

Inner Harbor Navigation Canal Hurricane Protection Project

Lake Borgne, New Orleans, LA



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In November of 2008, the U.S. Army Corps of Engineers issued notice for Shaw E&I to proceed for construction on the Inner Harbor Navigation Canal (IHNC) Lake Borgne Surge Barrier Project. In a joint venture project, Ben C. Gerwick, Inc. (BCG) and

INCA Engineers provided Shaw E&I with the detailed designs, drawings, management and theory, and construction aspects of the project. In particular, BCG facilitated the design and bid for construction phase, a task that is normally delegated to the Corps.

BCG is proud to team with Shaw E&I and INCA on this signature project. The challenges presented by this monumental project consist of a 2-mile long flood wall and two gate structures, signifying the importance of safety preparedness to the people of New Orleans

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View of the GIWW Bypass and Sector Gate Structures for the IHNC Flood Protection Barrier



Proposed Project Alignment

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against hurricanes, flooding, and natural disasters.

Innovative Solutions to Technical Challenges

As one of the principal designers of the IHNC project, BCG strived to produce creative and practical solutions to reduce construction costs without compromising structural performance. The challenging soil conditions consist of soft and muddy clay deposited by the Mississippi river, dictating the need for a high level of innovative foundation and structural design. The designers of the project preferred to use a robust structure with simple-to-build connection and joint details.

For the 9,000-foot long floodwall, the structural engineers opted for an efficient combination of

prestressed, 5.5-ft diameter cylindrical concrete piles, allied with structural 36-in diameter steel-pipe batter piles for strength and ease of construction.

Drawing on extensive experience in the field of float-in & heavy-lift construction techniques, the designers included precast concrete segments that will expedite construction. Most of the Gulf Intracoastal Waterway (GIWW) structures at the north end of the project are to be designed by BCG. The structure features a larger 150-ft wide opening, which will accommodate the 75-ft long steel sector gate leaves (designed by INCA). A cofferdam will also be constructed for dewatering. As part of the advance measures, a temporary restraining structure (TRS) will provide protection

against storms during construction. An additional 150-ft long, 62-ft wide concrete swinging barge-gate will provide temporary protection during the early phase of the project and flexibility during typical navigation scenarios. The swinging barge-gate will be precasted off site and floated into place.

Anticipating a high degree of uncertainty in long-term settlement, the geotechnical engineers were heavily involved in conducting a soil-structure analysis — a crucial step towards designing high quality sound marine structure foundations. Using state of the art finite element software packages such as PLAXIS, the engineers investigated soil-structure interaction and settlement, helping to resolve issues of seepage and piping.

Timeline of Construction Phases

Shaw E&I has finished moving the shoreline protection and cleaning the channel bottom along the Mississippi River Gulf Outlet (MRGO). The contractor will also elevate the MRGO bed, raising the recently de-authorized deep draft channel from approximately -40 feet to -15 feet. Additionally, contractors will soon finish driving load test piles throughout the area. Driving the test piles is the last necessary step to finalize the designs of the 2-mile long floodwall and gate foundations. The data obtained from the test piles will confirm the depths necessary to create the most secure structure and reduce risk to the people of New Orleans. The surge barrier will extend from

the floodwall north of the GIWW, east of the Michoud Canal to the levee on the west side of the MRGO. This barrier will include a 150-foot surge gate and a 150-foot barge gate to facilitate navigation along the GIWW.

With the continued collaboration of all firms, the Corps expects to complete the IHNC Lake Borgne project in 2011, with advance measures implemented during the hurricane season in 2009 to reduce the flood risk for people in the surrounding communities.

