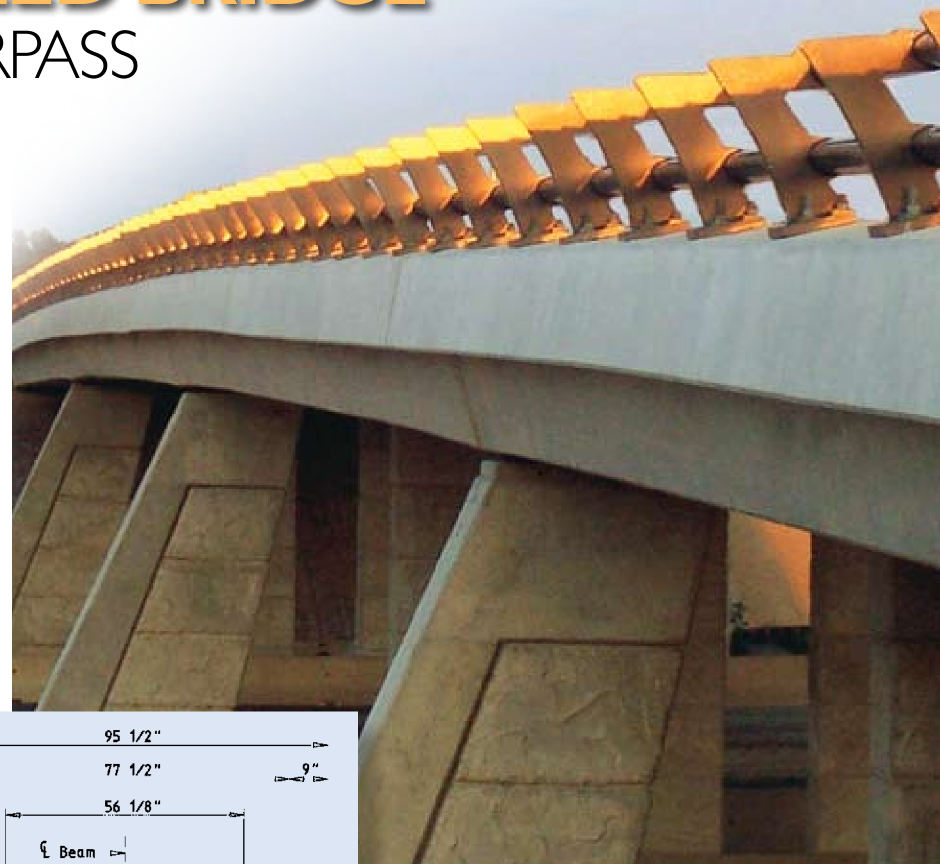
PREASSEMBLED BRIDGE
FACILITATES OVERPASS CONSTRUCTION

by Jamie Griffin, Lloyd Wolf, Gregg Freeby, Michael Hyzak, David Hohmann, and Randy Cox, Texas Department of Transportation



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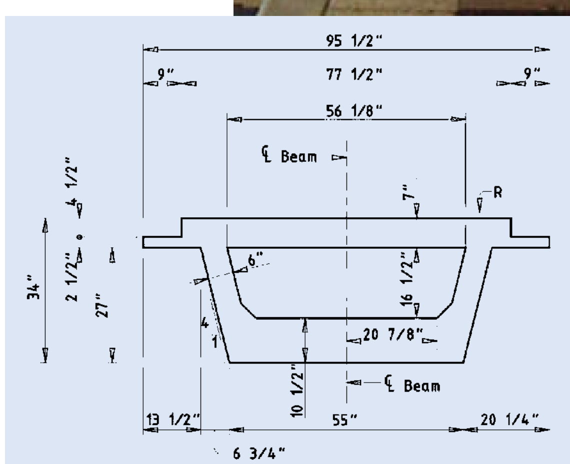


Typical pretopped U-beam section.

The design challenge was to provide an aesthetically pleasing set of bridges that minimized traffic disruption.

