Research Brief

Pretensioned Concrete Girder End Crack Control

Research Objectives

- Prove through physical testing and observation that debonding strands can reduce or eliminate critical girder end cracking
- Eliminate cracking in the bottom flange of the girders, where cracks could allow moisture to reach prestressing strands and induce corrosion that might affect the girder capacity
- Provide design recommendations for effectively using debonded strands in girders

Research Benefits

- Debonding proved to be an effective solution for end crack control and elimination
- Design specifications are recommended for 54W and 72W girders
- The modelling techniques used in this research have potential for further use in updating design standards for other girder sizes

Principal Investigator

Michael Oliva
University of Wisconsin – Madison
oliva@engr.wisc.edu

Project Manager

Dave Kiekbusch
WisDOT
david.kiekbusch@dot.wi.gov

Background

The Wisconsin Department of Transportation (WisDOT) currently constructs bridges with bulb-tee pretensioned concrete girders because of their efficiency in load resistance. That level of efficiency is reached by heavily prestressing the girders, a process that can cause cracking at the girder ends during de-tensioning. These cracks may endanger the structure as cracks can lead corrosive water to the steel strands, decreasing durability and capacity. This research primarily addresses cracking in the bottom flange, close to the strands, and aims to prove the effectiveness of strand debonding at girder ends to prevent cracking.

Methodology

Prestressed girders, 54 and 72 inches deep, were designed and built using three different debonded designs along with two standard designs to evaluate and prove the effectiveness of debonding. The girders were instrumented with various gauges to record internal strains and detect cracking during the prestressing or detensioning process.

Detailed analytical finite element models (FEM) of the girders were assembled using non-linear behavior to simulate the concrete cracking in the actual girders. The response predictions from the analytic models were compared with the measured response quantities from the actual girders to verify the accuracy of the analytic approach.

Analytical modelling was then employed to examine a wide range of possible 54 and 72 inch deep girder designs to select debonding patterns and the number of debonded strands that would best provide the desired uncracked performance in girders with various strand patterns.

Vibrating wire (VW) gauges were placed on reinforcing bars to measure concrete strain.

“Implementing the research findings to reduce cracking should ensure the girders do not need maintenance or replacement during the expected 75 year life of the bridge.”
– Dave Kiekbusch, WisDOT

Interested in finding out more?

Final report is available at: WisDOT Research website.

Results

Constructing girders with debonded strands proved to be an effective solution for end crack control and elimination, and comparison of analytic predicted behavior and measured girder response data showed that the nonlinear analysis techniques used were accurate.

Debonding 25 percent of the prestressing strands for various lengths at the girder end significantly reduced the concrete tension strains developed during detensioning of the 72W girders. The tension strains measured in reinforcing bars of the debonded girder were at least 200 micro strain less than in a normal girder, and the strains in the critical bottom flange were 70 percent less than in normal girders. Using staggered debonding or debonding all strands for 8 to 12 inches also proved effective at reducing or eliminating undesired cracks. Although debonding proved effective in reducing concrete tension and cracking, the American Association of State Highway and Transportation Officials’ (AASHTO) 25 percent debonding standard was found to be insufficient to prevent bottom flange cracking in girders with high prestressing.

Recommendations for Implementation

Nonlinear analysis techniques were used to provide WisDOT with recommendations for the best girder designs, and the research suggested that the WisDOT Bridge Manual for 54W and 72W girders should include debonding processes, particularly when a large number of strands are used. Inner column strands should also be cut before outer column strands during detensioning.

Other design suggestions to reduce concrete tension stresses and amounts of cracking that were evaluated did not prove to be sufficient in eliminating bottom flange cracking, and eliminating cracking altogether would require significant debonding.

The accuracy of the modelling techniques used in this research was very high and suggest there is potential for further use in updating design standards for other girder sizes.

This brief summarizes Project 0092-15-01,
“Implementation and Field Evaluation of Pretensioned Concrete Girder End Crack Control”
Wisconsin Highway Research Program