WHRP

Wisconsin Department of Transportation
Wisconsin Highway Research Program

Request for Proposal

Protocols for Concrete Bridge Deck Protections and Treatments

Questions submitted to research@dot.wi.gov regarding the content of this RFP are due no later than 4:30 PM (CST) on December 12, 2016

Responses to questions will be posted to the WisDOT Research and Library website http://wisdotresearch.wi.gov/rfps-and-proposals by 4:30 PM (CST) by December 19, 2016

Researchers must submit a PDF version of their proposal by 4:30 PM (CST) by January 20, 2017 to: research@dot.wi.gov

Researchers will be notified of the proposal review decision by May 1, 2017

For more information regarding this RFP contact the WisDOT Research Program at: research@dot.wi.gov. This RFP is posted to the Internet at: http://wisdotresearch.wi.gov/rfps-and-proposals

Wisconsin Highway Research Program
Request for Proposals
Structures Technical Oversight Committee

Protocols for Concrete Bridge Deck Protections and Treatments

I. Background and Problem Statement

In cold climate zones, deicing chemicals are applied to roads and bridge decks to melt snow and ice to help maintain safe traffic operations. Bridges are vulnerable to the use of deicing chemicals that may include chlorides. Over time, chlorides infiltrate the concrete deck and reach reinforcement within the deck. Most deicing chemicals have a detrimental effect to the long-term condition of the bridge deck by promoting corrosion of the deck reinforcement and deterioration of the concrete.

Bridge owners are faced with a number of strategies and tools to maximize the life of bridge decks. Many of these tools include crack filling and penetrant sealers or crack filling and/or thin overlays that are applied as methods to retard the infiltration of chlorides or to seal the deck from these chlorides. Penetrant sealers generally require more frequent (4-5 years) applications than thin polymer overlays (10-12 years). However, the application cost of the penetrant sealer is significantly less than the thin polymer overlay.

One question that owners must answer in maintaining bridge decks in cold weather environments is what approach is the most effective in preserving the bridge deck while maximizing its service life and being the most cost effective? Is it the use of crack sealers and penetrant sealers, the use of thin (polymer) overlays, or a combination of these treatments that provide the best strategy? If the answer is a combination of these treatments, what criteria should guide the application frequency of the treatment, and what are the conditions that would lead to a change in strategies? Specifically, if it is effective to use crack and deck sealers on a bridge deck, at what point in time or condition is the sealer no longer effective and a new strategy like thin overlay needs to be applied? In addition, for an existing bridge, is there an age or condition that would represent a missed opportunity to effectively initiate and benefit from some or all of these strategies? Currently, our policies and strategies are influenced by the expert elicitation of what has been historically successful to maintain our bridge decks. We desire to validate or modify these strategies with the correlation of historic data to policies and practices.

II. Objectives

The objective of this research is to develop recommendations and guidelines for protocols on the use of crack and penetrant deck sealers and thin polymer overlays. The recommendations should take the form of a lifecycle guide that would efficiently maximize the condition and longevity of bridge decks. The lifecycle guide should address progressive strategies and treatments (i.e., penetrant sealers, crack sealing, thin overlay, concrete overlay, deck replacement, etc.) and the transition points in the bridge deck criteria in which the optimal treatment should be applied to

the bridge deck (i.e. age, condition state, presence of chlorides, etc.), as well as the application frequency, and the point in the lifecycle where the treatment is no longer an effective or economical strategy.

III. Scope of Work

A. Conduct a comprehensive literature review and assessment of current practices at WisDOT and various other state DOTs, FHWA, industries, and manufactures. WHRP has an initial Literature Search that will be provided to Researchers.
B. Collect relevant WisDOT and other DOT policies and practices related to the application of deck sealers and thin polymer overlays. Also, incorporate consideration of applicable deck concrete material and construction specifications as appropriate.
C. Examine WisDOT and other state DOT Preservation Policies for bridges. Compare and contrast these policies and strategies as they relate to crack sealing, deck sealing, thin overlays, concrete overlays, and deck replacements.
D. Conduct a systematic evaluation of FHWA National Bridge Inventory (NBI) and element level bridge condition data and correlate to state DOT practices and strategies related to preservation of bridge decks. The research team should request access to the FHWA, Long Term Bridge Preservation Bridge Portal for collection of national bridge demographic and condition information. WisDOT staff will provide assistance in contacting the FHWA for access. The researcher should use established policies and practices as well as documented bridge condition history to identify and support conclusions related to bridge deck treatments and strategies.
E. Develop a lifecycle treatment plan for bridge decks that is specific to WisDOT bridges, specifications, and practices.
F. Summarize information available on the types of crack sealers, penetrant sealers, and thin polymer overlay systems used by various DOTs.
G. Develop recommendations and guidelines in a format consistent with WisDOT Bridge Manual, Preservation Policy Guide, and associated presentation materials for WisDOT practitioners.

