Piece BY Piece

BY MICHAEL P. CULMO, P.E.

Span-by-span bridge construction, using modular steel bridge elements, can serve as a viable and economical bridge-building alternative.

ACCELERATED BRIDGE CONSTRUCTION (ABC) has come a long way in the last 10 years.

And prefabricated, modular elements made with steel beams have been a big factor in making this happen, as they can be used to reduce the weight of the assemblies, thereby making crane installations more cost effective and viable.

Modular steel beam/deck elements generally consist of two or three steel beams with a composite concrete deck cast in the fabrication plant. They are erected quickly and joined with reinforced concrete closure pours made with high-early-strength concrete; a bridge superstructure can be built in as little as two days using this technique.

One of the more successful examples of this method was the 93Fast14 project in Medford, Mass. (a 2012 NSBA Prize Bridge Awards winner), which involved replacing 41 spans on 14 bridges along Interstate 93. The 14 bridge superstructures were replaced during ten 55-hour weekend work periods. The use of structural steel for the beam elements made the project possible since crane capacities controlled many of the sites.

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Span by Span

Let's take a look at the two common ABC methods to design and construct a multi-span bridge. The first is to detail multiple simple spans between supports, sometimes referred to as "span-by-span" construction. Conventional simple-span bridges require expansion joints at each pier—historically a problematic feature of many bridges—as leaking joints, considered by many to be the most common cause of premature bridge deterioration, lead to the corrosion of beam ends and deterioration of the substructures under the joints.

The second method for designing multi-span bridges is to use continuous-span beams, which do not require deck expansion joints at the interior supports, and require less structural steel for a given span arrangement.

Span-by-span beams are simply erected on the substructures without the need for splicing and shoring towers. The problem with leaking deck joints has been addressed by designing these bridges to be either joint-less or continuous for live load by using simple concrete pours at interior supports to eliminate the need for deck expansion joints. Using span-by-span techniques for the superstructure can accelerate the process by eliminating the need for welded or bolted field splices in continuous girders. Beam erection can progress very rapidly as the modular units are inherently stable. Once set, the crane can release the beam without the need for any external bracing.

One method that has been developed to eliminate deck joints on simple-span bridges is "link slab" technology. A link slab is built by simply casting the slab continuously across the pier linking the two spans. The link slab is designed to accommodate the live load rotation of the girders without significant cracking. This is accomplished by debonding a portion of the deck near the support to form the link slab, which acts as a flexible beam. The recommended

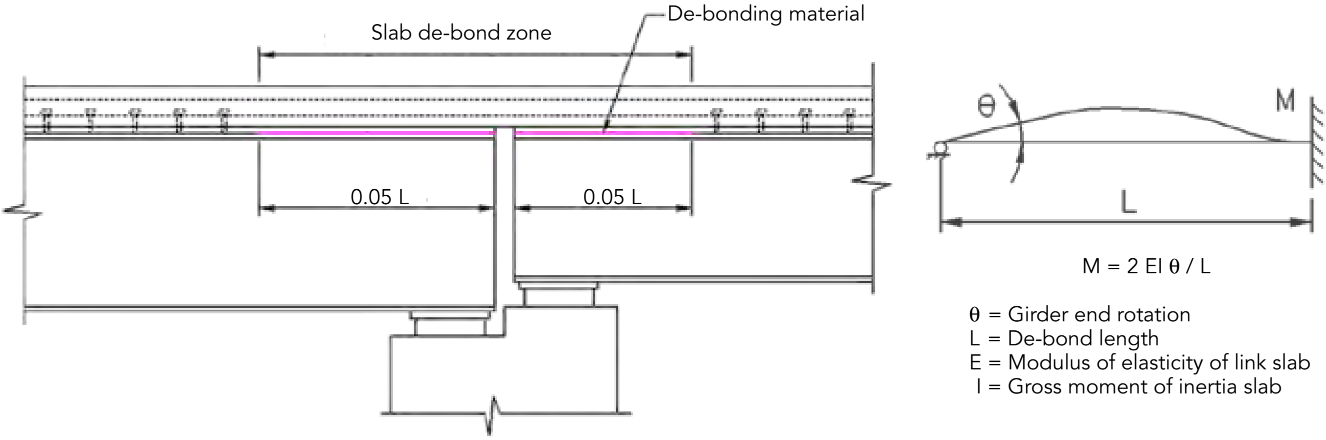
The 93Fast14 Project in Medford, Mass., demonstrated the viability of modular steel bridge construction by replacing 41 spans in ten 55-hour weekend work periods.

length of de-bonding is 5% of the adjacent span on each side of the pier. Keep in mind that link slabs are not a form of continuity. The bending moments in the link slab are much less than typical negative bending moments in continuous girder bridges; therefore, the design of the girders is based on simple-span supports.

The bending moment in the link slab can be calculated using a simple equation. Reinforcing can then be designed to resist the bending and control cracking. The bending stresses in link slabs are often less than the tension stresses that develop in continuous-span bridges. The same principals of crack control reinforcing design are applied to both.

Greater Efficiency

We are taught in engineering courses that continuous steel girders are more efficient than simple-span girders and that "least weight equals least cost." In principle, these lessons are true. But in order understand the true efficiency of steel bridge construction, the engineer needs to look at the total cost of the bridge, including the cost of connections, construction methods and deck reinforcement. In order to study the efficiency of span-by-span construction, we investigated the preliminary design of a hypothetical two-span bridge. The bridge selected is a typical expressway overpass with equal spans of 122 ft and five girder lines.

