CASE STUDY: Rehabilitation of Anacapa Island Lighthouse

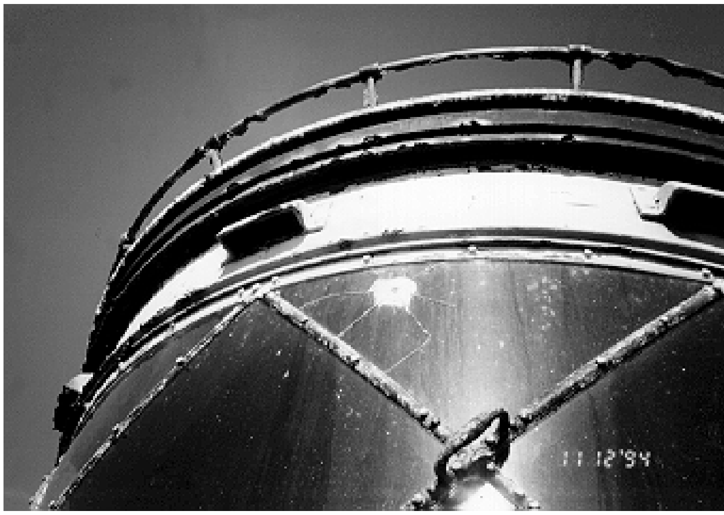

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Figure 18. Close-up of the deteriorated conditions of the Anacapa Island Lighthouse before rehabilitation.

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Anacapa Lighthouse is located on Anacapa Island, 11 miles off the coast of Port Hueneme, California. It was built in 1932 and was the last lighthouse built by the U.S. Lighthouse Service. Until the 1995-1996 Coast Guard rehabilitation, Anacapa Lighthouse had never undergone any major repairs.

Determining the Scope of Work

Civil Engineering Unit Oakland's Facility Inspection Team originally identified the need for this rehabilitation during an inspection of the lighthouse in 1992. The entire lighthouse was in such poor condition that it was labeled the worst lighthouse on the West Coast (see Figure 18). The inspection team initiated the paperwork that identified both the need for the rehabilitation and funds. Although most large Coast Guard projects normally take five years before being funded, Anacapa was in such poor condition that it was given a high priority; design work started within two years. In late 1994 the architect assigned to the project made his first site visit. The architect determined that the best way to repair the badly deteriorated cast-iron lantern house was to remove it from the concrete tower via heavy-lift helicopter and transport it to the mainland for overhaul. Further investigation, however, disclosed several insurmountable obstacles; he was forced to consider a more conventional but far from easy onsite rehabilitation of the entire lighthouse. The following scope of work was identified and budgeted for $325,000:

(a) Replace all broken lantern room glass.

(b) Replace the missing vent ball with a new fully functional replica cast 304 stainless steel (S/S) vent ball.

(c) Replace the severely deteriorated ladder rails on the lantern room roof with 304 S/S replicas.

(d) Restore the solid bronze lantern room door and lock to a fully operational condition.

(e) Abate all lead and asbestos coatings.

(f) Restore all vents to an operational condition.

(g) Repair all decorative concrete details and structural concrete.

(h) Replace all missing ventilation hoods and covers with historically accurate replacement parts fabricated from 304 S/S.

(i) Replace the severely deteriorated galvanized iron windows with new galvanized steel windows.

(j) Install new coatings that require minimal maintenance by Coast Guard personnel.

Logistics and Planning

Because Anacapa Island is home to several endangered bird species, the rehabilitation had to take place during the winter months and be completed before the late spring nesting season. The island is difficult to access; all materials had to be brought to and from the site either by boat or helicopter. Transportation costs ranged from $300 per hour for a barge to $500 per hour for helicopter services. Constant changing winter weather, rain, fog, 100 m.p.h. winds, and rough sea conditions often ruined the best logistical plans. Some days the landing area for the boat would go from calm at 6:00 a.m. to very rough by 10:00 a.m., forcing the contractor's supply boat to turn around and wait another day. Other days the wind was so strong that materials could not be delivered by boat or helicopter. Since the island was so remote, the workers had no choice but to stay on the island for four days at a time and work ten-hour days.

Everyone learned very early just how quickly work could come to a stop when equipment broke down or supplies failed to arrive. There was no quick run to the parts store or to the equipment rental center. A breakdown was either corrected onsite or the work was delayed until parts could be brought out to fix it. Sometimes the work could be postponed until another scheduled supply run was made to the island. There were a few times, however, when the helicopter had to fly out with nothing but a small part because no one else was coming out to the island for several days. A simple $30 item then cost the contractor $250 in helicopter services.

