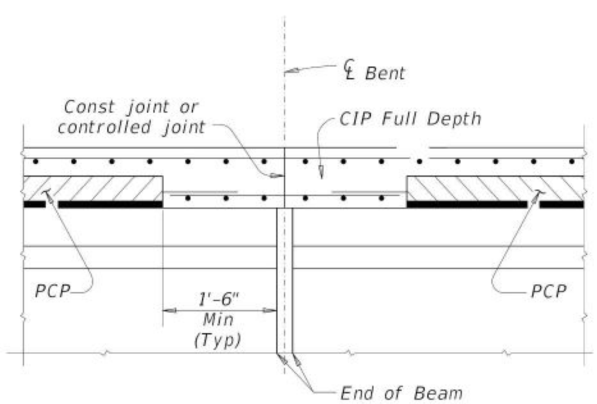
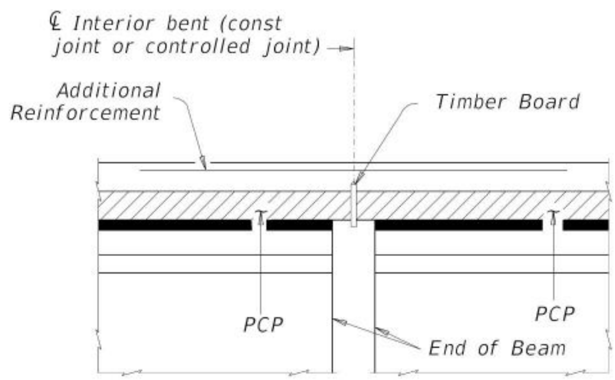
Simplifying Bridge Deck Construction in Texas

by John Vogel, Harris County Toll Road Authority; Kevin Pruski, Texas Department of Transportation; and John Holt, Modjeski and Masters



Traditional Texas Department of Transportation detail for termination of a prestressed concrete panel (PCP) used as a stay-in-place deck form at the interior support of a multiple simple-span unit. Figure: Texas Department of Transportation.



New Texas Department of Transportation detail for termination of a prestressed concrete panel at the interior support of a multiple simple-span unit. Figure: John Vogel.

Texas Department of Transportation (TxDOT) bridge deck construction heavily relies on 4-in.-thick prestressed concrete panels (PCPs) as stay-in-place (SIP) forms between prestressed concrete girders. Cast-in-place (CIP) concrete is later placed, and the PCPs become part of the bridge deck's structural system. TxDOT allows PCPs as a contractor option; their use is not tracked, but they are usually used whenever possible, which clearly suggests their efficacy.

Until a few years ago, PCPs were held back a nominal distance from all beam ends (with or without expansion joints), creating "boundaries" of full-depth CIP concrete deck that needed to be formed with SIP metal forms or timber forms.

Galveston Causeway

In some circumstances, TxDOT restricts the use of SIP metal decks forms for this closure at the beam ends and instead dictates the use of conventional forming, which is tedious and poses scheduling and safety complexities. Such was the case for the Galveston Causeway, a large bridge replacement project near Houston. TxDOT and the contractor worked together, with the aid of a TxDOT research program, to extend the panels from end to end of the span, thus eliminating the need for any conventional deck formwork between the beams. This subtle yet substantial change has become the new go-to option for bridge deck construction in Texas.

The Galveston Causeway carries Interstate 45 and connects Galveston Island with the Texas mainland. This bridge was designed in 2003 using AASHTO-type prestressed concrete girders and the standard PCP forming system for 7852 ft of approach spans. TxDOT's detailing practice required full-depth CIP thickened slabs at the ends of each span. SIP metal-form standard details were omitted from the plans for this area of the deck as part of the durability design of the bridge, but they were not explicitly prohibited. However, the contractor intended to use SIP forms because barge access in shallow water was limited and demolishing wood forms from an under-bridge platform for a 148-ft-wide bridge would be difficult. Based on work done by TxDOT researchers, the contractor proposed the use of PCP forms to improve the existing TxDOT detailing practice for bridge decks. From a static load standpoint, the researchers confirmed the adequacy of the concept of using PCPs for the full length of the girders, so the plans were revised to use PCPs for the full length of each span.