IV. WisDOT/TOC Contribution

WisDOT will provide the following support through the WHRP Project Oversight Committee and Regional Bridge Maintenance Engineers:

A. Work will be conducted with project oversight by the WisDOT Bureau of Structures and WHRP Structures Technical Oversight Committee (TOC). The TOC members will appoint a Project Oversight Committee (POC) to support the successful completion of the project.
B. The research team will not assume the availability of WisDOT staff or equipment in the proposal. If WisDOT or another entity donates equipment or staff time, a letter of commitment must be included in the proposal.
C. Expected level by staff/TOC members: Maximum of 40 hours over the duration of the project. The research team will consult with POC members in the selection of project sites.

D. This project will require travel for a meeting to finalize the work plan with the POC, and travel to Madison is required to report the results of the study to the TOC. Other interim reporting is also expected.
E. WisDOT staff will assist research team in contacting the FHWA for access to the FHWA, Long Term Bridge Preservation Bridge Portal for collection of national bridge demographic and condition information.
F. It is not anticipated that fieldwork will be required as part of the research project. However, if field work on or around in-service facilities is anticipated by the research, the proposal will need to discuss the nature and extent of needed traffic control and support assistance that will be requested from WisDOT. The researcher will need to closely coordinate with WisDOT regional personnel and possibly the county personnel where project fieldwork is being conducted. For WisDOT planning purposes, the Principal Investigator shall specify in his or her proposal, as practical, what specific traffic control will be required for this project, such as traffic flagging, signage, barricades, etc., as well as the duration needed (hours/day/location). It should not be assumed that WisDOT would fund the traffic control apart from the research project budget.

V. Required Travel

This project may require travel to Madison, WI for a meeting to finalize the work plan with the POC as well as interim reporting during the project. It is expected the PI will deliver the final presentation in person in Madison, WI.

VI. Deliverables

A. Reporting Requirements: Six (6) hard copies and an electronic copy of the final report delivered to WisDOT by the contract end date. This includes the report, special provisions, and structural details. Please refer to the Implementation section for further details.
B. Bridge Preservation Policy Guide updates and select Bridge Manual chapter updates.
C. Development of PowerPoint presentation to serve as a training tool for WisDOT Bridge Maintenance, Bridge Asset Management, and Regional Planning staff. WisDOT staff will provide the associated training.
D. Presentation Requirements: All projects require the PI to give a closeout presentation to the TOC after submittal of the draft final report.

VII. Budget and Schedule

A. Project Budget shall not exceed **$140,000.**
B. Proposed project duration is **24 months** starting around **October 1, 2017.**
   - Deadline for submittal of draft final report is three months prior to contract end date to allow for report review activities.
   - Deadline for research close out presentation is 4-6 weeks prior to contract end date.
   - Deadline for submittal of the Final Report is the contract end date.

VIII. Implementation

Successful implementation of this research will be achieved through the development of the following items:

- A lifecycle treatment plan for bridge decks that is specific to WisDOT and the preservation of our bridge decks. This should outline condition and age thresholds for treatment strategies and approaches.
- Updates to WisDOT Bridge Manuals chapters related to bridge maintenance and rehabilitation.
- Validation or updates to WisDOT Preservation Policy on Sealing and Thin Overlays and also recommendations for long term strategy for Wisconsin/Midwest Bridge Decks.
- A PowerPoint presentation to serve as a training tool for WisDOT Bridge Maintenance, Bridge Asset Management, and Regional Planning staff.

WisDOT Office of Finance, Policy and Improvement
Research & Library Services

4802 Sheboygan Avenue, Room 104
Madison, WI 53707

research@dot.wi.gov
http://wisconsindot.gov/Pages/about-wisdot/research

Literature Search -
Type E Overlays

To: Bill Oliva, DTSD, WHRP Structures Technical Oversight Committee

From: Andy Eiter, OPFI, Research & Library Services

Date: 09/12/2016

Topic: Improved Performance of the WisDOT Type E Overlay for Bridge Decks

Overview: Bridge decks, particularly in Mid-West and North East states, often suffer from deterioration that requires an epoxy overlay. Type E overlay is a one and one half inch concrete overlay placed on top of concrete bridges decks to address cracking and debonding problems. This literature search aims to gather information on the effects of ambient conditions, thickness, design mix and other factors in the performance of concrete overlays in order to help reevaluate current WisDOT specifications for the materials, methods, and performance of our Type E overlay for bridge decks. The following issues will be explored: concrete overlay performance, surface preparation, deterioration, cracking and delamination.