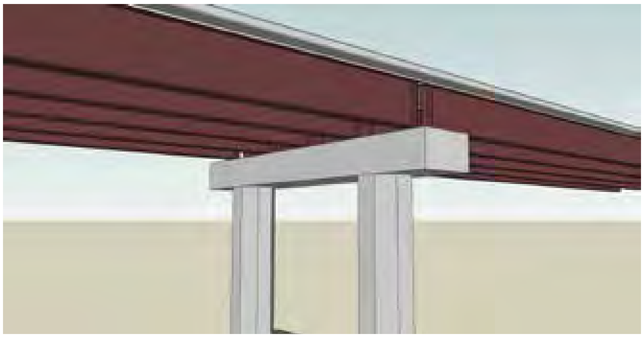


Bridge deck joints can be eliminated at piers through the use of "link slabs."

Typical two-span overpass bridge.

Continuous girder with bolted splices.

Simple-span bridge with joint-less deck.



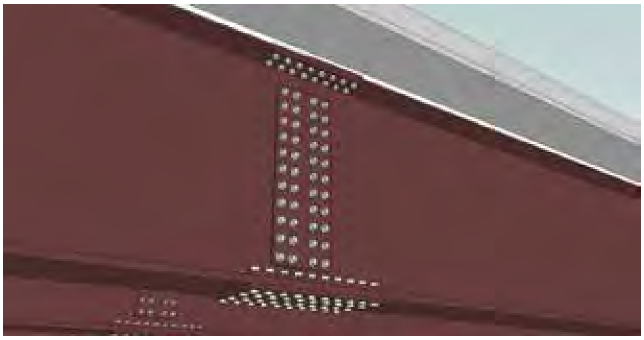
Two bridge types were studied for this structure: continuous girders and simple-supported girders. The NSBA computer program Simon was used to complete a preliminary design of the girders. (Simon is available for free at **www.steelbridges.org** and can be used to design efficient steel girders for simple- and multiple-span bridges based on the AASHTO LRFD *Bridge Design Specifications*.)

The results of the preliminary design showed that the simple-span bridge required 30 more tons of steel at a cost of $70,000 more than the continuous-span option (based on construction costs in the Northeast). The remainder of the study was dedicated to investigating the total cost of the bridge in order to determine if other factors would offset the increased cost for the structural steel.

On such factor was splicing. The 122-ft-long simple-span girders can be shipped in one piece (without field splices), where the continuous girders would need at least one field splice. The study assumed that two field splices would be required for the bridge. It may be possible to build this bridge with one splice, but the length of the pieces would be more than what some permitting agencies would allow.

Another NSBA computer program, Splice, was used to design the bolted splice for the continuous girder study bridge. This program can efficiently design a bolted field splice according to the requirements of the AASHTO LRFD *Bridge Design Specifications*. The final design of the splice included 116 high-strength bolts, and the cost for fabrication and installation of the splice was estimated to be $5,800 per splice (again, based on typical regional construction costs). By eliminating the need for bolted field splices in the span-by-span bridge, an estimated cost savings of $58,000 could potentially be realized.

The *Bridge Design Specifications* require the use of longitudinal reinforcing steel in the negative moment region of continuous girder bridges in order to control cracking due to composite dead load and live load moments. In general, the design of link slabs results in longitudinal reinforcing that is much less than that used in continuous girder bridges. In addition, the link slab reinforcing steel need only be applied over the link slab zone, which is typically smaller than the negative moment region of a continuous girder. For the study bridges, the link slab design saved considerable reinforcing steel when compared to the continuous-span bridge, which equated to an approximate savings of $22,000.



Bolted field splice designed using NSBA's Splice program.

Another avenue of potential cost savings with simple-span construction is erection. Many agencies require the use of shoring towers under bolted splices. Even if shoring towers are not used, the cranes are required to hold the girders until sufficient bolts are installed in the field splices, which is a less efficient process. The potential erection cost savings for the simple-span bridge was estimated to be approximately $30,000.

When it comes to bearings, simple-span construction requires two lines of bearings at the center pier, compared to one line of bearings in the continuous girder bridge. The simple-span bearings are small but there are more to fabricate and install, and the cost of the extra bearings was estimated to be approximately $1,500.

When the above items are accounted for, an estimated net cost savings of $38,500 could be realized for the span-by-span bridge.

Item	Net Cost Savings
Structural Steel	-$70,000
Bolted Splices	$58,000
Additional Deck Reinforcing	$22,000
Steel Erection Cost	$30,000
Bearings	-$1,500
Net Savings	$38,500

Net cost savings for simple-span construction as compared to continuous bridge construction.

To recap:

1. Continuous-girder spans require less structural steel and fewer bearings.
2. The simple-span construction method may not need bolted field splices, uses less additional deck reinforcement and may be less expensive to erect when compared to a continuous girder bridge.
3. Least weight of structural steel does not always equate to least overall bridge cost.
4. By using link slab technology, simple-span construction can be accomplished with a joint-less deck that is durable.
5. Simply put, simple-span construction is a valuable tool for accelerated bridge construction projects.

This study was limited in that only one bridge was investigated. Other bridge configurations will yield different results. In some cases, a continuous-girder bridge may have a lower overall bridge cost. The conclusion of the study is that simple-span construction should not be ignored due to concerns over the structural efficiency of the girders alone. When total bridge costs are applied, this method can be competitive or even less expensive than conventional continuous-girder designs.

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.

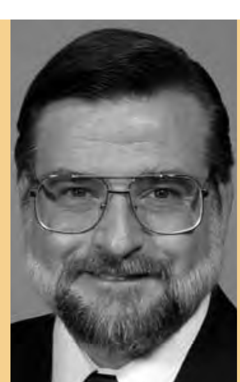
IN AUGUST 2010, the Massachusetts Department of Transportation (MassDOT) was in the process of performing remedial repairs to all of the bridge decks along I-93 in the City of Medford, Mass., when the seriousness of the project suddenly changed dramatically. A contractor had removed the wearing surface 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.

