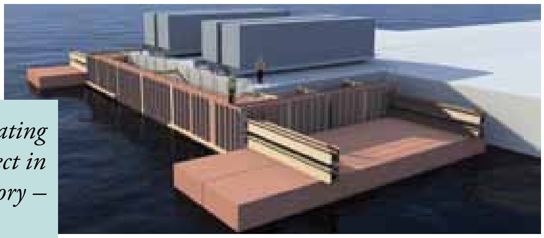
Floating Cofferdam for Repair of the Washington SR-520 Floating Replacement Bridge



By Hamid Fatehi, P.E., S.E.

COWI (formerly Ben C. Gerwick Inc.) was an Outstanding Award Winner for the Floating Cofferdam for Repair of the Washington State SR-520 Floating Replacement Bridge project in the 2014 NCSEA Annual Excellence in Structural Engineering awards program (Category – New Bridges and Transportation Structures).

The SR 520 Bridge crosses Lake Washington, linking Seattle and its neighboring cities to the East. The floating section of the bridge is more than 1.4 miles long, making it the longest floating bridge in the world. Afloat for more than 50 years, the four-lane bridge is often clogged by traffic and vulnerable to storms. The State of Washington is replacing the bridge with a new six-lane floating bridge, which includes 21 longitudinal concrete pontoons. Each longitudinal pontoon is approximately at 75 feet wide, 360 feet long and 28 feet tall. The first phase of cast-in-place in-the-yard construction resulted in structural cracking at the ends of four concrete pontoons due to design error. Following discovery of the cracking, COWI (formerly Ben C. Gerwick Inc.) was retained by Kiewit/General/Manson, a Joint Venture (KGM is the design-build contractor building and assembling the replacement bridge) to develop a repair plan that ensures that the bridge will meet the performance requirements. COWI's repair plan consists of multiple repair measures including crack injections with epoxy, transverse post-tensioning, waterproofing membrane, and carbon-fiber reinforced plastic wrap. A floating steel cofferdam was built to allow the repair work to be completed for the floating pontoons in a dry environment. As a design consultant to KGM, COWI completed the design of the cofferdam.

Design Innovations

The cofferdam weighs approximately 600 tons and is 96 feet wide, 44 feet long and 35.5 feet tall. The cofferdam design includes many innovative features in order to meet the project requirements such as safety, operability, watertightness, and adequate contingency. Features include:

- As a one-of-a-kind floating dry dock, the cofferdam has a highly asymmetric layout. The design includes ballast tanks that are strategically located inside the cofferdam so that the center of gravity aligns with the center of buoyancy.
- The ballast tanks and floating tanks are integrated into the structural framings of the cofferdam, which helps to achieve structural efficiency and substantial cost saving.
- An elaborate seal system was developed to ensure a complete watertight seal of the cofferdam, and to create a dry work environment for the pontoon repair inside the cofferdam at 26 feet below the lake water surface.
- Two hydraulically activated sliding gates are provided to enclose the sides of the cofferdam. The sliding gates are 26.5 feet tall and slide on UHMW bearing pads.
- Seven steel trusses are attached to the bottom of the cofferdam in order to provide its required strength. The cofferdam can be quickly raised vertically by picking up the trusses with a hydraulic jack system attached to flexifloats.
- Once the cofferdam is installed, it is subjected to buoyancy of 6,400 kips and must withstand a 5-year storm. The hydraulic pressures are transmitted to the pontoon through 18 hydraulic rams. Several three-dimensional finite element models of the cofferdam, bridge pontoons and launching barge were created to analyze the load effects for (1) the cofferdam operations and installation, (2) launching off a barge in a sideway manner, and (3) emergency removal of the cofferdam in case of an accident.

Fabrication and Launch

The cofferdam was assembled on the floating barge equipped with cofferdam supporting frames and a launch system. The launch rail system consisted of two steel wide-flange rocker beams with pins and hydraulic jacks to conduct a side launch from the barge.

After the cofferdam was assembled on the barge, it was towed through the Ballard Locks to Lake Washington. On November 26, 2013, the cofferdam was launched sideways off the barge into the lake. Hydraulic jacks pushed the cofferdam across the barge and onto two rocker beams. As the cofferdam passed beyond the pin of the rocker beam, the rocker beams rotated about a hinged connection and allowed the cofferdam to slide into the lake. A ballasting sequence and plan for the barge at different stages of the launching process were developed by performing floating stability analysis.

Cofferdam Installation

The cofferdam installation process starts with adding ballast water to the ballast tanks to increase its submergence so that it could float underneath the bridge pontoon with adequate underkeel clearance. A hydraulic jacking system reacting on two flexifloat assemblies was used to pull the cofferdam vertically into direct contact with the bridge pontoon and to compress the perimeter rubber seal of the cofferdam. Two sliding gates were moved by hydraulic jacks to close side openings between the cofferdam and the bridge pontoon. This resulted in an enclosure that allows for dewatering of the cofferdam. Water from the cofferdam was pumped into ballast tanks and Baker tanks on the top deck of the bridge pontoon, allowing the floating cofferdam and the bridge pontoon to stay level.

Summary

Up against a tight schedule, the designer and contractor completed the design and construction of the cofferdam within 8 months. The design and construction were fully integrated in a design-build process and underwent progressive review and check by the Owner, WSDOT. Close collaboration among the designer, the contractor, and the Owner was the key to the project success.▪

*Hamid Fatehi is Chief Project Manager at COWI Marine, Oakland, CA. He can be reached at **hmdf@cowi.com**.*