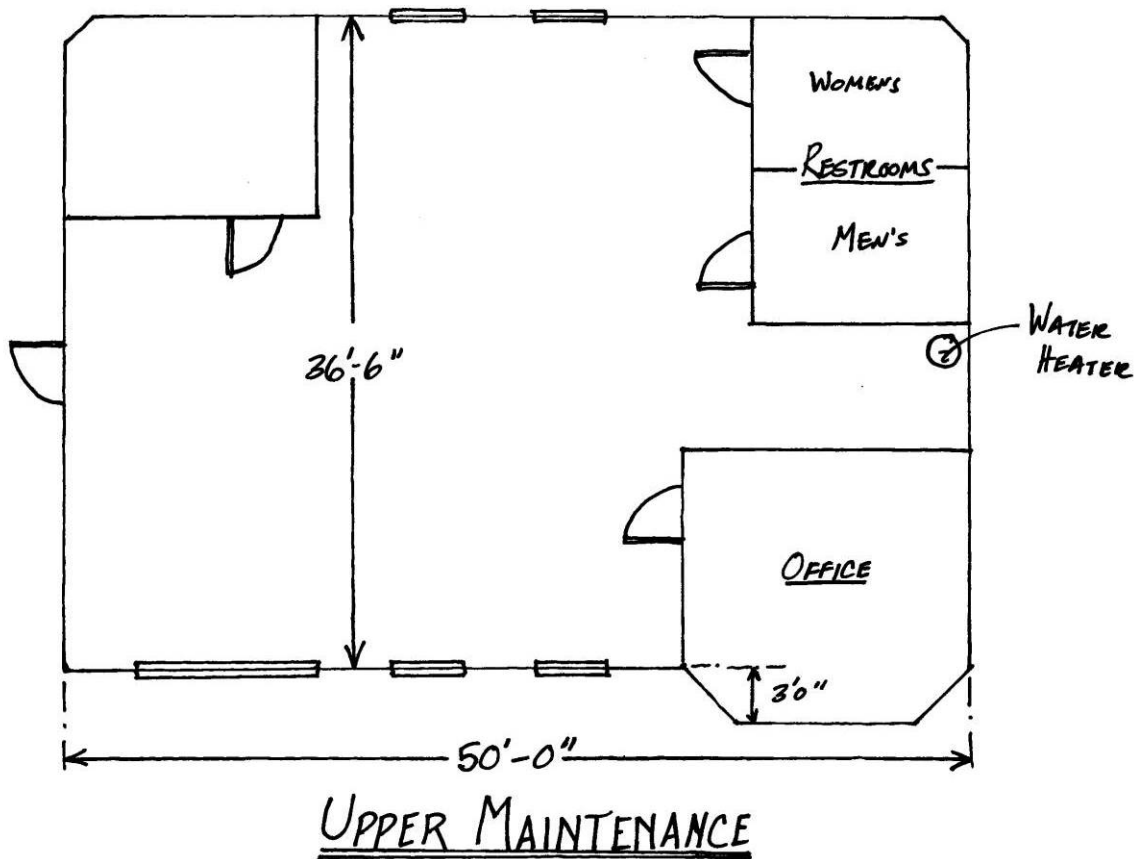


Figure 35: Plan Sketch of Upper Maintenance Facility

Park Ranger Martin Lane stated that the building is owned by the U.S. Navy but used as the primary maintenance building because the Lower Maintenance Facility, owned by NPS, is within the blast radius of a munitions depot at Fort Rosecrans and therefore to be infrequently used. The building is situated atop a hill that houses a large military bunker as seen from Lower Maintenance in Figure 36. The extent of the bunker is uncertain. Any possible interaction between the bunker below and Upper Maintenance has not been evaluated.



Figure 36: Bunker Entrance (Left) Upper Maintenance (Right)

Donald Kirby, Chief of Maintenance, estimated that the building was constructed in the 1960s. The building is typical of construction at the time. There are no significant signs of a major retrofit; the only noticeable repair was a reroofing that occurred some time after solar panels were removed from the roof.