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

Photos this page by CME Associates

➤ 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.

Photos this page by CME Associates

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

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.

"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/**.

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.

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)

Completely removing and replacing the bridge carrying westbound I-44 over the Gasconade River required a closure of less than 20 days.

Sliding Bridge *Speeds* Delivery

BY STEVE HAINES, P.E., AND CHIP JONES, P.E.

HALFWAY BETWEEN ST. LOUIS and Springfield, Mo., I-44 crosses the scenic Gasconade River along the northern border of Mark Twain National Forest. Built in 1955, prior to even the earliest portions of the Interstate Highway System, the bridge carrying the westbound lanes experienced considerable deck deterioration in recent years. As a result, Missouri Department of Transportation (MoDOT) scheduled the bridge for replacement in early 2011. The project included total replacement of the superstructure and repairs to the existing bent caps. MoDOT let the project with a maximum of 60 days of closure time allowed.

The replacement contract was awarded to Emery Sapp & Sons, Inc. (ESS) based on an aggressive construction schedule that limited the total bridge closure days to 35 days. After award of the contract, ESS enlisted Parsons to assist in developing an innovative slide-in construction scheme to replace the bridge on a greatly accelerated schedule in order to further reduce the amount of time the road would be closed to traffic. The ultimate goal was to limit the closure to 20 days total, which would earn ESS a $600,000 early completion incentive ($40,000 per day, capped at 15 days).

Parsons worked with ESS to develop the construction scheme to build the proposed replacement bridge adjacent to the existing bridge while maintaining traffic on the existing bridge. Once the replacement bridge was constructed, traffic was shifted temporarily to the eastbound span, while the existing westbound bridge was demolished and repairs were performed on the existing substructure. Once the repairs were complete, the replacement bridge was slid laterally more than 40 ft, using a hydraulic skidding system, and positioned on the reconstructed bents in less than 12 hours.

Proposed Bridge Replacement

The proposed replacement bridge was designed by MoDOT Central Bridge Office with the assumption that conventional construction methods would be used to construct the bridge. The layout consisted of a six-span bridge with the middle four spans being a

▲ 64-ton push/pull hydraulic jack.

◄ Final bridge location on the repaired existing bents.

▼ Replacement bridge at approximately the half-way point, moving from right to left.

Photos in this spread by Steve Haines.

◄ Slide plate, shown after the bridge has been slid into place.

Steve Haines, P.E., is a project engineer with Parsons, Denver. He has 16 years experience with the latest knowledge in bridge-moving techniques to minimize the impact to the traveling public and has performed bridge moves using multiple accelerated construction methods, including slide-in methods and Self-Propelled Modular Transporters. Chip Jones, P.E., is a division manager for Emery Sapp & Sons, Columbia, Mo. With more than 22 years of heavy construction experience, he has overseen dozens of complex infrastructure projects. His innovative approach has led to the successful completion of these projects throughout his 12-year tenure with Emery Sapp & Sons.

continuous unit and both end spans being simple spans for a total bridge length of 670 ft. The 36-ft, 8-in.-wide bridge is a composite steel plate girder with an 8½-in.-thick reinforced concrete deck. The four-span continuous unit used a four-girder cross section with a girder web depth of 72 in. and girder spacing of 9 ft, 8 in. The end simple spans also used a four-girder cross section with a girder web depth of 42 in. and girder spacing of 9 ft, 8 in. All structural steel was ASTM A709 Grade 50W.

Temporary bents designed to handle the loads due to the construction of the replacement bridge and the loads applied during the sliding operation were constructed adjacent to the existing bents while traffic remained on the existing westbound bridge. The proposed replacement bridge was at the same elevation as the existing bridge to eliminate any required bridge approach work. Building at the same elevation also limited any vertical jacking of the bridge required for the sliding procedures or during placement of the permanent bearings.

The top of each temporary bent was cast at a constant elevation to facilitate sliding the replacement bridge into place. This constant elevation required a minor modification to the original design to accommodate the normal crown section of the bridge, which in the original design would be created by using a stepped bent cap. To create the crown with the constant elevation bent cap, each bearing sole plate was thickened the same amount as the removed step. This method placed all the bearings at the same elevation at the top of the bent cap.

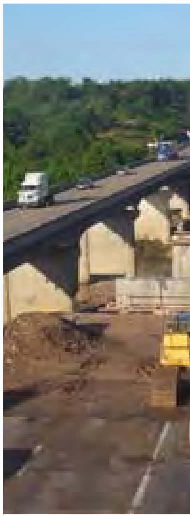
Sliding Setup and Procedure

The replacement bridge was built on top of sliding bearings under each girder at each bent location to eliminate any bearing transitions prior to performing the sliding operation. That allowed the contractor to slide the bridge into place using hydraulic jacks placed at each bent. The sliding interface between the top of the bent cap and the bearings was a standard stainless steel and Teflon interface. Stainless steel sheets were placed on top of both the temporary bents and the repaired permanent bent caps. The sliding pads placed under each girder were elastomeric pads with ⅛-in. Teflon sheets bonded to the bottom of each pad. The elastomeric pads attached to the Teflon sheets allowed for any minor rotations that occurred during the construction activities. The elastomeric pads also compensated for any minor variations in the bent cap during the sliding operation.

Completion of steel erection.

Deck reinforcing complete and ready for concrete placement.

Demolition of the existing westbound bridge begins on May 6.



The sliding materials and slide-in procedure were performed by heavy lift contractor, Mammoet. The total weight of the bridge superstructure was 2,050 tons. The hydraulic jacks used to slide the bridge over into place were 70 ton hydraulic jacks, one at each bent location, and all jacks were interconnected to control the differential rate at which the bridge was pushed into place.

