CENTER FOR TRANSPORTATION RESEARCH

PROJECT SUMMARY

Texas Department of Transportation

0-6919: Evaluation of Structural Cracking in Concrete

Background

Visual inspection procedures are commonly used to monitor the performance of in-service reinforced concrete bridge infrastructure. Current methods used for classifying the severity of structural cracking observed in reinforced and prestressed concrete bridge elements generally consist of various rating criteria in the form of pre-established concrete crack width and crack density limits. While concrete cracking data obtained from routine inspections of these types can aid in identifying bridge members that are degrading, or are exhibiting signs of distress, these inspections typically provide limited insight into the structural performance implications of damage or the severity of structural distress. Further, inspection evaluation criteria are almost always independent of member-specific design details in that information related to steel reinforcement ratios and layouts, material strengths, member geometries, and loading conditions are typically not considered when evaluating structural cracking in concrete bridges..

The primary objective of this project was to develop crack-based strength assessment procedures that employ visual concrete crack data as input (e.g., measured crack widths, crack inclinations, crack patterns, etc.) and provide quantitative output related to bridge member health. Focus was given to developing procedures that only require easy-to-obtain bridge member cracking data and the execution of low-cost analyses that can be performed using basic, and readily-available, software (e.g., MS-Excel or similar).

What the Researchers Did

The experimental protocols developed in project Project activities were focused on developing, and subsequently refining and validating, two different crack-based assessment procedures for in-service concrete bridge members: i) a cracked continuum shear strength assessment procedure that is rooted in concepts of reinforced concrete mechanics and can be used to examine shear-. related distress in concrete bridge members, and ii) crack pattern quantification procedures that employ fractal analysis techniques to perform image-based assessments of crack patterns for the purpose of gaining insight into bridge member health..

To guide and facilitate the procedure development efforts, an extensive literature review was initially performed to i) identify relevant TxDOT bridge members that have been shown to experience in-service shear cracking and to pose challenges related to assessing structure safety, ii) assess the current state-of-the-art related to damaged-. based assessment of structural concrete elements, and iii) gather experimental data to populate a visual crack measurement evaluation database to be subsequently used for the development and appraisal of the crack-based structural assessment procedures developed in this project.

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The experimentally-validated cracked continuum shear strength assessment procedure was used to develop member-specific visual crack inspection field aids that can be employed on-site to evaluate the structural implications of diagonal cracking observed in reinforced concrete bent caps. A general field aid construction procedure was also presented permitting member-specific inspection aids to be developed, as needed.

What They Found

This project produced several meaningful findings. Among the most noteworthy were:

- Diagonal crack widths, on their own, do not serve as reliable indicators of concrete member shear distress. Examination of experimental data gathered from the literature, and results obtained from the crack-based assessment procedures developed in this project, confirm that other cracking characteristics (e.g., crack inclinations) and member-specific design details (e.g., reinforcement details, material properties, loading conditions, etc.) must be considered when assessing the strength/safety-related implications of diagonal cracks observed in reinforced concrete members.
- The cracked continuum assessment procedure developed through this work is a viable, mechanics-based approach for carrying-out low-cost and simple-to-perform structural assessments of shear cracked bridge members. Employing the procedure to estimate the level of shear distress in diagonally-cracked reinforced concrete bent cap members that were constructed with TxDOT relevant design details and tested to failure in prior TxDOT research projects, the cracked continuum continuum assessment procedure was able to estimate the residual shear capacities of these members within 8 % of that measured experimentally, on average, and with a coefficient of variation of 19 % (92 data points/analyses).
- Fractal analysis procedures developed through this work can be used to perform image-based structural assessments of concrete bridge infrastructure. Fractal and multifractal analysis procedures can function in a highly-automated manner to quantitatively compare and contrast crack patterns from images of cracked bridge members obtained over time.

What This Means

The damage-based assessment procedures developed through this work can be used to supplement more traditional and qualitative concrete bridge inspection techniques by providing quantitative insight into visual concrete cracking of TxDOT bridge infrastructure. Employed regularly, these procedures can aid in prioritizing maintenance and repair efforts, and in identifying potential strength-related deficiencies associated with cracked in-service concrete bridge members. Further, the application of member-specific visual crack inspection field aids that can be created using techniques developed in this project may be used to provide immediate crack-based assessments on-site, or to forecast critical diagonal concrete crack widths and assist with ongoing bridge monitoring efforts.

For More Information

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