FHWA Report Offers a Fresh Look at Partial-Depth Precast Concrete Deck Panels

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Partial-depth precast concrete deck panels (PDDPs) are relatively thin prestressed concrete panels that span between girders. When combined with a cast-in-place (CIP) concrete topping, they act compositely with the CIP concrete to provide the full structural thickness of a bridge deck. PDDPs can have many advantages, including faster and safer construction, which makes them appropriate for accelerated bridge construction, as well as ease of design and improved quality.

PDDPs were first used in the United States in the construction of bridges in the 1950s, including a project for the Illinois Tollway in 1956. At least 25 state departments of transportation used PDDPs over the subsequent decades, and at least six states currently use them regularly.

In 1987, the Federal Highway Administration (FHWA) published a memorandum on PDDPs that addressed the issue of reflective cracking that had been observed in the CIP concrete topping in some states.[1] The FHWA memorandum shows design, detailing, and construction techniques that had been successfully used by state transportation agencies to construct bridge decks with minimal to no reflective cracking.

The problems with cracking (in relatively few states) hindered the growth of PDDPs. Today, some states use PDDPs in a limited manner, some have never used PDDPs, and others have used them but stopped after concerns with performance. Nevertheless, several states have been successfully using PDDPs for decades. Colorado, Missouri, and Texas use PDDPs for a large majority of bridge construction projects. A few other states, such as New Hampshire, Tennessee, and Utah, also have an established record of PDDP use.

In 2022, FHWA released a state-of-the-practice report titled *Partial-Depth Precast Concrete Deck Panels*.[2] The objective of this report is to encourage the use of PDDPs as a construction option. To help achieve that objective, the report summarizes the state of the practice for PDDP design and construction based on a review of standard practices of six states that are longtime and regular users of PDDPs.

State-of-the-Practice Overview

In the FHWA report, the "state of the practice" refers to the practices generally used by the state transportation agencies of Colorado, Missouri, New Hampshire, Tennessee, Texas, and Utah, which are the most frequent users of PDDPs. The following sections summarize the state of the practice of PDDP use in these six states.

Design

The six states typically use panel thicknesses ranging from 3 to 4 in., with ⅜- to ½-in.-diameter prestressing strands.

The *AASHTO LRFD Bridge Design Specifications*[3] and *PCI Bridge Design Manual*[4] provide guidance and requirements for pretensioning force and minimum concrete strength at transfer f'_{ci} that generally result in satisfactory performance, according to the six states. However, some states use a lower strand jacking force of $0.63f_{pu}$ (where f_{pu} is the ultimate strength of prestressing steel) and limit the concrete compressive stress at transfer to $0.19f'_{ci}$ to reduce the risk of panel cracking.

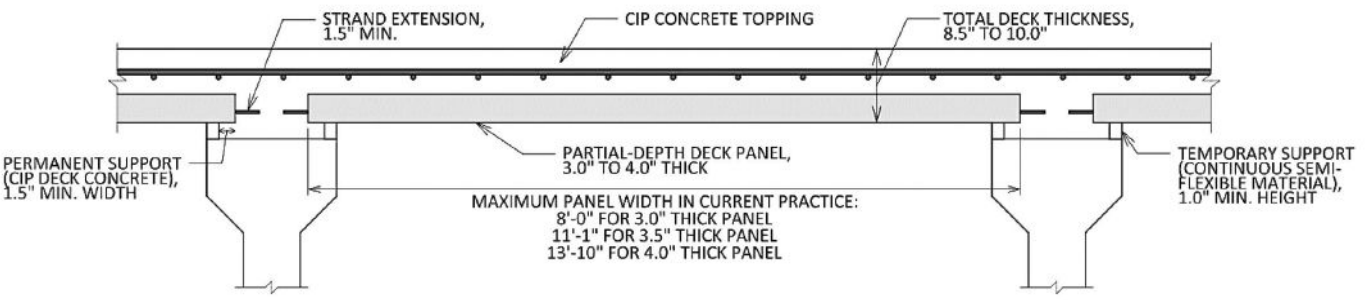
The state of the practice for the six states also includes providing minimum longitudinal distribution reinforcement (per Article 5.9.4.2 of the AASHTO LRFD specifications) and splitting reinforcement at the panel ends to minimize cracking.

