North heading trestle system

OPA Winner: The Inner Harbor Navigation Canal Floodwall

On August 29, 2005, Hurricane Katrina made landfall near the Louisiana – Mississippi state line, approximately 30 miles (48 km) east of downtown New Orleans, with 125 mph (205 km/h) winds and a storm surge in excess of 25 ft (7.6 m). Lake Borgne, a shallow brackish body of water east of New Orleans flanked on its north by the Gulf Intracoastal Waterway (GIWW) and its south and west by the Mississippi River Gulf Outlet (MRGO) and surrounded by low lying marsh, carried the massive storm surge straight to the mouth of the Inner Harbor Navigation Canal (IHNC) just 9 miles (14.5 km) east of downtown New Orleans. As a result of the catastrophic flooding that took place, Congress authorized the construction of systems that would bring a 100-year risk reduction level of flood protection to the city of New Orleans. One of the largest single components of this newly designed flood protection system, and the largest design-build civil works construction project in United States Army Corps of Engineers (USACE) history, is the Inner Harbor Navigation Canal Surge Barrier. Sited approximately 1.5 miles (2.4 km) east of the Inner Harbor Navigation Canal mouth, the surge barrier stretches from the south bank of the MRGO to the north bank of the GIWW, and acts as the first line of defense for the New Orleans area against hurricane storm surges approaching from the east. In April 2008, the USACE awarded this design-build contract to Shaw Environmental and Infrastructure of Baton Rouge, La. In May 2009, the partners of Traylor-Massman-Weeks, LLC (TMW) began work on the largest portion of this project, the Inner Harbor Navigation Canal Floodwall. TMW is a construction team comprised of Traylor Bros., Inc. of Evansville, Ind.; Massman Construction Co. of Kansas City, Mo.; and Weeks Marine, Inc. of Cranford, N. J.

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Design Criteria

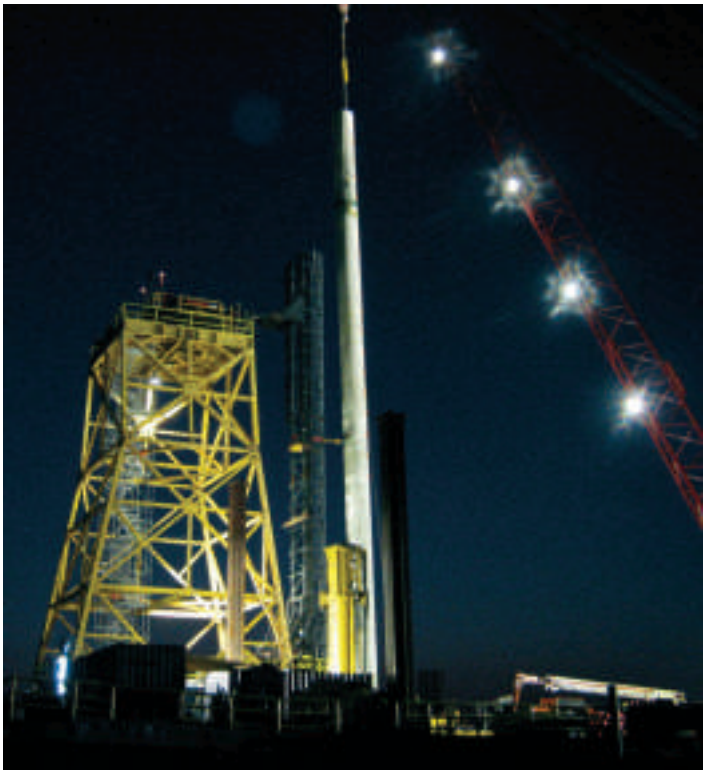
Due to the soil conditions at the site, the IHNC Floodwall and floodgates all required the use of deep foundations. The challenging soil conditions including the soft and muddy clays deposited by the Mississippi River, dictated the need for an innovative foundation and structural design.

Shaw E&I chose Ben C. Gerwick, Inc., as the structural engineer. The firm has a long history of innovative design approaches using precast concrete systems, components, processes and detailing. The firm helped expedite construction procurement while the design was being optimized. Drawing on its extensive experience in the field, the designers chose robust, simple-to-build connection and joint details that also expedited construction. In the design process, the firm strove to produce creative and practical solutions that reduced construction costs without compromising structural performance.