The jacks were connected to the steel superstructure using connection plates bolted to the bearing stiffeners. The bent diaphragms were redesigned to transfer the pushing loads more efficiently into the superstructure, which was the only modification to the structural steel required due to the slide-in procedure.

During the sliding operation, the jacks reacted against a steel slide plate that had been cast into the top of the temporary bents. Notches fabricated into each side of the slide plate spaced at approximately the stroke length of the jack provided the reaction points for the jacks. After each push cycle of the jacks, the jacks self-retracted and were pulled forward to the next adjacent notch. Pushing the bridge into place required a total of 12 cycles.

Transitioning to Permanent Bearings

Once in its final position, the bridge was transferred from the temporary sliding bearings to the permanent bearings. That required only minimal lifting because the slide-in procedure positioned the bridge very nearly at its final elevation.

The bearing transition was performed individually at each bent location. Due to limited space on top of the bent caps, the bent diaphragms were designed to handle the jacking loads required to transition the bearings. Six jacks were used to lift the bridge at each bent location. The jacks were controlled to extend at the same rate and raise the girders all at the same elevation.

The transition sequence began with raising the bridge

▼ 8:30 a.m.: Final preparations before the bridge move on May 16.

▼ 3:30 p.m.: Half-way point of the bridge move.

▲ Replacement bridge fully open to traffic on May 24.

▼ 7:00 p.m.: Final placement of the bridge.

Photos in this spread by MoDOT.

slightly to unload the temporary sliding bearings and remove them along with the stainless steel plate and the shimming material. The permanent bearing was then placed at each girder and the bridge was lowered into place. Once the jacks were unloaded and removed, the stainless steel plate and shimming material that was supporting the jacks was removed. This operation was performed individually at each bent until all sliding material had been removed and the bridge had been transferred onto its permanent bearings.

The slide-in procedure ultimately provided a very efficient replacement method that reduced the impact to the traveling public. Westbound traffic was switched to the eastbound bridge on May 5, 2011, which was the first significant impact on the traveling public. On May 16, 2011, the replacement bridge was slid into place in less than 12 hours. On May 23, 2011, one lane of the replacement bridge was opened to traffic, and fully opened the next day, which beat the goal of limiting the closure to 20 days.

The slide-in procedure required only minor modifications to the MoDOT-designed steel superstructure. The inherent flexibility of the steel superstructure allowed the structure to be moved into place without any damage or cracking occurring to the superstructure. MSC

Owner
Missouri Department of Transportation

Design Engineer
Missouri Department of Transportation, Central Bridge Office

Specialty Move Engineer
Parsons, Pasadena, Calif.

Steel Detailer and Fabricator
DeLong's Inc., Jefferson City, Mo. (AISC and NSBA Member)

General Contractor
Emery Sapp & Sons, Inc., Columbia, Mo.

Specialty Move Contractor
Mammoet, Houston

NSBA 2016 Prize Bridge Awards

THE COUNTRY'S BEST STEEL BRIDGES have been honored in this year's Prize Bridge Awards competition. Conducted every two years by the National Steel Bridge Alliance (NSBA), the program honors outstanding and innovative steel bridges constructed in the U.S. The awards are presented in several categories: major span, long span, medium span, short span, movable span, reconstructed, special purpose, accelerated bridge construction and sustainability. This year's 16 winners, divided into Prize and Merit winners, range from a mammoth marquee Mississippi River crossing to the country's first steel extradosed bridge. Winning bridge projects were selected based on innovation, aesthetics and design and engineering solutions, by a jury of five bridge professionals.

This year's competition included a variety of bridge structure types and construction methods. All structures were required to have opened to traffic between May 1, 2013 and September 30, 2015.

The competition originated in 1928, with the Sixth Street Bridge in Pittsburgh taking first place, and over the years more than 300 bridges have won in a variety of categories. Between 1928 and 1977, the Prize Bridge Competition was held annually, and since then has been held every other year, with the winners being announced at NSBA's World Steel Bridge Symposium. The following pages highlight this year's winners. Congratulations to all of the winning teams!

And check out past winners in the NSBA archives at www.steelbridges.org.

2016 Prize Bridge Awards Jury

- **David Spires**, P.E.
  Senior Engineering Manager with WSP Parsons Brinckerhoff
- **Michael Culmo**, P.E.
  Vice President of Transportation and Structures with CME Engineering
- **Brian Kozy**, P.E., Ph.D.
  Structural Engineering Division Team Leader with FHWA
- **Steve Jacobi**, P.E.
  State Bridge Engineer for the Oklahoma Department of Transportation
- **Carmen Swanwick**, S.E.
  Chief Structural Engineer for the Utah Department of Transportation

PRIZE BRIDGE: SHORT SPAN
ACCELERATED BRIDGE CONSTRUCTION COMMENDATION

Wampum Bridge, Lawrence County, Pa.

IN AN ALL-TOO FAMILIAR STORY, a bridge in Wampum Borough of Lawrence County, Pa., had fallen on hard times and wasn't going to get better.

The severely deteriorated existing concrete arch carried SR 288/Main Street over Wampum Run and provided a vital connection for both residents and the local trucking industry. The failing structure had previously been reduced from two lanes to one bidirectional lane, and its weakening condition would have eventually warranted a full closure in the near future, thus requiring a 22-mile detour that was viewed as both costly and extremely inconvenient for local travelers. Either way, the bridge would need to be repaired or replaced.