The roof consists of asphalt shingles over what is likely plywood sheathing on prefabricated wood trusses. The sheathing is thoroughly obscured by insulation. Trusses are made of 2x4 top and bottom chords with 2x4 diagonals. The trusses are spaced 24 inches-on-center and are blocked at the ridge.



Figure 37: Plywood Between Rafters

Exterior and interior walls are 4x wood-framed walls. Plywood sheathing on the walls is visible from the interior of the building as in Figure 37.

The floor is a concrete slab-on-grade and the foundation, if similar to other structures at Cabrillo National Monument, consists of concrete strip footings beneath exterior walls. Overall the building was observed to be in good condition. The structure appeared serviceable with no signs of significant deterioration or distress.

Findings

The lateral-force-resisting system consists of the wood roof diaphragm and exterior wood walls. The south facade is perforated by many openings, namely the garage door and four windows, rendering this wall considerably weaker than the others. The structure will act as a three-sided system and the east and west walls will experience slightly magnified forces to resist the torque induced under a seismic event. A sufficient amount of plywood nailing is required for the walls to resist large lateral forces. The nailing in the roof and wall sheathing could not be observed at the time of the site visit.

Assuming the nailing on exterior walls is similar to the 6-inch-on-center nailing in the plywood finished interior partitions, the walls should be adequate.

The roof-to-wall connection is critical in transferring forces from the roof diaphragm to the walls and should consist of blocking, clips and ties. Blocking could not be observed due to plywood sheathing extending above the top of the wall between trusses. Similarly the wall-to-floor connection is crucial to transfer forces from the wall to the foundation. Based on the age of construction, we assume anchor bolts in the sill, but no hold-downs were provided. Hold-downs are required to prevent uplift.

Some tall cabinets have the potential to be a falling hazard in an earthquake. A water heater, shown in Figure 38, was also not braced. Proper anchorage is critical for minimizing the fire hazard due to a broken gas line during an earthquake.



Figure 38: Unbraced Water Heater



Recommendations

Recommendation 109736.1

Install full-depth blocking between roof trusses over supports with fasteners between roof sheathing, blocking and the support below.

Estimated Cost

We estimate that the cost of construction would be on the order of \$20,000.

Recommendation 109736.2

Install hold-downs at the ends of shear walls, with the anchor bolts epoxied into the existing foundation. See Figure 14 and Figure 15 for typical shearwall construction and hold-down locations.

Estimated Cost

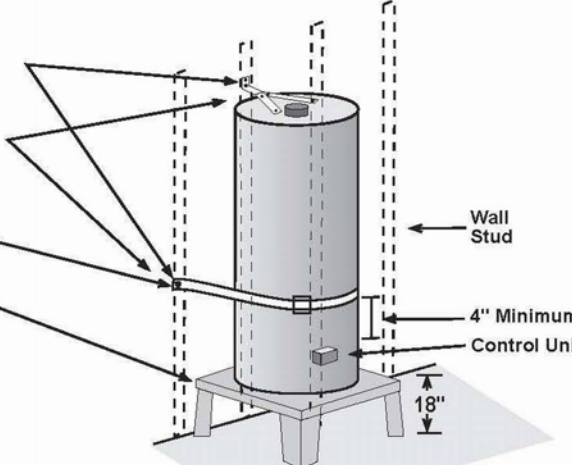
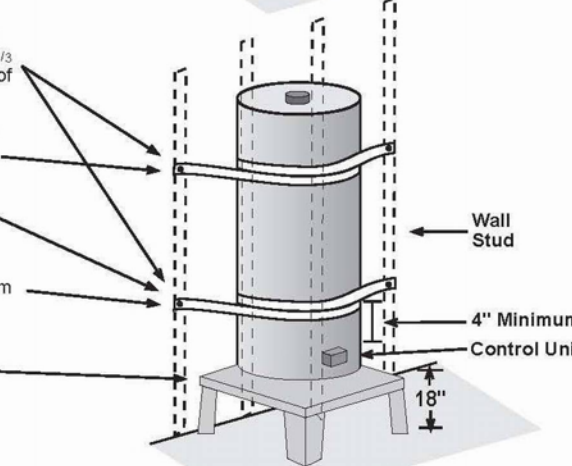
We estimate that the cost of construction would be on the order of \$5,000.

