



The benefit/cost analysis was performed in 2003



JTRP / INDOT RESEARCH PROGRAM

Research Pays Off

Synthesis Study Strengthening of Deteriorating Decks of Highway Bridges in Indiana using FRPC— SPR 2490

The service life of bridges is often reduced due to the corrosion of steel reinforcing bars in bridge decks and due to the cracking caused by loading in excess to the original design values with increased traffic volumes. In Indiana, numerous bridges are in need of upgrading or rehabilitation. Current upgrading practices include replacing the part of deteriorated portion of the deck structure by patching damaged areas or replacing the whole deck structure. Both of these practices have drawbacks. The first is time-consuming and provides only a short-term solution, while the latter is expensive and causes severe traffic disruption. Therefore, alternative solutions should be devised for the rehabilitation and upgrading of deteriorated bridge decks in Indiana.

Many industries, such as the aerospace and the automotive industries have successfully used Fiber Reinforced Polymer Composites (FRPC). These types of composite materials offer significant advantages over conventional civil engineering materials, such as concrete and steel. This is due to their chemical and corrosion resistance, lightweight, and high strength, which make them attractive

for the rehabilitation of civil infrastructures.

FRPC have been used in the replacement of deficient bridge decks. Studies of the feasibility and long-term performance of this type of application has been conducted. These studies have concluded that not only FRPC decks should be considered as an alternative to conventional reinforced concrete decks; they have a number of advantages over the latter. In particular, their ease of construction should be highlighted: instead of weeks only a few days are required for their successful installation and consequently traffic disruptions are minimized.

The objective of this research project is to study the feasibility of using of FRP as a retrofit or construction material for bridge decks. This has been accomplished by means of a comprehensive literature review of externally bonded FRPC strengthening systems and of the current state of knowledge on technologies involved in the design and construction of FRPC bridge decks. In addition, valuable information has been obtained through a web-based survey of other state Departments of Transportation (DOTs) on their experience with FRPC materials for bridge decks.

Research Findings and Implementation

The results from the literature review indicate that by externally bonding FRP plates (or sheets) and/or rods provide excellent retrofitting mechanisms to increase deck strength as well as stiffness of aging or deteriorated structures. The advantages of this retrofitting method include reduced labor costs, minimum shutdown time/cost and traffic disruption, and minimal maintenance requirements. It was further found from the literature review that the values of such increase in stiffness and strength varied for the different field applications. However, in all cases such an increase was observed. Furthermore, it was also found that the benefits of such a retrofitting system do not change with time. Most of the studies report that their FRP applications are performing very well. In fact, some of these applications are now 3 or 4 years old and continue to show excellent performance. In all cases, it is reported that the installation time is significantly reduced when compared to conventional reinforced concrete decks.

The experience of other state DOTs in the use of FRP as a retrofit and as a construction material for bridge decks was investigated by means of a web-based survey. All 50 state DOTs were contacted and 34 responded

the survey. Of the responding DOTs, 23 responded that they have used FRP for bridge deck rehabilitation and/or installed FRP bridge decks. The major reasons provided by these states for adopting FRP materials were their excellent strength, lightweight, and durability. Most of the states using FRP as a material for bridge deck rehabilitation reported that its main use was to strengthen and upgrade damaged bridge decks. Eight states responded that they had replaced a reinforced concrete bridge deck with FRP bridge deck. Based on their experience, these DOTs have not observed any problems with their FRP application. Twenty state DOTs have responded that they are considering using FRP in the future. Most of them plan to utilize FRP as a strengthening/upgrading system.

The current state of knowledge of FRP materials as a construction material for civil infrastructure indicates that it can be successfully used in many types of applications. The present study focused on their use for bridge decks. In order to further benefit from this technology, Indiana must become part of the increasing research effort in this area. Therefore, it is strongly recommended that a demonstration project be developed in this

state. With this in mind, a proposal has been developed and submitted to the FHWA Innovative Bridge Research and Construction (IBRC) program. In the proposed project, the three main spans of a bridge deck in Tippecanoe County will be replaced by 8" FRP deck panels. The scope of this project includes the evaluation and design of FRP

bridge deck panels to meet current code requirements. It also involves the reconstruction of an existing bridge deck using the innovative FRP deck panels. The monitoring of the performance of the developed application will also be part of the proposed IBRC project.

Potential Benefits

An FRP panel weighs 15-20% of a conventional panel, which comes to 18 pounds per square foot assuming a conventional panel weighs 100 pounds per square foot. An analysis of 55 bridges was conducted over a span of 50 years using initial construction cost of \$800,000/bridge and an overlay cost of \$300,000/bridge. A 50-year analysis period corresponds to the general design life of a bridge deck. An estimated maintenance cost was determined per bridge per year as \$58.14, and patching cost of \$69.17 per bridge per year. The resultant benefits were accounted in savings by avoiding patching and overlay costs due to using

FRP though the initial cost of FRP panel is higher than a conventional one.

*Cost of
Research
\$30,000*

Estimated Economic Value Over 50 Years At 5% Discount Rate

Costing Method	Number of Bridges	Discounted Cost /Bridge	Discounted Savings/Bridge	Discounted Total Savings (50 years)	Benefit/Cost Ratio
	[1]	[2]	[3] = [C - P]	[4] = [3] x [1]	[5] = [4] / \$30,000
Current (C)	55	\$877,851	\$76,731	\$4,220,220	140.67
Proposed (P)		\$801,120			

Assumptions

- That INDOT will use FRPC on 55 bridge decks (which is the number of decks replaced annually).
- That the analysis period of 50 years corresponds to the life of bridge decks.
- Patching and Maintenance costs obtained from Roadway Management.
- The \$877,851 is the discounted cost for bridge maintenance plus patching, and the \$801,120 represents savings from no patching.

References

- Sotelino, E. and Teng, M., "Strengthening of Deteriorating Decks of Highway Bridges in Indiana Using FRPC" Joint Transportation Research Project FHWA/IN/ JTRP-2001/15 Final Report, November 2001.