Steel Bridge NEWS
NATIONAL STEEL BRIDGE ALLIANCE DECEMBER 2006

REPLACEMENT

New Bridge Slated for Columbus

To pave the way for a new downtown landmark, demolition began the week of September 25 on the 68-year-old Main Street Bridge in Columbus, Ohio. The new span will link parkway developments on both sides of the Scioto River, contributing to the revitalization of the Columbus Civic Center. Total cost of the project is projected to be $44.1 million, with completion in 2009.

The new bridge will feature an innovative single-rib tied arch with a 400-ft span that will carry separate vehicle and pedestrian lanes. The arch will be inclined at a 10° angle from vertical, adding to the uniqueness of this signature structure. A pedestrian deck will sweep horizontally and vertically away from the roadway to provide an unobstructed view of the city's downtown.

The project team is led by DLZ Ohio, Inc., with HNTB Corporation as the lead structural design firm. The prime contractor is Kokosing, and Jansen & Spaans is the construction engineer. S.N. Pollalis of the Harvard University Graduate School of Design developed the initial design concept.

A MESSAGE FROM THE

Executive Director

As 2006 comes to a close, the steel bridge industry continues its efforts to increase market share, advance technology in bridge design and construction, and promote improvements for accelerated steel bridge deployment. We also continue to make excellent strides in providing protection and influence on the Buy American Provision for our industry.

Phase I of the *Steel Bridge Design Handbook* has been completed, and the chapters are available as PDF downloads from our new web site. Phase II is scheduled for a completion date of mid-2007 and the third and final phase will begin later this year. The chapters are based on the *AASHTO LRFD Bridge Design Specifications*, Third Edition, and will be upgraded online for each new specification edition. The chapters cover a wide range of topics about steel bridge design, fabrication and erection and include several design examples. The completed *Steel Bridge Design Handbook* will provide the steel bridge community with a valuable tool for answering many of their technical and design questions.

Our increased trade and public awareness efforts have continued to provide information on several signature bridges as well as everyday steel bridges. Included in this effort are interesting articles and information to educate and influence the decision maker in making the right choice in steel design and construction. A new web site (**www.steelbridges.org**) was developed, compiling information about NSBA as well as steel bridge information from all sectors of the industry. The web site can be viewed for all updated news, AASHTO documents, opinion statements, and meeting dates for the industry.

The political scene remains active. Privatization of roads and bridges is receiving more and more consideration, and our influence will be directed to assist these new decision-makers in using steel components. Many state and local authorities are choosing to look offshore, avoiding the Buy America Provision. Not only are these challenges presenting themselves on our coasts, but they have also migrated to several inland states. NSBA is dedicated to preserving the Buy American Provision and will continue to represent member mills and fabricators in their effort to keep our domestic steel bridge industry strong. The midterm elections should provide interesting times. Our efforts will evolve and we will continue nurturing existing relationships and making new friends where offices change.

On behalf of the entire staff of the National Steel Bridge Alliance, I would like to take this opportunity to wish you and your family a wonderful and happy holiday season and a prosperous new year.

Best regards,
Conn Abnee
NSBA Executive Director

EVENTS

Steel Bridge Symposium

The 2007 World Steel Bridge Symposium will take place December 4–7, 2007 at the Sheraton New Orleans Hotel, New Orleans, La. For exhibit and sponsorship information, contact Jody Lovsness at 402.758.9099 or lovsness@nsbaweb.org. For general information, contact Elizabeth Purdy at 312.670.5421 or purdy@aisc.org. Visit **www.steelbridges.org** for the latest information.

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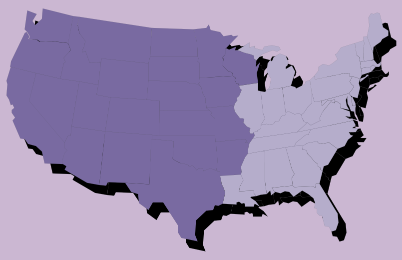
Regional Directors' Territories



MATERIALS

Prefabricating Standard Orthotropic Steel Decks

BY ROMAN WOLCHUK

The American steel industry must offer new and better products to more effectively compete in the bridge market. Wider use of cost-effective orthotropic steel decks provides one possible way to increase the role of structural steel for bridges. Currently, bridge engineers tend to consider these decks expensive and useful only for large bridges. They also associate them with complex design and analysis.