Conventional phased construction methods for maintenance of traffic were considered but would have required extensive and costly repairs to the arch, thus prompting both the Pennsylvania Department of Transportation (PennDOT) and designer Johnson, Mirmiran and Thompson (JMT) to take the replacement route. Project stakeholders wanted a reduced construction time frame and minimal inconvenience for travelers following the lengthy detour, and JMT and PennDOT agreed that this could be accomplished by using accelerated bridge construction (ABC) techniques.

Preliminary design began with research and discussions with engineering professionals from various states with bridges successfully built using ABC. JMT reviewed these other states' standards and special provisions, and discussed design and construction methods used on their successful ABC projects. As a result of this research, JMT presented a report concluding that a cost-effective structure could be completed in less than a month.

Various superstructure options were considered including multi-girder bridges with full-depth precast concrete decks, partial-depth precast concrete deck panels, adjacent butted beam superstructures, modular prefabricated superstructures and parallel beam superstructures with a conventional deck. PennDOT District 11-0's preference was to avoid post-tensioning and construct a joint-less structure using integral abutments. All stakeholders agreed that the best option was a 78-ft steel beam structure on integral abutments. The pile caps, wing walls, cheek walls, back walls, approach and sleeper slabs were designed to be precast units while the steel beams were to have the deck and barrier cast to them off-site using conventional methods to create three modular units. The initial construction schedule for this structure type was estimated to take 15 days to construct.

The geotechnical findings showed that the piles could be driven, but they would have to be re-struck after 48 hours. Due to the uncertainty of the foundation of the portions of existing arch structure that were left in place, predrilling was required to avoid striking the remnants of the arch during the pile driving operation. Adding predrilling and the waiting period of the re-strike affected the initial schedule, and several production activities were rescheduled to occur during the re-strike waiting period to maintain efficiency. The changes to the schedule increased the allowable timeframe to 17 days. Confident that the bridge could be open to traffic within this time frame, Road User Liquidated Damages (RULDs) were calculated and an incentive/disincentive of $36,000 per day was added to the construction contract.

Due to the accelerated design schedule, coordination with the railroads and limiting impacts to the adjacent railroad property were critical for the project's success. Both CSX and Norfolk Southern have property within the project limits, and the roadway tie-ins were designed to ensure the required right-of-way was minimal on the CSX property and was not necessary on the Norfolk Southern property. Additionally, through coordination with CSX, the necessity for flaggers was eliminated by providing construction fence to prevent the contractor from accessing railroad property.

Another challenge was coordinating the relocation of Columbia Gas Transmission's line in a narrow time window. The existing gas transmission line crossed the roadway less than 15 ft behind the existing abutment, and because the gas line was so close to the structure and the project used integral abutments, it was impossible to avoid impacting the line. It had to be relocated prior to construction and the design had to be expedited in comparison to a typical project due to the condensed design schedule. Through extensive coordination between JMT and Columbia, a relocation route was developed, avoiding the proposed abutments, drainage structures and guiderail posts as well as roadway excavation. The roadway was closed for seven days, the new bridge was constructed in 7 days and the overall project was open to traffic on August 24, 2014, well ahead of the September 21, 2014 milestone date.

Owner

Pennsylvania Department of Transportation, Bridgeville

Designer

Johnson, Mirmiran and Thompson, Inc., Moon Township, Pa.

Contractor

Joseph B. Fay Company, Tarentum, Pa.

ACCELERATED BRIDGE CONSTRUCTION COMMENDATION

Milton-Madison Bridge, Milton, Ky./Madison, Ind.

SINCE ITS COMPLETION IN 1929, when America was on the brink of the Great Depression, the original US-421/Milton-Madison Bridge served as a vital link over the Ohio River between Milton, Ky., and Madison, Ind.

A structure that was designed for the occasional Model-A Ford had seen its burden grow to more than 10,000 modern vehicles per day, including semitrailer trucks loaded at full capacity. Although it was historically significant, the aging bridge had become functionally obsolete. A TIGER discretionary grant from the U.S. government became the catalyst to one of the most innovative bridge replacement project endeavors in the nation.

Using the accelerated bridge construction (ABC) method, the project began with the construction of temporary approach ramps, allowing traffic to be rerouted off of the existing approach spans to begin their unobstructed demolition and replacement. While these phasing activities were occurring, sections of the 7,200-ton truss superstructure were being preassembled on barges for the eventual float-in and strand lifting onto temporary piers, which were constructed adjacent to each existing pier stem. The temporary piers were designed to support live traffic on the completed bridge in its temporary alignment, freeing the existing structure for explosive demolition and pier cap widening. The temporary pier caps featured a key design element—the "sliding girders"—which would serve as the pathway for the record-breaking truss slide. The nearly ½-mile long completed bridge, weighing more than 16,000 tons at the time of the slide, was moved 55 ft laterally into place atop the refurbished and widened pier stems of the existing bridge. ■

For more on this project, see "Move that Bridge!" in the February 2012 issue and the item "Biggest-Ever Bridge Slide" in the News section of the August 2014 issue, both available at ***www.modernsteel.com***.

Owner

Indiana Department of Transportation, Indianapolis

Kentucky Transportation Cabinet, Louisville

Designer

Buckland and Taylor, Ltd., North Vancouver, B.C., Canada

Contractor

Walsh Construction, Chicago

Steel Fabricator

High Industries, Lancaster, Pa. AISC CERTIFIED FABRICATOR

NSBA 2014 Prize Bridge AWARDS

FIFTEEN BRIDGES HAVE EARNED national recognition in the 2014 Prize Bridge Awards Competition. Conducted by the National Steel Bridge Alliance (NSBA), the program honors outstanding and innovative steel bridges constructed in the U.S.

The awards are presented in several categories: major span, long span, medium span, short span, movable span, reconstructed, special purpose, accelerated bridge construction and sustainability. This year's winners range from a reconstructed bridge that had been partially destroyed by a barge to a massive delta frame spanning the Shenandoah River.

