In-the-Wet Construction

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and

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(mistakenly not listed in WF29 report, he wrote this section of the report)

Ben C. Gerwick, Inc.

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In-the-Wet Construction

First used in the offshore oil industry and immersed tunnels

Immersed tube tunnels (Float-In)

Offshore drilling platforms (Float-In)

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In-the-Wet Construction
Also in bridge construction

Float-in Construction of Tacoma-Narrows Bridge Pier

Lift-in Construction of Confederation Bridge Deck

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What is "In-the-Wet" Construction?
An innovative method of prefabricating precast concrete (or steel) modules on land, transport and placing them in rivers as the in-situ form into which underwater concrete and mass concrete are directly placed. Therefore, a lock or a dam may be constructed without use of a cofferdam.

Float-In vs. Lift-In

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Why In-the-Wet Construction?

A Recent Development in Construction of Locks and Dams

- Minimizes impact to existing navigation traffic as much of the work is prefabricated off site and no cofferdam is required.
- Especially beneficial for expanding existing locks.

In-the-Wet Construction
Advantages of In-the-Wet Construction

Conventional Lock Construction with Cofferdam
- Risk of floods overtopping the cofferdam
- Risks of having severe scour and suspended sediments

Innovative Lock Construction without Cofferdam
- No Cofferdam leads to shortened On-Site construction schedule
- No Cofferdam results in cost and time savings
In-the-Wet Construction

Advantages of In-the-Wet Construction

- Maximize Off-site Fabrication
- Improve Quality Control of Concrete Elements
- Minimize Marine Work
- Cost Reduction

Greater Flexibility in Construction Process
- Off-season work - Schedule reduction On-Site

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In-the-Wet Construction

Disadvantages of In-the-Wet Construction

- In-the-Wet technology is relatively new so it lacks many “rules of thumb” of past experience.

- Many of the new details have to be developed by the designers or contractors; may require a steep learning curve for the first time users.

- There may be limited pool of available contractors.

- In-the-Wet technology may have less flexibility during construction.

- Particular attention needs to be paid to the connection and tolerances between each pre-constructed element.

- Since a cofferdam is not used the substructures or foundations are not visible.

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What is Float-in-Construction? 1/3

- Constructed in a dry dock or similar structure and floated to the construction site.
- The modules are usually thin-shell floating structures with internal ballasting compartments.
- Once the float-in modules are transported to and precisely positioned over the site, they are lowered down to a prepared foundation by means of ballasting.

Float-In Advantages 2/3

Float-in method has several major advantages over lift-in method:

- It avoids heavy lift equipment which sometimes represents a substantial portion of the project cost.
- The float-in modules can be made as large as practical without any concern for equipment capacity. Thus, it minimizes marine work and underwater joints.
- Use of large modules generally leads to shorter on-site construction time and lower cost.
Float-In Limitations

- The float-in constructability is severely limited by river conditions, such as draft and river flow velocity, 1-2 m/s.
- A launching system for loading out the float-in modules from a casting yard into river – A significant cost factor.
- A sophisticated positioning system and complex set-down process (e.g., ballasting/deballasting).
- Underwater tie-in of the float-in modules to their foundation may be complex.

In general, the float-in method is used effectively where the environmental constraints are not too severe, and the size and configurations of the prefabricated modules are favorable.

What is Lift-in Construction? 1/3

- Preferred where limited draft and higher river velocity.
- The prefabricated modules do not float. They are transported on barges and installed at project sites with heavy lift equipment.
- Auxiliary guiding systems (e.g. mooring and position guides) are often used in order to position the modules within acceptable tolerance.
Lift-In Advantages 2/3

- Since the lift-in modules are not required to float over water, their fabrication is substantially simpler than the float-in modules.
- Lift-in construction is largely independent of river level - draft, but is constrained by river flow velocity, with a normal upper limit of 2 to 3 meters per second.

