Changing **Some History**

By James Weaver, P.E.

Photo provided by Figg Bridge Engineers

Penobscot Narrows Bridge and Observatory replaces historic Waldo-Hancock bridge in Maine

Since 1931, all traffic heading up US Route 1 along the coast of Maine has crossed the historic Waldo-Hancock suspension bridge to access the colorful Down East Maine communities of Bar Harbor, Blue Hill, Castine, and Eastport. The deck of the narrow, two-lane, steel bridge soared over the Penobscot River, providing views of the Civil War-era Fort Knox and the town of Bucksport to the north, and Penobscot Bay to the south.

During the spring of 2003, the idyllic scene from the bridge was interrupted by engineers and contractors checking the condition of the main suspension cables. They found that the 75-year-old cables were far more severely deteriorated than believed, jeopardizing the integrity and safety of the bridge. The bridge was posted and access was denied for vehicles weighing over 24,000 pounds until viable stabilization and remedial repair options could be provided. An immediate decision was made to replace the bridge with a new, modern structure while a stabilization contract was undertaken to strengthen the main cables until a new bridge would be completed.

The Maine Department of Transportation (MaineDOT) selected Figg Bridge Engineers (FIGG) to design the replacement bridge. The time that it would take to design and build a replacement bridge was critical, since structural analyses indicated that the cable stabilization measures undertaken in 2003 would have a limited service life. The location of the new bridge is parallel to and immediately downstream of the existing bridge, and it was decided that the new bridge foundations would be located outside the limits of the Penobscot River to eliminate time-consuming permitting issues.

"Initially, we were concerned about the installed integrity and capacity of a large pile group. Difficult driving was anticipated due to the presence of cobbles and boulders, and there was uncertainty as to whether dynamic pile testing would detect damage at the pile toe," says Laura Krusinski, P.E., senior geotechnical engineer in MaineDOT's Bridge Program.

Photo provided by Cianbro

During the spring of 2003 , the idyllic scene from the bridge was interrupted by engineers and contractors checking the condition of the main suspension cables. They found that the 75-year-old cables were far more severely deteriorated than believed, jeopardizing the integrity and safety of the bridge.

The Project Begins

To replace the aging Waldo-Hancock Bridge, the design MaineDOT selected was a 2,120-foot long, cable-stayed, concrete structure supported by two obelisk-shaped pylons and abutments. "Since a new structure was quickly needed, a unique 'Owner Facilitated Design-Build' method of contract execution was tendered," says Christopher Burgess, P.E., S.E., Principal Bridge Engineer for FIGG. FIGG, headquartered in Tallahassee, Florida, designed the bridge, and also provided construction engineering services, and on-site technical assistance. A Maine-based joint venture of Cianbro/Reed&Reed, LLC was hired to build the bridge, bringing a combined work force with the resources, expertise and will to work collaboratively with the department and the design team.

Project Concerns

The Portland, Maine office of Haley & Aldrich served as the geotechnical consultant for the design team to address the variable and complex subsurface conditions along the bridge alignment. Bedrock is at and near the ground surface on the western side of the Penobscot River in Prospect, but extends to depths on the order of 100 feet on the eastern side on Verona Island, requiring a combination of foundations. The Prospect Pylon is supported on a reinforced concrete mat foundation bearing directly on a prepared bedrock surface, and the Verona Island Pylon needed deep foundations to support the bridge loads.

The Verona Island Pylon was originally designed to be supported on six foot-diameter, drilled shafts socketed 15 feet into bedrock. However, the Cianbro/Reed&Reed team proposed to support the pylon on high-capacity, steel H-section piles driven through dense glacial till soils to bearing in/on the underlying bedrock. They believed that the work could be done more quickly and more cost effectively with piles verses drilled shafts. Furthermore, Cianbro/Reed&Reed could do the work using their own experienced pile drivers.

MaineDOT and the design team had concerns regarding the practicability of driving 60 to 80-foot-long, closely spaced piles though dense granular soils containing cobbles and boulders up to three feet in diameter. “Initially, we were concerned about the installed integrity and capacity of a large pile group,” says Laura Krusinski, P.E., senior geotechnical engineer in MaineDOT’s Bridge Program. “Difficult driving was anticipated due to the presence of cobbles and boulders, and there was uncertainty as to whether dynamic pile testing would detect damage at the pile toe. This would be complicated by densification if the pile spacing dropped to 2.5D, as was planned. Furthermore, obstructions could twist and deflect piles to the path of least resistance, and this type of damage would be undetectable. Ultimately, we determined the risks to be within acceptable limits once a prudent design approach and a rigorous pile testing and quality control program were developed.”

Creating a new design

In a supplemental engineering analysis, MaineDOT, the design team and contractor, devised a pile foundation design that would help assure installation of a safe and stable pile foundation. The new design called for the installation of 288 HP14X117 steel H-section piles fitted with cast steel tips and having a design capacity of 215 tons (430 kips). Before the start of production pile driving, 12 piles were dynamically tested, including restrike and CAPWAP. Cianbro/Reed&Reed hired GRL Engineers, Inc. to conduct the dynamic pile testing, and MaineDOT provided full-time pile installation monitoring. No static load tests were conducted as the results of the dynamic load testing demonstrated that the piles could be installed to the required capacity without overstress.

Pile driving began in December 2003, with piles driven with a Delmag D62-22 single-acting diesel hammer with a maximum rated energy of 164,600 foot-pounds. The driving records for the production piles were consistent with the records of the test piles. During design it was estimated that the driven pile lengths would be on the order of 70 to 110 feet for a total estimate of 24,900 linear feet, and that the piles would be driven to practicable refusal in/on bedrock. The actual driven pile lengths ranged from 59 to 100 feet with an aggregate pile length of 20,700 linear feet. Based on the driving records, it was apparent that the piles developed the minimum ultimate capacity (950 kips at the required penetration resistance of six to nine blows per inch) in the glacial till.

Approximately four percent of the piles, distributed throughout the plan area of the foundation limits, were judged to have been damaged or impacted by the presence of cobbles or boulders in the glacial till. In the post-pile installation evaluation, FIGG concluded that the damaged/impacted piles did not affect the overall capacity of the foundation, and therefore no replacement piles were required.

Pile installation at the Verona Pylon was completed in March 2004, and the bridge superstructure was completed in the fall of 2006 at a construction cost of about $68.8 million. The timely installation of the pile foundation supporting the Verona Island Pylon was a critical element in allowing the replacement bridge to be designed and constructed in less than three and a half years. The aesthetically dramatic Penobscot Narrows Bridge and Observatory was opened to traffic in December 2006. ▼

Photo provided by Kevin Bennett