Timeline for IHNC:

2007, December — Initial bid

2008, Spring — Contract Awarded

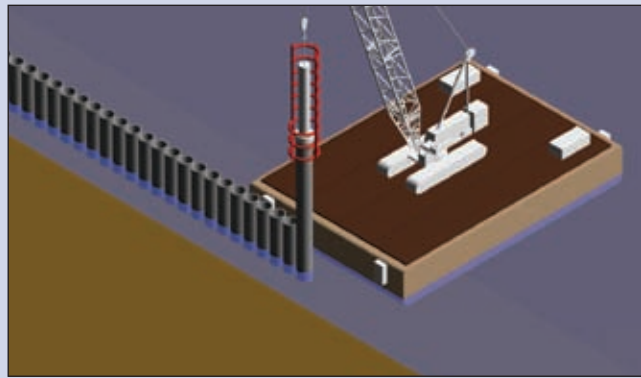
2009, Fall — Advance measures provide some level of protection during level of construction

2011 — Est. end of project

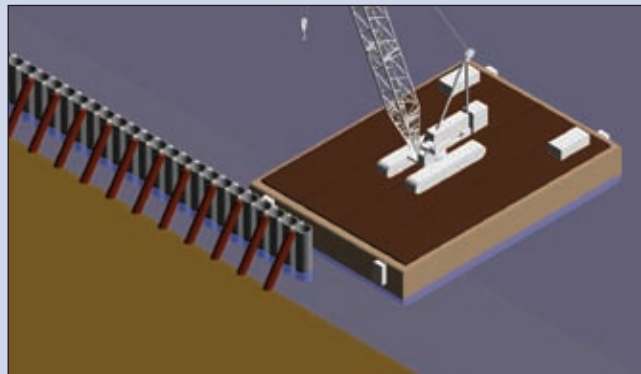
Year of Completion: 2011

Project Bid Price: \$695M

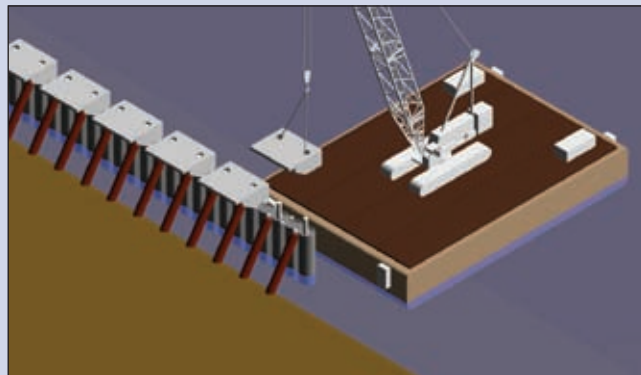
Client: U.S. Army Corps of Engineers, New Orleans District



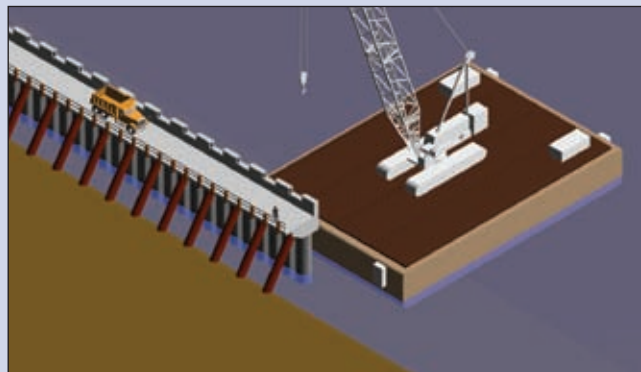
1. Installation of pipe piles from barge



2. Installation of batter piles



3. Installation of precast cap beam



4. Assembly of Precast Cap Segments on the Floodwall

Inner Harbor Navigation Canal

Lock Replacement in New Orleans



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Working with URS, Ben C. Gerwick, Inc. began the final design services for the Inner Harbor Navigation Canal (IHNC) Lock Replacement in New Orleans in 2002. The IHNC replacement lock will be a 110-foot wide lock with a chamber length of 1,200 feet, accommodating ship drafts up to 36 feet. Soft soils and space restrictions called for an innovative solution, using float-in concrete and in-the-wet construction that would address problems of the site without sacrificing safety or durability. This design involves the flotation and installation of the lock in five modules (two sector gate modules, GM1 and GM5, and three chamber modules, CM2, CM3, and CM4) which will be ballasted onto driven piles at the lock site.

