AWARD OF EXCELLENCE
LONGEVITY CATEGORY

Lake Merritt Boathouse: 10 Years Later

OAKLAND, CALIFORNIA
SUBMITTED BY SIKA CORPORATION


Fig. 1: Lake Merritt Boathouse in 2019

INTRODUCTION

The Lake Merritt Boathouse (Fig. 1) is located on Lake Merritt (a large body of inland, salt water) within the city of Oakland, California. It was built in 1909 to serve as an emergency pumping station in response to the 1906 earthquake. The building is U-shaped and has two stories, each approximately 8,500 sf (790 m^2). The two wings were used to store canoes and sailboats used for recreational purposes and the midsection was used to house a pumping station for firefighters. The foundation piers, girders, beams, and slabs are constructed of cast-in-place, reinforced concrete. The exterior façade consists of cement plaster over reinforced concrete.

Voters approved a plan in 2002 to return the dormant historic boathouse to its original design. In addition to upgrading the lower levels to enhance the boating facilities, the upper levels were renovated and converted to a restaurant. The new design required installation of micro-piles for seismic upgrade of the building. After installing a coffer dam, dewatering the area and beginning to excavate and expose the foundation, it became evident that the building substructure had many problems.

INVESTIGATION AND EVALUATION

The investigation to assess the extent of damage yielded some dramatic results:

- Most of the beams, girders, piles, and slabs had cracking, spalling, and signs of corrosion;
- Chloride contents in the concrete were very high, ranging from 0.4-0.9% by weight of concrete (20x theoretical threshold for corrosion to occur);
- Cover concrete over the reinforcing steel ranged from 0-1 in (0-25 mm); and
- Heavy corrosion was noted in many

areas with complete loss of the stirrups and/or the longitudinal steel in several locations.

The investigation concluded the concrete spalling was caused by corrosion of the reinforcing steel accelerated by insufficient cover and chloride ingress (Fig. 2).

REPAIR SYSTEM DESIGN AND IMPLEMENTATION

The owner and engineer had several goals to address the field conditions—including properly repairing the damaged concrete, protecting from moisture penetration and future steel corrosion, and structurally upgrading deficient members with minimal impact on the overall project schedule.

Site Preparation

Access to the work areas was a major challenge. Equipment was modified to excavate horizontally under the existing slab and substructure (Fig. 3). Because of the tight conditions and the requirement to replace all excavated fill with the original material, the project was completed in two phases. Once the earth was excavated, the work space was very tight, 3 ft (0.9 m) of clear head space.

Due to the muddy conditions and to ensure a clean, dry, and safe work area, a working platform was built. Netting was laid down first, followed by a layer of styrofoam, then tongue-and-groove plywood installed to provide a good surface to work from. The workers had to work from their hands and knees and used dollies to roll from one place to the next (Fig. 4).

Demolition and Surface Preparation

As the demolition began, the repair contractor inquired on the need to shore the slab during repairs. The engineer inspected the conditions and concluded it to be safe; however, shoring was installed as a measure of caution (Fig. 5). Not only did this add to the complexity of completing the repairs, it made a very tight work space even tighter. Old wooden piers were also found during excavation which required removal to gain access to the work area.

Significant demolition was required to remove spalled concrete and expose corroded reinforcing steel (Fig. 6). Sandblasting was not permitted and compressed air chipping guns were used for bulk concrete removal. All removals were reclaimed and recycled; thus the netting below the plywood and styrofoam ensured that debris was not left behind. Reinforcing steel was cleaned with wire brushes and grinders. Areas to receive carbon fiber reinforced polymer (CFRP) were grinded to remove surface laitance. Areas to receive a coating were powerwashed.

The work was performed in two phases and each phase was divided into smaller sections due to concern about

Fig. 2: Extensive spalling of the beams, girders, and slabs caused by severe corrosion of the reinforcing steel

Fig. 3: Modified excavation equipment to remove the mucky soil under the supported slab

Fig. 4: A worker works off his back on a mechanics crawler to grind and clean the reinforcing steel

Fig. 5: Work platform and shoring installed ahead of demolition (note corroded steel throughout and the tight working conditions)

Fig. 6: Significant demolition required to remove spalled concrete and expose corroded reinforcing steel

Fig. 7: Anodes installed throughout to combat the high chloride content in the concrete

Fig. 8: Girders after concrete placement and repair

Fig. 9: Girder after application of CFRP and slab after application of epoxy coating (note areas of shoring that required later touchup)

the lack of slab strength. The work sequence consisted of:

- Installation of galvanic anodes in the repair and core drilled into the beams and piles (Fig. 7);
- Application of a rebar coating and bonding agent;
- Installation of formwork; and
- Placement of the concrete repair material (Fig. 8).

Once the entire phase was completed, the next steps entailed:

- Surface preparation and installation of the CFRP (wet-layup technique);
- Surface preparation of the exposed concrete substructure surfaces (Fig. 9);
- Application of an epoxy coating;
- Removal of the shoring;
- Final clean-up and removal of the temporary work platform; and
- Backfill.

SUMMARY

Severe corrosion problems and structural deficiencies were uncovered once excavation began and the substructure was exposed in December, 2006. Thorough investigations were immediately employed to determine the extent and causes of the deficiencies. Plans and specifications were developed by February 2007. The repair contractor mobilized in April and started excavating in May and completed the repairs in September 2007.

The project was awarded LEED Gold certification. Uniqueness included sustainability/adaptive reuse of a historic landmark, coffer dam required to access submerged elements of the structure, excavation of saturated soil/soupy mud, tight access to the work space with 2-3 ft (0.6-0.9 m) headroom and shoring, load limits on the slab, restricted storage and work sequence, possible liquidated damages if the project was not completed on time, and dewatering to maintain access.

The full system repair/strengthening/protection approach was designed to withstand for many years. Ten years later, the repairs are still performing while the residents continue to enjoy the upgraded boating facilities and restaurant.

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SUBMITTED BY
Sika Corporation
Lyndhurst, NJ

OWNER
City of Oakland
Oakland, CA

PROJECT ENGINEER/DESIGNER
Degenkolb Engineers
Oakland, CA

REPAIR CONTRACTOR
Alpha Restoration
South San Francisco, CA

MATERIALS SUPPLIERS/MANUFACTURERS
Sika Corporation
Lyndhurst, NJ

Vector Corrosion Technologies
Tampa, FL