

0-6651: Continuous Prestressed Concrete Girder Bridges

Background

Most prestressed concrete slab-on-girder bridges in Texas are simply supported using standard precast, pretensioned girders with a cast-in-place deck and stay-in-place formwork. Spans are limited to about 150 ft due to weight and length restrictions on transporting the precast girder units from the prestressing plant to the bridge site. Such bridge construction, while economical from an initial cost point of view, may become somewhat limiting when longer spans are needed.

This project focused on developing additional economical design alternatives for longer-span bridges with main spans ranging from 150–300 ft, using continuous precast, prestressed concrete bridge structures with in-span splices.

What the Researchers Did

During Phase 1 of the project, researchers evaluated the current state of the art and practice relevant to continuous precast, prestressed concrete girder bridges and recommended suitable continuity connection details for typical Texas bridge girders. During Phase 2 of the project, researchers developed detailed design examples, conducted a parametric design study, and tested a full-scale modified Tx70 girder specimen containing three splice connections.

Based on the findings from Phases 1 and 2, design guidelines and recommendations were developed for in-span splice connection details for use in continuous precast, prestressed concrete girder bridges.

What They Found

Researchers found the following:

- *Feasibility:* In-span spliced girder technology allows the span length of precast concrete girder bridges to be extended beyond typical span-to-depth ratios without exceeding the transportable girder segment length limit of about 140 ft. While the Tx70 girder can be used for spliced bridges, modifications were needed including an increased top flange thickness and increased web thickness. Using a Tx82 girder reduces the prestressing and reinforcement requirements relative to a Tx70 girder. In addition, the Texas Department of Transportation is currently implementing deeper Texas I-shaped precast girders including constant-depth STx sections and haunched HSTx sections.
- *Design:* It is desirable to balance the dead load throughout construction, as much as practical, to ensure that the segments are aligned through the splice connections; after casting the deck and applying all post-tensioning, the bridge has negligible deflection and is under a constant state of

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uniaxial compressive prestress. Along with the typical service- and strength-based limit states considered for prestressed concrete girder design, special consideration is given to the connections at the splice locations. Sequencing of the precast, prestressed concrete girder fabrication, cast-in-place concrete on site, and post-tensioning operations is also an important factor in the design.

- *Construction:* The construction method and sequence are an important consideration in the design and should be coordinated between the engineer and contractor. Both shored and partially shored construction may be used. Contractors suggested that partially shored construction will lower the initial costs of construction. For partially shored construction, haunched sections are recommended to avoid compression failure over the pier.
- *Splice performance:* The tested splice connections were selected to represent more critical design parameters. The spliced connection detail performed well under service loads with no observed cracking. The connection exhibited acceptable performance with respect to strength up to ultimate, with some concentrated cracking due to the lack of pretensioning through the splice connections. Therefore, splices ideally need to be located in regions where the overall (positive and negative) moment demands are lower. Due to the effect of post-tensioning, small cracks closed after removal of loads. This may lead to better durability and lower maintenance costs in bridge structures.

- *Splice ductility:* Because of the existence of the deck, the splice connections showed moderate deformability under positive bending. To add further flexural capacity and maintain the ductility capability, additional top and bottom reinforcement may be added through the splice connection. The splice and girder sections are inherently less ductile for negative moments. To provide appropriate ductility, two options may be considered: increasing the area of the bottom flange, or embedding supplementary compression mild steel in the bottom flange.
- *Additional recommendations:* Additional modifications that are expected to improve splice connection behavior include lowering the post-tensioning steel centroid through the splice, locally increasing the web width at the splice, and intentionally roughening the surface at the interface of the girder and connection.

What This Means

For bridges spanning from 150–300 ft, continuous precast, prestressed concrete girder bridges with in-span splices can provide an economically competitive alternative to steel girder bridges and segmental concrete box girder construction. The tested splice connections performed well under service-level loads. However, the lack of continuity of the pretensioning through the splice connection region had a significant impact on the behavior at higher loads approaching ultimate conditions. Improved connection behavior at ultimate conditions is expected through enhanced connection details, and several detailing suggestions are discussed in the Phase 2 report.

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