Recommendation 109736.3

Provide standard bracing straps at the water heater, as shown in Figure 39. Secure tall cabinets and shelving that have the potential to become a falling hazard (approximately 3 locations). This is most easily performed with small clips fastened to studs, a post, or wall girts. Additional framing may need to be added if appropriate framing does not exist. Wall siding alone is not adequate to support the lateral loads from equipment or tall shelving.

Estimated Cost

We estimate that the cost of construction would be on the order of \$200 per location.

	STRAPPING REQUIREMENTS FOR Water Heaters CITY OF SAN DIEGO PLANNING & DEVELOPMENT REVIEW DEPARTMENT INSPECTION SERVICES: 9601 RIDGEHAVEN CT. SUITE 220, SAN DIEGO, CA 92123 Call (858) 492-5070 for information and (858) 581-7111 to schedule inspections.	INFORMATION BULLETIN 207 APRIL 1999
The State of California requires that all water heaters in our area be anchored or strapped to resist movement during an earthquake. This can be accomplished by installing any of the over-the-counter products especially made for restraining water heaters (example 1) or you can make your own out of a heavy-duty metal strap material (Example 2). It is required that at least two restraints are used, with one in the upper one-third and one in the lower one-third of the water heater. Fasten of the anchor or strap to the structure, use a screw not less than $\frac{1}{4}$" diameter with a minimum penetration of $1\frac{1}{2}$" into a wood stud of the wall, with a washer between the head of the screw and the restraint. Below are examples of acceptable methods for restraining a water heater. Note: A plumbing and gas permit is required any time a water heater is replaced.		
Example 1 These types of restraints are over-the-counter products sold at your local hardware store. Drill pilots on center line of stud, insert screws through punched holes in strap. Use washers. The lower strap must be a minimum of 4" above the control unit. This 18" stand is required for heaters installed in a garage location. 		
Example 2 Minimum 22 Gauge metal strap material installed within the top $\frac{1}{3}$ of the heater and the bottom $\frac{1}{3}$ of the heater. Drill pilots on center line of stud, insert screws through punched holes in strap. Use minimum $\frac{1}{4}$" screws with minimum $1\frac{1}{2}$" penetration. Use washers. The lower strap must be a minimum of 4" above the control unit. This 18" stand is required for heaters installed in a garage location. 		
This information is available on alternative formats for persons with disabilities. To request this bulletin in alternative format, call (619) 446-5446 or (800) 735-2929 (TT).		

DS-5207 (Rev. 4-99)

Figure 39: Water Heater Strapping



Building No. 71954, Lower Maintenance Facility



Figure 40: Lower Maintenance Facility

Description

The Lower Maintenance Facility is a single-story concrete masonry unit (CMU) building with wood-framed gablet and gable roof. It has approximate outside dimensions of 34 feet by 121 feet for a total area of 3670 square feet. It is used as a secondary maintenance storage facility. Primary maintenance is located at the Upper Maintenance building because Lower Maintenance is within the blast radius of a munitions depot at Fort Rosecrans. The north facade of the Lower Maintenance Facility can be seen in Figure 40.

No documentation was provided for the structure. The west portion of the building was probably constructed at a different time than the east portion as the roof types differ, roof ridges are discontinuous between the two portions, and there is a CMU wall running north-south between the two portions. A sketch of the building in plan is shown in Figure 41.