Keywords/Phrases:

- Type E
- Concrete overlay
- Bridge deck
- Surface preparation
- Delamination
- Performance
- Deterioration

Literature searches identify completed research and other authoritative information in an area of interest; works are categorized by type and listed in reverse-chronological order. Results are representative, rather than exhaustive, of available English-language studies on the topic. The listing below provides links to online copies of cited literature when available. Contact the WisDOT Library to obtain print versions of any citations or electronic full-text copies of an item not freely accessible.

Findings

Reports

Polymer Concrete Overlay Evaluation
Dalhberg, Justin; Phares, Brent
Iowa State University
2016
http://lib.dr.iastate.edu/cgi/viewcontent.cgi?article=1206&context=intrans_reports

Abstract:
The objectives of this work were to document the state-of-the-practice with respect to polymer concrete overlays, document the placement of two overlays in Iowa, monitor the field performance of the overlays over a two-year period, and relate their performance to material usage and/or workmanship. The two bridges—a Johnson County, Iowa bridge over I-80 on 12th Avenue in Coralville, and the Keg Creek Bridge on Hwy 6 in western Iowa, 10 miles east of Council Bluffs—were overlaid during the summer/fall of 2013. The process by which each bridge was overlaid was similar in many ways, although a few slight differences existed. Over time, each overlay has generally performed quite well with only a few areas of exception. It is believed that these localized areas likely underperformed due to poor deck preparation, improper polymer mixing, snowplow impact, or a combination thereof.

Deterioration Rates of Minnesota Concrete Bridge Decks
Nelson, Sara L.
Olson & Nezvold Engineers
2014
http://www.dot.state.mn.us/research/TS/2014/201440.pdf

Abstract:
Bridge decks are deteriorating across the state of Minnesota and limited funds are available to rehabilitate or replace them. The Minnesota Department of Transportation (MnDOT) Bridge Office is estimating construction costs well into the future to secure appropriate funding and to facilitate project programming. The rate at which bridge decks deteriorate is an important element used to estimate construction costs.

MnDOT provided decades of inventory and inspection bridge data for this project. This included National Bridge Inventory (NBI) condition code data for 2601 bridges with concrete decks. Based on conversations with MnDOT, it was agreed that deck deterioration rates would be determined by the length of time bridge decks stay, or drop, at NBI condition codes.

We analyzed the data to determine how many years, on average, a bridge deck remains at the various NBI condition code states. We also analyzed the data to determine what factors affect the rate of bridge deck deterioration. We looked at type of deck reinforcement (black bars, epoxy coated top bars, and all

epoxy coated bars), presence of concrete overlay, average daily traffic (ADT), presence of 3 inches of cover to the top mat of reinforcement, superstructure material, and location.

Evaluation of the Impermeability of Bridge Deck Overlays Using Embedded Wireless Moisture Sensors
Pailes, Brian M.; Brown, Michael C.; Foden, Andrew J.; Gucunski, Nenad
American Concrete Institute
2014

Abstract:
Overlays are installed on concrete bridge decks to improve ride quality, and in the case of impermeable overlays, also protect the deck from exposure to moisture and chlorides. Moisture and chlorides can penetrate over time into reinforced concrete, allowing for the initiation and progression of corrosion, which shorten the service life of a structure. To evaluate whether impermeable overlays are truly keeping moisture from penetrating into the concrete deck, researchers have implemented wireless moisture sensors in several bridge decks to monitor the moisture content of the deck below the overlay. In this study, the four overlays that are being monitored are a hot-mix asphalt wearing surface with a thermoplastic additive, an epoxy polymer concrete overlay, a fabric-reinforced liquid membrane with asphalt wearing surface, and a thin-set urethane membrane with an asphalt wearing surface. The moisture sensors have been installed at various locations in each deck including near the bridge joints, overlay construction joints, drainage paths, and under wheel paths. Results indicate that the hot-mix asphalt wearing surface with thermoplastic additive overlay only has moisture penetrating in regions that are near the joints. Measurements also indicate that the polymer concrete overlay has been effective at preventing the penetration of moisture. The latter two overlays, a fabric-reinforced asphalt membrane and a thin-set urethane, were recently installed and some preliminary conclusions may be offered about their effectiveness based upon early results.

