STATE

MAINE

New girder shapes, delivery methods spur new concrete techniques

by Wayne Frankenhauser Jr. and Michael Wight, Maine Department of Transportation

The 1610-ft-long Veterans Memorial Bridge, at a cost of $44.2 million, is the largest design-build project completed in Maine. Photo: Kimberly Brooks, T.Y. Lin.

Concrete bridges have a long history in Maine, and concrete bridges will continue to be built in the future because of new girder shapes, delivery methods, concrete technology, and erection methods that are being introduced. In many cases, these innovations make a major difference in cost, speed, or longevity.

Overall, the Maine Department of Transportation (MaineDOT) is responsible for 3700 bridges and minor spans, with total responsibility for about 2000 bridges and 800 minor spans. The rest have shared responsibility, including about 170 bridges overseen by the Maine Turnpike Authority. Approximately 45% of state-owned bridges are made with concrete.

Historically, there have been a tremendous number of concrete structures built in Maine. Concrete slab and tee beam bridges dominated construction until World War II, and concrete bridges continue to be a major design option. A key design consideration in Maine is the number of salt-water and fresh-water crossings where the bridge superstructure is very close to the water. Concrete is the material of choice because it performs well in these environments, and does not require costly coating systems.

Another factor when selecting materials for bridges is Maine's climate. There are frequent freezing and thawing cycles in the winter and spring, and the state uses lots of deicing chemicals to keep roads safe. This environment can be extremely harsh on bridges with elements exposed to salt spray from passing vehicles.

Extending Service Life

These factors inhibit Maine's goal of achieving a 100-year service life for its bridges, which is a high priority for MaineDOT. Teams often struggle to reach this goal, but are finding more techniques, in both materials and design details, to achieve it. Techniques that are proving valuable include high-performance concrete with low permeability and the use of corrosion-resistant reinforcement and strand such as epoxy-coated, glass fiber-reinforced polymer, carbon fiber-reinforced polymer, stainless steel, and dual-coated steel systems. These alternatives do not represent wholesale changes, but offer new approaches to details that can provide significant longevity, durability, and strength.

Strength is critical because it allows longer span lengths which can eliminate piers and joints. Eliminating joints offers a major way to prevent moisture penetration from becoming an issue, and Maine is working on more designs that take this approach.

As span techniques change, Maine is using more prestressed or post-tensioned precast concrete girders, such as box beams and segmental construction. For bridge spans less than 100 ft long, a precast concrete design is typically used, but this length has been increasing as more options are available.

NEXT, NEBT Benefits

Two innovative shapes helping Maine achieve its goals are the New England bulb-tee (NEBT) and New England extreme tee (NEXT) beams. Developed in conjunction with the Precast/Prestressed Concrete Institute's Northeast regional chapter, these girder shapes have achieved tremendous buy-in from local designers and contractors owing to the added benefits they provide. Their shapes help eliminate steps in the construction process; thereby speeding construction. Maine has become quite familiar with these designs, and they are the shapes most often used for I-beams today. Although the NEXT beams are quite new, Maine has already built about 10 bridges using them and has been very impressed with their performance so far.

The first NEXT-beam bridge built was the New Bridge over the York River on Route 103 in York, Maine, which was designed to be jointless. The seven-span, 510-ft-long structure replaced a 17-span, steel-girder bridge and features 55-ft-long end spans and 80-ft-long center spans, with integral abutments and pile-bent piers. Two options were provided, NEBT or NEXT girders.

The contractor selected the NEXT beam option to meet a variety of goals, including maintaining the existing profile, improving navigational clearance, and avoiding conflicts with existing substructure locations. The design met all the goals and provided 4 in. of additional clearance.

Designers like the NEXT beam because it provides a top flange that can support the cast-in-place deck without an intermediate diaphragm. It also has no closed sections, making inspections easier and providing a location for utilities. The NEXT beam will likely dominate the market in coming years.

The New Bridge over York River was the first use of the Northeast Extreme Tee (NEXT) beam. Photo: Vanasse Hangen Brustlin Inc.

New Delivery Methods

MaineDOT also is embracing new delivery methods, including design-build and construction manager/general contractor (CM/GC) approaches because of the innovations, speed, and cost savings they can generate. The format is chosen depending on the reasons for the project, available funding, and timing.