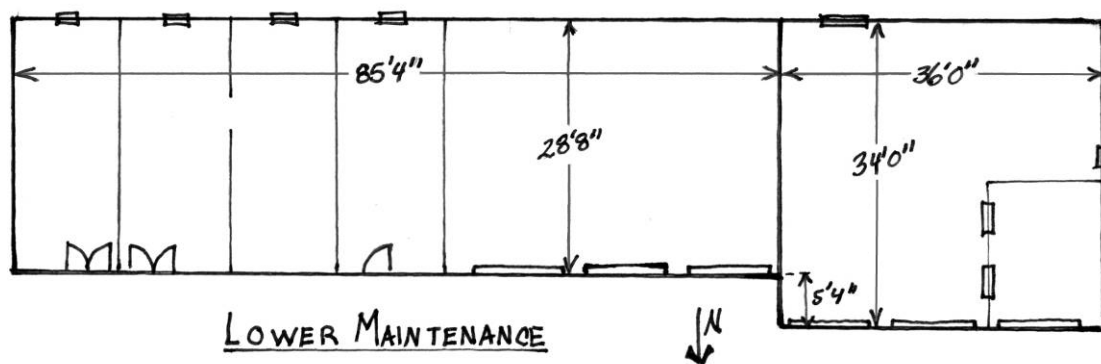


Figure 41: Plan Sketch of Lower Maintenance Facility

The external walls are composed of 8-inch thick CMU block. Internal walls are either CMU block or wood stud walls.

The floor is a concrete slab-on-grade, and the foundation is likely comprised of concrete strip footings beneath the walls.

Overall the building appeared to be in good condition. No significant signs of deterioration or distress were observed.

Findings

The primary lateral-force-resisting system consists of the plywood-sheathed roof diaphragms and CMU walls. We were unable to determine whether or not the walls were reinforced, but based on the approximate age of construction and the presence of anchor bolts in the top of the wall we assume the walls are at least lightly reinforced.

The walls in the north-south direction appear to be adequate for seismic loads given the size and configuration of the building. In addition, at least one internal wood framed wall frames to the roof and may also resist lateral loads in the north-south direction and limit the diaphragm span. The walls in the east-west direction may be adequate, but there are several large penetrations on the north wall that weaken the ability of that wall to resist seismic forces. This in turn creates a larger demand on the north-south walls as the building will have a tendency to twist around the stronger wall at the south facade.

Heavy CMU walls need to be braced out-of-plane. Hip roof joists running perpendicular to the north-south oriented walls should be able to brace those walls. Trusses brace the walls oriented east-west, provided that there is a positive connection between the top of the wall and the joists. Wall anchors attaching the top plate to the CMU wall as shown in Figure 42 were observed, although their frequency is uncertain and likely



Figure 42: Joists, Top Plates, and Anchor On CMU Wall

inadequate. In addition, the effectiveness of the roof framing acting as out-of-plane anchorage is compromised by the vertical offset between the top of the wall and the roof framing.

Trusses appeared to be blocked over the supports, such that there is likely a load path to the top sills. At the interior CMU wall, the hip joists do not appear to be blocked, but the space between covered in plywood. There does not seem to be a continuous load path from the roof to the wall in this case. The same may occur at the east and west most exterior walls. This connection was not observable during the site visit due to the extent of high shelving.





Figure 43: Unbraced Water Heater

There are numerous storage shelves in this facility, most of which are attached to the walls via a ledger and hardware. Given that some are directly connected to the walls and that this building is to be infrequently occupied, these represent a very low hazard. There is a small water heater, shown in Figure 43, that should be anchored to framing to minimize the chance of broken gas line and fire in an earthquake.

Recommendations

Recommendation 71954.1

Provide epoxy anchors from the top sill to the CMU wall such that anchorage occurs at a minimum of 48 inches-on-center. Provide full-depth blocking between roof joists or trusses at the interior CMU wall and the east and west exterior walls, with fasteners between roof sheathing, blocking and the support below.

Estimated Cost

We estimate that the cost of construction would be on the order of \$40,000.

Recommendation 71954.2

Provide standard bracing straps at the water heater as shown in Figure 39. Additional framing may need to be added if appropriate framing does not exist. Wall siding alone is not adequate to support the lateral loads from equipment or tall shelving.

Estimated Cost

We estimate that the cost of construction would be on the order of \$200.

Building No. 71974, Curatorial Building



Figure 44: Curatorial Building (Museum Storage Facility)

Description

The Curatorial Building, or Museum Storage Facility, is a single-story rectangular CMU building with wood-framed dutch-gable or gablet roof. It is approximately 28 feet by 72 feet in plan with a total area of 2016 square feet. It is a temperature and humidity controlled facility for archival storage. There is also a small office inside the building, though along with the Lower Maintenance Facility, it is in the blast radius of a munitions depot and is to be infrequently used. The south-eastern corner is shown in Figure 44.

