Determination how—or whether—to rehabilitate or replace the iconic John Greenleaf Whittier Bridge presented the design team, led by Parsons Brinckerhoff, with significant design, environmental and construction challenges.

The bridge’s deteriorated condition, substandard roadway geometry and capacity limitations, along with cost considerations for a proper, comprehensive rehabilitation, led to the decision to replace this vital transportation link in the regional commercial, industrial and recreational growth of northern New England.

The existing 1950s-era bridge—a fixed, 1,340-ft-long, twin-barrel, steel-arch truss structure—is a ⅓-scale replica of the iconic Bourne and Sagamore bridges spanning the Cape Cod Canal. It carries I-95 traffic over the Merrimack River to northern New England and into Canada as an alternative to congested, coastal Rte. 1. It is noteworthy for its eligibility for National Historic Register status.

Engineered elegance

The Whittier Bridge Replacement Project is one of five major projects at the center of the Massachusetts Department of Transportation’s (MassDOT) Accelerated Bridge Program (ABP) and the first in Massachusetts to design a network tied-arch bridge with an integrated shared-use path (SUP) on an interstate. Under MassDOT leadership, the Parsons Brinckerhoff design team developed an innovative staging plan that addressed the goals of the ABP: innovation in contracting, minimizing impacts to commerce and the public, and utilizing accelerated bridge construction.

The existing structurally and geometrically deficient bridge cannot be saved, resulting in an adverse effect on a historic resource. The solution to the replacement design had to address the heavily deteriorated condition and the need to maintain all lanes during peak commuter and weekend traffic. Addressing all of these needs during a comprehensive rehabilitation potentially would have required complicated interim bridge strengthening to allow partial demolition under traffic as originally proposed.

MassDOT and the designer came up with a creative solution for a full replacement that is elegant in its simplicity: Relocate all existing traffic onto the new northbound bridge, constructed with additional width for six interim lanes under Phase 1; demolish the existing northbound bridge; construct the new southbound bridge; relocate southbound traffic under four travel lanes; reconfigure the...
The replacement design includes a protected SUP with scenic overlooks and interpretive panels on the northbound barrel, supporting the Massachusetts Bicycle Transportation Plan, the Massachusetts Pedestrian Transportation Plan and enhancing multimodal connectivity.

northbound bridge for four travel lanes; and repurpose the surplus northbound deck as a SUP, creating a missing alternative link to transportation and recreational resources between Newburyport and Amesbury/Salisbury.

The project’s early success maintaining cost and schedule—fostering effective partnership and garnering community support—led to its selection by the Obama administration in September 2011 as one of 14 projects in the U.S. for an expedited permitting and environmental process intended to move it quickly from concept through construction and completion.

The team accomplished all permitting activities—local, state and federal—in an aggressively managed one-year period. The design team developed an enhanced 25% preliminary design to support the environmental assessment and permitting effort and packaged it for design-build procurement.

One of four

The design team evaluated four bridge types for the Whittier Bridge replacement. The design types included structural options for a network tied arch (steel plate or steel box girder approach spans), a box girder (steel plate, concrete box or segmental concrete box girders) and a cable stayed (concrete or steel box girders). The four overall bridge designs included:

- Network tied arch, the type most reminiscent of the existing arch-style bridge;
- Box girder;
- Cable stayed, similar to the new icon on Boston’s skyline, the I-93 Leonard P. Zakim Bunker Hill Bridge; and
- Extradosed, a modified cable-stayed bridge that allows the cables close to the towers to be omitted and the towers to be lower in proportion to the span.

The alternatives were comparatively evaluated for numerous engineering and environmental factors, including:

- Structural/redundancy;
- Highway/profile impact;
- Inspection and maintenance;
- Schedule impacts affecting accelerated bridge construction;
- Constructability;
- Environmental: shading [salt marsh], loss of river bottom [square feet], noise, fisheries, wildlife, floodplains, historic and visual impacts;
- Cost regarding construction, preventive maintenance and life cycle;
- Aesthetics regarding visual impact of structure, articulation of maritime channel location and driver’s view; and
- Section 106 criteria regarding the use of granite in piers, graceful lines, iconic structure, elegant arch and reuse of historic elements along the SUP, and reincorporating the porcelain and bronze Massachusetts great seals onto the new portal beams.