Winning bridge projects were selected based on innovation, aesthetics and design and engineering solutions, by a jury of five bridge professionals:

- Benjamin Beerman, Senior Structural Engineer, Federal Highway Administration/Resource Center, Atlanta
- Thomas R. Cooper, P.E., P.Eng., Lead Structural Engineer, Parsons Brinckeroff, Denver
- Robert Healy, Director of Structures, RK&K, Baltimore
- Thomas P. Macioce, P.E., Division Chief of the Bridge Design and Technology Division, Pennsylvania Department of Transportation, Harrisburg, Pa.
- Bert Parker, Senior Vice President/Chief Administrative Officer, Garver, Little Rock, Ark.

This year's competition attracted more than 30 entries and included a variety of bridge structure types and construction methods. All structures were required to have opened to traffic between May 1, 2011 and September 30, 2013.

The competition originated in 1928, with the Sixth Street Bridge in Pittsburgh taking first place, and over the years more than 300 bridges have won in a variety of categories. Between 1928 and 1977, the Prize Bridge Competition was held annually, and since then has been held every other year, with the winners being announced at NSBA's World Steel Bridge Symposium.

2014 PRIZE BRIDGE AWARD WINNERS

Prize Bridge Award winners

- Major Span: Shenandoah River Bridge Delta Frame, Jefferson County, W.Va.
- Medium Span: Dixie Highway Flyover, Boca Raton and Deerfield Beach, Fla.
- Moveable Span: Willis Avenue Bridge, New York
- Reconstructed: Huey P. Long Bridge, New Orleans
- Special Purpose: Phyllis J. Tilley Memorial Pedestrian Bridge, Fort Worth, Texas

Merit Award winners

- Major Span: Sakonnet River Bridge, Tiverton and Portsmouth, R.I.
- Long Span: Iowa Falls Bridge, Iowa Falls, Iowa
- Medium Span: North Halsted Street Tied Arch Bridge, Chicago
- Medium Span: Ramp TE over I-95, New York
- Short Span: River Road Over Ironstone Brook, Uxbridge, Mass.
- Short Span: Dodge Creek Bridge, Elkton-Sutherlin Highway (OR138), Ore.
- Reconstructed: Eggner's Ferry Bridge Emergency Replacement, Trigg and Marshall Counties, Ky.
- Special Purpose: Christina and John Markey Memorial Pedestrian Bridge, Revere, Mass.

Accelerated Bridge Construction Commendations

- Willis Avenue Bridge, New York
- River Road Over Ironstone Brook, Uxbridge, Mass.
- 130th Street and Torrence Avenue Railroad Truss Bridge, Chicago
- Eggner's Ferry Bridge Emergency Replacement, Trigg and Marshall Counties, Ky.

Sustainability Commendations

- Dodge Creek Bridge, Elkton-Sutherlin Highway (OR138), Ore.
- Huey P. Long Bridge, New Orleans
- Keene Road Bridge, Richland, Wash.

MERIT AWARD—Short Span

ACCELERATED BRIDGE CONSTRUCTION COMMENDATION

RIVER ROAD OVER IRONSTONE BROOK, UXBRIDGE, MASS.

The Massachusetts Department of Transportation (MassDOT) is a leader in the use of Accelerated Bridge Construction (ABC) practices.

So when it decided to replace a small bridge carrying River Road over Ironstone Brook in the Town of Uxbridge, Worcester County, with a folded steel plate girder structure, ABC guided the project.

The first application of its kind, the folded steel plate girders were fabricated from a single steel plate of uniform thickness that was then bent along multiple lines using a hydraulic metal press break to form an inverted tub shaped section. A system applicable for spans up to 60 ft in length, this type of fabrication eliminates costly details and processes that have made steel alternatives less competitive than other materials for short span bridges. The need for welding is significantly reduced, and the stability of the resulting girder shape eliminates the need for both internal and external cross framing.

To accelerate construction, the design used four 50-ft-long, 24-in.-deep folded steel plate girders, each pre-fabricated with a 6.5-in.-deep, 4-ksi concrete deck section attached using ¾-in.-diameter end welded shear studs. Each beam utilized a single 0.5-in.-thick, 50-ksi steel plate measuring 50 ft in length and 106 in. in width. These dimensions were critical to ensure that the multiple bends could be made using a standard press break. After bending them to the required shape, a minimal number of welded components were then attached to the beams, including end plates, sole plates and headed shear studs. Four bolted flange separator plates were also attached to the bottom of each girder to help maintain shape, and the entire beam was galvanized.

The decks were then cast in a precast shop with the beams oriented in an upright position with falsework supporting the cantilevers. The shipping width of each interior superstructure module measured 10 ft, 2 in. including headed rebars protruding 11 in. from each edge of the precast slab. Each exterior module was 8 ft, 7 in. in width including a single edge of protruding rebar and an integral concrete curb cast along the exterior slab edge.

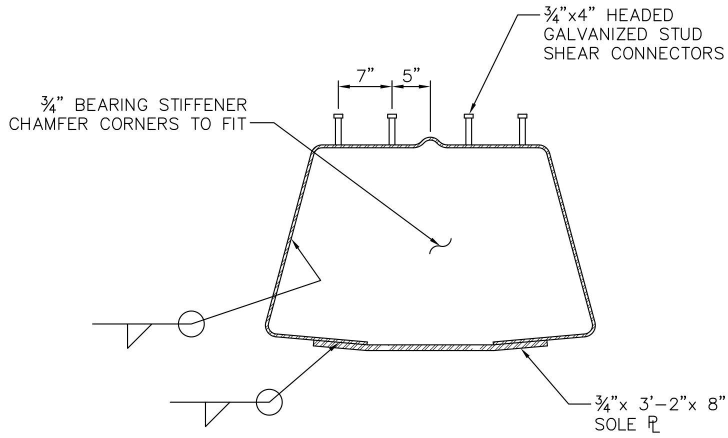
The design of the $1.7 million project (including roadway construction and approach work) was completed in July of 2010, and the construction contract was awarded to the John Rocchio Corporation that October. All four bridge replacements required thirteen weeks to complete, and the roadway was once again open to traffic in November of 2011. As the structure was the first folded steel plate girder bridge ever constructed and placed in service, MassDOT decided to instrument the bridge components with strain gauges to monitor stresses in the steel plates, deck and closure pours. Performance is currently being monitored by the University of Massachusetts.