The building was constructed in 2001 according to the architectural and structural plans. The structure appeared to conform to the plans; no significant deviations were observed.

The gablet roof is comprised of $\frac{5}{8}$ -inch staggered plywood sheathing over a combination of prefabricated common, scissor and boston hip wood-trusses at 24 inches-on-center. Trusses frame to the exterior walls and are blocked at the ridge and presumably of the walls.

The exterior walls are fully grouted 8-inch thick reinforced CMU walls. Interior walls consist of 2x4 wood stud walls.

The floor is a reinforced concrete slab-on-grade 5 inches thick. At the mobile storage rail assembly the floor is a 6-inch reinforced concrete slab-on-grade with a 2-inch thick concrete topping. The CMU walls sit on a foundation consisting of an 8-inch thick reinforced concrete stem wall on a 2-foot wide by 1-foot thick strip footing.

Overall, the structure appeared to be in good condition. No signs of significant deterioration or distress were observed.



Findings

The primary lateral-force-resisting system consists of the plywood-sheathed roof diaphragm and reinforced CMU walls. While not directly observed, plans indicate the walls are fully grouted and reinforced, ensuring that walls are more ductile and not prone to a sudden or brittle failure common to unreinforced walls. Given the size and configuration of the building, the walls appear to be adequate.



Figure 45: Shelf Anchor

Plans indicate blocking between trusses over walls, seismic ties and clips between the trusses, blocking and the wall top plate. The wall top plate has anchors at 3 feet on center. This ensures a continuous load path from the roof to the walls, and indicates that the walls are likely braced out-of-plane by the roof.

Walls are also connected to the foundation as their reinforcement extends to the footings. The load path is thus continuous to the foundation as well.

Shelving has been anchored to the walls as shown in Figure 45, and archival storage shelves are locked into a track system anchored to the concrete floor. These present very little threat during a seismic event.

Recommendations

There are no recommendations for this facility.

Pergola



Figure 46: Pergola Entry

Description

The Pergola is a shaded walk of pillars with roof covering the sidewalk entrance to the Visitor Center Complex. It connects the Visitor Center View, the Auditorium/Museum and Administration Building. The Pergola is about 154 feet long from the Visitor Center View Building to the roundabout in the parking lot and is 11 feet wide. At the parking lot it extends approximately 11 feet to the east and 22 feet to the west; in total, the pergola covers an area of 2541 square feet. The structure shades pedestrians in the complex and supports a large number of photovoltaic panels. Approximately 67% of the Pergola is covered in solar panels. The front entrance is shown in Figure 46 looking north.

About 52% of the Pergola was constructed as part of the Visitor Center Complex in 1965. It was then expanded to south to the roundabout. This expansion occurred before 1998, as it appears as existing infrastructure on unexecuted plans for a Resource/Science Office Building dated 1998; the Law Enforcement Support Building was constructed instead. The original portion of the Pergola closely matches the 1965 plans and the Pergola expansion echoes the original design scheme in the column sizes, beam sizes, spacing, and types of connections. The only noticeable difference is that at the roundabout the roof edges overhang by about 9 inches whereas elsewhere the roof edge stops just over the center of the columns.





Figure 47: Expansion Joint

The roof consists of $\frac{3}{8}$ -inch plywood sheathing over 2x3 lam decking on 6x8 beams. The decking and beams are exposed, probably weatherproofed, but not painted. Expansion joints, as shown in Figure 47, were provided for in the roof by way of 2½-inch by 2-inch steel angles fastened to the beams and the deck above via lag screws in slotted holes.

Roof beams span to 12-inch diameter painted wood posts spaced at 11 feet-on-center. There are no walls, though when the roof meets a building it is connected to the building's roof fascia, such as at the Visitors Center View building, or a ledger on the wall as at the Auditorium and Museum.