The storm surge barrier forms a dam that prevents the storm surge from progressing inland. The IHNC waterways behind the floodwall form a storage basin during a storm event. The 100-year storm surge design criteria requires a still water elevation (storm surge) of 21.6 ft (6.58 m) on the floodside of the wall, plus a significant wave height of 6.7 ft (2.04 m). During a design storm event, as the surge reaches the design elevation, storm-driven waves will splash over the top of the floodwall as rainwater accumulates behind the barrier, slowly filling the storage basin. The net increase of the water level in the storage basin, due to water overtopping the barrier during the design storm, is 1.5 ft (0.46 m). Water entering the IHNC basin from other sources adds to the basin's water elevation and results in a +8.0 ft (2.44 m) water elevation behind the barrier while the storm surge subsides to a water elevation of -2 ft (0.61 m) on the floodside. As a result, after a storm passes, the floodwall becomes a dam to withstand the water behind the wall until floodgates can be opened to allow the basin to drain.

Gerwick's geotechnical engineers participated in the site characterization and determination of design soil parameters based on laboratory, cone penetrometer and pressuremeter tests. The lateral resistance of soft clays in southern Louisiana to the large-diameter cylinder piles of the floodwall (expressed as a set of p-y curves) was further investigated through pile lateral load tests performed at the project site. These pile lateral load tests allowed for better insight of soil behavior during deformation of the tested piles. The in-situ soil stiffness under deformation was derived via field measurements of soil resistance and was used to represent the 3-D effects of soil-pile interaction in the finite element model. A profile of the soil conditions along the project alignment is shown in Figure 1.

TMW contributed greatly to the success of the project by electing to build a temporary trestle system that allowed dimensional control of both the 66 in (167.6 cm) diameter x 144 ft (43.9 m) long concrete cylinder pile and the 36 in (91.44 cm) diameter x 248 ft (75.6 m) long steel batter pile. TMW's use of the trestle and template paid huge dividends by enabling tight dimensional control, avoiding uncertainties associated with floating marine equipment, and allowing very rapid setup and pile driving. These factors reduced the construction schedule when combined with Shaw's advanced procurement of materials, USACE's accelerated review and approval of the design documents, and Gerwick's precast caps designed to accommodate reasonable field tolerances.



North heading cylinder pile night operation

Contract Work Overview

Subsequent to months of planning and based on 30% design, TMW received official Notice to Proceed on May 5, 2009, and began installation of permanent work in only four days. They drove the first of 1,271 66 in (167.6 cm) diameter x 144 ft (43.9 m) long concrete cylinder piles four days later, on May 9. Shortly thereafter, on May 29, 2009, they drove a second heading of 66 in (167.6 cm)

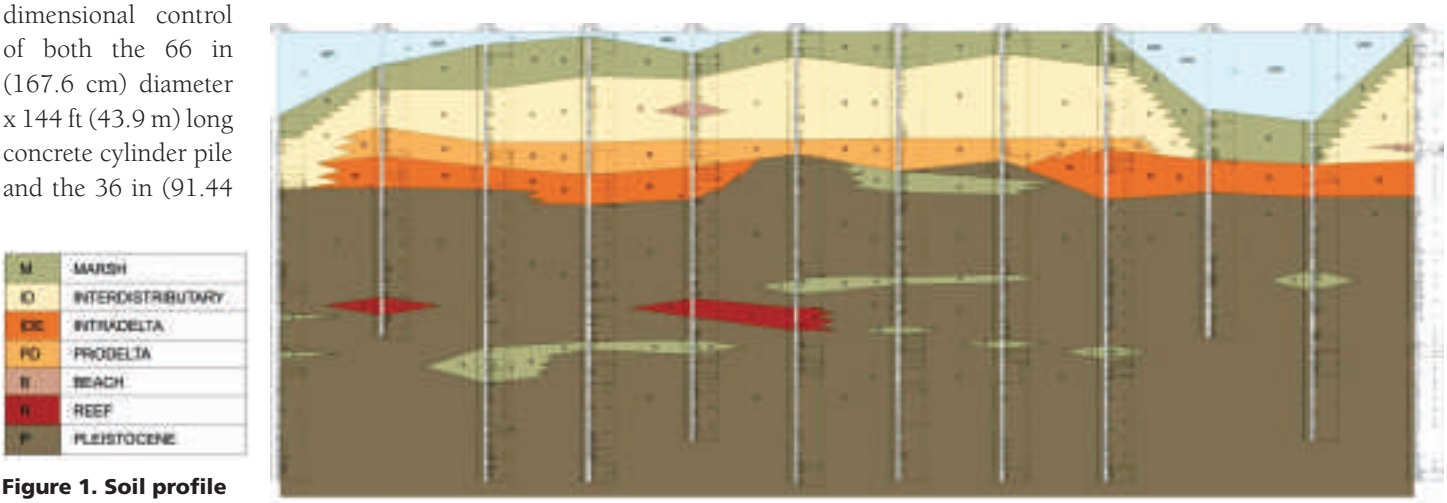
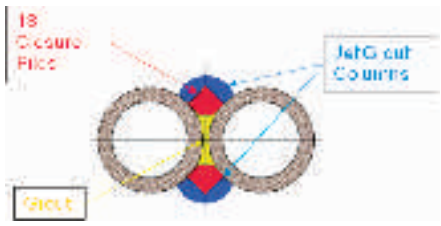