Dissimilar Metals

Anacapa Lighthouse did not have damage caused by dissimilar metals; however, a lot of new stainless steel (S/S) replacement parts were introduced and care taken to prevent any future problems. A barrier was applied in all cases where S/S was attached to the cast-iron or bronze areas of the lantern. S/S fasteners were coated with a modern anti-seize compound to prevent galvanic reaction and to take the place of the original white lead. A thick gasket made of roofing felt and coated with a silicone caulk was installed between the new S/S vents, vent hoods, and cast-iron lanternhouse walls (see Figures 19 and 20). The gasket was made from 15 lb. roofing felt which was inexpensive, easy to apply, and did not crush when the vents were bolted in place. Installing the new S/S ladder rail ring stanchions required a two-step process. First a coat of primer was applied and allowed to dry. Then a heavy coat of primer was applied and the stanchions were installed while the primer was still wet creating a watertight seal. This last step was needed because when the original stanchions were removed, a heavy coat of red lead was found sealing the joint.

On previous lighthouse rehabilitations broken bolts were replaced with 316 S/S to avoid painting the nonferrous metal; however, on more recent rehabilitations, a bolt

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Figure 19 (left). Buildup of rust in parapet wall vents.

Figure 20 (above). The finished vent installation: 15-lb. roofing felt was placed between the bronze vent grill and the cast-iron parapet wall.

that would develop a green patina to match the mullions was selected. All the broken bronze bolts on the lantern window mullions were replaced with marine grade silicone bronze instead of stainless steel. Use of the silicone bronze bolts also removed any concerns of dissimilar metal reaction, and they are equal in strength to stainless steel for this application.

Enclosure, Hazardous Waste Containment, Prep Methods, and Painting

The rehabilitation took place during the winter months, so no repair work could begin until the contractor completed an enclosure around the lighthouse. The enclosure served several purposes: containment of hazardous materials; protection of workers from severe weather; and a dry environment for the repair, prepping, and painting of the lighthouse. The first step in building the enclosure was the erecting of a scaffolding completely around the 30-foot concrete tower. Next was a weathertight plywood enclosure for the cast-iron lantern, complete with pitched roof to shed heavy rain. The final step was sealing the scaffolding in heavy shrink wrap to provide weather protection and containment of any hazardous materials (see Figures 21 and 22). The entire enclosure phase of the project took two weeks because of difficulties in handling the plywood and applying the shrink wrap in high winds. After the enclosure was complete, all deteriorated metal pieces that were scheduled to be replaced and did not require abrasive blasting were removed.

Because the lantern was sealed off from the rest of the tower while being blasted, chemical stripping of the paint could take place on the exterior tower walls and

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Figure 21. View of the plywood lantern enclosure and scaffolding.

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Figure 22. View of the lighthouse scaffolding covered with shrink wrap to contain all hazardous materials and protect workers from severe weather.

windows. The stripper was water-based and applied by brush and airless sprayer. After soaking for at least 1 1/2 hours, it was scraped off (see Figure 23). The stripped area was then neutralized with water and finished with power sanding where necessary. The interior lead-painted walls which were originally only to be lightly scraped and painted were causing problems. The paint was so old and brittle it continually flaked off. The abatement contractor asked for a change order to completely remove the paint because the current finished product was proving to be unacceptable. Chemical stripping of the interior walls had been selected over light blasting to save on the costs of transporting more blasting media to the island. Air-driven needle gun scalers using low pressure air, however, proved to be a more cost-effective method. The paint was so brittle, it shattered when struck by the needles, leaving the concrete virtually paint free (see Figure 24). There was no damage to the concrete and only lead-paint chips were left to be swept up and disposed of. This method could not be used on the exterior concrete because of the 3/8-inch white mortar skim coat that had been applied as a finish coat when the light was built in 1932.

After the interior walls were complete, the cast-iron spiral staircase was the last item to be abated. The blaster started at the top floor of the lantern and backed his way to the front doors. This process took three days and prevented any other interior work from taking place because of the dust. After the blasting was complete, the entire structure was swept and vacuumed before being rinsed down to remove the remaining dust. The water did cause flash rusting on the newly blasted cast-iron staircase but that was expected and did not pose a problem (see Figure 25). All surfaces were then wire brushed, prepped, and primed by a three-man team who only prepped what they could prime within an hour. Although the primer used was designed for use over flash-rust, we did not want to chance a coating failure.

The following generic paint systems were selected based on durability, performance over minimally prepared surfaces, non-toxicity, and permeability:

Figure 23. The water-based paint stripper was very effective in removing the many layers of paint from the exterior of the tower.

(1) Exterior ferrous metalwork: moisture cure urethane primer and top coat*

(2) Interior ferrous metalwork: moisture cure urethane primer and top coat*

(3) Exterior masonry and concrete: elastomeric acrylic, coarse texture

(4) Interior masonry: ‘breathable’ acrylic, minimum 55% permeability

*This product will cure in 99% humidity; this facilitated application during fog and misting weather.

Figure 24. The interior paint was effectively removed using needle gun scalers, without damaging the concrete as evidenced by the visible impressions of the formwork boards.

