OFFICE OF RESEARCH & BEST PRACTICES
Michigan Department of Transportation

Research Spotlight

Project Information

REPORT NAME: Effects of Debonded Strands on the Production and Performance of Prestressed Concrete Beams

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Strand debonding helps minimize bridge beam end cracking

Unexpected cracking at the ends of some prestressed bridge beams was discovered in Michigan despite practices in place to prevent it. Targeted research into the root cause of this problem led to a simple and straightforward solution.

Traditional soft sheathing on the ends of prestressing strands (left) was not producing the desired debonding effect in bridge beams. The use of rigid tubing (right) as an alternative made the difference.

Problem

The steel strands in a prestressed concrete bridge beam resist the tensile forces generated from traffic loading and the beam's own weight. At the beam's ends, those prestressing strands can result in unwanted internal stresses and cracking. To reduce this effect, MDOT bridge specifications follow design guidance from the American Association of State Highway and Transportation Officials (AASHTO) that calls for debonding a portion of the steel prestressing strands at the beam's ends.

With longer bridge beam designs in recent years and the longer debonded strand regions they require, MDOT has seen a growing trend in end cracking. After considering possible causes such as design flaws, poor quality materials or manufacturing errors, it appeared instead that all parties involved - designers, precasters and contractors - were faithfully following the specifications. MDOT decided to research what was causing end cracking and how to resolve it.

Approach

Debonding of prestressing strands is typically achieved by wrapping the ends of the strands with a soft polymer sheathing.

(continued)

> *"For all the existing work that shows the importance of strand debonding, this research took the critical next step of finding best practices to achieve it."*
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> **Steve Kahl, P.E.**
> Project Manager

However, end cracking was found in beams that were currently in service as well as beams that failed MDOT acceptance. This suggested a lack of true debonding. The agency initiated an investigation to determine if the soft sheathing material was achieving the desired debonding effect. The investigation also would include testing of more rigid tubing as an alternative sheathing material to determine if it could produce a higher degree of debonding.

Research

Investigators undertook an array of practical and theoretical approaches to reach an understanding of the causes of the end cracking and the mechanics of the materials involved.

- Laboratory tests characterized steel strands in various degrees of bonding with concrete. This included a study of the mechanical interlock between materials and the presence or absence of bonding behavior.
- Researchers created and tested small-scale bridge beams to examine stress transfer behavior of bonded and debonded strands using both traditional soft sheathing as well as the alternative rigid sheathing.
- Computer modeling and numerical simulation of the materials and their interaction helped explain and verify effects seen in the lab and the field.

Results

When soft sheathing was used for debonding, researchers found that bonding behavior was present to some extent between the strand ends and concrete, causing excess stress and end cracking. The results of lab tests and models were in close agreement, and they demonstrated that the damage effect was compounded when multiple strands were close to one another.

Investigations into replacing soft sheathing material with a rigid polymer were a success. The alternative material proved to be an effective way to create more clearance between steel and concrete and ensure debonding behavior. This solution carries a small tradeoff in ease of beam construction: The rigid sheathing lacks a split seam along its length that now facilitates the application of traditional soft sheathing.

In 2011, MDOT's bridge committee will evaluate the recommendations of the report to require the use of rigid sheathing to achieve the desired debonding effect. Department specifications typically would not call out debonding material in such level of detail. However, the research shows it may be worthwhile to do so.

Value

While the solution to this problem turned out to be relatively straightforward, the supporting research will help provide MDOT with a high level of confidence in this alternative approach. Finding a fundamentally sound solution is critical since premature end cracking has a significant impact on the durability of bridge beams. Implementing the right solution will help beams pass inspection and ultimately meet their intended service life.

Given the costs of beam repair and replacement, the change in fabrication method represents a highly cost-effective solution as well. The added effort and expense are minimal compared with the costs, both in terms of dollars and project and user delay, associated with bridge beams that fail to meet the agency's exacting standards.

RBP

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