The Texas Department of Transportation (TxDOT) employs innovative techniques to accelerate bridge construction while providing durable, economical, and aesthetically pleasing solutions on a wide variety of projects. From such bridges as the Jim Cowan Memorial Bridge at Lake Belton to the Cottonwood Creek and Battleground Creek Bridges, fully precast bridge systems have played an important role in reducing the impact of bridge construction to the traveling public in Texas' rural areas.

Reconstruction of I-35, the main north-south artery and a crucial commercial corridor in central Texas, necessitated the construction of several overpasses.

profile

LOOP 340 BRIDGES / WACO, TEXAS

ENGINEER: Texas Department of Transportation, Austin, Tex., and Structural Engineering Associates, San Antonio, Tex.

PRIME CONTRACTOR: Archer-Western Contractors, Arlington, Tex.

PRECASTER: Heldenfels Enterprises Inc., San Marcos, Tex., a PCI-Certified Producer

PRECAST SPECIALTY ENGINEER: Structural Engineering Associates, San Antonio, Tex.

PRECASTER'S ENGINEER: Unitech Consulting Engineers, San Antonio, Tex.

AWARD: Co-Winner of 2007 PCI Design Award for Best Bridge with Spans Between 75 and 150 ft

This construction provided TxDOT with a unique opportunity to utilize accelerated construction techniques in a dramatically different environment from the rural areas in which these techniques had previously been employed. Here, the design challenge was to provide an aesthetically pleasing set of bridges that minimized traffic disruption to the busy interstate by reducing construction time within the right-of-way of I-35. These bridges would then be used as prototypes for many such overpasses along the I-35 corridor.

TxDOT identified four candidate bridges on Route 340 Loop near Waco for which the prototype design would be formulated. Two 58-ft 3-in.-wide mainlane bridges and two 48-ft 3-in.-wide frontage road bridges, each comprised of four 115-ft-long spans crossing over I-35, were selected. The final design for the Loop 340 bridges incorporated pretopped U-beams, precast concrete column shells, and an innovative off-site preassembly method to reduce the impact to motorists caused by superstructure construction over the busy lanes of I-35.

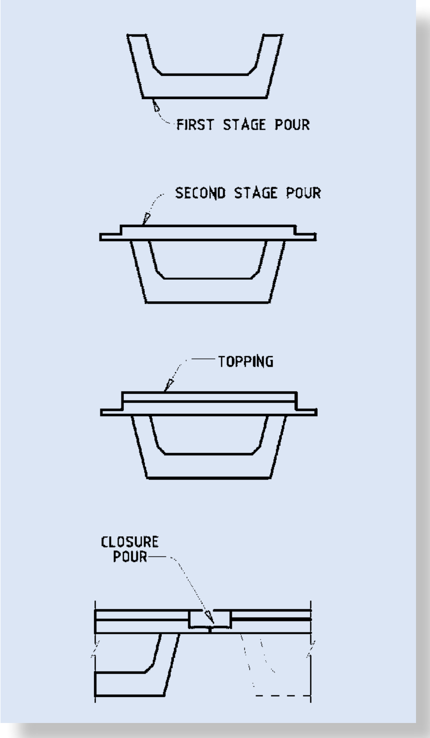
Pretopped U-Beam Design

The Texas chapter of the Precast Concrete Manufacturers Association (PCMA), together with TxDOT and partners in industry, developed a superstructure system to be used for the first time nationally in the construction of the Loop 340 bridges. New beams were developed from TxDOT standard precast, prestressed concrete U-beams that incorporated a 7-in.-thick top flange cast by the beam fabricator. Plans specified an additional 4 in. of concrete slab to be placed by the contractor at the off-site casting yard near the construction site. The top flange plus the 4-in.-thick pretopping provided a precast slab and reduced site-cast concrete to a narrow closure pour between pretopped beams. The exterior beam design included an overhang, also precast off-site, which eliminated the need for form removal over traffic, thereby reducing construction time and increasing worker safety.