Lift-in Limitations 3/3

- The size and configuration of lift-in modules is limited by availability of heavy lift equipment in the local region.
- Cost of heavy lift equipment and equipment utilization rate.
- Smaller modules - Underwater joining of multiple lift-in modules is complex and costly.
Examples of Innovative In-the-Wet Projects

Greenup Float-In

The Greenup plan of improvement includes a 183 m (600 ft) extension of the existing 183 m (600 ft) auxiliary lock to provide an overall length of 366 m (1200 ft), extension of the lock approach walls, filling and emptying system improvements, installation of a miter gate quick change out system for faster repairs to the lock miter gates and environmental mitigation. Extension of the auxiliary lock will be accomplished by lengthening the lock chamber with float-in concrete sections. This technique will utilize a dry dock at R.C. Byrd Locks and Dam to construct a concrete shell base raft. After the base raft is complete, the raft will be floated to a fit-out area at Greenup Locks and Dam where the walls are constructed on the base raft. The structure is then transported, positioned, and ballasted so that it will sink to its final position.

Areas of Innovation

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<tr>
<th>Hydraulic</th>
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<th>Environ</th>
<th>Design / Construct</th>
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Lock Dimensions

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<td>Length</td>
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<td>Width</td>
<td>33.5 m</td>
<td>Depth</td>
<td>4.6 m</td>
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J.T. Meyers – Float-In

This project extends an existing lock from 34 m to 366 m using float-in construction for the approach walls and supplemental thru sill filling system for newly extended chamber.

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<tr>
<td>366 m</td>
<td>5.5 m</td>
<td>34 m</td>
<td>4.9 m</td>
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Olmsted Lock and Dam – Floating Walls

Expensive and deep foundations, high seismic design loads, large water level fluctuations and heavy bed loads provided an impetus to develop a floating solution for the Olmsted Approach walls. A floating structure that is only anchored at each end instead of continuously or intermediately along the length as is typical for fixed structures would meet this goal. A structure that floats would also never be submerged; thus eliminating the requirement to wash mud from the structure.

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<tr>
<td>366 m</td>
<td>7.9 m</td>
<td>33.5 m</td>
<td>12.5 m</td>
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Kentucky Lock – Float-In

This project adds a new 366 m chamber adjacent to an existing 183 m chamber. Construction utilizes an innovative float-in cofferdam.

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<td>366 m</td>
<td>17.4 m</td>
<td>34 m</td>
<td>5.2 m</td>
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An integrated cofferdam into monolithic construction

Charleroi - Lift-In

Replacement and expansion of existing 17 m x 220 m and 17 m x 110 m locks with two new lock chambers, each 26 m x 220 m, done while maintaining traffic through the locks. Two innovative features highlighted:

Jump-form Construction

Local Cofferboxes

Internally braced local cofferboxes will be used to construct many of the lock wall monoliths. The cofferboxes will be used to dewater local areas for conventional construction of these lock monoliths.

The cofferboxes will be composed of HZ kin piles, AZ sheet piling, internal bracing and a tremie concrete seal.

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<tr>
<td>220 m</td>
<td>6 m</td>
<td>26 m</td>
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Caisson Method (7-01)

*While technically not In-the-Wet, it is built without a cofferdam. The lock chamber is constructed on the ground surface.*

When complete, the soil is removed beneath the lock chamber and it is lowered into its final position.

