

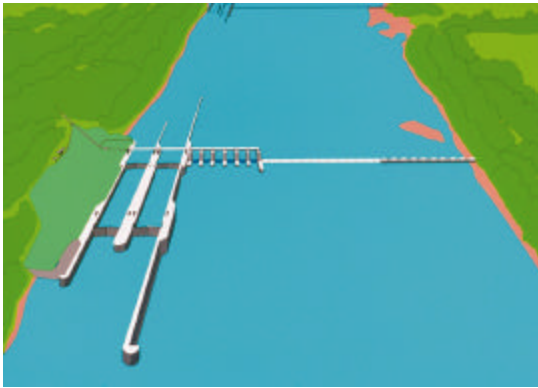
Pre-cast concrete applications for navigation dams and bridge piers

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Pre-cast concrete applications in marine construction of navigation dams and bridge piers have several advantages. Less disruption to navigation and water flow, lower cost of construction through the elimination of conventional large sheetpile cofferdams and site dewatering and shorter construction time by allowing concurrent construction of pre-cast segments and foundations. Less environmental impact by reducing dredging and elimination of site dewatering in addition to higher quality by allowing the use of pre-cast concrete produced in a controlled environment. Several recent examples demonstrate these advantages.

Olmsted Dam – Pre-cast Concrete Shells



The new Olmsted Dam on the Ohio River will be located near confluence with the Mississippi River.

It has an 800-ft. long tainter gate and a 1,400-ft. navigable pass section. Both sections use large-scale pre-cast concrete construction. The Olmsted Dam project is an engineering challenge for several reasons, including:

- Its proximity to the New Madrid fault system, which could impose an 8.4 Richter Scale seismic event on the structure,
- The river elevation typically will vary by approximately 30 ft. in a given year, and can vary by as much as 60 ft. in a hundred year period,
- The river discharge can exceed 950,000 cfs, and river velocities are controlled not only by river discharge but also by the uncontrolled downstream pool elevation,
- Geotechnically, the site has liquefiable soils, artesian water pressures and scour.



The design of the Olmsted Dam has completed the optimization study phase. We have in partnership with the United States Army Corps of Engineers, examined a variety of construction options, including:

- The use of a catamaran crane barge to lift-in 2,000 ton pre-cast

concrete shells onto a prepared bottom with pre-driven piles. Tremie concrete would then be used to integrate the shells with the piles to form a continuous dam and stilling basin. The Corps selected this option as the designated “In-the-Wet” construction alternative, after reviewing other innovative construction options including: a) float-in technology, b) braced cofferdam technology, and c) lift-in 800 ton pre-cast concrete shells.

- Three stages of cellular cofferdams for conventional “In-the-Dry” construction. The first stage would be built near the Kentucky shore to minimize disruption of barge traffic in the main channel near the Illinois shore. The second stage would be built near the locks on the Illinois shore in order to minimize scour impact on the lock. Finally, the third stage would be built mid-river and would tie into each of the previously built dam sections.
- The construction of a portion of the dam within a cellular cofferdam and a portion of the dam by the “In-the-Wet” method.

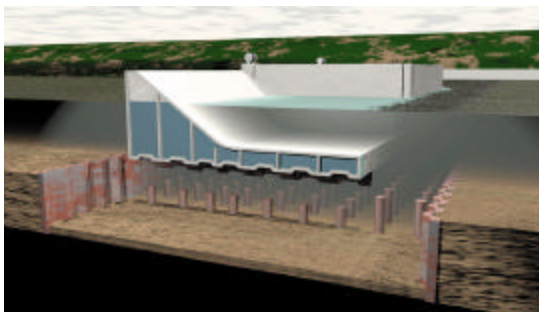
The goal of the pre-cast concrete application is to reduce the Government’s estimated construction cost range of \$300 to \$325 million by at least 15%.

Braddock Dam – Float-in Pre-cast Concrete Segments

We have designed a replacement for Dam #2 on the Monongahela River for the US Army Corps of Engineers by large-scale pre-cast concrete application “In-the-Wet”.

“In-the-Wet” construction methods use off-site prefabrication combined with lift-in or float-in of large precast segments onto pre-installed foundations. The segments are locked onto the foundation by under-base grouting and in filling of the segments with tremie concrete. Construction methods and procedures were developed for:

- Casting and launching of the pre-cast segments
- Transport, positioning and immersion of the segments on to the pre-installed foundations
- Under-base grouting and tremie in-fill of the segments



The new dam will be a 600-foot long structure with four gate bays. The “In-the-Wet” construction plan calls for breaking the dam into two segments of 333-foot and 265-foot. The segments will be constructed as closed bottom boxes in a two-level casting basin. The bottom of the boxes will be recessed for the installed foundation caissons.