Specifications permitting the use of standardized orthotropic decks not requiring elaborate analytical investigations would encourage their increased use. The Eurocode provisions for orthotropic decks, for example, expressly exempt some common bridge types from numerical fatigue investigations, provided that the decks satisfy certain geometric requirements and fabrication rules. The Japanese bridge code contains similar provisions.

The 1994 edition of the AASHTO LRFD specifications for orthotropic decks also dispenses with numerical investigations of fatigue strength of certain details not easily amenable to analytical treatment. The junctions of the ribs with the deck plate can be considered to have adequate fatigue resistance if the stipulated requirements for geometric proportions and welding details are satisfied.

It should be noted that provisions permitting the use of certain standard pre-tested bridge components, such as steel gratings, precast concrete deck panels or T-beams, without numerical strength and fatigue analysis by the designer have been already included in the earlier AASHTO specifications.

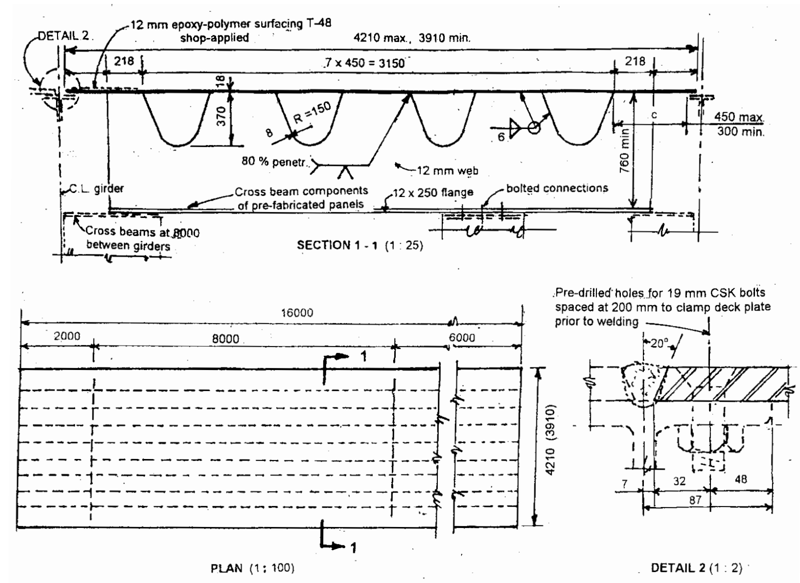


Figure 1. Proposed prefabricated orthotropic deck panels.

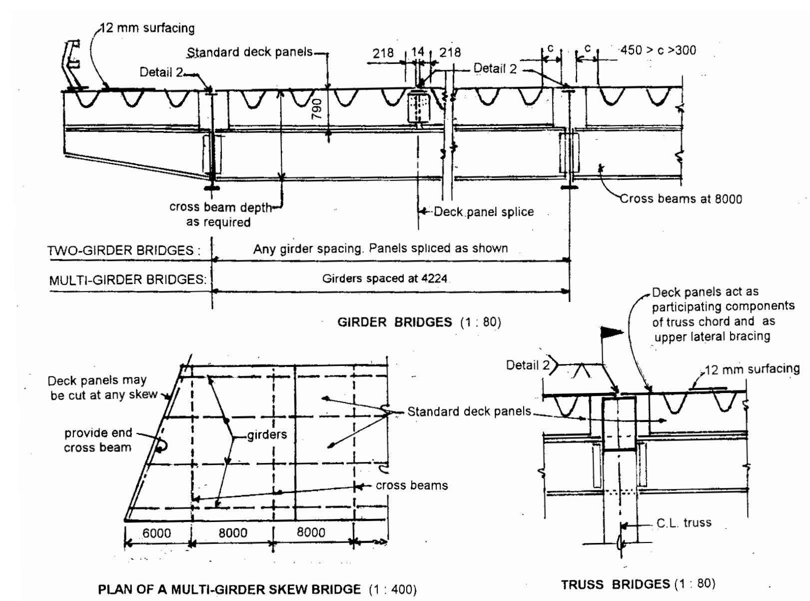


Figure 2. Applications to new bridges.