Performance History of Concrete Overlays in the United States
Fick, Gary; Harrington, Dale
National Concrete Pavement Technology Center
2014
http://www.cptechcenter.org/technical-library/documents/Performance%20History_FHWA%20acknowledgment_tagged.pdf

Abstract:
Concrete overlays are cost-effective, long-lasting solutions for pavement preservation, resurfacing, and rehabilitation and thus should be an integral part of every agency's overall asset management program. The purpose of this brief is to demonstrate the applicability of concrete overlays as an asset management solution on a wide array of existing pavement types and roadway classifications. It does this by providing a brief history of the construction of concrete overlays in the United States and then summarizing the details of 12 concrete overlay projects across the country. It concludes with a short list of additional resources.

Implementation of Performance Based Bridge Deck Protective Systems
Frosch, Robert J.; Kreger, Michael E.; Strandquist, Brad V
Purdue University
2013
http://ntl.bts.gov/lib/50000/50800/50827/viewcontent.cgi2.pdf

Abstract:
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 to prevent or delay the ingress of chlorides and moisture to the reinforcing steel. In the state of Indiana, this protective system typically comes in the form of a 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 in Indiana. This study reevaluates the state-of-the-practice of bridge deck protection in Indiana with the goal of enhancing the Indiana Department of Transportation's toolbox of bridge deck protective systems. Consideration was given to the state-of-the-art and state-of-the-practice in bridge deck protective systems used by other state transportation agencies as well as by international transportation agencies. Research focused on the practice of installing waterproofing membranes and the latest technologies being used. Based on the information gathered, various protective systems were evaluated, and recommendations are provided on the selection of the most appropriate systems for various bridge conditions. Furthermore, a system can be more fully explored and realized recommendation is provided to remove the moratorium on membrane systems so that the benefits of this this system can be more fully explored and realized.

An Integrated Study of Pervious Concrete Mixture Design for Wearing Course Applications
Schaefer Vernon R.; Kevern, John T.
Iowa State University and the National Concrete Pavement Technology Center
2011
http://www.intrans.iastate.edu/reports/FHWA-Pervious_Overlay_w_cvr2.pdf

Abstract:
This report presents the results of the largest and most comprehensive study to date on portland cement pervious concrete (PCPC). It is designed to be widely accessible and easily applied by designers, producers, contractors, and owners. The project was designed to begin with pervious concrete best practices and then to address the unanswered questions in a systematic fashion to allow a successful overlay project. Consequently, the first portion of the integrated project involved a combination of fundamental material property investigations, test method development, and addressing constructability issues before actual construction could take place. The second portion of the project involved actual construction and long-term testing before reporting successes, failures, and lessons learned. The results of the studies conducted show that a pervious concrete overlay can be designed, constructed, operated, and maintained. A pervious concrete overlay has several inherent advantages, including reduced splash and spray and reduced hydroplaning potential, as well as being a very quiet pavement. The good performance of this overlay in a particularly harsh freeze-thaw climate, Minnesota, shows pervious concrete is durable and can be successfully used in freeze-thaw climates with truck traffic and heavy snow plowing.

Application of a Polymer Concrete Bridge Deck Overlay to Bridges 290 and 291 in Wichita Kansas
Meggers, David A.; Bryd, Chris
Transportation Research Board
2011

Abstract:
The Kansas Department of Transportation uses multi-coat polymer concrete overlays for bridge preservation. The first multi-coat polymer concrete overlay was placed in 1999. To this point in time the Kansas Department of Transportation (KDOT) has placed over 90 polymer overlays all with the intent of protecting structures that are not seriously deteriorated minimizing chloride and water intrusion to preserve the structures while still very serviceable. Typically candidate structures have had minimal spalling which is repaired and may have cracked delaminated silica fume or high density overlays with no failure of the surface itself. The average savings of using a polymer overlay over a silica fume overlay as a maintenance bridge preservation action is $16.00 per square yard. Significant savings are also found in user costs and traffic control costs. Most of the structures that the polymer overlays have been placed on in Kansas are relatively short, 200 to 400 feet. However, two structures (Bridges 290 and 291) in Sedgwick County 12,496 and 12,110 feet long with approximately 44,800 vehicles per day in each direction with approximately 7 percent trucks, were overlaid in 2007 and 2008. The Kansas experience in general has been very good; however, it has not been without some problems and a learning curve. Additional wording has been added to the Kansas Standard Specification to provide additional attention to eliminating potential problematic issues. The Kansas Department of Transportation is planning on the continued use of the Multi-Coat Polymer Concrete Overlay for preservation purposes and on new bridge structures.