As each segment is completed, it will be launched by flooding the basin and towed to the site for the final outfitting. It will then be positioned over the foundation caissons with a mooring system mounted on the segment. Each segment will then be ballasted down onto 6 landing caissons and leveled with flat jacks. The pile tops and under-base will be grouted, and 8-foot of tremie concrete will be placed in the segment. Each segment will then be de-watered and the remainder of the dam including tainter

gates will be completed in the dry. The final plans and specifications were completed in November of 1998. Construction is scheduled to start in the spring of 1999 and be completed in 2002.

Other Pre -cast Concrete Innovative Construction Initiatives on the Inland Waterways



The U.S. Army Corps of Engineers has initiated several other major lock and dam developments using “In-the-Wet” or “Offsite prefabrication” construction methods. These innovative methods all utilize pre-cast concrete modules into which underwater tremie concrete is placed without the use of conventional cofferdams.

As part of the Corps of Engineers’ innovative construction initiative, the U.S. Army Engineers Waterways Experiment Station (WES) launched a comprehensive research program on various offsite prefabrication construction technologies. As a part of the WES’s research effort, we have been undertaking

special assignments to perform studies on a number of technical subjects:

- Assessment of floating crane equipment and lift-in techniques for transporting and installing large pre-cast concrete segments – the study evaluates the cost, performance, suitability and availability of various overwater lifting equipment. The study also identifies and classifies the types of pre-cast concrete segments for lift-in construction in terms of their sizes, weights, configurations, and general characteristics for transportation and installation.
- Assessment of underwater concrete construction technologies – this investigation reviews the performance requirements of tremie concrete, production and placement methods and procedures.
- Review of pre-stressing concrete technology – historically, pre-stressed concrete has only had a limited use in inland waterways navigation structures. With offsite prefabrication construction methods it is perceived that the use of pre-stressing will increase. The relevant subjects include: the design criteria for the ultimate strength requirements, serviceability requirements, fatigue strength requirements and durability for offshore structures.

Richmond San -Rafael Bridge – Seismic Upgrading Using Pre -cast Concrete Segments



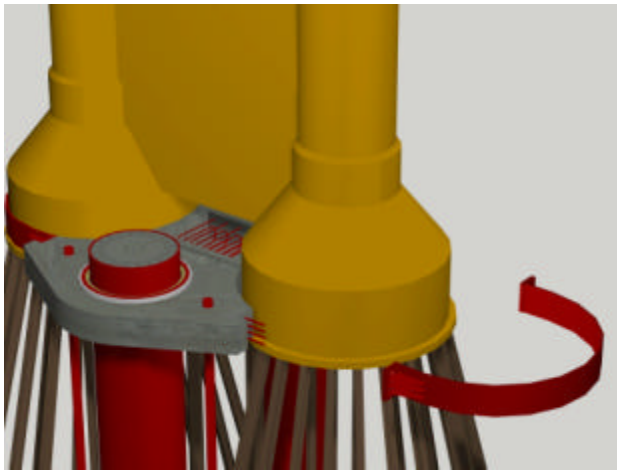
The 4.1 miles long Richmond-San Rafael Bridge, spanning across the northern part of the San Francisco Bay is one of six northern California toll bridges currently being seismically upgraded.

We are responsible for the final seismic retrofit design of the pile

foundations, concrete substructures and steel towers.

The existing concrete substructures consist of two or four concrete shafts interconnected by concrete spandrel beams and diaphragm walls. The concrete shafts are bell-shaped at the bottom to accommodate the large number of HP 14x89 steel piles, placed in concentric rings, which make up the underlying foundation. The two outer rows of steel piles are battered 3:12 and 2:12 respectively. Typical water depth is about 50 to 60 feet.

The existing pile foundations experience excessive horizontal displacement demands and will be strengthened by large diameter (10.5 feet to 13.5 feet in diameter) cast-in-steel-shell (CISS) concrete piling installed through new pre-cast concrete pile caps.



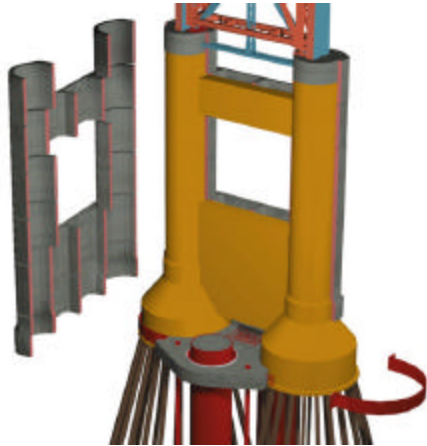
Laterally supported by the new large diameter piling the existing H-piles maintain their capability to carry overturning forces. The new pre-cast pile cap, through which the new pin-headed piling is driven, is decoupled from the existing foundation so that only horizontal forces are transferred between the new piling and as-built foundation.

