Concrete Dock Repair: Removal and Replacement of Concrete Slab

Port Arthur, Texas

Submitted by Structural Preservation Systems

Commissioned in 1901, the southern refinery of a major oil and gas company has undergone several upgrades. One area that had not experienced significant upgrades, however, was the concrete dock located just outside the refinery. Originally constructed in 1910, the 3000 ft (914 m) long dock is connected to an intercoastal waterway that leads to the Gulf of Mexico. This cast-in-place concrete dock serves as the off-load for crude oil and the on-load of petroleum products.

Approximately 4 years ago, a third-party engineering firm conducted an investigation of the dock, taking core samples to determine its structural integrity. A visual assessment was also performed. The results from the inspection and testing revealed substantial erosion on the bottom side of the dock. In particular, the concrete beams that supported the dock were in poor condition from the erosion and had visible damage, including reinforcing steel that was hanging in the water. During the process of collecting data, the engineering firm came up with a repair scenario that involved pouring back the entire slab at 2.33 ft (0.71 m) thick. This approach would limit the need for workers to perform work under the dock by instead building elaborate formwork to complete the repair.

Cause of the Problem and Solution for Repair

Several factors led to the deterioration of the dock. The dock is located only 2 to 3 ft (0.6 to 0.9 m) above the water, and the corrosive saltwater damaged the concrete. In addition, the structure's age contributed to its deterioration. Further, the dock has survived many severe storms and hurricanes in its lifetime, which contributed to the overall deterioration of the structure.

Based on the engineering firm's repair scenario, the repair contractor selected for the job presented a unique approach for the repairs—performing the repairs from the dock, not using barges. This approach was extremely attractive to the owner because of the logistical challenges a barge would have presented. Each time a ship would come to the dock, the barge would have to be moved. With ships docking each day, this would have led to a tremendous amount of downtime and greatly lengthened the project schedule. Not using a barge, however, required the repair contractor to carefully plan every detail of the project. Understanding this, the dock was removed in small, manageable pieces and work never had to stop for deliveries.

Preparing for Repair

To prepare the site for the project, crews barricaded the dock to ensure a safe environment for those loading and unloading ships. Next, the top of the slab area that was to be repaired was pressure-washed to remove residual oils from the surface prior to commencement of the repairs.

Concrete slab demolition; blue A-frame with chain hoist was used to lift out concrete blocks after they were saw cut

Concrete blocks stacked after being saw cut and removed from dock slab

Crews removing intermediate beams using pneumatic chipping hammers; due to the thickness of the beams, they could not be safely removed by saw cutting

Reinforcing steel being installed; bottom layer of a double reinforced system

Because of the large number of repairs to the dock, the team opted to cut large segments of concrete out of the dock and have them removed. To ensure a seamless process, crews laid out a grid pattern on the top of the dock slab that indicated the existing beam locations and sizes of the slab segments to be removed.

Out With the Old

To remove the concrete, crews saw cut concrete to the full depth through the slab and hoisted it out. The team cut 4 x 6 ft (1.2 x 1.8 m) segments out of the concrete and connected the concrete segments to an A-frame for removal. The A-frame was rolled to hand truck dollies. The segments were then wheeled to the end of the dock where a small crane hoisted them into trucks to be hauled away from the site. The team had to chip out these damaged portions using pneumatic chipping hammers and remove all debris by hand. Crews worked on scaffolding to accomplish this task. After communicating with the owner, it was determined that slurry water from concrete saw cutting would not be contained, which was acceptable.

In With the New

Once the concrete was removed, crews set and tied two layers of reinforcing. This new system used No. 6 bars and was designed to support the new slab. A waterproof barrier was installed to the remaining perimeter repair areas to mitigate water infiltration. Crews then fastened the remaining support rods through the deck and sealed the forms. Placement of the concrete was extremely challenging because a flood protection wall hindered access. A concrete boom truck was placed directly next to the wall at one end of the dock. Concrete had to be placed on the opposite end, which was 160 ft (49 m) away from the truck's location. The concrete that was poured back was 2.25 ft (0.69 m) thick.

The dock could never be repaired the way it was originally built because of safety concerns and the low clearance under the dock to the water. Therefore, plant personnel and engineers wanted to eliminate the contractor from having to form up the existing beams and instead opted to form one large beam. The original slab was continuous and had been formed in one pour. Crews removed the portions of the slab that were located in between the beams by cutting out concrete segments. For the portions of the slab located above the beams, the team chipped out 2.33 ft (0.71 m) of concrete to be even with the other removed portions. Once the beams were removed, crews placed concrete in between the beams to the proper thickness. This strategy helped maintain safety at the job site because crews could not perform any work underneath the dock because it was so close to the water.

The formwork was an engineered, fiberglass, corrugated deck that was to "stay in place" and was saltwater resistant. Converse to traditional projects, the deck to be poured back was completely supported on top of the pile cap structures through the use of coil rods, decking, and lumber. The system served as a work platform, concrete debris containment mechanism, and formwork. The removed portions of the dock were held in the A-frame for removal, which eliminated the need for cranes and barges.

The concrete took 4 days to cure, achieving 4000 psi (27.6 MPa) during that time. Once the concrete had been cured, crews removed the coil rods that were sleeved with polyvinyl chloride (PVC) and filled the holes with cementitious grout.

Confronting Challenges

Prior to the repair, crews thought the slab was a certain thickness, but it was actually much thicker in several places. Because the concrete slabs were thicker, the repair contractor had to decrease the size of the segments that could be removed. Further, the A-frame that was used to remove the segments had a load rating that the team had to consider. The weight load for the A-frame was increased when thicker portions of the slab had to be removed.

Another challenge occurred because of the creative way the team poured the dock back. The crews had to rely on some areas of the dock to support the formwork, such as the existing pile caps. Prior to placement, however, it was revealed that several of the pile caps were eroded, so crews had to add additional support. The suspended deck was supported by large I-beams that ran the length of the repair, with smaller beams running across the top of the deck. It was crucial that the I-beams spanned the pile caps to eliminate the risk of overloading the deck. An unforeseen condition arose when the crew had to move one of the large I-beams because it could not fit around unmovable equipment. Upon doing this, the team noticed that the pile cap used to support the I-beam was in poor condition. Therefore, crews ran another large W-14 beam across the top that extended out past the W-21. They supported this on a pile from the portion of the dock that was not being removed.

A Successful Repair Project

Even with the significant amount of work done by hand, there were never any workplace incidents at this job site. Crews worked around the clock, 7 days a week to get the project completed in a mere 2-1/2 weeks.

Many questioned the repair strategy for this job, and several stated that it could not be done. Competitors and even plant personnel did not think the job could be completed without the use of a barge and crane. The project was successfully completed, however, and this approach saved the owner a significant amount of money and reduced the project schedule. Proper planning ensured this project was a success. The owner was so pleased with the results that the team began repairing another section of the dock 1 week later.

Lowering of concrete hose to place final section of dock

Finished shot after removing forms and filling PVC holes with grout

Concrete Dock Repair

Owner
Valero Port Arthur Refinery
Port Arthur, Texas

Project Engineer/Designer
Goldston Engineering
Houston, Texas

Repair Contractor
Structural Preservation Systems
Sulphur, Louisiana

Material Suppliers/Manufacturers
White Cap Construction Supply
Beaumont, Texas

Deer Park Lumber
Deer Park, Texas