Chamber Module Shell Description

Each of the chamber module shells (CM2 and CM4) that Gerwick focused on will have the following properties during transportation to the lock site:

- **Weight:** over 45,000 tons
- **Draft:** 25 feet 9 inches
- 322 feet long, 180 feet broad, and 58 feet (installed El. -52.0' to El. +6.0') deep

These parameters, similar to, though at a larger scale than Gerwick's work on Braddock Dam, are a testament to the foresight and planning of the client, the U.S. Army Corps of Engineers, New Orleans District.

Design Changes: Shallow, Deep, or Intermediate?

During the course of design, CM2 and CM4 underwent numerous changes. For a September 2004 study, Gerwick compared two options for shells constructed in the dry and floated to the lock site. The preferred, *shallow draft* option allowed the permanent shell, from reference elevation -52.0' to -19.75', to be floated to the site with an average draft of 21'-3"; this option required reusable, temporary steel bulkheads around the shell perimeter from reference El. -19.75' to El. +6.0'. The deep draft option allowed the full height shell (from El. -52.0' to El. +23.0') to be built in

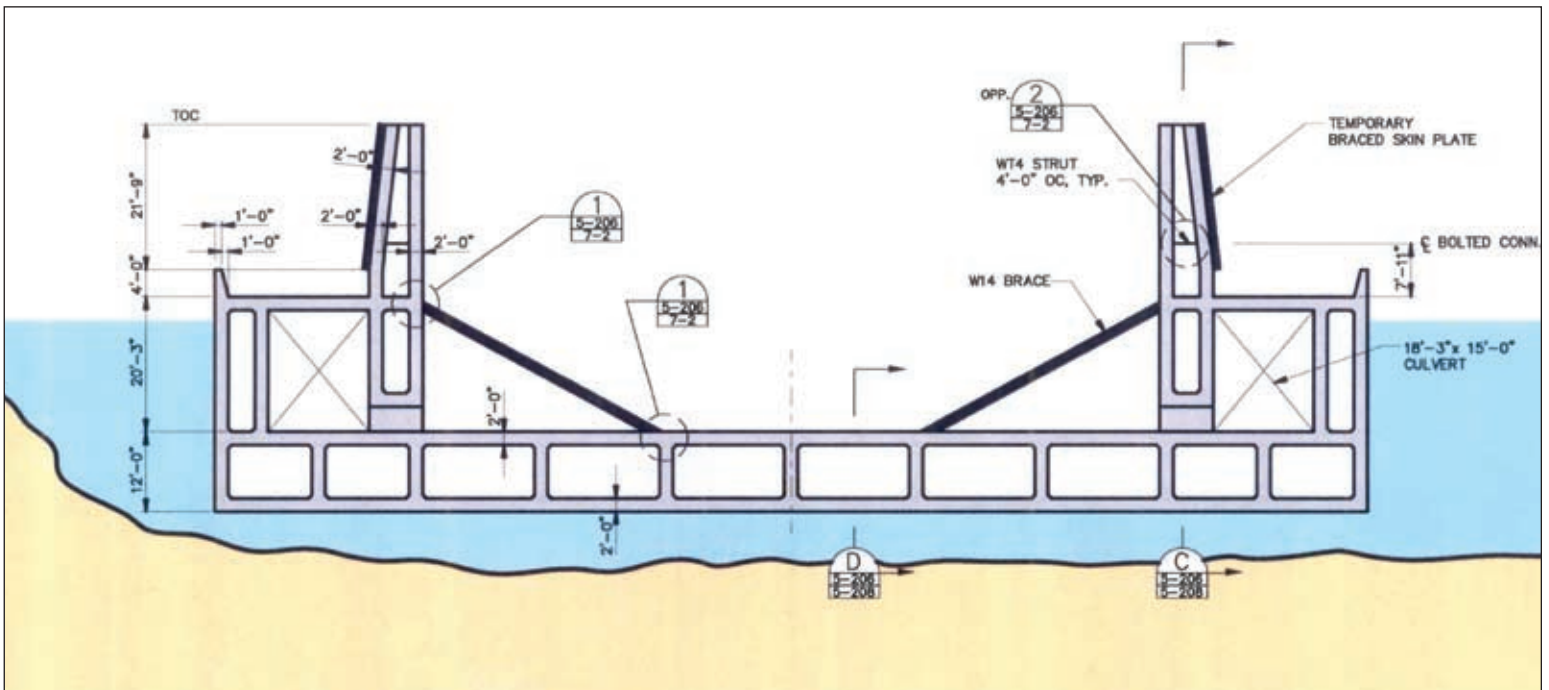


Figure 1 — The modified, shallow draft option that was carried through the DM-level Design

