Marine Structures: Pier Projects

By Tommy Pirkle and Randell Ogburn

Marine piers are abundant in the United States and are generally made of concrete. While composite materials, steel, treated wood support piles, and thick rubber fender systems are commonplace, concrete remains the main component of most pier structures. The majority of these structures were constructed long ago, and given their constant exposure to destructive elements, they require routine maintenance. This includes repairing the deteriorated concrete, which is exacerbated by inclement weather, freezing-and-thawing cycles, continuous wetting and drying from tidal action and, especially, the chlorides in salt water, which will eventually take a heavy toll on concrete and its embedded reinforcement. The shotcrete process has been the restoration method of choice by many to restore the concrete on a large number of these facilities seeking to combat the accelerated deterioration process that is part and parcel of concrete marine structures.

The single most important factor when bidding or working on a saltwater pier is having a complete understanding of the perpetually changing tides. Each day, as the sun, moon, and earth interact with each other, ocean levels fluctuate, yielding two high tides and two low tides. The ocean is constantly moving from high tide to low tide and then back to high tide, and there are approximately 12 hours and 25 minutes between the two high tides. Given that a considerable amount of marine repair work requires physically being on the water underneath the structure itself, the ever-changing tides cause a number of issues not confronted on more conventional job sites, including shortened work days and a work schedule that is constantly changing according to the tide (Fig. 1).

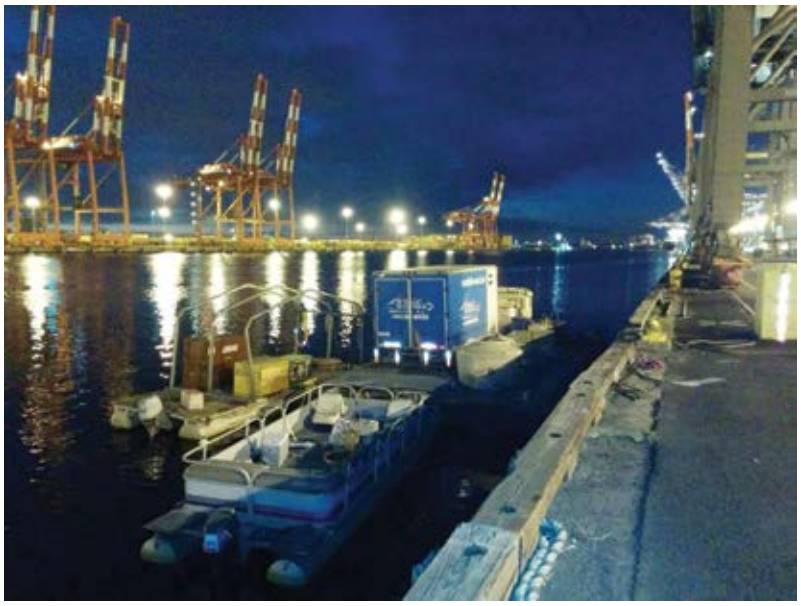

Fig. 1: Night work as a result of the constantly changing schedules

There are two main types of tides: spring tides and neap tides. Spring tides (which, contrary to their name, do not have anything to do with the season) are very strong and occur when the moon is full or new. Neap tides occur during the quarter moon phases and are very weak. This results in a smaller difference between high and low tides during a neap tide.

Another key factor to take into consideration during the bidding process for pier work is access. Using work floats to navigate throughout the site is preferred, but simple, provisional decking made out of lumber or cables and scaffold boards works well on higher-volume jobs or where the work is too high to reach safely from the float stage. Float platforms are the most cost effective if the work is accessible at both low and high tide. However, many times a wide float will not be able to get around the existing piles or can become grounded on unseen impediments in the water as the tide lets out. This is especially true in situations where additional piles were installed to support today's heavy cranes that are necessary to unload the ships' cargo (Fig. 2).

Port Elizabeth

Elizabeth Marine Terminal is located on the Newark Bay in Jersey City, NJ. It is operated by the NY/NJ Port Authority. This port is the 22nd busiest in the world and is the largest container port in the eastern United States. Port Elizabeth is comprised of a large pier with 10,128 ft (3088 m) of ship berth space. Work must be performed around docked ships from all over the world, which are in a constant state of loading and unloading their cargo. The design engineer's method of repair for this concrete structure is shotcrete, and the work generally consists of pile cap and underside deck repairs.