Figure 1. Soil profile

diameter concrete cylinder piles of the same configuration. The floodwall project alignment spans approximately 7,500 lf (2,286 m) closing off the Mississippi River Gulf Outlet (MRGO) and tying into the Gulf Intracoastal Waterway (GIWW) bypass structure. The 144 ft (43.9 m) cylinder piles were driven with 6 ft (182.9 cm) center-to-center dimensions leaving a 6 in (15.24 cm) gap between each, and making up the main foundation component of the floodwall structure. Remaining foundation components included a pair of 18 in (45.72 cm) x 59.75 ft (18.2 m) square "closure" piles to seal the gap between each cylinder pile and 36 in (91.44 cm) diameter x 248 ft (75.6 m) batter pile providing lateral support. Rather than being driven, closure piles were wet-set in 36 in (91.4 cm) diameter jet grout plumes. The steel batter piles were driven in two pieces on a 1.5V:1H batter, spliced at mid-drive, and spaced at 12 ft (3.7 m) center-to-center dimensions along the length of the floodwall. These components were then tied together with pre-cast and cast-in-place concrete caps and a 2 ft (61 cm) thick parapet wall topping out at elevation 26 ft (7.9 m).



Floodwall plan view, batter pile excluded

Challenges

The principal challenge of this project was the very aggressive construction schedule of only 18 months spanning through two hurricane seasons. This challenge created a need for a well-thought-out executable plan with means and methods focused on precision and finesse, but with the robustness to resist hurricane induced forces. Such systems do not normally lend themselves to speed. Fortunately, the experience and expertise within the three partners of TMW, along with assistance from engineering firms such as Huval and Associates, Inc. of Lafayette, La., and Genesis Structures, Inc. of Kansas City, Mo., the joint venture was able to engineer creative solutions to every obstacle.

Mobilization for projects of this magnitude also presented challenges, and in the middle of April 2009, working toward a start date of June 1, 2009 for production work, the scheduled start date was moved up to May 9, 2009. Also, a complete revamp of initial heading locations was implemented approximately two weeks prior to May 9, due to interface requirements with other on-site contractors. Dual headings were always planned for the project but instead of starting one heading at the far end of the job, another in the middle, and working in the same direction as originally planned, both headings had to start in the middle of the job and work in opposite directions, thus causing staggered starting dates. The site was accessible only by water, adding to the complication. Fortunately, TMW had customized fleets of equipment for all types of marine construction, and the necessary resources were pulled from across the country. The result was a job fleet of major equipment peaking at 16 barge-mounted cranes, 5 land-based yard cranes, 10 trestle-mounted pieces of equipment, and more than 40 material barges to support a two-shift workforce exceeding 350 men and women. TMW also received additional specialized equipment necessary to complete the work from industry leaders such as Jinnings Equipment, LLC of Fort Wayne, Ind., and Berminghammer of Hamilton, Ontario, Canada.