Designing the Standard Panel

Figure 1 shows a proposed design for a standard orthotropic steel deck panel. It is suggested that hot-rolled ribs replace the conventional cold-pressed ribs. Cold pressing of ribs in the fabricator's shop is an expensive process, requiring specialized heavy equipment. Generally, the length handled by fabrication presses cannot exceed about 12 m (40 ft). Other disadvantages of cold pressing are the high residual stresses and strain hardening at the corners of the ribs, reducing their fatigue resistance. Cold pressing also increases the difficulty of attaining the prescribed straightness tolerances, essential for correct welding of the ribs to the deck plate. Initially, however, the cold-pressed ribs would have to be used because the steel mills could produce hot-rolled profiles only if assured of sufficient tonnage.

The cost of fabrication and erection of orthotropic decks depends primarily on specialized labor, not the cost of the steel plate. The rib intersections with the cross beams are labor-intensive. Proposed deck panel design minimizes the number of such intersections by spacing the cross beams at 8 m (26 ft) and spreading the ribs farther apart. This modification requires a thicker (18 mm) deck plate, which is also desirable for reducing local deck flexibility. A stiffer deck plate improves the performance of the wearing surface.

Substantially longer rib spans of 9.8 m (32 ft) have already been used on one of our projects. They perform well under heavy traffic. To further reduce the labor cost, the detail at the rib intersections with the cross beams may be simplified by omitting the free cut-outs at the rib bottoms, which require laborious "wrapping around" of the welds and costly grinding smooth the weld ends and around the cut-out. Instead, the ribs with rounded bottoms are fitted tightly in the web cut-outs and welded continuously all around the rib periphery. This alternative is possible where the depth of the cross beam is at least

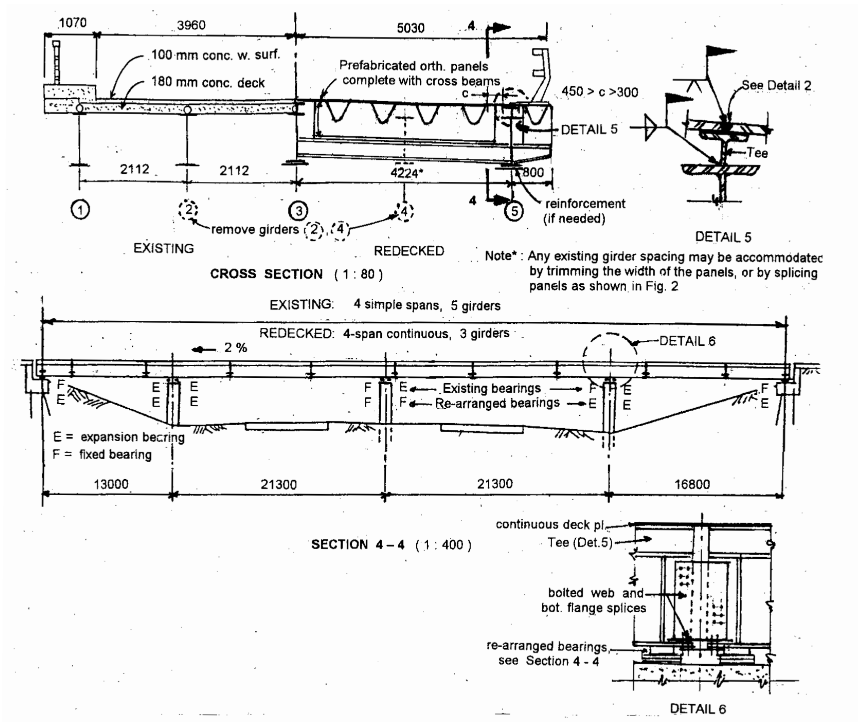


Figure 3. Re-decking of short-span stringer bridges.

twice the rib depth.

For good fatigue resistance, fabricators must strictly adhere to required tight dimensional tolerances. They should also choose welding methods and sequences to minimize residual stresses. The size of the proposed prefabricated panels is governed by their ability to be transported to the project site by truck.

