Maine's First Cable-Stayed Bridge

Advancing Technology for Cable Durability

By Thomas A. Doe, P.E., Christopher J. Burgess, P.E., S.E., Kaven Philbrook and Andrew Hauter

The original Waldo-Hancock Bridge stood watch over the town of Bucksport, Maine for 74 years. The steel suspension bridge provided safe passage along Maine's famed Route #1, carrying carloads of tourists through the years, in addition to significant commercial traffic related to regional paper-making, granite-quarrying, boat building, manufactured housing production and a host of freight items, such as delivery of home heating oil. Scheduled renovation work on the bridge began in 2002 and, in the summer of 2003, the main suspension cables were unwrapped to prepare for a visual inspection of the individual wires in the 37 cables that comprise each main cable. Deterioration of the main cable on the south side of the bridge was much more advanced than expected, leading Maine Department of Transportation to simultaneously undertake a strengthening project on the Waldo-Hancock Bridge and the design of a new bridge on a parallel alignment to the existing bridge.

In December of 2003, ground was broken for a new cable-supported bridge, as the design rapidly proceeded under an innovative owner-facilitated design/build process. The new bridge will be Maine's first cable-stayed bridge and utilizes cast-in-place concrete. A key element in the design of the new bridge, now scheduled to open to traffic in the fall of 2006, is the considerable attention and effort invested to provide a structure that will be durable and easy to maintain during its planned service life (to exceed 100 years). The bridge will be the first to utilize a unique combination of features designed specifically to protect the bridge and only the second to benefit from a pioneering cradle system, developed and patented by the bridge's designer.

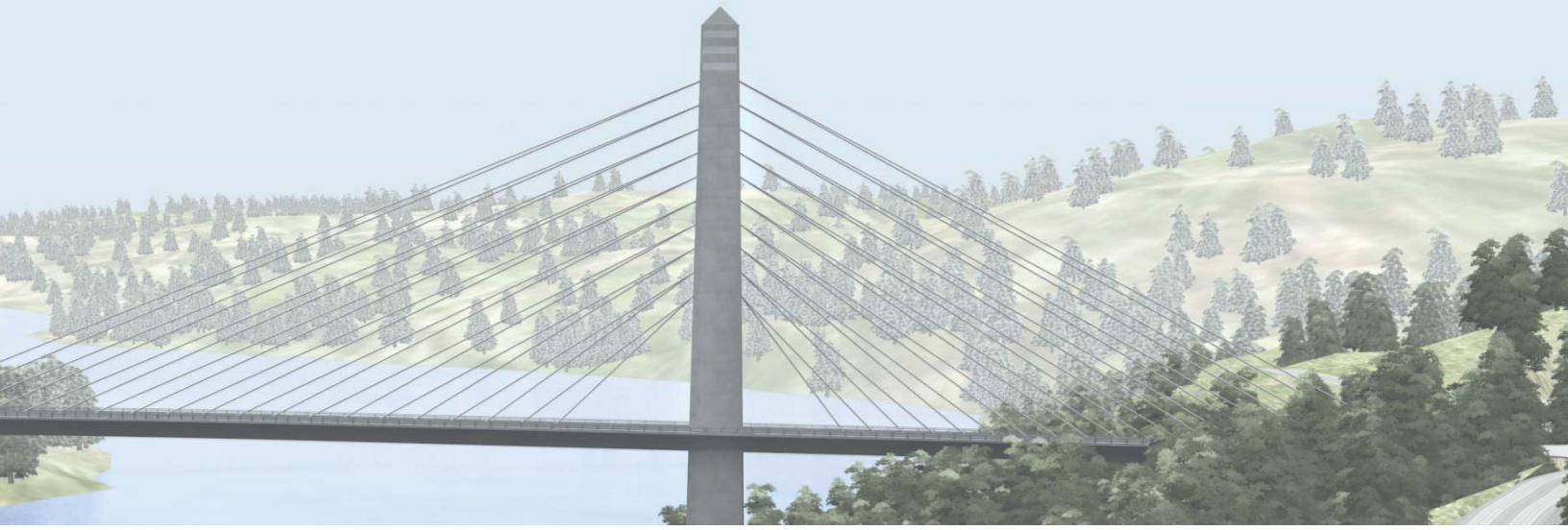
An innovative nitrogen gas protection and monitoring system will provide an enclosed environment of pressurized inert gas around each cable stay. The main components of the system are the gas, HDPE sheathing, reservoir tanks, anchorage-sealing caps and monitoring hardware. Nitrogen gas was selected based on its non-corrosive properties and ease of availability. An environment of pressurized pure nitrogen essentially eliminates oxygen, chlorides and moisture, all potentially corrosive elements.

The primary goal was to cost-effectively create a gas-tight sealed system that completely encloses the stays. After installation of each stay, it will be purged of moisture. Once dry, the existing air will be purged from the system by the injection of nitrogen gas. The purging process will be monitored to insure that only nitrogen gas is present. When the nitrogen is placed in the system, it will be pressurized to a value of two pounds per square inch.

A sealing cap covers the strand tails at each anchorage and fully encapsulates all anchorage hardware. A clear end plate allows direct visual inspection of the anchor area. Each stay will contain a 300 cubic foot nitrogen gas reservoir that will recharge the gas in the event of a drop in pressure. A gauge will record all fluctuations in pressure, and serve as a tool for the Department to easily monitor the status of the system and take corrective action if necessary. The annular space between the cable stay strand and the cradle sleeves allows gas to flow freely through the stay system in an isolated environment.