To ensure composite behavior between the PDDPs and the CIP concrete, the state of the practice is to roughen the top surface of the PDDPs to a minimum amplitude of ⅛ in. The six states have found that roughness pattern and orientation are not important.

In the states' experience, PDDPs can be used with any type of steel or concrete girder.

Figure 1 shows a CIP concrete deck that includes only one mat of reinforcement in the CIP concrete topping, with the strands in the PDDPs serving as the bottom mat of reinforcement. Figure 1 also illustrates options for supporting the PDDPs. In some cases, a grout bed is installed to support the ends of the PDDPs.

Figure 1. Example section of a bridge deck composed of partial-depth precast concrete deck panels with a cast-in-place reinforced concrete topping. All Figures and Photos: Federal Highway Administration.



Fabrication and Handling

For fabrication, the states generally use PCI MNL 116, *Manual for Quality Control for Plants and Production of Structural Precast Concrete Products*.[5] Similarly, for repairing PDDPs, the state of the practice is to use PCI MNL 137, *Manual for the Evaluation and Repair of Precast, Prestressed Concrete Bridge Products*,[6] or PCI Northeast's *Guidelines for Resolution of Non-conformances in Precast Concrete Bridge Elements*.[7]

PDDPs must be designed for handling, shipping, and erection. The *PCI Bridge Design Manual*[4] states that the locations of the lifting devices should ensure that the panel concrete stresses remain within limits during handling. The lifting devices must also be designed.

Panel Installation and Placement of CIP Deck Concrete

To minimize the potential for cracking of the CIP concrete deck, the panels should be in a saturated surface-dry state at the time the CIP concrete is placed. During CIP concrete placement, it is important that the panel ends are continuously supported with concrete or grout to minimize the potential for reflective cracking and ensure the deck's long-term performance.

Emerging Concepts

The FHWA report discusses several emerging concepts and variations of typical PDDPs. This includes the use of new materials such as ultra-high-performance concrete and fiber-reinforced polymer reinforcement. Additionally, the report discusses the use of the AASHTO empirical design method for the CIP concrete portion of the deck, along with the studies that have been performed and the states that allow it.

International Practices

The report also looks at PDDP practices in countries other than the United States. PDDPs are being used in countries that have similar practices to the United States, such as Canada. In the United Kingdom, the typical panels are quite different, being only 12 in. wide with a single lattice bar truss per panel in lieu of prestressing. In Spain and Australia, PDDPs are fabricated for the full width of a bridge deck, with lattice bar trusses extending above the panel with no prestressing.

Precast concrete partial-depth deck panels after installation, but before placement of cast-in-place concrete topping.

Precast concrete partial-depth deck panels stored at the fabricator's facility. The panels must be designed for handling, storage, shipping, and erection, as well as the placement of the cast-in-place concrete topping and service conditions.

Perceived Barriers and Solutions to the Use of PDDP Technology

The report addresses barriers to the use of PDDP technology as perceived by state transportation agencies, including concerns about reflective cracking of the CIP concrete above PDDPs, panel rejection due to cracking during fabrication, and cost. Each concern is addressed in detail along with the experiences of the states that are regular users of PDDPs.

Strategies to Effectively Deploy PDDP Technology

The report concludes with possible strategies to deploy PDDPs. These strategies include developing standard specifications and details for PDDPs, ideally combined with a demonstration project. A flowchart depicting a suggested implementation plan is also provided in the report. Sometimes, in thinking about the future, we can find the answers in the past. PDDPs are a good example of a past practice that can meet many present and future needs, with a little technical assistance.

References

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