The panels will act as top flanges of longitudinal girders, as shown in Figure 2. Erectors will weld the edges of the panels to the tops of the girders in the field. These welds will resist the interaction shears between the steel roadway deck and the girder.

Wearing Surfaces

We've proposed a thin (12-mm or ½-in.) epoxy-polymer surfacing of the type proven on such projects as the Poplar Street Bridge in St. Louis and the Macdonald Bridge in Halifax, Nova Scotia, Canada. This material has relatively low susceptibility to temperature effects. Bituminous surfacings exhibit undesirable stiffening at low temperatures that may result in pavement embrittlement and cracking.

Note the critical location on the deck in the vicinity of the rigid main girders where the deck plate is subject to sharp local curvature, causing maximum tensile strain in the surfacing, as shown in Figure 4. To minimize this effect the distance **c** between the web of the rib and the deck plate support at the girder (see Sect. 1–1, Figure 1) must be sufficiently large. Our investigation indicates that, with distance **c** within the indicated limits, the resulting strains may be safely withstood by the thin surfacing of our choice. But much larger strains and stresses will develop in a thick bituminous pavement at low temperatures, possibly causing its failure.

Applying the Prefabricated Panels

Figure 2 shows that prefabricated panels of this type could be used for all kinds of steel bridges with two or more rolled-beam stringers or plate girders. The needed roadway width can be obtained by longitudinally splicing the deck plates of two or more panels. For skewed bridges the end panels may be cut at any angle. In the end bays the rib spans should not exceed 6 m (20 ft). In truss bridges the panels will function as participating components of the truss chords and as the lateral bracing.

Figure 3 shows possible application of prefabricated panels to re-decking of short span stringer bridges. Overpass structures over the interstate highways built in the 1950s to 1980s typically consist of four simple spans, as shown in Section 4–4. Rolled-beam stringers are generally spaced at about 2.1 m (7 ft) with composite or non-composite concrete decks that have open joints at the piers and the abutments. On most of these structures the concrete decks are deteriorated. The use of prefabricated orthotropic panels would offer the following advantages:

- elimination of the open deck joints at the piers by using a continuous deck plate between the end abutments.
- conversion of simple span stringers to con-

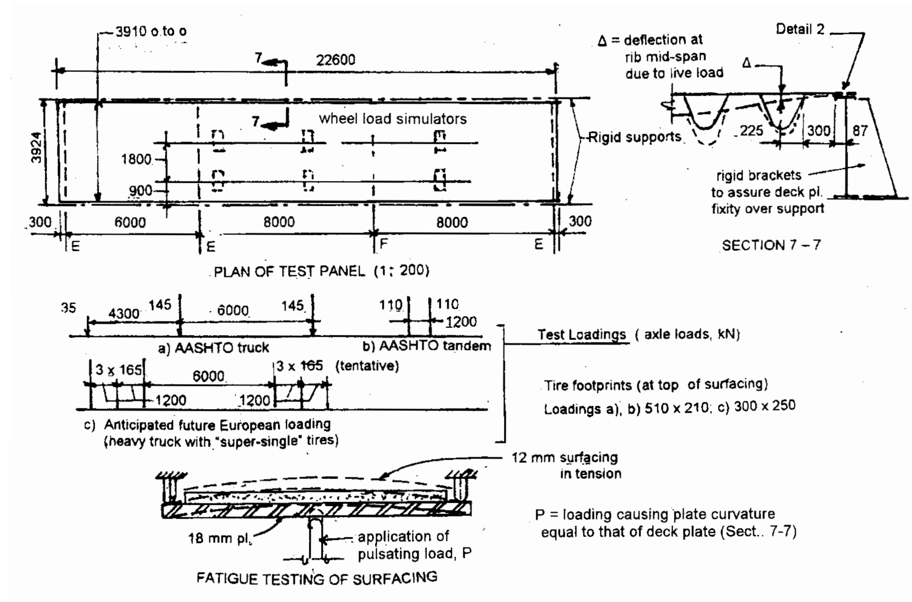


Figure 4. Proposed testing of panel prototypes.

tinuity, considerably decreasing the positive moments due to live loads.

- the possibility of eliminating two out of the existing five stringers, as shown in the cross section.