This concept has a number of advantages:

- Complicated connections sixty feet below sea level between the new pile cap and existing bells are avoided;
- The thickness/mass of the pile cap is reduced and;
- Additional overturning demand on the battered H-piles is avoided.

The four-foot thick pre-cast pile cap comprises two identical halves with overlapping reinforcement extending from each half. The pre-cast pile cap halves are each supported by three 14 inches diameter steel pipe piles. Leveling plates with elastometric bearing pads are placed on top of the pipe piles and adjusted with shim plates to match the elevation of the existing bell foundations. Tremie concrete is placed in the reinforcement splice pocket to connect the oil cap halves monolithically.

Semi-circular steel casings are placed around each of the existing foundation bells and are connected by high strength rods embedded in the pre-cast pile cap. Elastometric bearing pads attached to the sides of the pre-cast pile cap combine with the steel casings to transfer lateral forces between the pile cap and existing foundation. The large diameter steel piles are placed and driven through an oversized steel reaction collar attached to the pre-cast pile cap. The steel reaction collar comprises two concentric circular steel plates separated by a strip of elastometric bearing pads.



As part of the project we developed a concept of using pre-cast concrete jackets to strengthen the existing concrete piers.

Unlike steel jackets, concrete jackets can be designed to resist corrosion in the aggressive tidal-splash zone for the remaining 100-year life expectancy of the bridge.

A concrete mix with a low water-cement ratio, fly ash, and moderate amounts of an active pozzolan was specified to allow the jackets to be constructed using a 2.5-inch minimum concrete cover with non-coated

reinforcement. The concrete in the splash and tidal zone will receive a polyurea coating. The reduced cover impedes micro cracking and reduces the weight of the jackets.

The concrete jackets will be match-cast horizontally in approximately 10-foot tall segments and placed around the existing shafts, spandrel beam and diaphragm wall in two halves, connected by transverse HS rods. HS rods will also connect the pre-cast segments vertically.

Two thirds of the pre-cast concrete jackets will be submerged under water when placed in their final position. The pre-cast jacket concept allows for a high degree of offsite prefabrication followed by in the wet erection with minimal use of divers.

An erection frame is placed on top of the existing shafts that allows two pre-cast segments to be placed on each side of the concrete substructure above water. HS rods are used to connect the segments on the outside of the shafts.

The segments are then lowered down making room for the next two segments to be placed. Prior to joining the segments an epoxy coating is placed on top of the match-cast surfaces. This can be done above water. The next two segments are then placed and bolted together on the outside of the shafts. Vertical HS rods are then placed in ducts and connected to the first segments through couplers. The vertical HS rods are then pre-stressed.

More segments can now be placed, bolted and stressed together until the entire pre-cast concrete jacket is lowered to its final position. The last items to be installed are the HS rods on the inside of the existing shafts, some of these penetrating the diaphragm wall below water. Divers will be required to assist in coring the holes through the diaphragm wall.

Bath-Woolwich Bridge – Pre-cast Concrete Footing Shells

Construction bridge foundations under water is an expensive operation and usually represents 40 to 50% of the total bridge cost. One way of reducing this cost is to perform as much of the foundation work as possible on shore by prefabrication and then floating (or lifting) completed elements into position. With this objective in

mind, we designed a floating cofferdam system for the Bath-Woolwich Bridge across the Kennebec River at Bath, Maine.

The design for the piers was based in using 8-foot diameter drilled shafts. A typical pier foundation will be located in 45 feet of water and will contain 4 drilled shafts supporting a 33-foot by 36-foot deep footing block with the top of the footing about 3 ft below low tide.

This design is very efficient because it significantly reduces the depth at which the footing is constructed. However, it does create the problem of how to construct an underwater footing suspended 28-feet off the river bottom.



In order to reduce the amount of work in the river, the following construction sequence was developed:

- Pre-install the drilled shafts using a two-stage template.
 - Construct a pre-cast concrete footing shell on shore and attach a temporary steel follower cofferdam.
- Launch the cofferdam and tow it to the bridge site.
 - Position the cofferdam over the drilled shafts fix it in position with 4 spud piles.
 - Lower the cofferdam down over the pre-installed drilled shafts with jacks located on top of the spud piles.
 - Lock the footing to the drilled shafts by placing 4-foot deep tremie seal.
 - De-water the cofferdam and construct the footing and pier shaft in the dry.
 - Flood and remove the follower cofferdam for reuse on the next pier.

This construction sequence minimized work in river and allowed the drilled shaft installation to proceed concurrently with the onshore fabrication and launch of the pre-cast concrete cofferdams.

Installation of the drilled shafts started in October 1997 and the first pre-cast footing shell with follower cofferdam was launched April 28, 1998. The bridge is scheduled to be completed in late 1999 or early 2000.