a deeper graving site, and then floated to the lock site with a 29'-10" draft. USACE N.O.D. selected the shallow draft option with modifications.

The *modified shallow draft* option (25'-9" draft) was developed for the Design Memorandum (DM)-level 100% submittal. Instead of full-perimeter, temporary, steel bulkheads to El. +6.0', the refined design relies, for the most part, on heavily-reinforced, slender, concrete walls that will be incorporated into the permanent structure. (See Figure 1.)

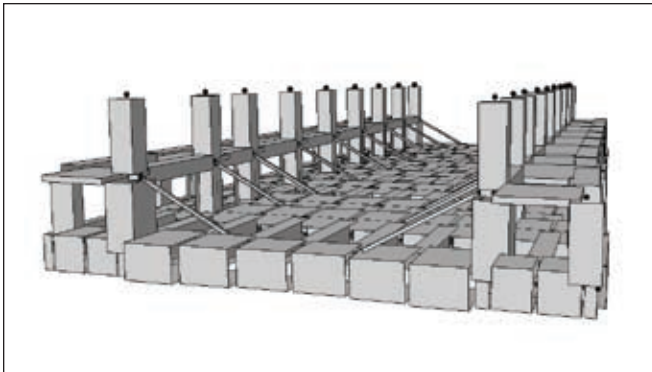


Figure 2 — Three-dimensional finite element frame model used for the floating shell analysis

The Flotation, Set-down, and Connection Process

The CM shells will be constructed out of reinforced concrete at a graving site away from the lock site. Internal compartments and temporary bulkheads and bracing, to block off the chamber space, will allow each shell to float when the graving site is intentionally flooded and opened to the waterway. Tugs will tow the shell to the lock site, passing beneath two bridges with limited clearances and drafts. The shell will be positioned over previously installed driven piles. Ballast concrete will then be placed in the dry, internal cells over the culverts, in the lock floor, and then in the lock walls. As the concrete filling proceeds, the draft of the CM shell will increase from 26 feet to 46 feet. Sand ballast will be added in the lock chamber to bring the shell into contact with landing piles and prevent it from re-floating if the water depth increases during construction (up to three feet). The CM will be attached to uplift-resisting tension piles, and three feet of concrete will be placed beneath the shell by tremie pipe, connecting it to the remaining piles. Lastly, the upper lock walls (from elevation +6'-0" to +23'-0") will be formed and cast in concrete, allowing the sand ballast and temporary bulkheads and bracing to be removed.

Services

The Inner Harbor Navigation Canal Ship Lock replacement included:

- 100% DM level Design drawings
- 3-D finite element modeling of the CM shells for construction stages including flotation, ballasting, and set-down with 1 1/2-foot, long-period waves
- naval architectural calculations of floating stability and trim
- the draft study report
- a report on the use of lightweight (controlled density or low density) concrete to reduce draft

Gerwick's focus was on controlling construction complexity and structural weight (hence draft), in a lower cost structure with superior durability.

A major challenge was fine-tuning the ballasting sequence (concrete fill and moist sand) to reduce stresses in the CM shells. As the shell hogged or sagged through major construction stages, analysis showed that its strength was adequate, but special attention to detailing was required to prevent cracking. Gerwick increased reinforcement and adjusted the ballast to prevent cracking, leakage, or durability problems.

Project Status

When Hurricane Katrina flooded New Orleans at the end of August 2005, the IHNC float-in lock replacement project was enjoined. At the end of October 2006, Gerwick made the DM-level Design 100% Drawing Submittal.