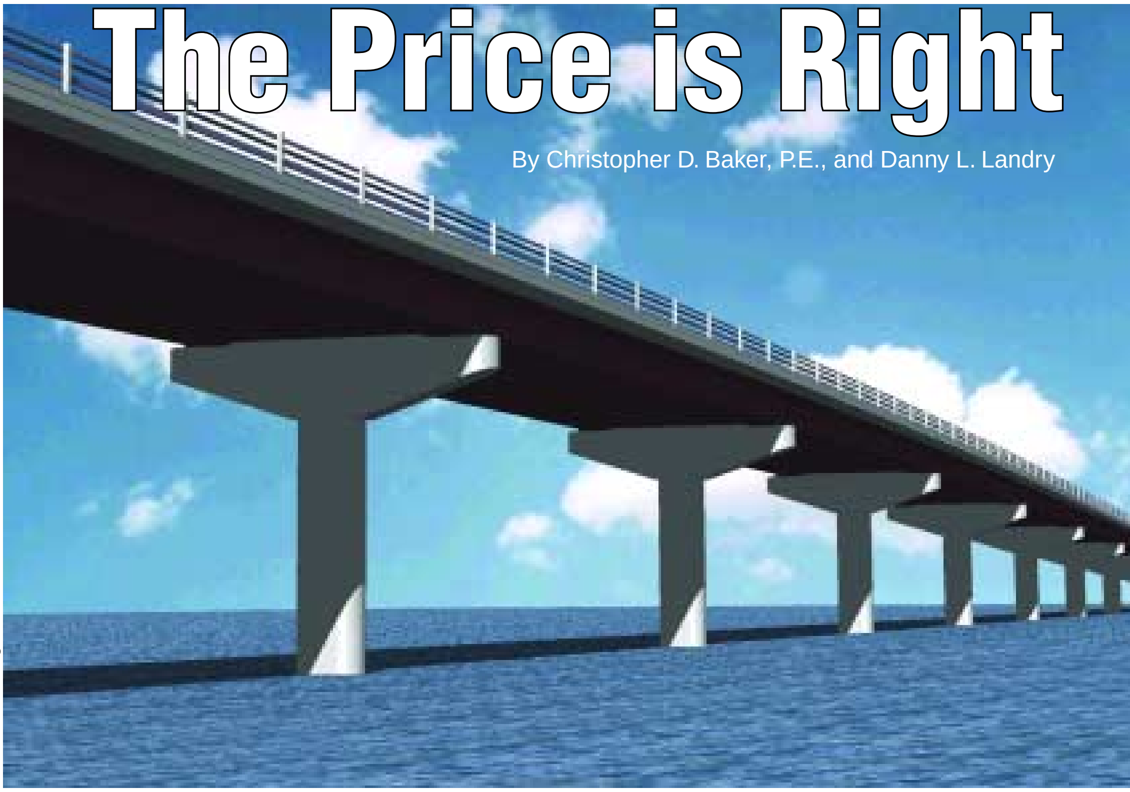
The Price is Right

By Christopher D. Baker, P.E., and Danny L. Landry



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Cost-effective design makes steel the material of choice in dual-design bidding for the new Missisquoi Bay Bridge in Vermont.

Construction of the new Missisquoi Bay Bridge for the Vermont Agency of Transportation (VTrans) began May 2004. The new Vermont Route 78 Bridge closely parallels the existing causeway and 550′ bascule drawbridge. It crosses the northeast arm of Lake Champlain between the towns of Alburg and Swanton. The new bridge is a vital link between Vermont, New York, and the Province of Quebec—especially for commercial vehicles.

The original bridge, completed in 1938, badly deteriorated and was in need of substantial repairs. In 1988, deck deterioration required welding the drawbridge shut, thus prohibiting water vessels more than 13′ high from passing beneath it.