The posts are founded on 12-inch diameter reinforced concrete piers 2-feet 6-inches beneath the top of the neighboring 4-inch thick concrete paving. A 2½-inch diameter pipe, embedded within the pier, extends into the wood post and is fastened with two $\frac{5}{8}$ -inch bolts per the detail on the original plans, shown here as Figure 48.

Overall, the pergola was observed to be in good condition. A few plugs that had once disguised countersunk bolts are missing, though this does not affect the integrity of the connection. Rim boards are connected to posts via toenails, some of which have come loose or have insufficient edge distance. Loose nails should be driven back in, and rim boards having nails with insufficient edge distance should be connected by nails with sufficient edge distance to prevent them from being a falling hazard in a seismic event. Otherwise, the structure appeared serviceable with no signs of significant damage or distress.

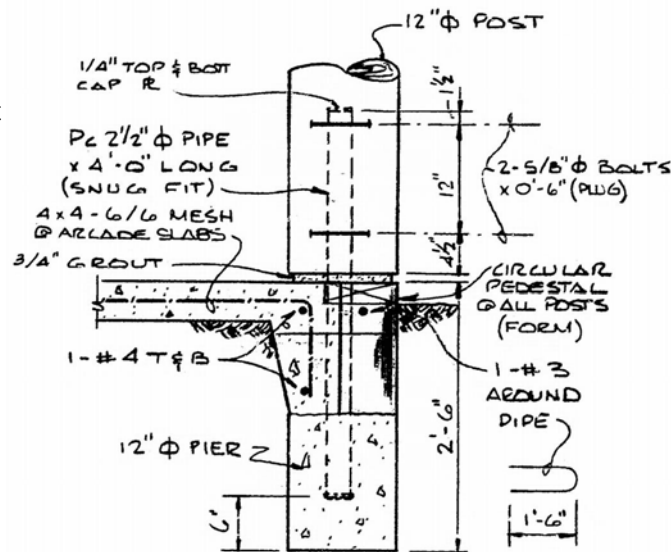


Figure 48: Post Connection

Findings

The primary lateral-force-resisting system consists of the plywood-sheathed roof diaphragms and cantilever columns. Beams are attached to columns with thru-bolts and there is little risk of uplift or rolling. The columns are substantial and may be adequate to resist lateral forces caused by an earthquake, however, the roof is often covered with solar panels, increasing the dead load of the structure and the seismic forces it will generate. The original structure was

not designed for this load and it is possible that the columns are inadequate, considering this additional load. Subsequent design should take these loads into account.

Columns are attached to piers via a pipe and bolts in an effort to provide a load path to the foundation. This pipe may not be sufficient to withstand the flexural stresses expected in an earthquake given the additional dead loads on the structure.

The piers themselves appear insufficient. They are quite shallow at 2 feet 6 inches below grade and are unlikely to be sufficient in resisting overturning or flexural moments in an earthquake. In fact, the 2005 Resource Management Office plans showing the Law Enforcement Building and Pergola expansion specify a minimum of 5 foot deep piers below new Pergola columns. This implies that by today's standards, piers shorter than 5 feet deep are probably inadequate in resisting seismic loads. Moreover, the first foot of soil around the pier cannot be relied upon to provide lateral resistance, and the paving slab is too thin to provide restraint; as such, these independent piers are at risk of failure in an earthquake. Being on independent piers, the columns are in danger of great amounts of differential movement in an earthquake causing higher stresses in the roof and greater damage to finishes and equipment. A foundation that ties several columns together would alleviate this tendency and provide greater rigidity.

Where the columns are also part of a building, such as at the Museum and Auditorium, the foundation consists of a strip footing that maybe capable of resisting earthquake induced moments. Furthermore, at the Museum and Auditorium, the columns will act less like cantilevered columns and more in conjunction with the shearwalls, a stiffer form of resistance.

At other locations close to the Administration Building and the Visitor Center View Building, expansion joints allow for only a small amount of movement between the Pergola and the neighboring building. The current system is highly flexible, and these expansion joints may not allow for enough movement. Instead, the bolts will move to the end of their slotted holes and forces will be shared between the Pergola roof and the neighboring building roof or wall.



