Project Summary
Texas Department of Transportation

0-1895: Evaluate the Effect of Allowing the Use of $12\sqrt{f'_c}$ to Load Rate Prestressed Concrete Bridges

Background

In Texas, the procedures in the AASHTO Manual for Condition Evaluation of Bridges (MCEB) are used to determine the load rating of existing structures. A large number of prestressed concrete bridges that were constructed in the 1950s and 1960s have load ratings that fall below the minimum design vehicle specified in the MCEB. The direct consequences of the reduced load ratings range from increasing the frequency of structural inspections and posting of maximum permissible live loads to strengthening or replacing the bridge. The load ratings for this group of prestressed concrete bridges are typically controlled by the serviceability limit state criterion in the MCEB related to the tensile stress in the concrete. A low load rating implies that these bridges have experienced damage due to daily vehicular traffic. However, observations made by Texas Department of Transportation (TxDOT) personnel during routine inspections indicate that the condition of these bridges is very good, and that there are generally no signs of deterioration.

The discrepancy between the conditions implied by the load ratings and those observed in the field implies that the tensile stress serviceability limit state in the MCEB is conservative. The MCEB specifies a limiting tensile stress of $6\sqrt{f'_c}$ for the inventory-level load rating. In an effort to improve the load ratings of these older prestressed concrete bridges, TxDOT increases the concrete tensile stress limit when used to evaluate the serviceability limit state criterion. A limiting tensile stress of $7.5\sqrt{f'_c}$ is most commonly used, but occasionally limiting tensile stresses as high as $12\sqrt{f'_c}$ have been selected. The primary objective of this investigation is to evaluate the impact of using these elevated tensile stress limits when calculating the inventory-level load rating of older prestressed concrete bridges.

What the Researchers Did

The investigation was divided into three phases. In the first phase, diagnostic load tests were conducted on five prestressed bridges in the Austin District that had been designed in the 1950s and 1960s. The tensile stress in the concrete controlled the inventory-level load rating for all five bridges, and the inventory-level rating factor was less than 1.0 for four of the five bridges. In the second phase, fatigue tests of prestressed concrete beams were conducted in the Ferguson Structural Engineering Laboratory. The load rating criteria were evaluated critically in the third phase, and recommendations were developed, including the fatigue limit state directly in the load rating process.

Research Performed by:

Center for Transportation Research (CTR),
The University of Texas at Austin

Research Supervisor:
Sharon L. Wood, CTR

Researcher:
John Breen, CTR

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What They Found

Before the diagnostic load tests, all bridge spans were inspected visually by the research team. No evidence of cracking of the concrete or corrosion of the reinforcement was observed. However, the measured live load response indicated that flexural cracks were present in most of the beams. The precompression was sufficient to close the cracks in the absence of live load, which is why the cracks were not detected by the research team.

The live load distribution factors in the AASHTO Standard Specifications for Highway Bridges were found to be conservative for all bridges tested. The live load distribution factors in the AASHTO Load and Resistance Factor Design Bridge Specifications were found to be less conservative in some cases and more conservative than those in the Standard Specifications in other cases.

The fatigue life model for Detail Category C was found to be a reasonable approximation of the measured fatigue response of prestressed concrete beams. Data from more than 80 beams were considered, and the fatigue model was conservative for all but 3 of the beams. Using this model, the stress range in the strand is the only parameter needed to calculate the fatigue life of a prestressed concrete girder.

The calculated maximum tensile stress in the concrete was found to be a very poor indicator of the tensile stress in the strand. At the same level of maximum tensile stress, the live load stress range in the strand varied by a factor of 4 to 10, depending on the length of the girder. Therefore, it was necessary to calculate the stress range in the strand to evaluate the fatigue response of the bridges. Detailed analyses indicated that four of the five bridges had an infinite fatigue life and the fatigue did not limit the design life of the remaining bridge. Therefore, posting was not required for any of the bridges.

What This Means

It is recommended that the capacity limit states defined in the AASHTO Manual for Condition Evaluation of Bridges be used to determine the inventory and operating-level ratings for the class of prestressed concrete bridges studied in this investigation. Rather than using the serviceability limit states defined in the MCEB, the fatigue limit state should be evaluated directly. However, a specific load rating is not tied directly to the fatigue limit state. Rather, the calculations indicate if a spectrum of loading vehicle limits representative of interstate traffic along a major transportation corridor in Texas limits the fatigue life of the bridge. The proposed procedures are similar in concept to those for steel bridges in the AASHTO Manual for Condition Evaluation and Load and Resistance Factor Rating of Highway Bridges.

For More Information:
Research Engineer - Andrew Griffith, TxDOT, 512-465-7403
Project Director - Keith Ramsey, TxDOT, 512-416-2250
Research Supervisor - Sharon L. Wood, CTR, 512-471-7298

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Texas Department of Transportation
Research and Technology Implementation Office
P.O. Box 5080
Austin, Texas 78763-5080
512-465-7403