The pretopped U-beam is comprised of a 34-in.-deep precast, prestressed concrete beam with a 4-in.-thick topping slab added at the off-site casting yard, for a total final section depth of 38 in. The beams are spaced at approximately 8 ft on center and utilize 0.6-in.-diameter strands on a 2-in. grid. With up to 77 prestressing strands and concrete strengths of 6500 psi at release and 7400 psi final, the beams can span up to 115 ft, for a span-to-depth ratio of 36.3.

The design required debonding up to 75 percent of the prestressing strands in the beam ends to satisfy allowable tensile stresses at release. While AASHTO limits debonding to no more than 25 percent of the total number of strands, previous experience had shown success with up to 75 percent of strands debonded in prestressed concrete beams. This experience was supported by research conducted at the University of Texas at Austin confirming the successful use of 75 percent debonding and by further calculations to ensure that the beams would have adequate shear resistance.

In order to facilitate inspection and reduce the chance of honeycombing in the bottom slab, the beam fabricator cast the bottom flange and webs as the first step of a two-stage placement. In the second stage, the fabricator placed the 7-in.-thick top flange. After the specified release strength was attained, the prestressing strands were released and the beams were transported to the contractor's staging yard near the construction site, where the final 4-in.-thick topping was placed.



Pretopped U-beam construction sequence.

PRECAST, PRESTRESSED, PRETOPPED, CONCRETE U-BEAMS / STATE OF TEXAS, AUSTIN, TEXAS., OWNER

BRIDGE DESCRIPTION: Two mainlane and two frontage road bridges comprised of newly developed precast, pretopped U-beams spanning 115 ft over I-35. Precast substructure features individual columns with no bent cap. Superstructure completely preassembled in off-site casting yard to obtain final elevations and grading prior to placement on-site.

STRUCTURAL COMPONENTS: Precast, pretopped U-beams incorporating a 4-in.-thick pretopped slab from the beam fabricator, with an additional 4-in.-thick slab cast by the contractor in an off-site precasting yard. Individual precast concrete columns with no bent caps.

BRIDGE CONSTRUCTION COST: $8.4 million

Formliners were used to simulate limestone blocks for the column shells. The column shells were precast for rapid erection.

Beams were preassembled for casting the deck.

A 4-in.-thick topping was cast on the beams before onsite erection.

Precast Column Shells

In keeping with the goals of reducing construction time within the right-of-way and reducing impact to the motoring public, column shells were precast at the contractor's off-site staging yard and then moved into position within the right-of-way. The columns were precast full height using a hollow rectangular section and featuring a unique formliner to produce the appearance of large limestone blocks. Outer columns were designed with a tapered width for added aesthetic value.

Once ready for placement, the column shells were moved into their final locations within the right-of-way and placed on top of a conventional drilled shaft with a top-cast footing and a projecting reinforcing steel cage. Elevations were adjusted with the aid of leveling pads. Infill concrete completed the precast column assembly. Due to the wide spacing of the pretopped U-beams, each line of beams was able to be directly supported on individual columns, eliminating the need for a bent cap. Bent cap construction constitutes a considerable amount of construction and curing time within the right-of-way, so elimination of the bent cap through the use of the individual columns further reduced construction time.

Prefabricated Bridge Construction System

Among the most unique developments featured in the construction of the Loop 340 bridges was the off-site preassembly of the bridge spans. In order to address grading issues when adding the final 4-in.-thick slab, the contractor erected the beams on temporary supports constructed to simulate the permanent supports on which the beams would ultimately rest. The supports were designed to provide the same cross-slope, longitudinal slope, and relative elevation between beams as specified for the finished structures.

The beams were first assembled side-by-side on temporary supports and bearing pads. The contractor then placed reinforcing steel for the remaining 4-in.-thick slab, and formed and placed the final topping slab and outside curbs, using blockouts to form the longitudinal and transverse closure strips that would be cast after the beams were moved to their final locations. The topping was graded using a screed to help achieve the correct elevation and to account for differential camber between beams.

