0-6816: Partial Depth Precast Concrete Deck Panels on Curved Bridges

Background

While partial depth precast concrete panels (PCPs) are commonly used as stay-in-place formwork for straight bridges, the panels are not currently permitted on horizontally curved girder systems in Texas. TxDOT would like to extend the use of PCPs to bridges with curved girders for the purpose of accelerating bridge construction and providing an alternative for the forming systems currently used on curved steel girder systems. This report focuses on the stability of PCPs that rest on polystyrene bedding strips. The project studied the behavior for PCPs with and without a positive connection to steel girders and also considered the behavior of the current TxDOT reinforcing details for PCPs with concrete U-beam systems.

What the Researchers Did

This project's main goal was extend the use of PCPs to curved girder systems. The study included steel I-girder systems, steel tub girder systems, and spliced prestressed concrete U-beams, which are currently being considered for use in some Texas bridges. To accomplish this objective, both experimental and analytic work were conducted at the Ferguson Structural Engineering Laboratory at The University of Texas at Austin, including these major tasks:

1. An experimental program was used to study the stability of unconnected PCPs on bedding strips. The deformation of the girder systems during construction were simulated in the laboratory to determine the limits at which bedding strips of various sized could safely support PCPs. Parametric finite element analysis (FEA) studies of long-span curved steel I-girder and tub girder systems were used to investigate the maximum deformations various systems.

2. A connection between PCPs and steel girder systems was developed, employing large-scale laboratory tests and finite element modeling techniques.

3. Large-scale tests performed in the laboratory evaluated the bracing potential of the PCP/ connection system on a twin steel I-girder system and a steel tub girder system. Both girder systems were tested to simulate the behavior of curved girder systems.

4. After validating the finite element models with the laboratory experiments, parametric FEA studies evaluated the bracing potential of connected PCPs on various long-span curved steel I-girder and tub girder systems.

5. An experimental program was used to study the closure pour and reinforcing details to connect the PCPs to the top of the concrete U-beam.

6. Parametric FEA studies were performed for the concrete U-beams to investigate the load demands on the PCP panels with the closure pour details.

What They Found

1. The laboratory experiments and parametric

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FEA showed that the PCPs with appropriately sized bedding strips are stable and can withstand the deformations experienced by steel I-girder and steel tub girder systems during construction with common degrees of curvature found in practice.

2. The connections between the PCPs and steel girder systems were tested in the laboratory and proved to have significant stiffness and strength. The in-plane stiffness of the PCP/connection system was represented with a simplified model using truss members to allow it to be easily integrated into finite element models.

3. The large-scale laboratory experiments for the short- to medium-span steel twin I-girder and tub girder systems showed that using the PCP/connection system as a shear diaphragm bracing element increased the systems load-carrying capacity, reduced the deformations of the girders, and reduced the forces in the midspan cross-frame for the simply supported I-girder test.

4. The parametric FEA for the long-span curved steel I-girder system showed that using the PCPs as shear diaphragm bracing elements adjacent to the girder supports did not significantly reduce the forces in the cross-frames and did not significantly reduce the twist of the bridge system. Therefore, using PCPs in these long-span systems does not provide much benefit from a stability perspective. The parametric FEA for the long-span curve steel tub girder system indicated that the girders are too flexible to erect the steel superstructure without a top lateral truss. Therefore, it is not feasible to use PCPs as bracing elements to replace the top lateral truss for these systems due to the construction sequence.

5. The stiffness and strength of the current TxDOT detail to connect the PCPs to the top of the concrete U-beam were determined through laboratory experiments and the failure mechanism was observed. Several modifications were tested that had beneficial effects on improving the behavior and strength of the connections. Unfortunately, due to the limited number of tests performed in this program, the behavior of these closure pours is not fully understood, and further research may be needed before a definitive "improved" detail can be fully developed.

6. Comparisons between experimental results and the predicted demand for horizontally curved girders systems from the parametric FEA showed that the existing detail was inadequate for long-span curved systems and requires modifications.

What This Means

With properly sized bedding strips, PCPs can be safely used as a forming system on horizontally curved girder systems. Using connected PCPs as bracing elements on long-span curved steel I-girder and tub girder systems did not prove to be particularly useful. On short- to medium-span straight and mildly curved systems, however, connected PCPs are likely useful as diaphragm bracing elements. The existing TxDOT detail for the closure pour and reinforcing details to connect the PCPs to the top of the concrete U-beam has capacity issues and requires modifications. Several modifications were tested that had beneficial effects on improving the behavior and strength of the connections; additional work is necessary to arrive at the most efficient detail.

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