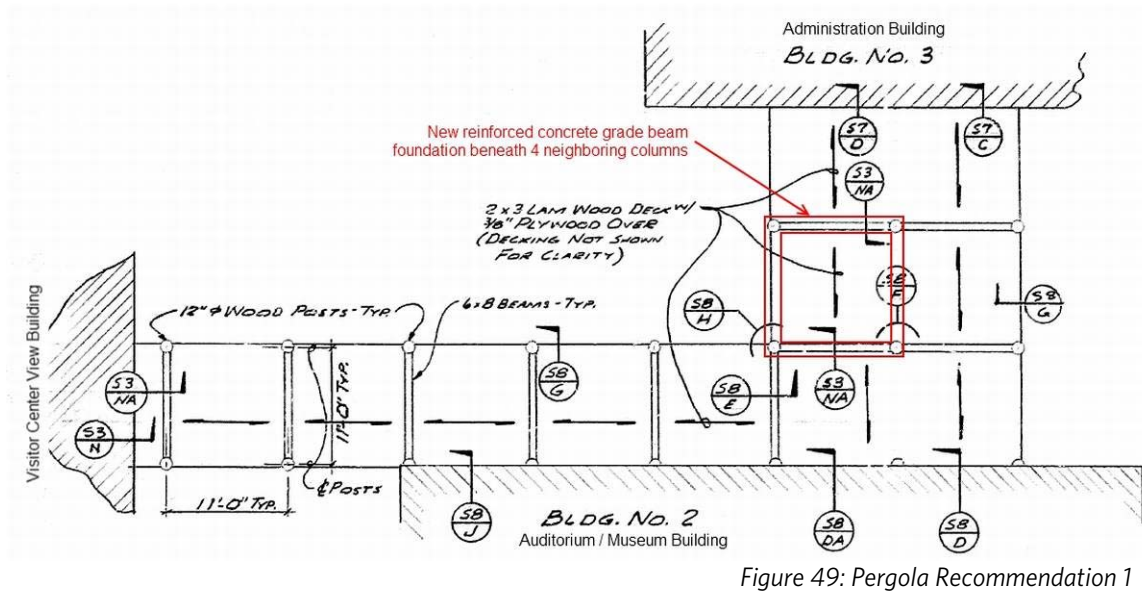


Figure 49: Pergola Recommendation 1

Recommendations

Inherent in the design of the Pergola is an open feeling and visual repetition. It is difficult to maintain the more or less unobstructed views and airy feeling while providing sufficient lateral restraint.

Recommendation 1

Remove select pier foundations and install a grade beam foundation interconnecting the bases of select columns in a ring formation similar to that shown in Figure 49. Shore Pergola roof and columns as necessary. The grade beam should consist of concrete with longitudinal steel reinforcing and closed ties. It should be capable of resisting seismic loads expected to be delivered by the columns above. See recommendation 2 for more details.

Estimated Cost

We estimate that the cost of construction would be on the order of \$20,000.

Recommendation 2

Replace select columns with columns capable of resisting expected lateral loads such as a steel column with wood fascia or covering. Fasten the roof sheathing and beams to columns. Connect columns to foundation with anchor bolts and base plate capable of resisting expected seismic loads and moments.

Estimated Cost

We estimate that the cost of construction would be on the order of \$15,000.

COST ESTIMATE

We have provided rough order-of-magnitude cost-estimates associated with each of the recommended improvements. Included in the cost estimates are hard costs for materials and labor only; this may not adequately account for total project costs. The cost estimates were developed in-house and based on engineering judgment, influenced by experience with similar facilities and access conditions. When appropriate, the cost estimates include further structural evaluation, on site investigation, structural analysis, and/or development of a schematic-level seismic upgrade. These estimates should be considered approximate, and are intended for initial planning and guidance on budgeting. The estimates should be verified on a case-by-case basis in more detail prior to the implementation of recommended improvements. Refer to the end of the individual building discussions for the cost estimate related to the recommended work for each of the facilities.