Design-build methods are being used more often—about eight have been completed in recent years—primarily when speed is of the utmost concern or the project is large and complicated. Those methods offer more opportunities for contractors to use their own

The Penobscot Narrows Bridge in Waldo and Hancock Counties, a cast-in-place concrete segmental cable-stayed bridge, was created when renovation plans showed needed repairs were too extensive. The distinctive bridge was completed in just 30 months. Photo: Maine Department of Transportation.

expertise and skill to reduce time and costs for the project. By not being overly prescriptive to the design-build team, some good innovations have resulted. Often, the project has specific challenges and the contractors have created great solutions.

An example is the Penobscot Narrows Bridge in Waldo and Hancock Counties. The design consists of a cast-in-place, concrete segmental, cable-stayed bridge. A design-build system was used because initial plans to renovate the old bridge were scrapped once the extent of deterioration became known. The 2120-ft-long cable-stayed design provided a signature look for the historic area proved to be the most cost effective, and would allow traffic access quickly. It was completed in just 30 months.

One of the largest design-build projects undertaken was the 1610-ft-long Veterans Memorial Bridge, which is used by about 22,000 vehicles per day. The $44.2-million structure consists of twin post-tensioned, precast concrete, segmental box-girders with cast-in-place concrete piers. The structures, with segments varying from 8 to 11 ft in length, were joined with a cast-in-place concrete closure strip.

By offering the design-build option and alternative technical concepts, the team was able to propose a new alignment that saved significant time and money, and shortening the bridge by 800 ft. This strategy not only saved initial cost and long-term maintenance needs, but it dramatically improved the intersection. These results are why Maine will continue to use design-build options in the future.

Speed Is Key Focus

Speed of construction has become a key focus, especially when emergencies arise. The emphasis on reducing user costs has led to new techniques that offer dramatic results. The rebuilding of the Bracket Brook Bridge and North Branch Bridge in the Carrabassett Valley in 2011 are prime examples of what can be accomplished. Destroyed by Hurricane Irene, the bridges provided the main access to Sugarloaf Mountain, a major ski-resort area. Their loss created a 79-mile detour a few months before the ski season began. The project was let on a CM/GC basis, with the goal of having temporary bridges in place within seven days of the August 28 destruction and permanent replacements ready in less than three months. Adjacent precast concrete voided slabs were chosen for Brackett Brook Bridge, while adjacent box beams were selected for the North Branch Bridge. These choices were selected by MaineDOT and the contractor based on input from local suppliers for what products were most available and fastest to deliver and construct.

The Brackett Brook Bridge and North Branch Bridge (shown here) in the Carrabassett Valley had to be rebuilt quickly following their destruction in 2011 by Hurricane Irene. Completed on a CM/GC basis, different concrete designs were used for each based on materials available for fastest construction. They were reopened in less than three months. Photo: Maine Department of Transportation.

Although created on an emergency basis, the project became a lesson in constructability and accelerated bridge construction techniques. The bridges have conventional designs, with integral abutments, but the speed of construction was extraordinary. The ability to achieve this pace through close coordination with the contractor proved that having this input early can provide a big benefit.

Aesthetics More Important

Aesthetics has become more important, primarily for urban areas where bridges are more prominent. Regardless of location, local stakeholders have become more involved in the process, with concerns about appearance, duration of construction, and other factors.

An example is the Covered Bridge over the Kennebec River in Norridgewock, Maine, which had to be replaced despite being named one of Maine's most significant twentieth-century bridges. A 10-person committee, including local authorities and other state stakeholders, agreed on a new bridge that replicated the historic appearance but provided a 100-year service life and additional clearance over the river.

Designers created a three-span bridge with a cast-in-place, tied-arch center span and precast, prestressed concrete bulb-tee beam approach spans. The tied-arch span contains two parallel 300-ft-long concrete arch ribs with six cast-in-place transverse braces. The arches rise 60 ft above the deck.

The new design of the Norridgewock Bridge consists of a three-span bridge with a cast-in-place, tied-arch center span and precast, prestressed concrete bulb-tee beam approach spans. Photo: Maine Department of Transportation.

These examples show ways that MaineDOT is using concrete designs and techniques to reduce costs, provide longer service lives, and speed construction of its bridges of all shapes and sizes. Alternative contracting methods and techniques to extend service life will continue to be employed, especially with new ways to eliminate bridge joints. Maine's goal is to better serve its citizens by taking designs for cast-in-place concrete and precast concrete bridges to the next level.

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EDITOR'S NOTE

For more information about the bridges mentioned in this article, see the following issues of ASPIRE™: New Bridge, Spring 2011; Penobscot Narrows, Winter 2007; Veteran's Memorial, Summer 2012; and Covered Bridge, Fall 2011.