PROJECT

Precast Bridge BUILT in only EIGHT DAYS

by Peter E. Stamnas and Mark D. Whittemore. New Hampshire Department of Transportation

Minimizing construction-related traffic delays and improving work-zone safety are key drivers for New Hampshire DOT to create fast construction plan

The New Hampshire Department of Transportation (NHDOT) has taken a lead role in promoting the benefits of high performance concrete (HPC) in bridges because of its ability to improve the quality of the material and extend bridge life. Recently, the department took that focus a step further by using HPC and precast, prestressed concrete components to erect a 115-ft-long bridge in only eight days.

The program's goal was to create a prototype system that could be followed for other projects as the need arose. Such rapid speed of construction provides a number of significant benefits. They include mitigating traffic delays and improving worker safety in construction zones, which are critical issues today. The initial plan was to design the bridge and prepare for the construction, so the actual assembly and disruption to traffic would be completed in two weeks. Ultimately, the contractor exceeded expectations by easily beating that schedule.

Precast Box Beams Used

The new single-span concrete bridge replaced two existing spans carrying Mill Street over the Lamprey River in Epping, New Hampshire. The bridge features a precast concrete, adjacent box beam superstructure and a precast concrete substructure. One of the reasons that this site was chosen to test this procedure was that its location minimized the overall risk of using a newly developed and untested substructure system. NHDOT wanted to

profile

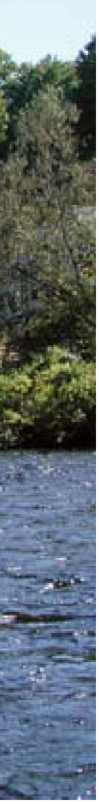
MILL STREET BRIDGE / EPPING, NEW HAMPSHIRE

ENGINEER: New Hampshire Department of Transportation, Concord, N.H.

DESIGN/CONSTRUCTION/INSPECTION TEAM: NHDOT, Bureaus of Bridge Design & Construction

PRIME CONTRACTOR: R.M. Piper Construction, Plymouth, N.H.

PRECASTER: J.P. Carrara & Sons Inc., Middlebury, Vt., a PCI-Certified Producer



The Epping, New Hampshire, bridge features a precast concrete, adjacent box-beam superstructure and a precast concrete substructure.

ensure the system would work before incorporating it into a high-traffic situation where failure would not be an option.

A significant portion of the project's funding was provided through the Federal Highway Administration's Innovative Bridge Research and Construction program. To create the final design, NHDOT worked with engineers at the University of New Hampshire, local contractors, and the technical committee of the Precast/Prestressed Concrete Institute's Northeast Region.

The bridge features 3-ft-deep adjacent box beams cast with 8000 psi compressive strength HPC and 0.6-in.-diameter prestressing strands. Full-depth grouted shear keys were used. Two rows of 1/2-in.-diameter strand were used to transversely post-tension the deck at six locations along the box beams. The riding surface features a waterproofing membrane and a bituminous pavement overlay. The superstructure is supported by an all-precast concrete substructure, composed of full-height cantilevered precast concrete abutments founded on precast concrete spread footings using 5000 psi compressive strength concrete.

The design format allowed the contractor and precaster to determine the specific method of bridge assembly.

The project was let using an approach somewhere between a traditional design-bid-build delivery and a design-build delivery project. The approach kept design control with NHDOT engineers but turned over the specific method of bridge assembly to the contractor and precaster. The contractor and precaster determined where joints within the substructure would be introduced and how the precast bridge elements would be assembled.

NHDOT typically constructs abutments using cast-in-place concrete, but on this project, that approach would have required six separate concrete placements and approximately one month for construction. Using precast components, the abutment construction could be completed in less than two days. The footings were divided into individual sections to facilitate shipping and handling. These pieces were standardized to reduce fabrication costs, and precasters used a template to ensure a proper fit between the stem and footing elements.

The precast footings were set to proper grade using leveling screws installed near the corners of the footing elements. This proved to be a simple and cost-effective detail. A flowable grout bed was placed below the footings through grout tubes spaced at 5-ft centers in the footings. The minimum 3-in. thickness for the bed provided a sound, unified, bearing surface that acts as the 'glue' between the bearing materials and the roughed bottom surface of the precast footing.

Precast concrete abutments were set onto the precast concrete footings using reinforcing bars grouted onto reinforcement extending from the footings.

PRECAST CONCRETE REPLACEMENT BRIDGE / NEW HAMPSIRE DEPARTMENT OF TRANSPORTATION, OWNER

BRIDGE DESCRIPTION: A 115-ft-long, single-span bridge constructed in eight days

STRUCTURAL COMPONENTS: Seven 3-ft-deep precast concrete box beams, 11 abutments and wingwall pieces, 10 footing pieces, and four pilasters

CONSTRUCTION COST: Total: $1.047 million; Bridge cost: $806,000

Fitting the precast concrete wingwalls and abutments onto the footings required close tolerances and careful handling to ensure they fit together.

Careful attention was paid to ensure splice sleeves connected smoothly at the site.

The minimum compressive strength required to resist full design loading of 250 psi was easily achieved overnight.