Lith (7-02)

*A new lock chamber built to replace a small existing lock. The lock chamber is built on the ground surface and the ground beneath is then removed to lower the chamber to its final elevation.*

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<td>200 m</td>
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<td>18.5 m</td>
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Two Examples of Float-In and Lift-In with More Detail

Braddock Float-In

Chickamauga Lift-In

Innovations in the Braddock Dam Design

- Two 11,000 tons precast concrete float-in segments
- A unique two-stage cast & launch system for two segments
- Tow the segments 27 miles to the site through two locks
- A unique positioning system to install the float-in segments on site to a tolerance of 50 mm
- A high performance underwater grouting and tremie concrete
Construction Sequence

- Precast Dam Segment
- Tow the Dam segment to the site and Position it over Drilled Shafts
- Ballast down the segment and place underbase grout
- Place tremie concrete
- Dewater the dam segment and place concrete infill

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Prefabrication and Outfitting

Towing the Segment 42 km from the fabrication to the lock/dam site

Leetsdale (Fabrication Site)

Braddock L/D

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Installation of Segment 1 on June 18, 2002

Positioning the Segment
- Mooring Anchors and Winches
- Horn Guides
- Hydraulic Rams
- Flat Jacks on Top of Drilled Shafts

Foundation

Set-down Operations
- Sequential Ballasting and De-ballasting
- Grouting of the Shear Pin Connection on Top of Drilled Shafts

Underwater Grouting and Tremie Concrete Seal

Placing 10,500 m³ Mass Tremie Concrete and 8,000 m³ Concrete Fill within the Float-in Segments

Grouting the Foundation 2000 m³ Of Underbase Grout under Water

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Pier Construction and Gate Installation

In-the-Wet Construction

Project Completion - August 2004
Lift-In Construction

Chickamauga (11-03)

Lock renovation and expansion using lift-in construction techniques to work with difficult geological conditions and to maintain operation during construction.

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Lock Dimensions

- Length: 183 m
- Lift: 14.8 m
- Width: 34 m
- Depth: 5.7 m

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In-the-Wet Construction

The Old and New Chickamauga Locks

- The Old Lock is plagued with AAR and scheduled for demolition by 2014.
- The New Lock is located downstream of the Chickamauga Dam Spillway and adjacent to the old lock.

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Project Challenges with Landward Cofferdam

- Maintain Navigation During Lock Construction
- Limited Width for Cofferdam – Stability of Cells
- Difficult Geologic Conditions

Sloping Rock Formations
Embedded Clay Seams
Solution Cavities

Innovative Lift-in Cofferdam Design

- In-the-Wet Construction of the Segmental Cofferdam
- In-the-Dry Construction of the Integral Lock Wall
In-the-Wet Construction

Advantages of the Segmental Lift-in Construction of Chickamauga Lock Cofferdam and Lock Wall

• Cofferdam stability with limited width and under Complex and Uncertain Geologic Conditions
• Navigation traffic during construction of the new lock
• No Landward Cofferdam Demolition
• Less Rock Excavation
• Little adverse environmental impact
• Cost Savings

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Drilled Shaft Installation and Testing Under Water

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A typical Box Cofferdam Segment is 16-m by 14-m by 7-m in size

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Towing a Lift-in Cofferdam Box Segment to the Site

Positioning and Jacking the Box Segment

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Place Tremie Concrete Seal

Dewater The Box Cofferdam

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Placing Tremie Concrete Infill and Grouting the Foundation

Completion of the Cofferdam by 3/2010

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Comparison with Conventional Methods

• Many engineering solutions for the innovative in-the-wet construction have to be identified, evaluated, and carefully developed from concepts to details.
• In some cases, it is advantageous to combine the conventional method and the innovative In-the-Wet method in the same project and take advantage of both methods to deal with the risks and complexity in various parts of the project.

In-the-Wet Construction

Conclusions

• The in-the-wet construction method, in many cases, has demonstrated significant advantages over the conventional cofferdam method.
• The float-in construction is preferred when the environmental/river conditions are not restrictive.
• The float-in is preferred when the casting/launching systems are available and economical, and structural size/configuration are favorable.
Conclusions (Cont.)

• The lift-in construction is preferred when lift equipment is available to install a large number of prefabricated modules.
• The lift-in is preferred where environmental and river conditions impose severe restrictions on the float-in construction.
• The in-the-wet method may be combined with the conventional method to take advantage of both methods to deal with the risks and complexity in a project.

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