The Kansas Experience with Polymer Concrete Bridge Deck Overlays
Meggers, Dave
Iowa State University
2009

Abstract:
The Kansas Department of Transportation (KDOT) uses multi-coat polymer concrete overlays for bridge preservation. The first multi-coat polymer concrete overlay was placed in 1999 on Bridge No. 46 in Shawnee County, Kansas, as a research project. Four suppliers were invited to place materials on the structure. Each material was allotted 100 linear ft of deck, 333 square yards per supplier. To this point in time, KDOT has placed over 90 polymer overlays all with the intent of minimizing chloride and water intrusion to preserve the structures. Typically, candidate structures have had minimal spalling that has been repaired, and may have cracked delaminated silica fume or high density overlays with no failure of the surface itself. There are a number of structures under heavy traffic and no failures have been found due to delaminated concrete overlays. The intent of KDOT in using the polymer overlays is to place them on structures that are not seriously deteriorated and require minimal deck repair, thus preserving structures that are still very serviceable. Three new structures in Kansas have had polymer overlays placed on them due to construction errors which resulted in cracked bridge deck concrete or a loss of concrete cover due to settings of the placement machine. One structure has had an overlay placed when new by design. The average savings of using a polymer overlay over a silica fume overlay as a maintenance bridge preservation action is $16 per square yard. Significant savings are also found in user costs and traffic control costs. Most of the structures that the polymer overlays have been placed on in Kansas are relatively short, 200 to 400 ft. However, two structures in Sedgwick County 12,496 and

12,110 ft long, with approximately 42,500 vehicles per day in each direction and approximately 7% trucks, were overlaid in 2007 and 2008. The Kansas experience in general has been very good; however, it has not been without some problems and a learning curve. Additional wording has been added to the Kansas Standard Specification to provide additional attention to eliminating problematic issues such as spillage of resins, moisture, and preventing contamination after shot blasting. Familiarity with the specification is important. There are now several contractors in Kansas with significant experience placing the polymer overlays. KDOT is planning on the continued use of the multi-coat polymer concrete overlay for preservation purposes and is intends to begin using the overlays on new bridge structures.

Guidelines for the Surface Preparation/Rehabilitation of Existing Concrete and Asphaltic Pavements Prior to an Asphaltic Concrete Overlay

Wen, Haifan; Titi, Hani; Singh, Jaskaran
Bloom Consultants, LLC
2005
http://wisconsindot.gov/documents2/research/04-05surfaceprep-f.pdf

Abstract:
A large percentage of the asphaltic paving projects performed in Wisconsin are asphaltic overlays of existing concrete or asphaltic pavements. Due to varying performance of overlay, a standard set of guidelines is needed to determine the amount of surface preparation which provides a consistency along with more accurate and stable project budgets for this type of work. Literature review of WisDOT and national practices of pre-overlay repair of existing concrete and asphaltic pavements was conducted. Previous asphalt overlay projects were reviewed and overlay performance was analyzed. In addition, three overlay projects during 2004 construction season were studied in the field.

For asphalt overlay of existing concrete pavements, it was found that overlays with doweled concrete base patching performed best, followed by non-doweled concrete base patching and then asphaltic base patching. Partial depth repair is needed to fix the medium severity transverse cracks and longitudinal/transverse distressed joints in existing concrete pavement. A minimum of three inches, practically three and half an inch, overlay thickness was found to be able to mitigate reflective cracking in overlay. All high-severity joints/cracks/patches should be repaired. The current IRI in overlay was highly correlated with initial IRI of overlay, indicating the importance of profile index. The roughness prediction model used in the NCHRP 1-37A 2002 design guide was calibrated with locally available data.

For asphalt overlay of existing asphalt pavements, block cracking in existing asphalt pavement does not adversely affect the overlay when milling is used. Existing asphalt pavement with extensive alligator cracking should be pulverized to prevent the reflection of underlying alligator cracking. Milling the existing asphalt pavement can not eliminate the reflection of transverse cracking in existing asphalt pavement. The ratio of overlay thickness to milling depth should be kept a minimum of three to prevent longitudinal cracking from reoccurring in overlay.