Installation of the new deck can be done expeditiously, one lane at a time, minimizing traffic restrictions. Eliminating two stringers provides the further advantage of reducing future painting and maintenance cost.

Testing Prefabricated Panels

The use of prefabricated panels without detailed numerical investigation by the designer will require certification of their strength and fatigue resistance by testing of prototypes. Such certified standard prefabricated panels could then be confidently specified by engineers and owners without the need for analytical drudgery and uncertainty.

Figure 4 shows the proposed testing panel. Its framing plan will make it possible to study the structural behavior of the 8-m (26-ft) interior spans and the 6-m (20-ft) spans of the ribs at the ends of a bridge. The tests should subject the panels to live loads representing current AASHTO specifications and possible future European heavy truck loading.

Several panels must be fabricated to complete the loading test series and to compare the effects of various fabrication factors, tolerances, welding procedures and panel treatment methods. This will be a large and costly testing program. We are fortunate to have in the U.S. the excellent Lehigh University/ATLLS testing facilities, well experienced in full-scale testing of large orthotropic deck prototypes. This work could possibly be shared with laboratories in Europe or in Japan where the steel industry and transportation authorities may be interested in prefabrication of standard decks.

The testing program will also include testing of wearing surfacing for fatigue resistance in flexural tension. Such tests are made on small specimens of the deck plate with applied surfacing as shown schematically in Section 7–7 of Figure 4. Practical methods for such testing at various temperatures have been worked out by the University of Missouri, where tests of this kind were successfully carried out for the Poplar Street Bridge and other projects. Manufacturers of the thin surfacing proposed for the panels may be willing to cosponsor such testing.

We expect that such pre-fabricated standard panels, produced in large quantities by industrial methods, will be substantially less costly than the decks designed and fabricated for a specific project. Current practice requires:

- considerable engineering design effort
- excessive time needed for preparation, review and approval of the shop drawings
- engineering inspection.

Avoiding these time-consuming procedures will not only reduce the cost, but will also considerably shorten the construction period.

Roman Wolchuk is a principal with Roman Wolchuk consulting Engineers, Jersey City, N.J.

Simple-Made-Continuous Bridge Cuts Costs

Cost-effective detailing was only one of the advantages of a simple-made-continuous weathering steel girder bridge in New Mexico.

BY TED L. BARBER, P.E.

THE NEW MEXICO DOT HAS GREATLY IMPROVED MULTI-SPAN, PLATE-GIRDER STEEL BRIDGES DESIGNED AS SIMPLE-SPAN FOR DEAD LOADS AND CONTINUOUS FOR LIVE LOADS. These designs ease fabrication and erection, helping to keep steel bridges competitive with concrete. The simple-made-continuous concept cuts costs through repetitive fabrication, full-length girder erections, simplified connections, and flexible deck-pour sequencing.

Bridge Overview

The bridge discussed here crosses the Rio Grande River on NM 187, near Array. This two-lane, four-girder structure, designed by the NMDOT, has five 105-ft spans and a width of 34.5 ft. The substructure consists of driven, filled, steel pipe piles. Concrete curtain walls surround the piles to five feet below grade. The construction phase started in the fall of 2004, completing in the summer of 2005.

On an earlier project, the simple-made-continuous concept served in a dual-design analysis (steel vs. pre-stressed concrete bridges) for a bridge on US 70 in southern New Mexico. Design consultant for the US 70 bridge alternates was Parsons Brinckerhoff, Inc. Bids by construction contractors for these bridge alternates differed by only 0.2 percent out of a total project construction cost of $21 million. This small differential cost tipped the decision to look at applying the simple-made-continuous concept to steel bridges located in similar geographies.

The NM 187 steel bridge project incorporated further improvements in design and construction details. Selection of the superstructure type depended heavily on economic analyses of various configurations of steel girders and pre-stressed concrete beams, while limiting the depth of the new superstructure. The preliminary design scenarios determined that pre-stressed concrete required five girder lines, but steel plate girders required only four girder lines.

A shallower depth decreased the earthwork required to build the bridge approaches, as well as the amount of right-of-way needed for a new parallel offset alignment. It also improved the bridge aesthetics in the river area. Other bridges built along the same river have vertical curves that seem somewhat out of place for this river valley.