These alternative type studies and a robust public-participation program led the design team to recommend a structure that gracefully mimics the aging much-admired steel-truss arch bridge using a modern application of a steel network tied-arch bridge that complements its environs and to which important historical artifacts from the old bridge will be attached. Innovative construction staging will accomplish multiple goals: (1) accelerating the construction schedule, (2) providing safe travel over the bridge for automobiles and commercial vehicles during construction and demolition, (3) minimizing detours of interstate traffic to the local roadway network, (4) encouraging alternative “greener” transportation by incorporating the SUP on the bridge to connect through a local pathway system to a park-and-ride facility in Newburyport, (5) improving substandard interstate roadway geometry and bottlenecked traffic flow and (6) using innovative contracting techniques such as design-build.

Something entirely different

Originally constructed between 1951 and 1954, the “Relocated U.S. 1” was built to...
provide expressway service from Boston and its northern suburbs connecting to the New Hampshire Turnpike and the Maine Turnpike, both of which were constructed in the late 1940s. The four-lane expressway (two lanes in each direction) was constructed from Danvers to immediately south of the New Hampshire state line in Salisbury and in 1956 was redesignated as I-95.

From 1967 and 1969, I-95 was widened north of the bridge to provide three travel lanes in each direction to I-495 in Salisbury, and four travel lanes in each direction from I-495 north to the New Hampshire state line. Then, from 1973 and 1977, I-95 was widened south of the bridge to provide four travel lanes in each direction from Rte. 113 in Newburyport to Rte. 1 in Danvers. In 1977, the bridge’s cast-in-place reinforced concrete deck was replaced and the bridge roadway reconfigured to create three 12-ft travel lanes in each direction between the existing trusses. Breakdown lanes on the bridge were eliminated, except for 2-ft offsets; concrete barriers installed along the outer shoulders and the center median protected the trusses and suspender cables from collisions. In 1991, the original bearings were replaced.

Since 2003, MassDOT has undertaken structural repairs as needed. These repairs include installing vertical steel rods to supplement the existing deteriorated wire rope hangers, repairing corroded floor beams and stringers and repairing bracing members. Low load ratings resulted in additional recent repairs that include installing strengthening steel plates to reinforce heavily corroded floor beam and stringer ends. The gusset plates (typical structural elements of a truss bridge) are load-rated in accordance with the February 2009 Federal Highway Administration (FHWA) Gusset Plate Load Rating Guidance, which was issued following the catastrophic collapse of the I-35W truss bridge in Minneapolis on Aug. 1, 2007.

The benefits of building an entirely new structure are obvious. Maintenance costs are significantly lower for many years with a new structure. Driver safety is enhanced by the replacement construction staging the design team has developed because it moves traffic off the old bridge onto the new structure.

The job called for a three-phase build with a two-phase demo of the existing bridge. This sequence required building three northbound lanes, relocating northbound traffic onto the new bridge, demolishing the northbound side of the existing twin-arch structure with live traffic on the southbound side, building three additional lanes to relocate the southbound lanes to the new structure, demolishing the existing southbound portion and constructing to the final eight-lane configuration.

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quickly. The new bridge roadway will comply with AASHTO’s Geometric Design of Highways and Streets by providing four travel lanes on each barrel, consistent with the connecting roadways north and south, with full shoulders and compliant breakdown lanes on both barrels. Finally, the replacement design includes a protected SUP with scenic overlooks and interpretive panels on the northbound barrel, supporting the Massachusetts Bicycle Transportation Plan (2008), the Massachusetts Pedestrian Transportation Plan (1998) and enhancing multimodal connectivity.