Figure 25. After the cast-iron stairs were blast-cleaned, they were rinsed to remove all traces of lead dust; flash rust immediately formed (as seen in this photo). Before painting, this light rust was removed with wire brushes.

Concrete Repair

The 3/8-inch white mortar finish coat that had been applied over the exterior concrete when the light was built in 1932 was not identified in any of the original drawings. As a result, no one looked during the work site visit for signs of delamination. After the scaffolding was in place, however, several areas were found to be loose between the 10- and 30-foot elevations. The foreman became concerned that other unidentified delaminated areas would fall out after the job was complete and ruin his work. The foreman inspected the entire tower and found an additional 100 square feet of delaminated mortar. After receiving approval to repair any bad mortar, he personally chipped away all the loose mortar and applied a two-part masonry patch material. The repair work was of such high quality that the patches were unnoticeable when the tower was repainted (see Figures 26 and 27).

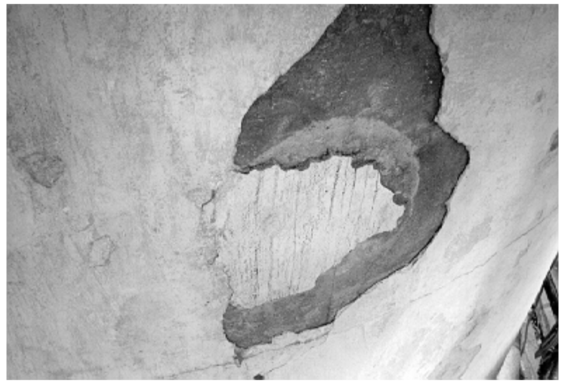

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Figure 26. Once the scaffolding was erected, areas of the delaminated white mortar finish coat were removed.

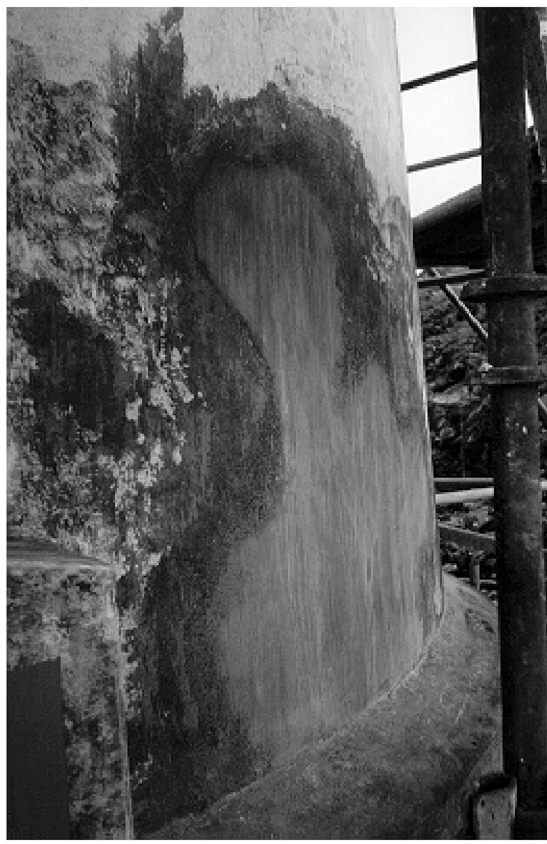

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Figure 27. The areas where the loose mortar finish coat was removed were repaired with a two-part mortar patch. The final texture on the patch was tooled to match the historic wall surface. The patch was completely invisible after the tower was painted.

Of the 12 tower windows, 8 required extensive exterior concrete repairs. Rusted rebar had spalled the concrete and caused severe damage. The old rebar was removed, new holes drilled and the new rebar epoxy injected in place. The rebar was then covered, packed, and reshaped with a two-part Sika Flex product.

One major area of concern was the concrete gallery deck located outside the lantern. This deck had considerable damage in two areas without any evidence of the cause. The outer rebar showed signs of corrosion but the damage went 18 to 24 inches deeper into the concrete. Since freezing was not an issue, the cause of the damage was at first unknown. Closer examination revealed signs of an explosion inside the concrete, and we noticed bolt patterns for two old antenna mounts directly above the area. We determined lightning to be the cause. There was no practical way to dig out the


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Figure 28. Close-up of the damaged concrete gallery deck after the loose concrete has been removed and before the damaged concrete was repaired using pressure-injected epoxy grout.

broken concrete; the project was already over budget. We decided to do a pressurized epoxy injection and fill all the voids. The area was prepped and pumped full. The outer three inches were left unfilled so the two-part mortar patching compound could be used to restore the damaged area (see Figures 29 and 30).


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Figure 29. The first application of the mortar patch material to the damaged concrete.


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Figure 30. The finished concrete repair is virtually invisible after the surface has been painted.


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Figure 31. Close-up of the finished metal work on the lantern.


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Figure 32. View of the finished lantern