Once the final 4-in.-thick topping cured and the bridge rail was attached, the beams were transported from the

TxDOT developed a prefabricated system appropriate for construction in high-traffic areas.

off-site staging yard to the bridge construction site where they were placed on the individual columns. The initial night-time placement rate was one span per night, but ultimately increased to two spans per night as the contractor became more familiar with the system. An exterior beam with final deck and curbs weighed approximately 148 tons.

Pretopped beam placement marked the only times during which the mainlanes of I-35 were closed to traffic. After all beams were in position forming the bridge superstructure, the contractor placed reinforcement in the longitudinal and transverse closure strips and placed concrete, tying the bridge together. Stay-in-place forms were used in the closure strips. Since the forms prevented concrete from leaking onto the lanes below, I-35 was opened to traffic during the placement of the closure strip concrete. Grinding was permitted to a maximum depth of 1/2 in. in order to achieve final required grades, but the pretopped U-beams aligned so well in their final positions that no grinding was necessary. After the closure strips cured, the bridge was ready for traffic.

Beams were erected at night.

Conclusion

The preassembled prefabricated bridge system proved to be a successful alternative to traditional construction over high-traffic roadways. Although the preassembly did incur additional costs, at $86.06 psf compared to $62.00 psf for conventional prestressed concrete beam bridge construction, the direct cost of the bridges still proved economical. Indirectly, the time saved by motorists and commercial operators in the form of reduced construction-related delays further validated the increase in cost.

Pretopped U-beams were joined in the field with longitudinal and transverse closure placements.

With the successful construction of the Loop 340 bridges, TxDOT has not only developed a prefabricated bridge system appropriate for construction in some high-traffic areas, but has also found this system effective in mitigating damage to the local environment. As more of these bridges are commissioned along interstates and in rural areas, we look forward to continuing to provide unique solutions designed to minimize the impact of bridge construction to the motoring public.

Jamie Griffin, Engineering Assistant; Lloyd Wolf, Bridge Design Group Leader; Gregg Freeby, Bridge Design Group Leader; Michael Hyzak, Senior Bridge Design Engineer; David Hohmann, Design Section Director; and Randy Cox, Bridge Division Director, are all with the Texas Department of Transportation.

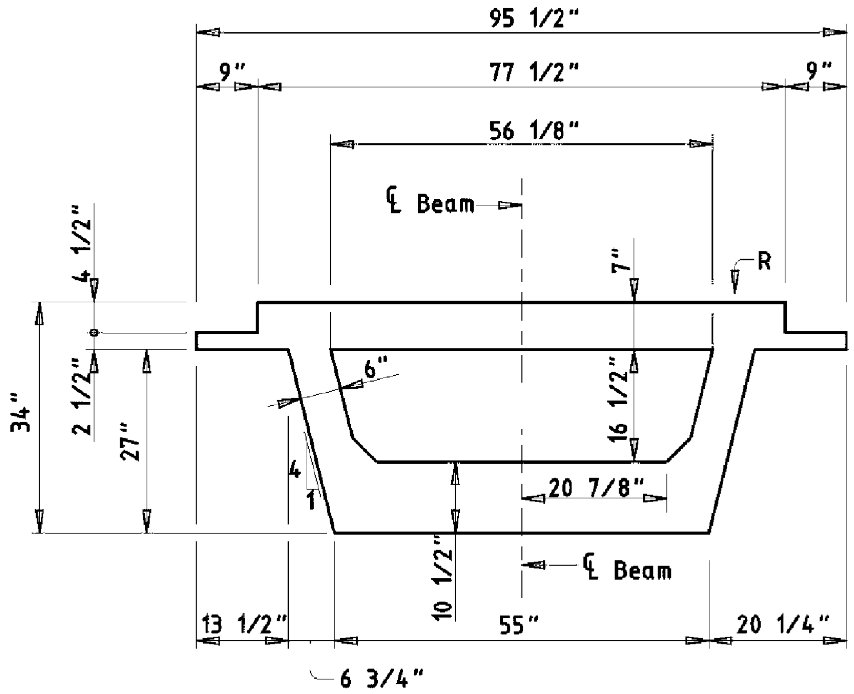
For more information on this or other projects, visit www.aspirebridge.org.

