Joint Transportation Research Program

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Implementation of Performance-Based Bridge Deck Protective Systems

Introduction

When considering the durability of a bridge, the concrete deck is often the most vulnerable component and can be the limiting factor affecting service life. To enhance the durability of both new and existing bridge decks, a protective system is often provided. The main requirements of an effective bridge deck protective system are the following:

- Create a physical barrier to prevent the ingress of chlorides and moisture
- Provide a sacrificial wearing surface
- Extend the life of the bridge deck for both new and existing bridges

In the state of Indiana, this protective system typically comes in the form of a latex-modified concrete overlay or a thin polymer overlay. Another protective system widely used in the United States and in many countries internationally consists of a waterproofing membrane overlaid with asphaltic concrete. Due to a history of poor performance in the 1970's and the 1980's, a moratorium has been placed on the installation of waterproofing membranes and asphalt overlays in Indiana.

While there are a variety of techniques and systems that can be used for bridge deck protection, history and experience have resulted in limited practices in the state of Indiana in this regard. Therefore, the objective of this research is to provide the Indiana Department of Transportation (INDOT) with an enhanced toolbox of bridge deck protective systems that can extend the life of a bridge deck for both new and existing construction.

Findings

A review of the state-of-the-art and state-of-the-practice in bridge deck protective systems was conducted with an emphasis on membrane systems and their use domestically and internationally. Indiana experiences with various protective systems were also documented. Based on this information, the various technologies were evaluated and the most promising technologies and practices were identified. Recommendations are provided on the use of bridge deck protective systems for both new and existing bridge decks. The major findings are as follows.

Waterproofing Membranes

Indiana Usage. Although historically, membrane systems have not performed successfully on Indiana bridges, the Indiana Toll Road Concession Company, the operating and maintaining agency for the Indiana Toll Road, installed membrane systems on eight bridges along the toll road which have been in service for two years. These bridges serve as a wealth of knowledge about membrane systems for INDOT, and their performance should be monitored over time and documented.

Domestic Usage. Since its first use as a protective system, states in the US have been greatly divided over the merits of membrane systems. States in the northeast and along the west coast have had a generally positive experience with membrane systems, whereas many Midwestern states, including Indiana, avoid their usage due to a history of poor performance. Currently, 29 states use membrane systems, 14 of which provide a list of approved membrane products.

International Usage. Although the individual systems being used vary in many ways, all of the countries investigated as part of this study use waterproofing membranes with asphalt overlays as the primary protective system for bridge decks. The countries that were studied are Canada, the United Kingdom, Spain, Germany, Sweden, Denmark, Australia, and Japan.

Other Bridge Deck Protective Systems

The use of concrete overlays as a bridge deck protective strategy is extensive in the US. Latex-modified concrete overlays have been used since the 1970's and are still used by many state transportation agencies. Silica fume overlays have also been used for over 30 years but have been generally phased out due to early age cracking and difficulty in construction. In addition, the following concrete overlays have been used experimentally in several states: high-reactivity metakaolin concrete overlays, early-strength latex-modified concrete overlays, and fibrous concrete overlays. In the US, thin polymer overlays became a widely used system in the 1990's and this system has experienced a rapid increase in usage in the past

two decades. This system was found to provide many benefits which include a quick installation time, a thin application, and a straightforward installation process. Two other systems, SafeLane® by Cargill, Inc. and Rosphalt® by Royston Laboratories, which have been implemented occasionally in the US, have been used with mostly positive responses.

Comparison of Systems

Installation. It was recognized that the most important factor leading to the success of any protective system is the quality of the installation. Of the three main systems evaluated, thin polymer overlays require the least intensive installation process, whereas membrane systems require a very extensive installation process. Additionally, because of the large thickness of an asphalt overlay, auxiliary work is required to reconstruct the joints, drains, and approaches on existing bridges when a membrane system is installed. Other concerns regarding the installation of membrane systems became evident throughout the study. These concerns include the added dead load of the asphalt overlay and the loss of ability to inspect the top-side of the concrete deck.

Service Life. While latex-modified concrete overlays have been observed to provide the longest expected service life in surveys completed by US and Canadian transportation agencies, membrane systems are also expected to provide long service lives. As an example, Danish engineers expect membranes to provide a service life of 50 years. Thin polymer overlays are expected to provide the shortest service life of the three systems.

Cost. Although they provide the shortest service life, thin polymer overlays have the lowest initial cost and the lowest life cycle cost. The costs associated with installing a concrete overlay or membrane system are comparable to each other and are both higher than that of a thin polymer overlay.

Implementation

Based on these findings, the following recommendations are provided.

Current Protective Systems

The practice of installing latex-modified concrete overlays and thin polymer overlays has been successful in Indiana; therefore, it is recommended that these two systems continue to be implemented.

- Latex-modified concrete overlays are recommended for bridge decks where more extensive damage is observed. Because these systems provide a long service life, they are also recommended for more critical bridges as both a preventative maintenance and a rehabilitation measure.
- Thin polymer overlays are recommended for situations where quick installations are required and where a thin protective system is needed. It is also recommended that thin polymer overlays be considered as a preventative maintenance system on new bridge decks.

Moratorium

It is strongly recommended that INDOT uphold the moratorium on asphalt overlays used without a waterproofing membrane. However, it is recommended that the moratorium on waterproofing membranes with asphalt overlays be removed. This system has significant potential for increasing the service life of bridge decks.

Membrane Systems

Due to the large amount of auxiliary work that is necessary to install a membrane system on an existing bridge (i.e. reconstruction of joints, drains, and approaches), it is recommended that membrane systems be installed on new bridges or on existing bridges that required reconstruction of approaches and joints. However, it is recommended that membrane systems be avoided where extensive patching is required. It is also recommended that INDOT develop an installation specification and a product approval process. By performing a pilot study which involves the installation of a membrane system on a new bridge, the new specification can be tested and any necessary changes can be made prior to standardizing.

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