A set of guidelines was developed to be included in the Facility Development Manual and Construction and Material Manual.

Performance Specification for High Performance Concrete Overlays on Bridges
Sprinkel, Michael M.
Virginia Transportation Research Council
2004
http://www.virginiadot.org/vtrc/main/online_reports/pdf/05-r2.pdf

Abstract:
Hydraulic cement concrete overlays are usually placed on bridges to reduce the infiltration of water and chloride ions and to improve skid resistance, ride quality, and surface appearance. Constructed in accordance with prescription specifications, some overlays have performed well for more than 30 years whereas others have cracked and delaminated before the overlay was opened to traffic. The use of performance specifications should increase the probability that concrete overlays will be constructed with high bond strengths and minimal cracks and will perform well for many years.

The report describes the Virginia Department of Transportation's (VDOT) first experience with the use of a performance specification for the construction and acceptance of a high performance concrete overlay. Acceptance and payment were based on measurements for air content, compressive strength, permeability to chloride ion, and bond strength. Target air contents, high compressive strengths, low permeability, and good bond strengths were maintained throughout the project. Performance specifications with adjustments to the compensation specified in the contract likely influenced decisions made by the contractor and material supplier, and VDOT obtained a better product. VDOT should use the performance specification developed for this project for future bridge overlay projects.

Bonded Concrete Overlay Performance in Illinois
Winkleman, Thomas J.
Illinois Department of Transportation
2002
http://www.idot.illinois.gov/Assets/uploads/files/Transportation-System/Research/Physical-Research-Reports/143.pdf

Abstract:
Two bonded concrete overlay rehabilitation projects were constructed in Illinois during the 1990's. The first project was constructed in 1994 and 1995 on Interstate 80, east of Moline. The second project was constructed in 1996 on Interstate88 near Erie. The existing pavements for both the Interstate 80 and Interstate 88 projects were 8-inch thick continuously reinforced concrete pavements. The Interstate 80 rehabilitation was designed as a 4-inch thick plain concrete overlay. This project includes six experimental sections using various percentages of microsilica added to the standard mix design. In addition, microsilica grout was used as a bonding agent between the original pavement and the new bonded concrete overlay in some sections. The Interstate 88 project was designed as a 3-inch thick plain concrete overlay. This project includes two experimental sections, which incorporate different surface preparation methods prior to the overlay placement.

This report summarizes the performance of these two bonded concrete overlays. The design, construction, maintenance, and costs of these projects are addressed. Visual distress surveys were conducted annually for both the Interstate 80 and Interstate 88 projects. In addition, these projects were tested annually for an International Roughness Index value. Condition Rating Surveys were

conducted every two years to define the overall condition of the pavement. Results of these tests and visual surveys are included within this report.

The performance of these two projects has been quite different. The Interstate 80 project has shown significant distress, and was in need of maintenance only four years after construction. The Interstate 88 project has not developed significant early distresses. Potential explanations for the difference in performance, including initial pavement condition, traffic volume, and overlay construction are explored.

Tensile Bond Strength of a High Performance Concrete Bridge Deck Overlay
Federal Highway Administration
2000
https://www.fhwa.dot.gov/pavement/concrete/mcl9904.pdf

Abstract:
This paper presents results from an evaluation of a 2-year old fiber reinforced high performance concrete (HPC) overlay bonded to a badly deteriorated concrete bridge deck. The subject evaluation was focused on determining how well the overlay concrete was bonding to the underlying deck. To ensure long service of the rehabilitated deck, itis imperative that the overlay is well bonded to the underlying concrete. The evaluation consisted of employing a field tensile bond test (pull-off test) at 13 locations along the bridge decks and approaches, as well as subsequent laboratory tensile tests on seven companion cores for comparison testing. Results indicate that the non-metallic fiber reinforced HPC overlay is bonded sufficiently to the underlying concrete. However, all tensile failures occurred in the substrate material within 8mm of the bond interface, indicating that the existing bridge-deck concrete is the weakest portion of the system. It is suggested that the low tensile strength in the top portions of the bridge-deck concrete may be a result of existing delaminations or damage from milling and partial depth concrete removal during rehabilitation.

