Research Corner

Precast, prestressed concrete products for infrastructure

Stephen J. Seguirant and Richard Miller

For decades, PCI-funded research has contributed significantly to the use of precast, prestressed concrete products for infrastructure, primarily bridges and waterfront structures. Some research projects have had a direct impact on the design of both superstructure and substructure components, while others have planted the seed for further, more extensive research.

One Daniel P. Jenny Fellowship[1] that had a direct impact on bridge design was the development of the NU prestressed concrete I-girder series in Nebraska. Concurrent with the advancement of high-strength concrete and larger-diameter prestressing strands, these girder sections are significantly more efficient than their forerunners. This research also served as the starting point for development of the WF I-girder series in Washington State.[2] In some cases, the increased efficiency of these sections has reduced the required number of girders in a given bridge compared with the older girder sections of the same span and depth. Obtainable pretensioned concrete I-girder lengths have also increased up to the current maximum of 223 ft (68 m). Other states have also adopted girder sections of similar proportions as local standards.

Another project[3] that made a direct impact on precast, prestressed component design addressed spiral confinement reinforcement in prestressed concrete piles in moderate to high seismic regions. Current American Association of State Highway and Transportation Officials' *AASHTO LRFD Bridge Design Specifications*[4] requirements for piles, similar to those in earlier building codes, result in closely spaced, large-diameter spiral reinforcement based on historical tests of concentrically loaded columns. In concentrically loaded columns, the cover spalls as the maximum load is approached and the requirements for spiral reinforcement are intended to ensure that the confined core of the column after spalling is at least as strong as the column before spalling. However, the purpose of spiral reinforcement in prestressed concrete piles used in moderate to high seismic regions is to enable the pile to undergo large flexural deformations while maintaining axial load capacity that is usually much less than half of the concentric load capacity. The PCI-sponsored project examined the needed rotational ductility for the higher seismic design categories and proposed revised requirements for spiral reinforcement. These revised spiral requirements were adopted in ACI 318-19[5] chapter 18, as requirements for concrete deep foundations were transferred from the international building codes into ACI 318-19. *Specification for Precast, Prestressed Concrete Piles* (PCI 142), an upcoming PCI standard,[6] which will combine pile design requirements from both the building codes and AASHTO LRFD, has also incorporated these revised spiral requirements for prestressed concrete piles. AASHTO Committee T-10 on Concrete Design has initiated a working agenda item to adopt PCI 142.

PCI had a major role in research on the use of ultra-high-performance concrete (UHPC) for precast concrete elements, including bridge elements. PCI funded four Jenny Fellowships and then a major research project on UHPC. A recent report by the National Cooperative Highway Research Program (NCHRP Report 999)[7] details the use of UHPC for joints in deck bulb-tee girders and cites PCI work on UHPC. A more detailed discussion of PCI's efforts in UHPC will appear in a future Research Corner column.

Beyond materials and structural design considerations, PCI research also addresses production and operational items. The strength of lifting loops made of prestressing strand is one such example. The only information available on using lifting loops made of prestressing strand was for 0.5 in. (13 mm) diameter strand. As bridge producers have transitioned to 0.6 in. diameter (15 mm) strand and stainless steel strand for some products, there was a need to evaluate the strength of these lifting loops.[8] A soon-to-be-completed supplemental research project will provide guidance for the safe vertical load capacity of 0.6 in. strand lifting loops and include recommendations for multiple strand loops. These recommendations are expected to appear in chapter 3 of the next update of the *PCI Bridge Design Manual*.[9]

In some cases, PCI has funded Jenny Fellowships or small research projects that have contributed to the development of new products. Full-depth precast bridge decks are one example. Although many different agencies sponsored research on full-depth precast concrete bridge decks, the record shows that PCI funded at least four separate Jenny Fellowships and one research project on this subject, all of which contributed to development of these systems.[10,11]

The PCI Research and Development Council has funded Jenny Fellowships and research projects in other areas that have an impact on bridge design. Fellowships and projects in the areas of high-strength concrete, self-consolidating concrete, and strand bond are examples.

In the transportation sector, PCI Research and Development Council isn't the only research funding source. Outside of PCI-funded research projects, PCI and its members have been active participants in research projects for other agencies that benefit bridge design. Notably, PCI members have conducted or served on advisory committees for numerous research projects on precast, prestressed bridges conducted by NCHRP. Some representative NCHRP projects are given in the following NCHRP reports, found on the Transportation Research Board website at TRB.org:

- *NCHRP Report 496: Prestress Losses in Pretensioned High-Strength Concrete Bridge Girders*
- *NCHRP Report 517: Extending Span Ranges of Precast Prestressed Concrete Girders*
- *NCHRP Report 519: Connection of Simple-Span Precast Concrete Girders for Continuity*
- *NCHRP Report 549: Simplified Shear Design of Structural Concrete Members*
- *NCHRP Report 603: Transfer, Development, and Splice Length for Strand/Reinforcement in High-Strength Concrete*
- *NCHRP Report 621: Acceptance Tests for Surface Characteristics of Steel Strands in Prestressed Concrete*
- *NCHRP Report 654: Evaluation and Repair Procedures for Precast/Prestressed Concrete Girders with Longitudinal Cracking in the Web*
- *NCHRP Report 849: Strand Debonding for Pretensioned Girders*
- *NCHPR Report 895: Simplified Full-Depth Precast Concrete Deck Panel Systems*

Many of these NCHRP projects have resulted in changes to the AASHTO LRFD specifications and facilitated the use of precast, prestressed concrete bridges.

Although it's not the traditional focus of the PCI Research and Development Council, bridge and infrastructure components have benefited from PCI-sponsored research. Many of these projects also initially explored a potential topic that then led to additional funding from other agencies to expand on the topic.

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