How Massachusetts' I-93 Fast 14 accelerated bridge construction project used unitized construction to raise the bar for efficiency.

A Production Line Approach to Bridge Replacement

BY MICHAEL P. CULMO, P.E., JOSEPH GILL, P.E., SHOUKRY ELNAHAL, P.E., AND ALEXANDER K. BARDOW, P.E.

IN AUGUST 2010, the Massachusetts Department of Transportation (MassDOT) was in the process of performing remedial repairs to all of the bridge decks along I-93 in the City of Medford, Mass., when the seriousness of the project suddenly changed dramatically. A contractor had removed the wearing surface on several of the bridges in order to make the necessary deck repairs. One evening, a large pothole developed on the bridge over Route 28. The ensuing repair required the removal of significant amounts of deteriorated concrete, which resulted in a patch that grew to encompass a large portion of several lanes of the bridge. The repair took several days and the resulting traffic impacts affected the entire Metro Boston area.

Prior to the deck failure, MassDOT had already begun a feasibility study for the replacement of the bridge decks using accelerated bridge construction techniques. The plan was to replace the bridge decks in the summer of 2012 using prefabricated deck panels. The pothole that formed on the Route 28 overpass underscored the need to expedite the replacement project before similar potholes developed on other bridges.

The scope of the project involved all I-93 overpass bridges in the City of Medford, which totaled 14 bridges with 41 spans. The poor condition of the decks led MassDOT to decide to accelerate the design of the project and complete the construction in 2011. The goal was to complete the major portions of construction between June 1 and September 4, 2011. This decision was made in August 2010; therefore the design and construction had to be completed in approximately 12 months. The design/build (DB) method of contracting was chosen to expedite the process. A preliminary design was undertaken at the same time as the procurement process for the DB contract.

Project Approach and Traffic Management

CME Associates was selected to develop the project concept and 30% of the design plans, due in part to its experience with accelerated bridge construction techniques. CME worked very closely with the in-house design and construction staff at MassDOT in a collaborative effort to expedite the preliminary design.

Michael P. Culmo, P.E., is vice president for structures and transportation, CME Associates, Inc., East Hartford, Conn. Joseph Gill, P.E., is president and CEO of Gill Engineering Associates, Needham, Mass. Shoukry Elnahal, P.E., is MassDOT's deputy chief engineer for bridges and tunnels and Alexander K. Bardow, P.E., is MassDOT's director of bridges and structures.

➤ Rapid and efficient demolition was the first step in each bridge replacement.

➤ **Center:** The prefabricated bridge units (PBUs) developed by MassDOT can accommodate skews in both end-to-end and side-to-side applications.

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The goal was to give the DB teams a workable set of drawings that could be used for the development of their proposals. This was necessary since the time frame from contractor selection to replacement of the first bridge was only four months.

I-93 is an eight-lane elevated expressway in Medford and carries approximately 180,000 vehicles per day. All but one of the bridges on I-93 carries the highway over local features such as city streets, state highways and the Mystic River. All of the bridges are steel stringer spans with concrete decks, and all but one are multiple-span structures. Early in the feasibility study process, a decision was made to replace the entire superstructures. This was due to a number of factors including the advanced deterioration of beam ends brought on by years of leaking deck joints.

Traffic management is always a major factor in accelerated bridge construction (ABC) projects. Additionally, the amount of time and space that can be provided to the contractor affects the potential options for ABC methods. Vanasse Hangen Brustlin (VHB) was brought in to develop the traffic management plan for the project due to their significant knowledge of the traffic patterns in the area. The company also worked in collaboration with the department's traffic engineering office to expedite the design.

The team investigated the possibility of an aggressive traffic management strategy that involved the full closure of one side of I-93 for an entire weekend, thereby giving a contractor full access to each bridge. The plan was to close two lanes of traffic in each direction and re-route the traffic to one side of the interstate via two crossovers. The counter-flow traffic would be separated by a movable temporary concrete barrier that

➤ From a design standpoint, parapet walls easily could have been included on the PBUs; however an alternate temporary barrier system allowed transporting the PBUs without the extra weight of the parapet wall concrete, since they could be cast later after the bridge was in place and open to traffic.

Designing the PBUs with Grade 50 weathering steel beams and an integral concrete deck, all assembled off site, kept the structure depth to a minimum and the weight low.

would be put into place on Friday night. In order for this plan to work, a significant portion of the weekend traffic would need to be detoured around the project site. Fortunately, the Boston metropolitan area has several belt highways (I-495 and Route 128) that could accommodate long-haul detour traffic. Local detours also were available that could accommodate overflow traffic.

MassDOT undertook an unprecedented public involvement program during the build-up to the start of construction. The department's goal was to inform every citizen in the Boston area prior to the start of construction. MassDOT named the project the "Fast 14" to simply and clearly describe the intent of the project to the traveling public and used all forms of media to get the word out. During construction, up-to-the-minute traffic message boards were used to provide accurate delay times that allowed travelers to make informed decisions on detours.

Bridge Design

One goal of the project was to salvage the bridge abutments and piers. An analysis of the substructures indicated that there was sufficient capacity to replace the existing steel stringer superstructures with structures of equal weight, but significant increases in structure weight were not possible. The vertical clearance was limited on many of the existing bridges, so a thin superstructure was required in order to increase the clearance as much as possible. Following a structure type study, the design team selected a modular steel bridge system—the ideal solution to these two constraints—consisting of Grade 50 weathering steel beams combined with a concrete deck that would be cast off site.