The scope of work includes deteriorated concrete removal, cleaning or replacement of severely rusted reinforcement, and the installation of welded wire reinforcement with anchors. Shotcrete is then applied and cured. Where the

Fig. 2: Preparation of the work barge

work is not visible, a natural gun finish is specified. Another typical, yet more difficult repair is the total encapsulation of the top of a support pile to a concrete pile cap with shotcrete. The piles have to be recentered underneath the pile cap using a come-along and wedges to secure it in place. After the removal of barnacles and other contaminates, any unsound concrete is removed and welded wire reinforcement is wrapped around the pile cap and the support pile, thus "bridging" or "locking" them together. Expansion anchor bolts are installed to secure the welded wire reinforcement and shotcrete is then applied with a minimum thickness of 6 in. (150 mm). This jacket type of repair is extremely tidal-affected, as the top of the pile and pile caps are often completely submerged during certain high-tide cycles.

Ferry Slip Renovations at Liberty State Park

Liberty State Park is located on the Upper New York Bay and is one of New Jersey's most dramatic and popular parks. This park is the only location in New Jersey with ferry service to Ellis Island and the Statue of Liberty. Passengers board the ferries from loading platform piers adjacent to the Ferry House Building. Ferry House Platform #2 is a concrete box structure built on timber piles and supported by large triangle-shaped concrete pile caps, also supported by timber piles (Fig. 3 and 4). The only access to the underside or inside of the structure is through a small hatch deck door on top of the platform deck. Spalled concrete including severely eroded pile caps below the platform deck and along the length of the inside and outside walls were repaired with shotcrete. Various spalls along the outside walls were over 9 in. (225 mm) deep and only accessible during a low spring tide elevation, thus allowing only 2 hours of productive work time. Concrete underdeck beams were also repaired. The beams ran the width of the pier and were only reachable by the workforce during neap tide cycles. Narrow, lightweight float stages were used to execute this

Fig. 3: Spalls along the outside wall of the Ferry House Platform #2

Fig. 4: Triangle-shaped piles and underdeck beams repaired and encased with shotcrete

work because the only access was limited by the small hatch door. Surprisingly, the inside walls of the structure were in decent shape, with minor spalling but with substantial concrete erosion. The spalls were chipped, walls pressure-washed, and galvanized welded wire reinforcement installed and supported with expansion anchor bolts attached to the substrate. Shotcrete was then applied to a thickness of 3 in. (75 mm) to fill the spalls and add additional coverage over the existing reinforcement on the eroded sections of the walls (Fig. 5).

Safety Concerns

Typically, when there is ship activity, pier security is very strict. A current Transportation

Workers Identification Credential (TWIC) card along with a Secure Worker Consortium (SWAC) card for NY/NJ Port Authority work are generally required for every person to enter a facility or work on a ship pier.

Working on a pier structure is dangerous and safety should be a top priority. A Health & Safety Plan (HSPA) and a Job Hazard Analysis (JHA) should be written before mobilization and issued to all employees.

Besides the normal safety concerns related to any shotcrete project, a JHA for working on a pier should include the hazards associated with working on a work barge or float stages, with special considerations to access and egress. The JHA should also include workers wearing and maintaining a coast guard-approved Personal Flotation Device (PFD), instruction on boat safety, and education for handling unexpected wakes generated from water traffic.

Fig. 5: Unsound concrete removed with pneumatic chipping hammers

The destructive effects of water, especially salt water, mean that concrete-based marine structures such as piers require constant upkeep. Freezing-and-thawing cycles, tidal wetting-and-drying action, inclement weather, and chloride exposure often accelerate the damage and erosion sustained by concrete exposed to the marine environment. At the same time, pier work, by its very nature, creates a number of atypical issues not encountered on non-marine job sites. Productive work days are shorter. Access is typically limited. Workers have to work from unstable floats rather than solid ground. Unforeseen impediments to working can abruptly arise, more so than at on-land sites. Because of these conditions and issues, pier work requires an understanding of marine science, creative solutions, and most importantly, patience.

***Tommy Pirkle** has over 30 years of experience in the shotcrete industry and is Co-Owner of Eastco Shotcrete LLC. He is an ACI Certified Nozzleman and oversees company sales and operations.*

***Randell Ogburn** is a Supervisor for Eastco Shotcrete, LLC, with over 30 years in the shotcrete business. His area of expertise and primary focus is on marine structures. At Eastco, he is responsible for developing and executing the work plans for marine and other projects.*