Dock Rebuild and Strengthening

Tampa, FL

Submitted by Premier Corrosion Protection Services, Inc.

Phosphate is used mainly as a crop fertilizer throughout the world and central Florida produces the majority of the world's phosphate. The storage and shipping of this material in bulk is a monumental task. The phosphate is brought into the facility via railroad and is stored in a large warehouse until it is ready for shipment.

When a ship arrives at the dock to receive the phosphate, it is transferred via conveyors onto a moving loader that spans approximately 100 ft (30 m) over the open water and runs the full length of the dock. There are two bridges constructed of prestressed double tees that connect the dock to the land for vehicular traffic.

The dock is constructed of prestressed concrete double "tees." Each of the two beams is 20 in. (508 mm) thick by 6 ft (1.8 m) high and 100 ft (30 m) long. Half of the dock was constructed in 1968 and the other half in 1982, and it has been in constant use. The loader runs on a single railroad track the full length of the dock (and a double track on land) and weighs 1,500,000 lb (680,389 kg).

PROBLEMS THAT PROMPTED THE REPAIR

In the fall of 2012, a section of the dock that was built in 1968 collapsed, causing the loader to fall into the bay. After the loader was retrieved, an inspection was performed on the 800 ft (244 m) long section of the remaining dock to look for structural deficiencies.

One major problem discovered during the inspection was that a section of the dock appeared to have been struck in two locations by what was felt to be a barge during a storm. These damaged areas had 70% of their prestressed cables either broken or weakened.

The remainder of the dock had numerous cracks and spalls on the beams caused by saltwater infiltration due to its close proximity to the water. The bottom of the beams were only 6 in. (152 mm) above the water at high tide and were frequently below water during mean high tide (at full moon) and when ships' wakes splashed them.

INSPECTION AND EVALUATION METHODS

Inspection methods included visual inspection and sounding of the concrete to determine void areas. Because of the severity of the damage in the two locations previously mentioned, a repair method was recommended by the engineering firm that employed a prefabricated carbon-fiber plate installed over the repaired section of the beam, which would be capable of withstanding the 1,500,000 lb (680,389 kg) loader.

SITE PREPARATION AND PRODUCT SELECTION

All spans of the dock were prepared per ICRI Technical Guidelines. Additionally, materials and application methods were determined by adhering to the recommendations of Guideline No. 320.1R-1996, "Guideline for Selecting Application Methods for the Repair of Concrete Surfaces"; Guideline No. 320.2R-2009, "Guideline for Selecting and Specifying Materials for Repair of Concrete Surfaces"; and ACI 440.2R-02, "Guide for the Design and Construction of Externally Bonded FRP Systems for Strengthening Concrete Structures."

Contaminated concrete was removed from behind the reinforcing steel and an epoxy bonding agent/corrosion inhibitor was applied. A high-strength, fast-curing, silica-fume-enhanced polymer concrete was then used to fill the prepared areas to be flush with the existing surfaces.

Concrete being prepared for repair on bottom of beams

REPAIR AND PROTECTION OF THE STRUCTURE

By far the most glaring damage was that done to the bottom of the two beams where the prestressed cables were broken or weakened. This is why a prefabricated carbon-fiber plate was to be installed over the repaired section of the beam that would be capable of withstanding the loader.

In addition to this repair, the bottom of all the beams were repaired over their entire length and encapsulated with fiber-reinforced polymer (FRP) composite material (fiberglass) for a minimum of 2 ft (0.6 m) above the bottom in stirrup fashion to ensure that there would not be any water infiltration to the beams.

Deteriorated concrete being removed from bottom of beams

Work was difficult, as it had to be performed from the water

REPAIR PROCESS EXECUTION AND APPLICATION METHOD

One major obstacle to overcome was the tides, as well as ships entering and leaving the port facility causing, at times, large wakes.

Prefabricated floating platforms were constructed and towed to site. These platforms were secured to one another, making a continuous floating platform, and were secured to the dock with expansion bolts and lines, allowing the platforms to rise and fall with the tides. A floating turbidity barrier was secured around the working area.

Repairs to the two major areas that had 70% of the prestressed cable loss were prepared by cutting out and removing the damaged section. Reinforcing bars were then doweled into the existing beam using epoxy gel. The area was then formed and 5000 psi (34 MPa) concrete was placed into the forms.

After the forms were removed and the concrete was cured, temporary steel “shelf angles” were installed 1 in. (25 mm) below the beam. The carbon-fiber plates were lowered by hand to the floating platform. A thickened epoxy coating was applied to the top of the carbon-fiber plate and slid onto the shelf angle. Wood wedges were driven below the plate to “snug up” the plate to the bottom of the beam. Tap-Cons were then installed through the plate into the concrete beam to secure the plate.

The following day, an average of four layers of unidirectional carbon-fiber cloth was installed in stirrup fashion on the inside face of the beams. The remainder of the dock received spall repair per ICRI Guidelines.

Using a single-component, high-strength, silica-fume-enhanced concrete allowed FRP composite material to be installed on the entire length of the bottom of each beam. The FRP wrap was installed in stirrup fashion 2 ft (0.6 m) up each side and across the bottom, fully encapsulating the bottom of the beams, ensuring no further water intrusion and preventing any further spalling or cracking.

Finally, a liquid-applied rubber coating was installed over the entire dock structure, sealing the concrete from any further intrusion of water or moisture.

VALUE ENGINEERING

The repair method of using a custom-designed carbon-fiber plate for the strengthening of the severely damaged sections of the dock was really the only repair method that could have been employed in this case. Because of the close proximity to the salt water coupled with the wake thrown by passing ships, a structural steel support installed below the beams would have been in the water. A suspension type of repair could not have been installed due to the loader that runs the full length of the dock.

Installation of FRP wrap

Workers completing repairs on bottom of beams

The only other solution would have been the replacement of the 100 ft (30 m) of dock, costing hundreds of thousands of dollars and time that the client did not have. This solution employed a small fraction of the replacement cost and all repairs for this portion of the project were completed in less than 2 weeks.

After the completion of the project, tests were performed to establish the new load capacity of the dock. The test results for the repaired/strengthened section of these beams showed that the installed plate has a tensile capacity of 2,364,200 lb (1,072,383 kg).

The owner was extremely satisfied with the project. It was completed under budget and ahead of schedule.

Florida Dock

OWNER
CSX Transportation
Tampa, FL

PROJECT ENGINEER/DESIGNER
V2 Composites, Inc.
Auburn, AL

REPAIR CONTRACTOR
Premier Corrosion Protection Services, Inc.
Tampa, FL

MATERIAL SUPPLIERS/MANUFACTURERS
MAPEI Corporation
Deerfield Beach, FL

V2 Composites, Inc.
Auburn, AL

Completed repairs on dock showing loader