A summary of the recommendations and associated cost estimates are provided in Table 7. The total estimated cost of all recommendations for each building is included in the table. In addition, an importance level is assigned to each recommendation. This rating considers frequency of occupancy, building size and weight, structural system type and configuration, urgency of the existing condition, and the relative threat of the hazard. The following key is used to convey the importance level:

- Urgent (significant hazard)
- Important (moderate hazard)

In addition, some of the recommendations are intended to mitigate hazards from non-structural elements that can post a significant risk to life safety, such as anchorage of file cabinets, shelves, and water heaters. Recommendations are made for anchoring currently unsecured non-structural items for each of the buildings. For historic structures, the recommendations take into consideration the wish to preserve significant architectural elements while reducing the probability of seismic damage.

Table 7 - Summary of Recommendations and Cost Estimates

Building Number and Description	Importance Level	Recommendation	Cost Estimate	Total
Building No. 71983, Visitor Center View Building	■ 71983.1	4 New Moment Frames and Associated Foundations	\$100,000	
	□ 71983.2	Replace Rusted Hardware at Eaves	\$5,000	
	□ 71983.3	Clamp Top of Column	\$1,000	\$106,000



Building Number and Description	Importance Level	Recommendation	Cost Estimate	Total
Building No. 71929, Administration Building	■ 71929.1	Replace Let-In Braces with Sheathing	\$30,000	
	■ 71929.2	Install Hold-Downs	\$10,000	
	□ 71929.3	Cabinet Bracing (14)	\$2,800	\$42,800
Building No. 109735, Visitor Contact and Law Enforcement Support Building	□ 109735.1	Cabinet Bracing (5)	\$1,000	\$1,000
Building No. 71945, Auditorium / Museum / Supply Room / Restrooms Facility	■ 71945.1	Investigate Location of Shearwalls	\$1,500	
	□ 71945.2	Cabinet Bracing (5)	\$1,000	\$2,500
Building No. 71965, Military History Museum Building	■ 71965.1	Install Blocking and Fasteners at Roof	\$8,000	
	□ 71965.2	Cabinet Bracing (1)	\$200	\$8,200
Building No. 71952, Point Loma Lighthouse	■ 71952.1	Anchor Dwelling and Tower Walls at every Floor and Roof	\$25,000	
	■ 71952.2	Install Plywood Sheathing at Roof, Block Joists	\$75,000	
	■ 71952.3	Install Blocking at Lean-To Roof Joists	\$10,000	
	■ 71952.4	Patch Masonry	\$5,000	\$115,000
Building No. 71932, Assistant Lighthouse Keepers Quarters and Restroom	■ 71932.1	Install Hold-Downs at Shearwalls. Add Strapping Above and Below Windows	\$5,000	\$5,000
Building No. 71953, Lighthouse	■ 71953.1	Install Plywood Sheathing at Pipe Chase Walls	\$9,800	

Building Number and Description	Importance Level	Recommendation	Cost Estimate	Total
Overlook Restrooms Building	■ 71953.2	Install Blocking at Roof Joists, Anchors at Sill, and Plywood Over Ceiling Framing	\$15,000	
	■ 71953.3	Patch and Repair Mortar	\$1,500	
	■ 71953.4	Condition Assessment of Footings	\$1,500	\$27,800
Building No. 71941, Entrance Station Building	■ 71941.1	Add Straps Around Windows and Install Hold-Downs at Shearwalls	\$5,000	\$5,000
Building No. 109736, Upper Maintenance	■ 109736.1	Install Blocking Between Roof Trusses	\$20,000	
	■ 109736.2	Install Hold-Downs at Shearwalls	\$5,000	
	□ 109736.3	Cabinet Bracing & Water Heater (4)	\$1,200	\$26,200
Building No. 71954, Lower Maintenance Facility	■ 71954.1	Install Blocking and Anchors at Top of Wall	\$40,000	
	□ 71954.2	Brace Water Heater	\$200	\$40,200
Building No. 71974, Curatorial Building		None	N/A	N/A
Pergola	■ 1	New Concrete Foundations	\$20,000	
	■ 2	Install New Columns	\$15,000	\$35,000