Journal articles

Chloride-Induced Corrosion Deterioration of Bridge Deck with Latex-Modified Concrete Overlay
Balakumaran, Soundar, S. G.; Weyers, Richard E.; Brown, Michael C.
Materials Journal
Vol. 113, Iss. 4, pp 483-491
July 2016

Abstract:
Overlaying an existing bridge deck with a low-permeability concrete layer would ideally reduce the rate of ingress of chloride, thus delaying the corrosion process. It is essential to study the effect of overlays on the service life of bridge decks. A bridge deck with latex-modified concrete (LMC) overlay was selected, as a part of the Federal Highway Administration's Long-Term Bridge Performance project, in the state of New Jersey for corrosion testing and modeling. Electrochemical corrosion tests were conducted and samples were collected for laboratory testing. Powdered concrete samples at various depths contained higher chloride contents in the LMC overlay than expected. Although the rapid

chloride permeability test showed significantly lower permeability for the LMC layer, chloride diffusion rates and percent saturation were higher than in the original deck concrete. Because the chlorides mainly diffuse through concrete pore water, despite the lower permeability of the LMC layer, 40% of the chloride contents at bar depths were higher than 1 lb/yd3 (0.59 kg/m3).

Forensic Engineering Applied to Failures in Concrete Polymer Materials
Fowler, D.
Restoration of Buildings and Monuments
Vol. 18, Iss. 3, pp. 213-219
July 2012

Abstract:
Forensic engineering is a relatively new discipline that is involved with the investigation of probable causes of failures. Failure does not necessarily involve injury or death; failure implies that the structure of component did not perform as intended. The scientific method is recommended for seeking probable causes of failure. Examples of polymer concrete overlay failures are discussed. Typically, these thin overlays delaminate from the surface as the most usual form of failure. In one case, an overlay delaminated from a concrete roadway although a short distance away the same material performed very well. The cause was quite perplexing until a chance remark led to the solution. The third example concerns the failure of epoxy anchors in the Big Dig in Boston. This was a high visibility failure and it involved many errors by several staff of the construction team.

Advancing the Technology of Bridge Deck Overlays
McLean, Ed
Concrete International
Vol. 34, Iss. 2, pp. 31-34
February 2012

Abstract:
Bridge deck overlays are commonly used to extend the service life of bridges in the United States. In the typical overlay operation, the concrete wearing surface is removed, repairs are made at delaminations and spalls, and a new wearing surface is installed. This article shows how overlays have been successfully executed using a number of mixture types, including low-slump portland cement concrete (PCC), PCC mixtures with silica fume (SF), and latex-modified concrete (LMC). By the 1990s, the Virginia Department of Transportation (VDOT) saw a need for having a low-permeability cement-based overlay that could develop to high strength in less than 4 hours. Such a mixture would allow work to be completed rapidly (overnight or on weekends), thus minimizing traffic delays and congestion on heavily traveled roads. After evaluating mixtures produced with various rapid-setting cements, VDOT selected an overlay concrete comprising Rapid Set® Cement that is coupled with a latex mixture. Known as very high-early-strength latex-modified concrete (LMC-VE), this technology provides a low-permeability concrete overlay that can be opened to traffic hours after installation.

Characterization of Interface Bond of Ultra-High-Performance Concrete Bridge Deck Overlays

Harris, Devin K.; Sarkar, Jayeeta; Ahlborn, Theresa M.

Journal of the Transportation Research Board
No. 2240, pp. 40-49
2011
http://trrjournalonline.trb.org/doi/pdf/10.3141/2240-07

Abstract:
Critical components of the nation's bridge network, concrete bridge decks, are deteriorating at a rapid rate. This deterioration can be attributed to several factors; however, winter salt application, the diffusion of chlorides to the reinforcing steel, and eventual corrosion of the reinforcement are primary culprits. Multiple protection solutions, include concrete protective systems, sealers, additional cover to the reinforcement, membranes, and epoxy-coated reinforcement, but each solution has shortcomings and does not completely address the problem. Ultra-high-performance concrete, a relatively new material with exceptional strength and durability characteristics, may be a solution to these problems when it is used as a thin overlay on bridge decks. An experimental study was performed to evaluate the bond strength between an ultra-high-performance concrete overlay and a normal concrete substrate with different types of surface textures, including smooth, low roughness, and high roughness. Slant shear and splitting prism tests were performed to quantify the bond strength under compression combined with shear and under indirect tension. Test results demonstrated that under compressive loading, the bond strength was greater than the strength of the substrate when the surface texture was greater than the standard smooth finished mortar surface. For the bond strength under indirect tension, results were not highly sensitive to the surface roughness. In both cases, the measured bond strengths fell within the ranges specified in the American Concrete Institute's "Guide for the Selection of Materials for the Repair of Concrete."