The stay cable gas protection system utilized in the new Penobscot River Bridge is a world first, to the best of our knowledge. This unique system will provide two additional layers of protection by completely surrounding the stays with an inert gas, and secondly, through automatic and continual monitoring of the gas pressure level. Monitoring will allow the Maine Department of Transportation real-

Rendering of the 1160 foot cable-stayed main span of the Penobscot River Bridge that will carry Route 1 along the Main coastline and is located adjacent to historic Fort Knox near Bucksport, Maine. The western pylon will feature a multi-level observatory that will be open to the public.



time knowledge of any potential compromise of the system. Four levels of protection are provided to assure redundancy for the stay cable system:

- Epoxy coating on the stay strands
- Outer layer of HDPE sheathing around the stays
- System filled with nitrogen gas to purge potential corrosives, and
- Sealed system with monitoring equipment.

This proactive approach will allow maintenance crews to identify and address potential concerns in the future, at an early stage.

An additional monitoring tool for the Penobscot River Bridge is a series of force monitoring systems on each stay. Dywidag Systems International is providing the force monitoring systems, which can accurately determine the force within 1% using a portable field laptop unit. The system is very rugged, requires no maintenance, has no moving parts and will provide monitoring throughout the projected service life of the bridge, allowing Department employees ease in regularly monitoring the forces in the cable as part of their inspection procedures, without the need for lift-off equipment or the utilization of special expensive techniques such as vibration measurements. With this monitoring system, the force in the cable may be obtained in minutes without any interference with the traffic on the bridge. The leads from the sensors are placed in a gas tight box located inside the box girder just under the cable anchorage, maintaining the integrity of the sealed gas monitoring system.

As previously mentioned, the new bridge design also includes the use of a cable-stay cradle system (U.S. Patent No. 6,880,193) designed by FIGG, the engineer of record for the project. This is the second installation of the cradle system that allows for the use of a continuous cable stay from bridge deck to bridge deck, carrying the stay through a stainless steel sleeve in the cradle assembly. The individual sleeves increase durability by protecting the strands and eliminating strand-to-strand contact. The cradle system also eliminates anchorages in the pylon, reduced tensile forces in the pylon and more streamlined pylon dimensions. Any given strand may be removed, inspected and replaced with a new strand at selected intervals to verify the condition of the stays, without compromising the bridge's integrity. The first cradles were positioned in the seventh lift on each of the pylons on July 18th, 2005. After the successful pours in each of the lifts, Kaven Philbrook, project manager for the contracting team said, "Working with FIGG, DSI and Maine DOT on the construction engineering methods for the erection and correct alignment adjustments for the cradles proved to be a huge success."

The proactive and pioneering approaches that the Maine Department of Transportation has encouraged for the Penobscot River Crossing Bridge cable stay system advance the standards for future cable-stayed bridge designs. There will be opportunities to analyze and evaluate the monitoring records from this stay system, resulting in further advancements in industry understanding of cable-stay bridge performance and enhanced long term durability. The beauty and durability of the new bridge will benefit many generations by providing safe passage over the Penobscot River narrows, while visitors and residents enjoy views from the multi-story observatory that will be located at the top of the western pylon. Maine Department of Transportation and the design-build team have created a landmark that will endure well into the 22nd century.▪

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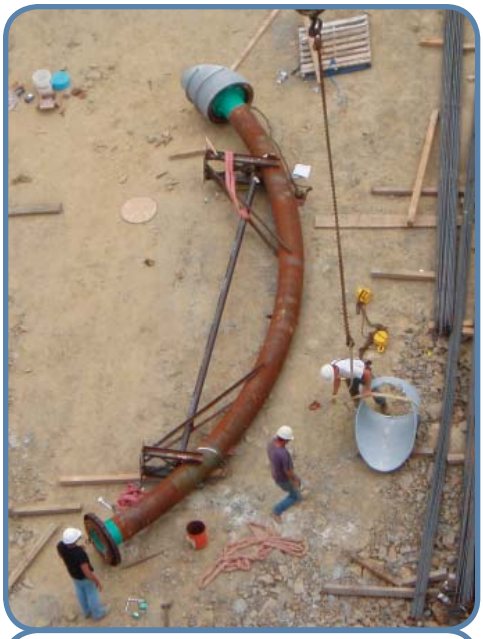
The western pylon, adjacent to the Fort, is being cast in 16 lifts from deck level to the base of the public observatory, located at elevation 389 feet.

The first two cradles were positioned in the seventh lift on each of the pylons on July 18th, 2005.

Thomas A. Doe, P.E., Project Manager, Maine Department of Transportation, is a life long employee of the Maine Department of Transportation. Tom is focused on providing Maine with a safe, attractive and state-of-the art bridge that is well constructed. Christopher J. Burgess, P.E., S.E., Principal Bridge Engineer, FIGG, led the technical focus throughout the design and construction of the bridge. He is on site for the construction of the project, working closely with Maine Department of Transportation and the contracting partners. Kaven Philbrook, Project Manager, for the Cianbro/Reed & Reed contracting team on this project and has more than 25 years of construction engineering experience with Cianbro. Andrew Hauter, Project Manager, Dywidag Systems International, is serving as the project manager for the post-tensioning and cable stay system supplier on this project. He is a member of the PTI Stay Cable Materials Committee.

A "cheese plate" at each end of the cradle accommodates the individual strands for each cable stay. The stays range from 41 to 72 strands on the Penobscot River Bridge. FIGG holds U.S. Patent 6,880,193 on the cradle system.



Workers complete assembly of the first cradle prior to installation during the seventh lift on each of the two pylons. Cradle #1 has a total length of 34 feet 4 inches, outside diameter of 16 inches, and will carry 41 strands and weighs approximately 9,000 pounds.

Design Team

Owner – Maine Department of Transportation
Engineer of Record – FIGG
Contracting Team – Cianbro Corporation, Reed & Reed LLC
Cable Stay System Supplier – Dywidag Systems International