To ensure competitive bidding, VTrans commissioned dual designs for the project: post-tensioned segmental concrete and steel plate-girder construction. The design engineer's estimate for both designs came in fairly close, with the cost of steel somewhat lower despite the record increases in steel prices during the first quarter of 2004. The lower cost of steel enticed its use for the bridge, since this project required nearly 2,500 tons of structural steel. About a dozen interested contractors studied the plans, including those pre-qualified for post-tensioned segmental concrete bridge construction.

During the design period, engineers estimated construction cost for the project at about $33 million. Yet prior to bidding, the estimate was reduced to $29.5 million in anticipation of economies of scale for a large project. At the time of bidding, however, difficult site conditions, environmental permits and material prices all worked against these economies of scale.

Four contractors bid on the project. A segmental concrete bridge would have been the first of its kind in Vermont. However, given the fact that steel design was especially economical and straightforward, all four contractors rejected the concrete design bid. Cianbro Corporation of Pittsfield, ME, produced the lowest bid of $32.2 million, about 25% below the highest bid. The high bidder, Fru-Con, was pre-qualified to bid the segmental concrete option but chose instead to bid steel.

Structural Design Snapshot

The design process for the steel bridge superstructure was characterized by the following considerations:

- Load Factor Design Method of the AASHTO Standard Specifications for Highway Bridges. VTrans is in the initial stages of adopting Load and Resistance Factor Design.
- (L/1000) maximum live-load deflection (1.8″). This is based on three traffic lanes loaded with the AASHTO HS-25 vehicle.
- Allowances for future steel section losses up to 1/8″ and a future concrete barrier railing were included in the design.
- The steel girders are cambered for full dead load with an added residual camber of about 2″ per span. The maximum dead-load deflection is about 6″.
- Additional stiffeners at bearing locations were provided to accommodate future jacking and bearing replacement.

The final steel design is a 3,600′ straight structure that runs parallel to and is about 65′ south the original causeway and bridge, which runs east and west. The 2% grade of the new bridge results in the 35′ vertical clearance for watercraft and eliminates the need for a drawbridge. In the end, this project will remove about 300′ of the old causeway on the east side, leaving roughly a 1,000′ opening for watercraft.

Designed to metric dimensions, the bridge is 43.3′ (13.2 m) wide (curb to curb) with two 12′ traffic lanes bracketed by about 10′ shoulders. The bridge structure consists of 23 equal spans of 155.5′ (47.4 m) each.

Deck support consists of four weathering-steel plate girders spaced at 11.8′ (3.6 m). This wide spacing eliminates the need for a fifth girder and associated diaphragms, contributing greatly to the economical nature of the design. Weathering steel will minimize future maintenance, and steel girders adjacent to the bridge joints will be painted to match the weathering steel look.

The bridge contains four modular steel/compression seal joints located at both the east and west abutment, as well as at Piers 7 and 15. Fixed steel pot bearings with an elastomer are located at Piers 3, 4, 10, 11, 12, 18, 19, and 20. The other locations have expansion bearings. Designers checked the possibility of a jointless bridge but considered the expansion too great.

This superstructure also consists of three units of continuous spans:

- From the west (Alburg) abutment to Pier 7—one 1089′ (332 m) unit of seven spans.
- From Pier 7 to Pier 15—one 1243′ (379 m) unit of eight spans.
- From Pier 15 to the east (Swanton) abutment—one 1243′ (379 m) unit of eight spans.

Plans call for field splices at 40 locations in order to construct the continuous girders. Still, all splices are at the discretion of the contractor and fabricator to maximize flexibility for girder fabrication, delivery, and erection.

The bridge substructure incorporates 10′-diameter single-drilled shafts with 1″-thick steel casings. The casings are embedded and excavated in the soft soil below the water. The contractor will drill into the ledge and place a rebar cage into the casing. Next, concrete will be poured into this encased shaft. In this case, drilled shaft layouts for both the steel and concrete designs were identical.