The economical steel bridge design incorporated an easily fabricated and constructible bridge superstructure with no traditional bolted splices between piers. Eliminating these bolted splices avoided the shoring towers required for erection. The design implemented constant plate thicknesses and dimensions with no flange transitions. One-piece diaphragms, positioned on wide spacing, also facilitated easy erection. The steel girders, all grade 50W, have a total depth of 54 in. The web is 0.472 in., and the cross sections of the top and bottom flanges are 0.866 in. by 13.78 in. and 0.866 in. by 17.32 in., respectively.

Superstructure Detailing

New detailing ensured that the top plate connecting in-line girders at the piers would slip properly under DC1 construction loadings, allowing beam-end rotation. By contrast, on the US 70 project the contractor placed the deck and pier diaphragm in one continuous pour. Construction workers had to tighten all top continuity plate connection bolts before slab pour because of their location inside the concrete pier diaphragm. This induced some level of stress throughout the beam. The shear resistance of neoprene bearing devices induced these forces, which are caused by beam-end rotation under deck pour loadings.

Figure 1. Dual-design analysis indicated that steel required only four girders, while concrete pre-stressed beams required five (for the same depth).

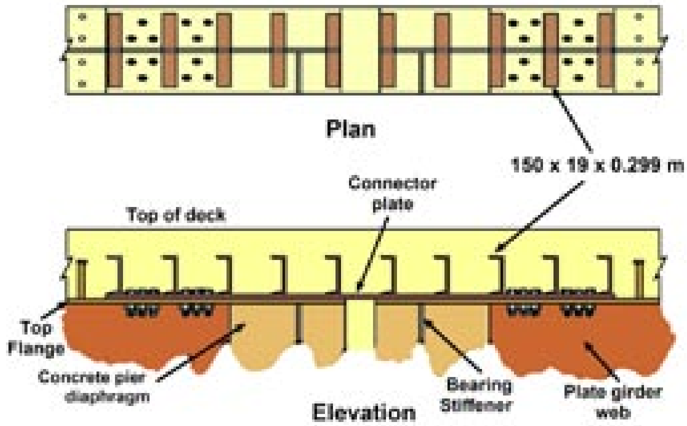


Figure 2. Connection plate bolts outside the pier permit tightening after the deck pour, minimizing induced stresses.

NMDOT improved the girder connection for the NM 187 bridge design by placing the bolts outside the poured concrete diaphragm at the piers (Figure 2). Bolts placed heads-up and nuts-exposed-down permitted tightening of the connection after pouring of the deck and pier diaphragms. After deck pours, the bolt heads were locked into the concrete deck. Workers tightened bolts by turning nuts with direct tension indicators from below. Final tightening came after all concrete had been poured for the deck and pier and abutment diaphragms, prior to opening for traffic.

The design required adding reinforcing bars to normal deck reinforcement patterns longitudinally over the piers. The additional reinforcement achieved the required negative moment capacity for the bridge's continuous live-load function. Under live loads the continuity connection plate will be lightly stressed. The continuity plate connection also added redundancy in the event that future deck deterioration reduces the effectiveness of the deck reinforcement for negative moment capacity.

The bearing stiffener plate on each beam end at the piers served to develop compression for this moment connection. A simple plate perpendicular to the web and bearing stiffener braced the bearing plate in the compression zone.

This type of connection also gave more flexibility to the bridge contractor on pour sequences. Contractors in the state want to pour entire bridges in one day. The 500+ cubic-yard volume of concrete on this bridge deck prevented a one-day pour. But with this design, contractors can pour across spans, pier concrete diaphragms, and bulkhead 6.5 ft from a pier cap.

Reviewers of shop drawings made a change requesting that the fabricator bend the connection continuity plates to conform to beam dead-load camber at each beam end. This allowed the connection plate to fit up with loose bolting during dead-load application. The top-plate slippage also avoided unintended shear deflections in the steel-reinforced neoprene bearing pads during the slab pour, as well as any induced moment in the girders.

Additionally, the reviewers requested a small increase in the length of the slotted hole in the continuity plates to aid erection tolerances. As a result, the contractor was able to erect beams and lift continuity plates (with bolts) into place without any alignment problem. Bridge erection was simple and straightforward.

