The benefit/cost analysis was performed in 2003

JTRP / INDOT RESEARCH PROGRAM

Research Pays Off

Nonmetallic Reinforcement for Concrete Bridge Superstructures— SPR 2325

The development of Performance Related Specifications (PRS) requires the identification of key performance levels for a given structural system. The first attempt to develop a methodology for PRS can be traced to 1980 when the Federal Highway administration (FHWA) instituted a new research program category. The two main objectives of the program were:

1) To provide a more rational basis for payment reduction plans.

2) To develop additional specifications related to the performance of flexible and rigid pavement structures.

In the early and mid-1980s, the FHWA, the National Cooperative Highway Research Program (NCHRP), and the American Association of State Highway and Transportation Officials (AASHTO) began a cooperative effort searching for supporting data needed for the development of PRS. The idea was to develop performance models that would allow relating the material and construction testing parameters collected at the time of construction to the future performance of the complete project. However, it was concluded that the existing databases were inadequate to derive the needed performance models.

The objective of the research study was to develop the essential components of a PRS for concrete bridge superstructures for application in the state of Indiana. In Volume 3 of the final report, research work conducted to investigate the behavior of fiber reinforced polymer (FRP) reinforcement is summarized. This study focused on the behavior of FRP reinforced concrete structures with an emphasis on bond and shear. For the bond investigation, three series of beam splice tests were performed on specimens reinforced with steel, glass FRP, and aramid FRP to determine the effect of the different types of reinforcement on bond, cracking, and deflections. The main objective of this volume is to provide design guidelines for the use of FRP reinforcement in bridge superstructures.

Research Findings and Implementation

The results of the tests conducted, as cited above, indicate that the use of FRP reinforcement leads to lower bond strengths and, therefore, require longer development lengths. The specimen crack widths and deflections were substantially larger for FRP specimens than steel specimens due to the significantly lower modulus of elasticity. Analysis of the test results resulted in recommendations for modifying the empirical development length equation of ACI 318-99 design code for use with FRP reinforcement.

For the shear investigation, two series of beam tests were conducted on specimens reinforced with steel, glass FRP, and aramid FRP to determine the effect of the different types of reinforcement on the concrete shear strength. All specimens did not contain transverse reinforcement. The test results indicate that the use of FRP reinforcement leads to lower concrete shear strengths than steel reinforcement for equal reinforcement cross-sectional areas (longitudinal reinforcement percentages). Analysis of the test results resulted in recommendations for the calculation of concrete shear strength.

Based on the findings of this research, design and construction specifications and recommendations are provided that can be used for the design and construction of FRP reinforced bridge decks. These recommendations will be implemented in a JTRP study "Implementation of a Non-Metallic Reinforced Bridge Deck." This study will evaluate the design and construction recommendations in a prototype laboratory deck specimen as well as through a pilot field study that incorporates nonmetallic reinforcement in a bridge deck.

Potential Benefits

An analysis of 55 bridges was conducted over a span of 50 years. Using FRP bars the cost of conventional bridge increases by 6.4 to 8.7%. Using initial construction cost of $800,000 of conventional bridge, FRP bar bridge cost considered was $860,000. Cost data analysis resulted in an estimated maintenance cost per bridge per year of $58.14, and deck patching cost of $69.17 per bridge per year. This cost information was obtained from INDOT, Operations Support.

Though the initial construction cost is higher, the resultant benefits were accounted in savings by avoiding patching and overlay costs.

Cost of Research $161,250

Estimated Economic Value Over 50 Years At 5% Discount Rate

Costing Method	Number of Bridges [1]	Discounted Cost /Bridge [2]	Discounted Savings/Bridge [3] = [C - P]	Total Discounted Savings (50 years) [4] = [3] x [1]	Benefit/Cost Ratio [5] = [4] / $161,250
Current (C)	55	$877,851	$16,731	$920,220	5.71
Proposed (P)		$861,120			

Assumptions

- That INDOT will use FRP bars in construction of 55 bridges, which is the number of bridge decks replaced annually.
- That the analysis period of 50 years corresponds to the general bridge deck design life.
- Discounted cost/bridge is based on 50 year life and the difference between C and P is the savings in deck patching.

References

- Frosch, R., Mosley, C. and A. Koray Tureyen,“ Performance Related Specifications for Concrete Bridge Superstructures-Volume 3: Nonmetallic Reinforcement” Joint Transportation Research Project FHWA/IN/ JTRP-2001/8 Final Report, October 2002.