Aesthetically Pleasing Solution with Minimal Impact

Accelerated construction techniques and enhanced bridge aesthetics have long been touted as a means of reducing construction-related delays and improving the appearance of our local roadways. The Loop 340 bridges gracefully combine rapid construction techniques and striking architectural features to produce a set of bridges remarkable in both form and function. The aesthetics concept, developed by TxDOT engineers, incorporates sloped exterior columns, slender beams, and a short sloped overhang reflecting the slope of the exterior columns. A new open steel railing, used for the first time nationally on these bridges, was also developed to complement the bridge aesthetics. Large formliners to simulate limestone blocks provided the surface texture that completed the unique appearance of the substructure. This careful attention to aesthetic detail produced the graceful and dynamic style of the Loop 340 bridges and served as further evidence that a focus on function and economy does not exclude the addition of aesthetic features.

The preassembled superstructure and precast columns reduced time spent within the right-of-way, improved worker safety, and allowed for greater environmental controls. Since most construction activity occurred at the off-site casting yard, little construction waste was introduced into the environment surrounding the construction site. The contractor was better able to contain construction waste at the casting location than would have been possible in conventional on-site construction at a high-speed interstate highway, thereby preventing excessive dust and other waste from affecting the local community and interstate traffic.

The Loop 340 bridges have thus incorporated the elements of sustainability—they not only significantly diminished construction-related delays and the related impacts to the community, but have provided a series of attractive and distinctive bridges that are the subject of pride for the surrounding areas.



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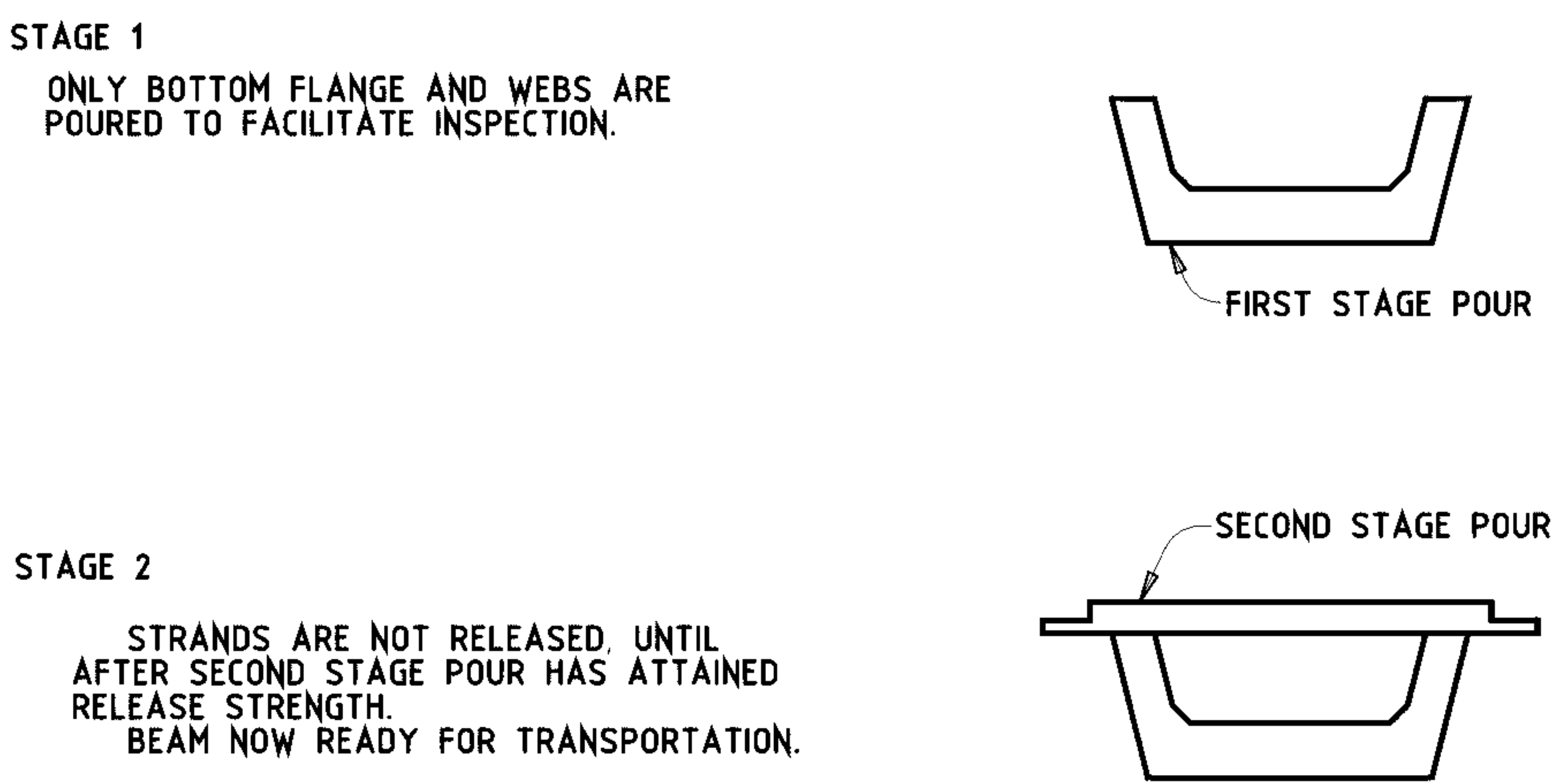