Lessons were learned on the Galveston Causeway project as bridge construction progressed and details were modified to improve constructability and performance. In Texas, decks of simple-span bridges are placed continuously over interior bents, creating multispan continuous deck units, and the decks are expected to crack at the centerline of the bent. On the Galveston Causeway, various techniques to produce a neat crack were tried with mixed results. The first few deck units cast had jagged cracks at the interior bents. Ceramic tile backer

Old detail at the girder end showing the stay-in-place metal formwork on each side of the girder. Photo: John Holt.

board was used to form the gap over the beams where there were no panels, but no provisions except the use of preformed polyvinylchloride (PVC) crack inducer were made to force the crack.

Modifying Details

Details were revised to better align PCP joints over interior bents and keep the panel gap uniform across the bridge. Allowance of some gap between panels is necessary to align panels over the centerline of the bent. Additionally, the area between beam ends, where there are no panels, needs some type of vertical joint form to induce a crack at the desired location. Vertical and straight cracks are desirable to avoid spalling at the crack. A ¾-in.-thick lumber board was specified over the beams to match the panel gap at the centerline of the bent. The timber board is not required between the panels because backer rod or foam board would suffice, but full-width timber board would be acceptable. The contractor troweled a groove at the joint location to make it possible to install the PVC crack inducer in a neat, straight line directly over the panel gap, because large aggregate prevented good alignment of the joint former. The preformed crack inducer simply deformed around the aggregate because the concrete stiffens before the joint former can be installed. Cracks at interior bents were 0.016 in. wide without the crack former and 0.005 to 0.007 in. wide with the improved crack-control joint details.

On occasion, when the PVC crack inducer has been left out, contactors have used a saw cut as a "crack creator," which has not been successful. The saw cut cannot be made in a timely fashion, and, with age, the previously hidden cracks become visible, meandering back and forth across the saw cut, creating slivers of concrete that spall. Currently, the method outlined in the TxDOT standard is to use the PVC crack inducer at the top as well as a timber board that is glued on the vertical faces of the PCPs at the centerline of the interior bent and extends the full width of the bridge between edges of exterior beam flanges. Attached to the board is a timber strip with a triangular cross section to drive the crack from below.

Another lesson learned from the Galveston Causeway project is that there will be small gaps below the expansion joint rails that need to be plugged to contain the CIP concrete. A sheet metal angle was used to bridge the gap between the expansion joint rail and the PCP with the flat of the angle on top of the PCP. However, this detail breaks the bond between the panel and overlay, potentially inducing delamination. A better solution is to adhere sheet metal to the steel expansion joint flush with the edge of panel. TxDOT's expansion joint detail on its PCP standard drawing shows the PCP edge flush with the edge of the steel expansion joint. This is believed to be important to allow CIP concrete to fill the space and provide support for the steel expansion joint rail. Thus, placement of the end PCP at expansion joints requires precision—the contractor needs to plan the placement of the other PCPs to maintain the maximum allowable gap of 1 in. between any adjacent panels. When extending PCPs to the full length of the span, gaps become necessary to accommodate tolerances of prefabricated elements. It is not typical to seal the gaps between abutting panels, but filling/sealing is required when there is a significant gap. When CIP end closures are required, panel joints must be tight.

The use of PCPs for the full length of the girders on the Galveston Causeway project was a success that has been replicated elsewhere with other girder types or with skewed bents. The detail is now part of the TxDOT standard drawing for PCPs and has been widely embraced by Texas bridge contractors. The details can be found at https://www.dot.state.tx.us/insdtdot/orgchart/cmd/cserve/standard/bridge-e.htm.

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New detail used at the Galveston Causeway project with PCPs extending to the end of the girder. The expansion joint rail at the end of a unit was installed abutting the edges of the PCPs. The last PCP was lowered—taking advantage of the increased haunch depth at the end of the girder used to accommodate the beam camber—to thicken the cast-in-place deck to add capacity and provide space needed for shear studs on the expansion joint. Photo: John Vogel.