Closure pile and batter pile operations

Construction

The joint venture used floating equipment, along with a custom engineered trestle system supporting specialized templates and equipment, to overcome many of the challenges. The trestle was the backbone of what appeared to be a heavy civil construction assembly line. It was founded in the marsh on 36 in (91.44 cm) diameter x 130 ft (39.62 m) steel friction pile bents that had to support vertical loads excess of 250 tons (223 tonnes) and hurricane-induced loading. Once workers installed these bents, they created a stable work platform using double W36 x 150 beams that spanned the 50 ft (15.24 m) bent spacing. These beams were topped with crane rails and required alignment within fractions of an inch. These rails allowed work platforms and templates to traverse the system of straight and 620 ft (188.98 m) radius sections using electric gear driven motors, facilitating the precise installation of the permanent work.

The total trestle system was approximately 2,000 ft (610 m) long and operated on a repetitive basis to remove, reinstall and engineer adaptation to prevent conflicts with permanent work and to keep construction activities on schedule. The largest of three pile-driving templates using the trestle support system was the 36 in (91.44 cm) diameter batter pile. This double stage, three level template weighed 250 tons (223 tonnes) and included hydraulically driven guide arms, a welding station for pile splicing, and two service cranes with a 350 ton (313 tonne) Manitowoc 7000 for support of the BSP hydraulic hammer and 200 ft (60.96 m) leads, and a 250-ton (223-tonne) Manitowoc 999 for pile loading.

Aerial view of batter pile operation

The second largest template using the trestle system was that at the north heading 66 in (167.6 cm) pile driving operation. This template included an 80 ft (24.28 m) tower supporting 84 in (213.36 cm) Conmaco leads with a custom engineered universal joint at the base and spotter at the top allowing minuscule adjustments to meet the required tolerances. A 600 ton (536 tonne) Manitowoc 4600 service crane was used for pile loading and driving.

Completed floodwall foundation pile

The south heading 66 in (167.6 cm) pile driving relied less on the trestle system and more on the highly specialized pile driving Weeks Marine crane dubbed the "526." This crane includes a capacity of 350 tons, 6 falls, 245 ft (74.68 m) of boom, 150 ft (45.72 m) of custom leads, a telescoping spotter with a working radius of 122 ft (37.19 m), and Raymond steam driven hammer capable of 180,000 ft-lbs (244,047 Nm) of impact energy. All this is contained on a 292.5 ft x 80 ft (89.15 m x 24.38 m) barge along with a Link Belt 418 assist crane for material handling and pile rigging. Although the "526" has been used in the past without separately supported independent templates, specifications at the IHNC Floodwall project required that they be used. Consequently, a trestle system followed, using the same foundation design as that at the north heading, carrying a secondary template. Immediately following the north and south heading cylinder pile operation was the 18 in (45.72 cm) x 59.75 ft (18.2 m) square closure pile operation. These piles were installed in pairs and wet-set in 36 in (91.44 cm) diameter jet grout plumes to close the gap between each cylinder pile. Layne GeoConstruction of Bridgewater, Mass., provided drilling and grouting services while TMW provided equipment and platforms for installing the piles. Workers installed a grout bag to fill the interstitial space left between each of the cylinder pile to approximately minus 20 ft (6.10 m) and placed grout to seal the wall. Once all the foundation components were in place, the last step was the pre-cast and cast-in-place cap sections that tied the complete foundation system together and allowed it to act as a unit.

Conclusion

In summary, TMW installed 4,454 individual, permanent and countless temporary piles, removed 26,000 cu yd (19,878 m^3) of pile spoil material, placed 68,000 cu yd (51,990 m^3) of concrete, injected 530,000 cy yd (15,008 m^3) of jet grout soil stabilizer and placed 300 pre-cast cap sections weighing 90 tons (80.36 tonnes). The project was the largest civil works, design-build project ever taken on by the USACE; one that will provide flood protection for the city of New Orleans and the surrounding area for many years. During the work, TMW accrued over 1 million manhours and zero lost time accidents, reaching 100% completion within the required 18-month schedule. TMW received the 2010 USACE Mississippi Valley Region and New Orleans Hurricane Protection Office "Project Superior Safety Performance Award." Through the dedication of all parties involved, especially the aggressive pursuit of this project by the USACE, everyone in New Orleans and the surrounding area can rest easier, as the level of flood protection has been dramatically increased.