Improving Precast Concrete Girder Erection Bracing in Texas

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During construction of a single-span precast, prestressed concrete girder bridge for the State Highway 130 project, both exterior beams rotated outward approximately 2.5 degrees during slab placement and lost full contact with their neoprene bearings (**Fig. 1**). The girders were 34-in.-deep Texas Department of Transportation (TxDOT) Type B beams, which are no longer used for new construction by TxDOT. The overall deck width was approximately 61 ft; there were nine beams in the cross section spaced at 6 ft 10½ in.; and the exterior fascia beams supported a 3 ft deck overhang, as measured from the beam centerline.

This troubling performance occurred despite the beam erection and slab placement bracing being installed in accordance with plan requirements and specifications. The plans called for temporary timber X-bracing spaced at 30 ft maximum for the approximate span length of 65 ft. Each temporary timber X-brace was coupled with a no. 5 reinforcing bar welded to the shear reinforcement that extended from the tops of the beams, to form a tension tie across the bridge width. These braces were key elements of TxDOT's previous standard details for erection bracing and slab placement and were intended to address beam stability for wind loading and the torque caused by overhang brackets loaded with a slab screed and finishing machine.

With TxDOT's widespread use of precast concrete partial-depth deck panels for deck construction, there is a complication in the installation of the tension ties between girders, which are no. 5 reinforcing bars welded to the projecting shear reinforcement. These top tension ties are installed during beam erection, then later removed as needed to allow installation of the 4-in.-thick precast concrete deck panels. The ties are then reinstalled after panel installation is

Figure 1. During construction of a single-span precast, prestressed concrete girder bridge for the State Highway 130 project, outward rotation of fascia beams resulted from deck construction. This photo was taken after removal of erection and slab placement bracing. All Photos and Figures: Texas Department of Transportation.

Figure 2. Installation of no. 5 top tension tie after installation of the 4-in.-thick precast concrete partial-depth deck panels. The tie is bent downward at each end to allow welding to projecting shear reinforcement. Deck panels at expansion joints are set 2 in. lower than typical panels to provide a thickened end for enhanced deck strength and stiffness.

Figure 3. Timber X-bracing (left) was a required element in previous bracing standards for the Texas Department of Transportation (TxDOT). However, this bracing would sometimes lose contact with the girder due to fascia beam rotation during deck construction (right). The new TxDOT standard bracing detail uses horizontal timber bracing between the bottom flanges.

complete. During beam erection, the no. 5 tie is welded close to the top of the beam, providing a stiffer and more effective connection with the projecting shear reinforcement. After panel installation, the no. 5 reinforcing bars need to be bent down on both sides of the 4-in.-thick precast concrete deck panels to allow welding to the shear reinforcement (**Fig. 2**).

Research

The poor performance of the previous standard details led to a TxDOT-funded research project to better understand the problem and develop solutions. Project 5706, "Impact of Overhang Construction on Girder Design," led by Dr. Todd Helwig at the University of Texas at Austin, investigated fascia girder behavior during deck and overhang placement for both precast concrete and steel girders.[1] The research team identified a number of construction details that were potentially problematic and focused the research program on the following areas:

- Potential loss of contact between beam and timber X-bracing during deck installation (**Fig. 3**)
- Lack of stiffness at the connection between the no. 5 top tension tie and the projecting beam shear reinforcement when bent down and welded after precast concrete partial-depth deck panel installation
- Neoprene bearings with limited axial and rotational stiffness

Finite element analysis of the State Highway 130 bridge indicated that the beams leaned outward as a rigid body and that the timber X-bracing was mostly ineffective in preventing the observed fascia beam rotation. The Project 5706 report recommended horizontal bottom-flange bracing as a more effective restraint against fascia girder rotation, still coupled with the no. 5 tension tie at the top. The horizontal bracing is also significantly easier to install than X-bracing.

A bridge identical to the bridge that put focus on this problem was constructed with the recommended horizontal bracing. This second bridge, with geometry and overhang loading essentially identical to the first bridge, performed as desired. TxDOT engineers measured girder rotation at each end of both fascia beams

Figure 4. As an alternative to the no. 5 reinforcing bar welded to the girder shear reinforcement, a 12-gauge galvanized steel strap anchored to the top flanges allows installation of precast concrete partial-depth deck panels without removing and reinstalling the top tension tie.

before and after deck placement and found no measurable outward lean of the fascia girders.

The research led to a recommended design methodology for erection and slab placement bracing. TxDOT implemented this design methodology on its new series of prestressed concrete I-girders, called Tx girders, that were specifically designed to provide greater stability during handling, transportation, and erection. The Tx girders require significantly less bracing than TxDOT's historical beam sections that predated and were similar to AASHTO shapes. A key element in the bracing design is the stiffness of the neoprene bearings. The bearings for the new Tx girders are much wider and are designed to have more compressive and lateral stiffness, which helps limit the amount of external bracing required. TxDOT replaced the timber X-bracing with more effective and more easily installed timber horizontal bracing. The top no. 5 tension tie weld detail was retained.