MassDOT considers this project a success as a new technology was implemented at a competitive price and resulted in a 28% reduction in the on-site construction schedule when compared to a more conventional adjacent precast concrete box beam alternative. The project has also opened the door for a steel alternative in a span range generally dominated by precast concrete solutions.

Owner
Massachusetts Department of Transportation, Boston

Engineer
Gannett Fleming, Inc., Mount Laurel, N.J.

General Contractor
John Rocchio Corporation, Smithfield, R.I.



MERIT AWARD—Reconstructed Category
ACCELERATED BRIDGE CONSTRUCTION COMMENDATION

EGGNER'S FERRY BRIDGE EMERGENCY REPLACEMENT, TRIGG AND MARSHALL COUNTIES, KY.

On January 26, 2012, an 8,679-gross-ton cargo ship struck a 322-ft-long span of the Eggner's Ferry Bridge.

The bridge carries U.S. 68 and KY 80 over Kentucky Lake on the Tennessee River, and the collision effectively closed the western gateway to the Land Between The Lakes National Recreation Area and the only crossing of the lake in Kentucky.

Through an innovative approach to design and construction, the Kentucky Transportation Cabinet (KYTC), Michael Baker Jr., Inc., and Hall Contracting of Kentucky, Inc., were able to replace the span and reopen the bridge to traffic before Memorial Day that year.

Kentucky Lake is a major navigable reservoir adjacent to the 170,000-acre Land Between The Lakes National Recreation Area, which attracts thousands of tourists each year. The Eggner's Ferry Bridge is a 43-span, 3,348-ft-long bridge that provides a vital access point to the recreation area and an important link in the region's transportation system; the detour around the damaged bridge was 42 miles.

Redundancy was an important part of the solution. The preliminary design of the truss assembly was for a parallel chord truss without verticals. Baker redesigned the gusset plates to make all of them a uniform 0.75-in. thick and similarly specified the use of identical sections for the top chord and end diagonals, the bottom chord, the top bracing and struts, the stringers and the floor beams. Designing the truss with only six sizes of rolled sections helped the steel fabricator, Padgett, Inc., and the steel detailer, Tensor Engineering Company, to expedite the detailing and fabrication of the parts by early April. Baker coordinated closely with Tensor to have the shop drawings completed, reviewed and stamped in less than three weeks. Easily accessible material, simple and repetitive connections and high-tech fabrication were the keys to expediting the project. The 13,000 bolt holes that were used to assemble the truss were drilled using computer-controlled equipment, resulting in zero misfits.

The Eggner's Ferry Bridge rehabilitation project demonstrates the importance of careful coordination with the steel detailer and fabricator and intelligent selection of materials and fabrication details. The use of rolled steel sections in the construction of the new truss eliminated the need for cutting plates and welding, saving valuable weeks of fabrication. Although a slightly heavier truss was used, the consistent sizes of all the components of the new truss ultimately saved days in the fabrication and assembly of the replacement truss. A similar approach could be used by bridge engineers to accelerate the delivery of other bridge replacements or repairs, or even new bridge construction projects.

In addition, lifting a replacement superstructure onto a bridge's existing piers can accelerate construction and minimize the need for lengthy closures, detours, and other traffic disruptions. This project demonstrates that this technique can be used effectively to accelerate repairs to a severely damaged bridge.

On May 15, Hall floated the barge down the lake to the bridge site and used two cranes to lift the new truss from the barge onto the existing piers. The installation of the stay-in-place forms and studs and the pouring of the 6.5-in.-thick concrete deck were completed by May 20. The guardrail was installed and the bridge was opened to traffic, with a celebration by the governor, local officials and the community, on Friday, May 25—two days ahead of schedule.

For more on this project, see "Down but not Out" (11/2012).

Owner
Kentucky Transportation Cabinet – District 1, Paducah, Ky.

Engineer
Michael Baker Jr., Inc., Louisville, Ky.

General Contractor
Hall Contracting of Kentucky, Inc., Louisville

Steel Team

Fabricator
Padgett, Inc., New Albany, Ind. (AISC Member/NSBA Member/AISC Certified Fabricator)

Detailer
Tensor Engineering, Indian Harbour Beach, Fla. (AISC Member/NSBA Member)

ACCELERATED BRIDGE CONSTRUCTION COMMENDATION

130TH STREET AND TORRENCE AVENUE RAILROAD TRUSS BRIDGE, CHICAGO

The intersection of 130th Street and Torrence Avenue in Chicago serves approximately 38,000 vehicles a day, including traffic to and from the nearby Ford Motor Company Plant.

In addition, more than 50 freight trains cross on two at-grade Norfolk Southern (NS) tracks near the intersection, making it a major bottleneck for both rail and vehicular traffic. To eliminate these conflicts, a three-tiered grade separation design was developed for the intersection, and the new Chicago, South Shore & South Bend (CSS&SB) commuter/freight railroad truss is a key component.