The design intentionally centers the bridge's vertical alignment at the crest of a vertical curve, allowing for the uniformity of all girders and greatly simplifying the bridge in design and detailing for construction. Steel girders for this bridge were detailed for the same exact length, plate thickness, dimensioning, and camber, facilitated by a slight adjustment to the length of end spans. Simple horizontal steel channel diaphragms added to the bottom flange in the negative moment region over the piers provide additional buckling resistance.

Design Firsts

The bridge represents the first in-house design of a steel bridge with this detailing and the first project to implement *AASHTO LRFD Bridge Design Specifications*. No commercial software packages are available for the simple-made-continuous steel design concept. Instead, STAAD Pro structural analysis software and Mathcad performed a two-stage analysis and design calculation for the beam lines. For the first stage, all spans were simple. The second stage transformed joints at piers to moment connections for girder-line analysis. STAAD Pro also allowed factoring of loads and graphical presentation of the location of axle loads and their position at maxima. Many of today's software programs seem to lack presentation of positions for the loading on the structure. Mathcad performed the calculations for the steel design using the LRFD code.

Fabrication and Erection

Global steel market conditions delayed the start of fabrication of the girders for the project. The nationwide supply of steel decreased between the time of bidding and notice to proceed. The contractor asked for suspension of work on the contract for three months over the winter to allow for delivery of the raw plate to the fabricator.

NMDOT planned this bridge for construction during the low-flow stage of the river. It was essential to complete spans 4 and 5, the two spans over the river, before the water reached spring irrigation levels. In spite of the three-month suspension of work, fabricated steel delivery and erection took place to complete the two river spans on time. The flexibility of the simple-made-continuous girder system permitted the contractor to pour spans 4 and 5 while beams had not yet been erected on spans 1, 2, and 3. Thus, the contractor was able to fulfill this contact requirement.

Economical and fast fabrication resulted primarily from the repetition of girder design throughout the structure. Repetition in shop fabrication increased productivity by at least 25 percent. Like-size flanges, webs, and girder lengths provided the most advantageous price and delivery of steel plate from the mill. Additional advantages included:

Figure 3. A connection plate bolts the top flanges of the two girders that meet at a pier, making the girders continuous for live loads.

- Detailers could develop shop drawings for one girder; all others were nearly alike.
- The fabricator cut flanges and webs using only one drawing.
- Shop fabrication necessitated only one jig for tacking and welding.
- The continuity plates that spliced the girders together at the piers were all identical and could be processed full-size using CNC equipment.
- The girders did not require full layout and assembly in runs.
- Assembly drilling, required for conventional bolted girder splices, was unnecessary.

With all parts alike, erection efforts in the field were much more efficient as well. Big savings resulted from:

- Eliminating bolted field splices between piers.
- Eliminating sandblasting of girders (the bridge is not in an area exposed to view).
- Specifying weathering steel, which will develop a rich color and form a protective patina in time.

Two relatively small cranes, readily available in the state, easily erected the steel beams. Prestressed concrete beam bridges often require much larger cranes and large mobilization costs, difficult lift configurations, and more erection time. The State of New Mexico is in the middle of a $1.5 billion road and bridge improvement bond program over six years. One of the goals is to facilitate smaller bonding requirements so that more construction firms are able to bid projects. Using resources within the state are essential for this program.

The design phase of this project started before steel price levels increased over the past few years. Despite these increases, cost per square foot for this bridge came in lower than some other concrete bridges recently bid in the state. With a total deck area of 18,170 sq. ft, the cost of this bridge as reported to the Federal Highway Administration was $75 per sq. ft. Prestressed concrete girder bridges of comparable square footage were $68 and $88 per sq. ft. each.

This simple-made-continuous project showed that steel bridges can compete with pre-stressed concrete in a predominantly concrete bridge state. This concept will work well in other similar river and dry stream-bed crossings of significant length and requiring at least two spans. This type of design is limited to maximum girder lengths that can be hauled to the bridge location; otherwise, expensive traditional field splices are necessary. MSC

Ted Barber is a bridge design unit supervisor with the New Mexico Department of Transportation (NMDOT) in the Bridge Design Section.

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