Construction and Performance of Pervious Concrete Overlay at Minnesota Road Research Project

Schaefer, Vernon R.; Kevern, John; TIzevbekhai, Bernard; Wang, Kejin; Cutler, Heath E.; Wiegand, Paul

Journal of the Transportation Research Board
No. 2164, pp. 82-88
2010
http://trrjournalonline.trb.org/doi/pdf/10.3141/2164-11

Abstract:
Portland cement pervious concrete (PCPC) has shown great potential to reduce roadway noise, improve splash and spray, and improve friction as a surface wearing course. A study is under way at Iowa State University and the National Concrete Pavement Technology Center to develop mix designs and procedures for PCPC overlays for highway applications. A report is produced on the construction and performance of a PCPC overlay constructed at the Minnesota Road Research Project low-volume roadway test facility to determine the effectiveness of pervious concrete as an overlay. Issues related to construction of the overlay are described, as are results of field tests to characterize the condition of the pavement 7 months following construction, to determine flow characteristics of the overlay, and to characterize the tire–pavement noise of the overlay. Results of these studies show that effective PCPC overlays can be designed for wearing course applications.

Modeling of Bond Stresses of Overlay–Bridge Deck System
Issa, Mohsen A.; Alrousan, Rajai Z.
Journal of the Transportation Research Board
No. 2113, pp. 72-82
2009
http://trrjournalonline.trb.org/doi/pdf/10.3141/2113-09

Abstract:
This study investigated direct and indirect factors influencing the bond strength between the concrete overlay and the bridge deck by using finite element analysis (FEA) and experimental validation. In addition, it presents reliable guidelines for the required bond strength that is needed for concrete to avoid potential delamination under various possible induced stresses. The purpose of the FEA is to predict and correlate the live load– and shrinkage-induced stresses at the interface between the concrete overlay and the bridge deck and to correlate these induced stresses with the direct tensile bond strength of the overlay. Fifteen full-scale prototype bridge systems without and with various thicknesses of overlays were studied. In addition, 42 overlay–bridge deck slab segments were created considering the relative thickness ratio of the overlay to the bridge deck slab (t sub overlay/t sub slab) and the relative elastic modulus (E sub overlay/E sub slab). Also, 210 overlay–bridge deck slab segments were created considering t sub overlay/t sub slab, E sub overlay/E sub slab, and slab concrete compressive strength (f' sub c). The effectiveness and accuracy of the FEA guideline models were compared with Fowler's guidelines. The FEA results reveal that the live load– and shrinkage-induced shear stresses are about 1.5 to 2.5 times the induced normal stresses, in good agreement with most of the published research. Overlay thicknesses of 38 and 63 mm (1.5 and 2.5 in.) were recommended as the minimum and maximum allowable thicknesses that will prevent the overlay from debonding when the deck is subjected to AASHTO HS-20 truck loading plus impact as well as shrinkage loading.

Standards & Specifications

Guide to Concrete Overlays: Sustainable Solutions for Resurfacing and Rehabilitating Existing Pavements (3rd edition)
Harrington, Dale; Fick, Gary
National Concrete Pavement Technology Center
2014
http://www.cptechcenter.org/technical-library/documents/Overlays_3rd_edition.pdf

Abstract:
The primary goal of this guide is to fill the knowledge gap about concrete overlays so that pavement owners can confidently include concrete overlays in their toolbox of pavement solutions and make more informed decisions about designing and constructing them. Another goal is to help owner agencies understand and appreciate the versatility of concrete overlay solutions. This is not a complete step-by-step manual, nor does it provide prescriptive formulae or specifications for designing and constructing concrete overlays. Rather, as the title suggests, this booklet provides expert guidance that can supplement practitioners' own professional experience and judgment. In particular, since the 2nd edition was published, this edition enhances original material with updated information on the following topics:
• Evaluating existing pavements to determine if they are good candidates for concrete overlays

• Selecting the appropriate overlay system for specific pavement conditions
• Managing concrete overlay construction work zones under traffic
• Accelerating construction of concrete overlays when appropriate

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Standard Specifications for State Road & Bridge Construction
Kansas DOT
2015
https://www.ksdot.org/Assets/wwwksdotorg/bureaus/burConsMain/specprov/2015/717.pdf

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