MassDOT developed a plan to engage the public early for this critical project, reaching out to the three affected communities (Newburyport, Amesbury and Salisbury), which formed the Whittier Working Group (WWG). The WWG met bimonthly with officials of the three towns early on. The group’s initial purpose was to discuss ideas and collaborate with MassDOT and the Whittier Bridge project team in developing a draft EA/EIR, filed early in fall 2010, to meet deadlines associated with legislative funding for the ABP. The WWG will remain in effect throughout the accelerated bridge design-build process, meeting with MassDOT at least bimonthly to provide ongoing suggestions on common interests to MassDOT until construction is completed. One of the ideas the WWG promoted was incorporating the SUP on the bridge.

**A monumental first**

Upon reviewing the project’s Section 106 documentation, FHWA and MassDOT determined that the removal and replacement of the National Register-eligible Whittier Bridge would constitute an adverse effect.

The proposed design of the replacement bridge, a double-barrel network tied-arch superstructure with steel-girder approach spans, will partially mitigate the adverse effect associated with the removal of the existing National Register-eligible bridge by providing a new, context-sensitive, monumental gateway structure—the first network tied-arch in Massachusetts—at this important crossing of the Merrimack River near the state’s northern border. The Section 106 consulting parties, WWG and the public expressed overwhelming support for MassDOT’s preferred alternative and agreed to other mitigation measures that include salvage and reuse of certain ornamental artifacts from the existing bridge, preparation and installation of interpretive signage at the proposed overlooks on the new bridge and continued consultation.

The design team developed innovative sequencing to meet a key MassDOT ABP goal:
to complete projects with minimum disruption to people and commerce.

The original concept was a three-phase build with a two-phase demolition of the existing bridge. This sequence required building three northbound lanes, relocating northbound traffic onto the new bridge, demolishing the northbound side of the existing twin-arch structure with live traffic on the southbound side, building three additional lanes to relocate the southbound lanes to the new structure, demolishing the existing southbound portion and constructing the final eight-lane configuration.

The new bridge has a 75-year design life and was designed with modern materials and details to withstand the rigors of New England weather. The design utilizes a belt-and-suspenders approach of weathering steel and a state-of-the-art coating system of metalizing and top paint to ensure the longevity of this new icon over the Merrimack River.

The project demonstrates how innovation leads to an inventive solution that addresses public agency and community goals. The staging for the project greatly reduces travel delay and community traffic diversion impacts and results in a permanent community benefit: a path connecting the three towns to a regional park/ride/transit center.

The shortnose sturgeon is the only endangered species in the project area. MassDOT coordinated with NMFS and the Massachusetts Division of Marine Fisheries (DMF) in their review of the effects of the proposed demolition, construction and dredging activities on essential fish habitat. In a letter dated June 8, 2011, NMFS concurred with the determination “that the proposed reconstruction of the Whittier Bridge . . . is not likely to adversely affect any listed species under NMFS jurisdiction.” In a letter dated Sept. 8, 2011, DMF determined that “since the proposed in-water work will include cofferdams to contain siltation, a time of year (TOY) restriction is not recommended for in-water work.” DMF further clarified in correspondence dated Dec. 9, 2011, that the installation or removal of cofferdams in the Merrimack River will be limited to one cofferdam at a time, so no time-of-year restrictions will be required.

Public embrace

This project’s enduring message is that creative staging and design can meet project goals without compromising the finished product and even improve upon the project’s original intent. The public has embraced the network-arch bridge replacement, SUP and linear museum of 15 interpretive panels along the path. Travelers and communities benefit from the attention to staging that reduces the construction schedule by 20 months. The first-phase overbuild and single simplified demolition and final build produce the desired eight traffic lanes and requisite shoulders. The first-phase construction to support the existing six lanes results in additional width that in the end is repurposed into a SUP that provides the three communities with an alternative transportation and recreational resource.

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