Pretopped U-beam construction sequence.

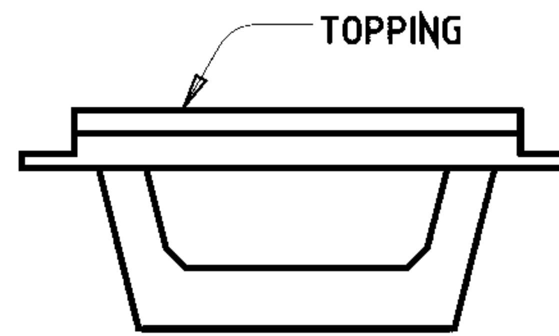
STAGE 3

AT CONTRACTOR'S YARD (NEAR JOB SITE), TOPPING & CURB SHALL BE POURED AND RAIL SHALL BE INSTALLED PRIOR TO ERECTION.

TOPPING SHALL BE GRADED TO ACCOUNT FOR DIFFERENTIAL CAMBER OF BEAMS IN THE SAME SPAN.

THE RESULTING TOPPING SURFACE SHALL CONFORM TO THAT REQUIRED BY PLANS.

BEAM NOW READY FOR ERECTION.



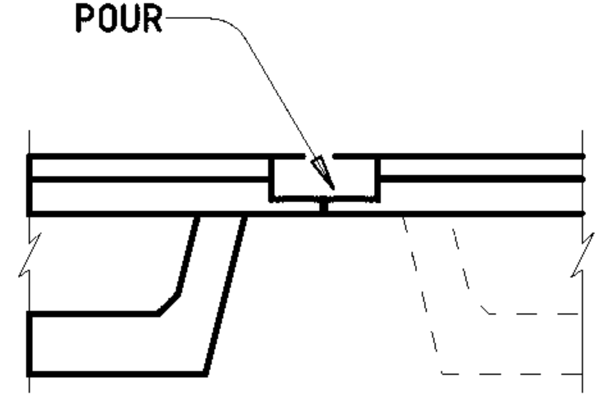
STAGE 4

AFTER ERECTION, CLOSURE POURS SHALL BE MADE BETWEEN BEAMS TO TIE SUPERSTRUCTURE TOGETHER.

STAY-IN-PLACE FORMS SHALL BE USED FOR CLOSURE POURS.

AFTER CLOSURE POURS HAVE REACHED SUFFICIENT STRENGTH, GRINDING OF THE ROADWAY SURFACE MAY BE NECESSARY TO ACHIEVE REQUIRED GRADES.

NO MORE THAN ½" OF GRINDING WILL BE PERMITTED AT ANY ONE LOCATION.



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Beams were preassembled for casting the deck.