Cost-effective Steel Design

All bridge girders are identical except for flange thickness. Each holds the same 17.7″ (450 mm) flange width, which greatly simplifies fabrication. The flange thickness ranges from 3.15″ (80 mm) to 0.87″ (22 mm) thick to accommodate changing strength requirements along its length. The 0.63″ (16 mm) girder web thickness allows for a partially stiffened girder section, further reducing fabrication labor and costs. This web and flange thickness includes the addition of a 1/16″ "sacrificial" layer required by VTrans for all steel bridges.

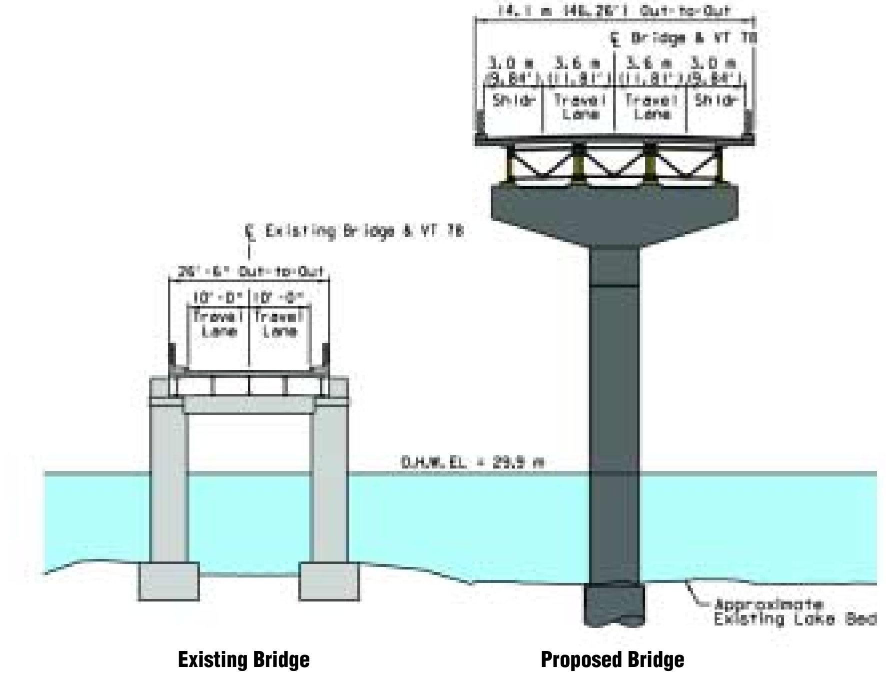
Identical angle-iron K-frames spaced at roughly 22′ (6.8 m) sit within three bays, which are situated between the four girders. Since nearly all the K-frames are identical, the fabricator can set up a jig to produce them in assembly-line fashion. As mentioned previously, the girders have few additional stiffeners, with the exception of jacking stiffeners at the piers for construction purposes. The southernmost bay, however, contains additional supports between the K-frames for utilities.

The bridge's concrete deck has a thickness of about 9.5″ (240 mm) and is protected with sprayed-on membrane waterproofing. The deck is also topped with a 3.15″ (80 mm) wearing surface layer of bituminous concrete. Wide spacing between the girders precludes the use of stay-in-place forms. The deck, therefore, is formed with plywood and timber, which slightly increases its cost.

Full Speed Ahead

The new bridge is slated for completion in 2007. Much of the construction must take place between early May and the end of October, as this time parameter is part of the rules set forth by the Vermont Agency of Natural Resources to help protect the Eastern spiny soft-shelled turtles that inhabit the original bridge causeway.

According to High Steel Structures, because the design is so concise, detailing costs will be significantly reduced. In addition, detailing work that would have taken three to five months should now only take one month. With the project running smoothly, the bridge may be ready for use in as early as 2006. ★



The higher vertical clearance of the proposed bridge eliminates the need for a bascule drawbridge at the center of the span.

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