INDOT Research

TECHNICAL *Summary*

Technology Transfer and Project Implementation Information

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Strengthening of Deteriorating Decks of Highway Bridges in Indiana Using FRPC

Introduction

The service life of bridges is often reduced due to the corrosion of steel reinforcing bars in bridge decks and to the cracking caused by loading in excess to the original design values due to 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.

Strengthening of Reinforced Concrete (RC) structures by bonding external steel plates and composite plates or sheets is an effective method for improving structural performance under both service and ultimate load conditions. A main disadvantage of using steel plates is the potential for corrosion at the epoxy/steel interface with consequent reduction in bond strength when exposed to harsh environments. Composite plates or sheets, on the other hand, offer several advantages over their steel counterparts, such as ease bondage to irregular surfaces, lightweight, etc.

FRPC have been used in the replacement of deficient bridge decks. Studies of the feasibility and long-term performance of this type of application have 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 Transportations (DOTs) on their experience with FRPC materials for bridge decks.

Findings

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. From the literature review, it was found that the values of such the 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.

A number of demonstration projects that studied FRP bridge deck panels have been conducted countrywide. These projects range from small-scale pedestrian bridges to large-scale highway bridges as well as from deck replacement to bridges made entirely of composite materials. 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 desk 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 by a 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 results from the literature review and DOT survey indicate that FRP materials have been successfully used in civil infrastructure applications, and in particular for bridge deck strengthening and replacement. It also appears, from the results of this study that the use of FRP in bridges is likely to continue and potentially become a mainstream material in the near future.

Implementation

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 focuses in their use for bridge decks. In order to further benefit from this technology, Indiana must become part of the increasing research efforts 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.

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