Texas A&M Transportation Institute

PROJECT SUMMARY

Texas Department of Transportation

0-6863: Develop Strong and Serviceable Details for Precast, Prestressed Concrete Bent Cap Standards That Can Be Implemented on Everyday Bridge Construction Projects

Background

With hundreds of new bridges constructed in Texas every year, the use of accelerated construction techniques is critical to minimizing the impact of construction on traffic. For substructures, the use of precast bent caps can significantly reduce construction time. Precast reinforced concrete (RC) caps have been used in Texas since the early 1990s, and standard connection details have been available since the early 2000s. This project investigated the use of pretensioned caps to eliminate or reduce cracking. An alternative connection for precast caps was developed.

What the Researchers Did

Full-scale experimental tests of precast bent caps were conducted with loading simulating the indeterminate demands in multicolumn bent caps. A reinforced concrete cap was tested to provide a performance baseline. Pretensioned caps investigated the amount of prestressing and shear reinforcement, the use of internal voids, the length of the overhang, and detailing of end regions. All tests incorporated a new design for a precast connection that used a single void (a pocket) in the bent cap placed around column dowel bars and the site filled with concrete (Figure 1). Results of experimental tests were used in developing design recommendations for pretensioned bent caps.

Figure 1. Fabrication and Placement of a Bent Cap with a Pocket Connection.

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What They Found

Researchers found the following:

- **Connections:** The pocket connection permitted easy fabrication/placement and provided acceptable performance under design loads.
- **Effect of prestressing:** Pretensioned caps delayed the onset of cracking and, once cracks formed, limited the number and width compared to the RC cap (Figure 2).
- **Crack closure:** Design of bent caps for zero tension under dead load allowed for flexure cracks to fully close upon removal of live loads.
- **Voids:** At design loads, the flexural response of voids was as expected, but shear cracks formed earlier than anticipated. Peak load-carrying capacity was not affected by the void, but the failure was more brittle.
- **Amount of prestressing:** Increasing the number of strands improved the flexural cracking strength significantly and reduced the angle of shear cracks, but was ineffective in increasing the shear cracking strength.
- **Overhangs:** The use of prestressing permits the use of longer overhangs that do not exhibit cracking under design loads.
- **Shear design:** Use of American Association of State Highway and Transportation Officials (AASHTO) sectional design methods for pretensioned caps may result in unconservative designs as a result of inaccurate predictions of crack angles.

What This Means

Pretensioned bent caps are an attractive substructure component because they offer contractors an option for fabrication by prestressing plants and can be used to eliminate or reduce cracks. Two sets of design recommendations were developed to enable implementation of pretensioned caps. The first allows for conversion of RC designs to pretensioned designs. For a new design, flexure design is based on the concept of zero tension under dead load to ensure cracks close upon removal of live load. Shear design recommendations include a modification of AASHTO sectional design methods to ensure that crack angles are physically admissible. Design examples are provided for conversion of RC to pretensioned caps, new design of standard substructures, use of voids to reduce weight, and detailing of end regions. A final example demonstrates how engineers can leverage the benefits of the pretensioned caps to reduce the number of column lines in a substructure, providing the potential for substantial savings in construction costs.

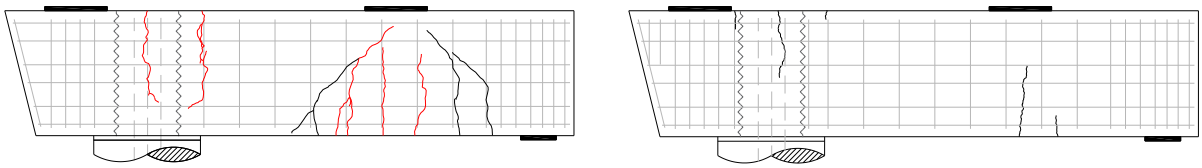

Figure 2. Crack Map of Reinforced Concrete (Left) and Pretensioned (Right) Bent Caps. Red Lines Indicate Cracks Exceeding AASHTO Limits.

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