The units, which MassDOT named Prefabricated Bridge Units (PBU), were

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Center: A 2-ft, 8-in. width was chosen for the closure pours connecting adjacent PBUs to reduce the width and weight of the units.

The 2-ft, 8-in.-wide closure pour between PBUs was made with high-early-strength concrete that achieved a compressive strength of 2,000 psi in four hours.

designed to allow side-to-side construction or end-to-end construction using conventional cranes. Similar techniques had been used by other state agencies on similar projects, which meant that the system was feasible. Through a detailed construction timeline analysis, the design team determined that using PBUs it was feasible to replace the largest bridge on the project, the four-span structure over Route 16, in 55 hours. In fact, the team determined that it was feasible to replace two multi-span structures in the same time frame.

The beams were designed as simple spans to eliminate the need for continuity connections in the field; however, the decks were designed as jointless using "link slab" technology, which involves casting a continuous deck over interior supports. The decks are purposely debonded from the beams near the support, which allows for end rotation of the beams without significant cracking in the deck. This technique has been used effectively in several states, including Massachusetts. The connection between the PBUs was a simple 2-ft, 8-in.-wide cast-in-place concrete closure pour made with high-early-strength concrete. The mix design required a compressive strength of 2,000 psi within four hours. The connection was designed with simple lapped reinforcing bars. The width of the pour was selected to reduce the width (and weight) of the units, which aided in the shipping and handling of the units during construction. Casting of the parapets prior to installation was allowed; however the weight of the parapets would most likely have exceeded the capacity of the cranes. In lieu of that, temporary barriers were designed to be placed in the shoulders of the roadway allowing for installation of the parapets after opening the bridges to traffic.

Construction

On January 19, 2011, the DB joint venture team of J.F. White and Kiewit Construction were identified as the best value team. MassDOT issued a Notice to Proceed on February 8, 2011. The team included the design firms of Tetratech, Gill Engineering, Dewberry and Lin Associates. With only four months to build the first bridge, the DB team decided to hold weekly meetings with MassDOT, FHWA and the preliminary design team to work through the final design and detailing. These collaborative meetings continued through the final design phase and into construction and proved vital in the successful deployment of this aggressive project. By having key decision makers involved, "over the shoulder" reviews were completed that helped keep the project on track.

Although the project includes 504 steel girders, the design team kept the detailing simple by using prismatic sections. Welded plate girders were used to minimize the structure thicknesses. Shop drawings were delivered to MassDOT in electronic format within days of the notice to proceed. Once fabricated, the steel was shipped to Jersey Precast Corporation, near Trenton, N.J., to have the decks cast on top of the PBUs.

Construction of the first bridge commenced on June 4, 2011. The contract documents provided a construction window of 13 weekends for the majority of the work. No construction was allowed on the July 4 holiday weekend and two weekends were set aside for inclement weather; therefore, the 14 superstructures had to be completed in only 10 of the 13 weekends. This required the replacement of multiple bridges on several of the weekends.

The first bridge, a three-span structure over Riverside Avenue, was completed ahead of schedule. The second weekend involved the replacement of two bridges—a total of six spans—at the Salem Street interchange. Those bridges were also completed ahead of schedule. The White/Kiewit team worked tirelessly throughout the summer, completing the 14 bridges in the first 10 available weekends. The last bridge was completed on August 14, 2011, three weeks ahead of the Labor Day holiday. All bridges were completed ahead of schedule, opening up the roadway for Monday morning commuter rush hour.

"Fast 14" Project Numbers

Bridges	14
Spans	41
Girders	504
Tons of steel	2,600
Replacement time	10 weekends

Additional information about this accelerated bridge construction project is available at **http://93fast14.dot.state.ma.us/**.

The Fast 14 program is an example of how steel girders can be used in accelerated bridge construction projects. The reduced weight and minimal structure thickness was advantageous for construction of bridges in an urban environment. The use of modular prefabricated bridge units allowed the contractor options for installation of the units based on the space available at each site. The system is adaptable for various span configurations and skews. MassDOT is looking to expand the use of PBUs on other projects throughout the state as part of its Accelerated Bridge Program.

One of the most significant aspects of the Fast 14 project was the collaboration and teamwork used to expedite the design and construction of this ambitious project in just 12 months. MassDOT made this project a priority and applied the personnel to make it happen. MSC

Owner
Massachusetts Department of Transportation

Concept and Preliminary Design Team
CME Associates, East Hartford, Conn.
Vanasse Hangen Brustlin, Inc., Watertown, Mass.
Nobis Engineering, Lowell, Mass.

Design/Build Team
J.F. White/Kiewit Joint Venture
Tetratech Corporation, Framingham, Mass.
Gill Engineering Associates, Inc., Needham, Mass.
Dewberry – Goodkind, Inc., Boston
Lin Associates, Inc., Brighton, Mass.

Steel Detailer
Structal – Bridges, Claremont, N.H. (AISC and NSBA Member)
Tensor Engineering Co., Indian Harbor Beach, Fla. (AISC Member)
Tenca Steel Detailing, Inc., Quebec City (AISC and NISD Member)
Candraft, Inc., New Westminster, British Columbia (AISC and NISD Member)

Steel Fabricators
Structal – Bridges, Claremont, N.H. (AISC and NSBA Member)
Griener Industries Inc., Mount Joy, Pa. (AISC and NSBA Member)
Michelman-Cancelliere IronWorks, Inc., Lehigh Valley, Pa. (AISC and NSBA Member)