The complex reconfiguration involves 130th Street and Torrence Avenue being realigned and lowered below the existing NS tracks. Two new NS structures are being constructed on new alignments and the new CSS&SB structure is already in place on its new alignment. Once fully completed, the project will provide a three-tiered grade separation to relieve traffic congestion and improve the efficiency of rail service in the area. Making sure all the project components fit in this complex puzzle while maintaining all rail traffic required the CSS&SB railroad truss span to be constructed first.

The preliminary design, geometry and location of the truss were based on minimizing impacts to railroad operations during construction; meeting NS horizontal and vertical requirements at both the existing and proposed alignments; tying back into the CSS&SB existing tracks while accommodating a track spiral; and accommodating the proposed widened and realigned Torrence Avenue.

At the end of preliminary design, the proposed CSS&SB structure consisted of a 368-ft-long truss with abutments skewed at 45°; the skew was implemented to have the shortest span possible. During the early stages of the final design phase, other geometric and logistical constraints by the site and stakeholders surfaced, requiring the geometry of the truss to be revisited. The detailing and fabrication of the skewed portal frames of the truss were found to increase the cost of the truss and make fabrication and construction more complex. With accelerated bridge construction (ABC) techniques already approved by major stakeholders, it was also noted that maintaining a skewed truss would make installation more challenging as the self-propelled mobile transporters (SPMTs) would have to guide the truss into place while moving on a diagonal. It was determined that a longer truss with squared abutments would provide a more economical design and would better facilitate construction.

The elimination of the skew had numerous advantages. The volume of concrete required at the abutments was reduced by approximately 30% due to the reduced width of the truss substructures. The end floor beam span was also reduced from approximately 57 ft, 8 in. to 40 ft, 2 in., eliminating the need for an intermediate bearing for the floor beam. The revised and final layout of the truss resulted in a 394-ft span center to center of bearings with supports perpendicular to the structure. The longer truss span required the east abutment to shift a couple feet to the east due to an increase in bearing size from the size estimated during preliminary design. This shift brought the track closer to the truss due to the spiral curve at the end of the truss span. Because of this, the engineer had to make sure the bridge was wide and tall enough to meet the railroad's clearance requirements, and the width of the truss increased from 36 ft, 8 in. to 40 ft, 2 in. center to center of trusses.

The use of high-performance steel was the best, most durable and economical material choice for the truss bridge. It extended the bridge's expected life to 100-plus years and reduced long-term maintenance. This massive double track, ballasted deck, through truss is just a part of the larger complex grade separation structure, which also includes five approach spans consisting of 54-in.-deep pre-stressed box beams. The truss substructure consists of full height concrete piers supported on driven steel piles. An excavation support system was required to protect the existing NS tracks during construction of the new piers.

Once the truss was in place, the contractor and railroad teams continued to work on the bridge, placing the ballast and ties on the truss, installing the catenary wires that power the CSS&SB trains and putting the finishing touches on the truss. On October 25, 2012, the first CSS&SB train crossed the new railroad truss bridge.

For more on this project, see "Big Roll" (03/2013).

Owner
Chicago Department of Transportation – Division of Engineering, Chicago

Engineer
Alfred Benesch & Company, Chicago

General Contractor
Walsh Construction Company, Chicago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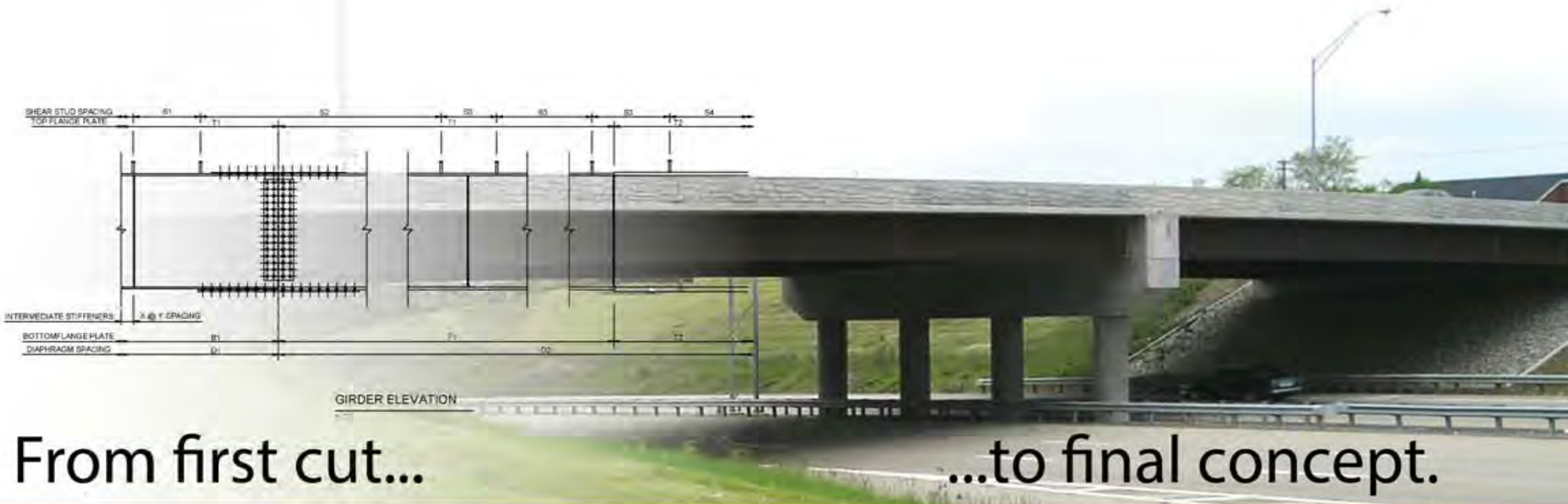
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