A TxDOT construction engineer has suggested an alternative to the top no. 5 tension tie, which is to use a galvanized steel strap anchored to the girders' top flanges to provide the necessary restraint. The advantage of this option is that the straps can be installed during beam erection and the precast concrete deck panels can be installed without having to remove the tie (strap). In addition, the galvanizing provides long-term corrosion resistance to the exposed steel strap. **Figure 4** shows bridge girders braced with these steel straps.

Implementation

TxDOT made the first significant revision to its prescriptive construction bracing requirements for precast concrete Tx girders as a result of the recommendations of Project 5706.[1] Implementation of the galvanized steel strap option has been limited and lessons have been learned, specifically that the 12-gauge steel straps are thick enough that the straps must be prebent to lie flat on top of the girder at the lower side of the deck cross slope.

TxDOT's standard drawing (**Fig. 5**) for minimum erection and bracing requirements for its I-girders provides the bracing details and the brace spacing limits, both of which depend on girder type and overhang width.[2]

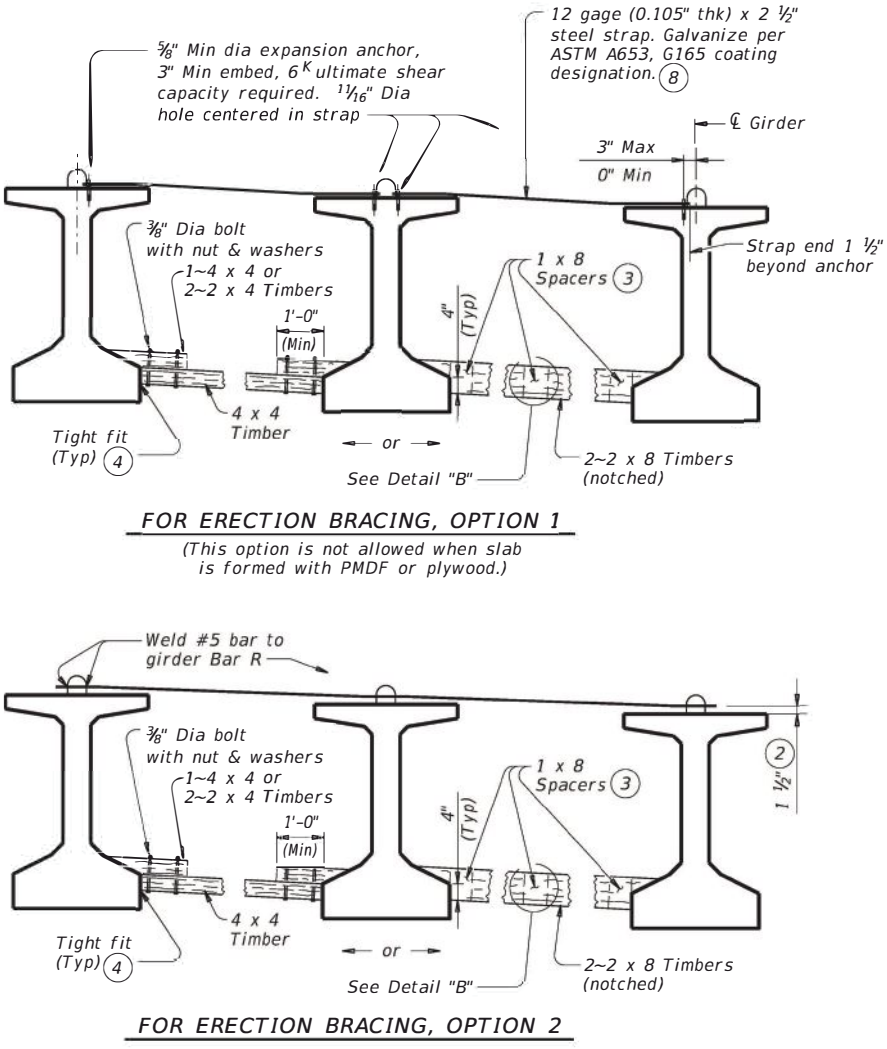

Figure 5. Horizontal bracing details for prestressed concrete I-girders during erection and slab placement from Texas Department of Transportation's standard drawing "Minimum Erection and Bracing Requirements: Prestressed Concrete I-Girders and I-Beams."[2]

In addition to the bracing discussed in this article, the standard drawing also requires a temporary diagonal timber and cable brace at each end of the first girder erected. The size of the cable and the cross section of the timber brace have been increased for the longer Tx girders compared to previous bracing details.

References

1. Yang, S., T. Helwig, R. Klingner, M. Engelhardt, and J. Fasl. 2009. *Impact of Overhang Construction on Girder Design*. Report FHWA/TX-10/0-5706-1. Austin: Center for Transportation Research, Bureau of Engineering Research, University of Texas at Austin. https://ctr.utexas.edu/wp-content/uploads/pubs/0_5706_1.pdf.
2. Texas Department of Transportation (TxDOT). 2017. "Minimum Erection and Bracing Requirements: Prestressed Concrete I-Girders and I-Beams." Bridge Division Standard drawing. ftp://ftp.dot.state.tx.us/pub/txdot-info/cmd/cserve/standard/bridge/mebcsts1-17.pdf.

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