Splice Sleeves Provide Connections

Standard details were provided in the plans to address various types of joints. Vertical joints in the stems and footings required grouted shear keys, while horizontal joints in stems and between the stems and footings were designed as full moment connections with grouted splice sleeves. The splice sleeves were cast into the front and back faces of the stem elements to accept reinforcement extending from the bottom footing element. High-strength grout was pumped by hand into the splice ports to complete the connection.

Matching the splice sleeves in the footings and wingwalls proved to be the most challenging pieces for the precaster to produce. Careful attention had to be paid to how each piece was laid out to .ensure the splice sleeves would match and connect up smoothly at the site. It required a lot of coordination to make it work, but everything went smoothly. The contractor developed a detailed assembly plan to minimize the costs and time needed.

Seven box beams were used in the single-span bridge, with five abutment and wingwall pieces on one end and six on the other, plus 10 footing pieces. The precaster also supplied four precast concrete pilasters, which were set along the top of the abutment walls on each side of the outside box beams to add a decorative touch.

The project moved smoothly once erection began. Bad weather slowed the preparation work, but casting continued at the plant. This timetable ensured that the components were ready when the site was prepared, so construction would proceed as planned despite the weather complications.

Design Offers Potential

The precast concrete substructure system used on this project offers great promise for future construction. It emulates the favorable aspects of cast-in-place construction, such as:

- Using standard design concepts
- Incorporating elements produced locally with readily available materials
- Providing easy construction and assembly
- Creating a durable structure

At the same time, it improves on some aspects of cast-in-place construction by:

- Significantly reducing the time to construct the substructure
- Being constructed to tight tolerances
- Providing a high-quality solution using HPC

The reduction of construction time is a critical issue today in all work zones. Because not all projects can be planned in advance under these conditions, partial use of these techniques may be the right answer in many instances. Precast substructures, for instance, could be used on bridge projects that cross commute rail lines.

Pros and Cons to Consider

One of the key advantages offered by precast components is that they can be cast in advance so they are ready to be assembled in the available construction window. Savings realized on items such as the reduced rental time for a temporary bridge and wasted labor to mobilize the construction crew around these windows helps to compensate for the additional costs associated with the fabrication and delivery of the precast pieces.

Achieving the aggressive schedule used on this project may require the mobilization of two or more construction crews working in parallel. That may exclude some smaller contractors from being able to bid the project. At the same time, accelerated construction using precast components may expand those opportunities, increasing competition, and ultimately reducing costs.

The accelerated timetable also minimizes construction-related traffic delays on high-volume roads. This provides a significant advantage, particularly on projects where construction may extend into a second construction season. Accelerated construction creates risks for the contractor that will increase his costs. The magnitude of those costs will vary between projects and will be site specific. As these risks are minimized, the cost will follow.

At the same time, the increased cost due to accelerated construction must be evaluated in comparison to the value gained in reduced user costs for shorter-term detours and less need for traffic-control items. The long life that precast concrete components can provide for the bridge also offers savings that should be factored into a life-cycle study.

One option offering potential is to substitute precast substructure components for cast-in-place elements. Typical cast-in-place elements could be designed for use on the contract drawings, with standard details for emulating these elements included as well. The contractor then could decide the means and methods to use in order to complete the project on time and within budget on his own. On the downside, the owner cannot take full advantages of the potential savings in engineering and plant-preparation costs. The substructure detailing on this project, for instance, was reduced by half, from 10 plan sheets to five.

The precast concrete substructure system used on this project offers great promise for future construction.

For these reasons, NHDOT considers the Epping project not only a great success on its own, but we see it as a strong starting point for a promising concept. That was made even more apparent during this past spring, when the bridge was submerged after heavy rains caused the Lamprey River to surge well above its typical level. When the river subsided, the bridge was found to have sustained no damage (photos below).

Shortening the Learning Curve

Creating a bridge that can be constructed in eight days requires careful planning and design. These are some of the ideas we learned that are critical in creating a fast construction project:

- Limit angle changes between abutment and wingwalls to 30, 45, 60, and 90 degrees.
- Stem heights for abutments and wingwalls should be detailed in 6-in. increments, and site grading should be used to fine-tune the solution.
- Batters on abutment and wingwall stems should be eliminated. The overall thickness of the stems should be minimized to reduce weight.
- Footing widths should be detailed in 6-in. increments, with a maximum width of 12 ft to minimize transportation difficulties.
- Alternate backfill materials should be considered, with flowable fill rather than granular material offering a strong option.
- Maximize construction access. Precast substructure elements can weigh as much as 30 tons and may require large cranes.
- Details at vertical joints between elements should be standardized. Attention to shear key preparation, grout material, and grout installation is critical.
- Standardize as many components as possible. It is a key to success in accelerated construction.

The ease of construction and the overall effectiveness of the details have demonstrated the viability of this system and opened the door for many applications in the future. Such techniques are not limited to NHDOT but can be applied by other transportation agencies across the country. We look forward to confronting the challenges created by using rapid bridge construction techniques on future projects.

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Precast concrete footings were set on a flowable grout bed, and leveling screws were installed near each corner to adjust the footings to the proper grade.

Seven precast concrete box beams were erected. They were cast with high-performance concrete, allowing the 115-foot bridge to be designed as a single span.

The bridge features a total precast concrete design, including box beams, abutments, wing walls and footings.

The new 115-foot, single-span precast concrete bridge carrying Mill Street over the Lamprey River in Epping, N.H., was finished with eight days of construction, which followed six weeks of preparation.