WisDOT Research Program

Annual 2020 Report

Foreword

I am pleased to present the Wisconsin Department of Transportation's (WisDOT) 2020 annual report on research activities. This report highlights WisDOT's efforts to uphold its mission to provide leadership in the development and operation of a safe and efficient transportation system.

WisDOT's Research and Library Services Unit facilitates the department's research activities and provides access to information that fosters data-driven decision making. Over the last year, the team has continued its efforts to align research and the department's strategic priorities; to facilitate the accelerated implementation of research results; to promote the application of promising materials and technologies; and to support the adoption of associated policies and procedures to demonstrate accountability to our transportation stakeholders and the public.

WisDOT's $4.69 million research program funded 59 research projects, completing five of the 18 Wisconsin Highway Research Program (WHRP) projects and leading three of the 41 projects funded through the Transportation Pooled Fund (TPF) Program.

Research and library staff completed five synthesis reports and 16 literature searches; responded to 348 information requests; and delivered 569 resource items. The research program also collaborated with educational institutions, organizations within the transportation industry and state and federal agencies to develop and disseminate valuable, innovative ideas of shared interest by participating in national studies and panels.

Despite the additional challenges brought on by the Covid-19 pandemic, WisDOT's Research and Library Unit continued to deliver quality services and produce actionable research. I am proud to recognize these accomplishments and would like to thank the many staff that serve on research committees and panels at the national, state and department levels. Their expertise and guidance are critical to the success and implementation of research.

Craig Thompson, Secretary–designee
Wisconsin Department of Transportation

This is a report of research and technology transfer activities carried out by the Wisconsin Department of Transportation through the Part B research portion of the State Planning and Research Program of the Federal Highway Administration, U.S. Department of Transportation. The report describes activities during Federal Fiscal Year 2020, covering October 1, 2019 through September 30, 2020.

Contents

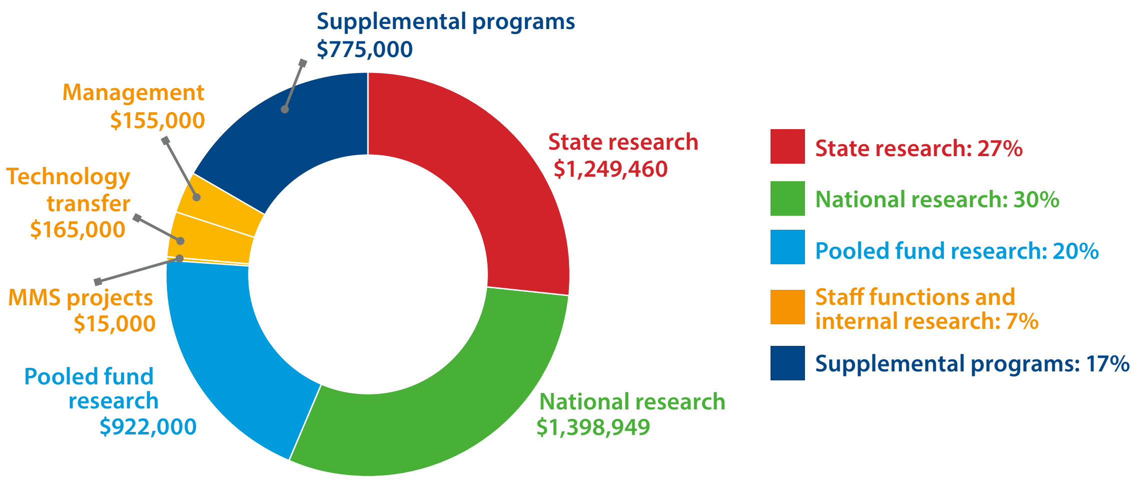
Common acronyms used in this document

AASHTO	American Association of State Highway and Transportation Officials
DBM	(WisDOT) Division of Business Management
DBSI	(WisDOT) Division of Budget and Strategic Initiatives
DMV	(WisDOT) Division of Motor Vehicles
DOT	U.S. Department of Transportation
DSP	(WisDOT) Division of State Patrol
DTIM	(WisDOT) Division of Transportation Investment Management
DTSD	(WisDOT) Division of Transportation System Development
EXEC	(WisDOT) Executive Offices
FFY	Federal Fiscal Year
FHWA	Federal Highway Administration
NCHRP	National Cooperative Highway Research Program
SPR	State Planning and Research Program
TPF	Transportation Pooled Fund
TRB	Transportation Research Board
UW	University of Wisconsin
WHRP	Wisconsin Highway Research Program
WisDOT	Wisconsin Department of Transportation

Program overview

The Wisconsin Department of Transportation (WisDOT) managed a $4.69 million program for research and technology transfer services during federal fiscal year (FFY) 2020.The State Planning and Research Part B (SPR-B) federal program funded 92 percent ($4.31 million) of the program, while state funds covered the remaining eight percent ($0.37 million).

Research program funding



State research

The Wisconsin Highway Research Program (WHRP), established in 1998 by WisDOT in collaboration with the University of Wisconsin–Madison, aims to better design, build and reconstruct the state's transportation system. The four areas of focus include geotechnics, structures and flexible and rigid pavements. See pages 7–8 for all completed and in-progress projects.

Pooled fund research

The Transportation Pooled Fund (TPF) program allows federal, state and local agencies and other organizations to combine resources to support transportation research studies of common interest. In FFY 2020, WisDOT research led three pooled fund projects and participated in 38 others. These projects include advances in engineering methods and materials; safety; and performance measures. For a full list of pooled fund projects, see pages 9–10.

Supplemental projects

WisDOT partners with various institutions to research transportation topics outside the scope of its other programs, such as connected vehicles, data analytics and liquid brine.

National research

The department participates in national research initiatives through the Transportation Research Board (TRB), National Cooperative Highway Research Program (NCHRP) and American Association of State Highway Transportation Officials (AASHTO) Technical Services Program.

Staff functions and internal research

Efficient management of transportation knowledge and research findings contributes to continuous performance improvement. The Research and Library team conducts technology transfer activities and library services to coordinate dissemination of research recommendations to enhance operations within the department.

Funds for WisDOT's Materials Management Section (MMS) internal projects, including the investigation and implementation of new materials and methods, are also included in the research program.

Featured research

Examples of research that contribute to achieving the department's strategic mission are listed below. The realized or anticipated impacts to the state of practice are included for each project, to reaffirm the department's commitment to data-driven decision making through implementation of applied research recommendations.

Evaluation of Penetrating Sealers Applied to Saw Cut Faces in Concrete Pavement Joints

(WHRP 0092-18-01)

Project Brief and Final Report:
http://wisconsindot.gov/Pages/about-wisdot/research/rigid-pave.aspx

The biggest challenge in preserving concrete pavements in cold-weather climates is premature joint deterioration. WisDOT has applied sealers to the saw-cut faces of joints on several projects to reduce their susceptibility to damage and improve pavement performance; however, there has not yet been an investigation into the effectiveness and economy of the practice. This study was conducted to evaluate the uniformity and effectiveness of current practice and to develop standards for applying sealers.

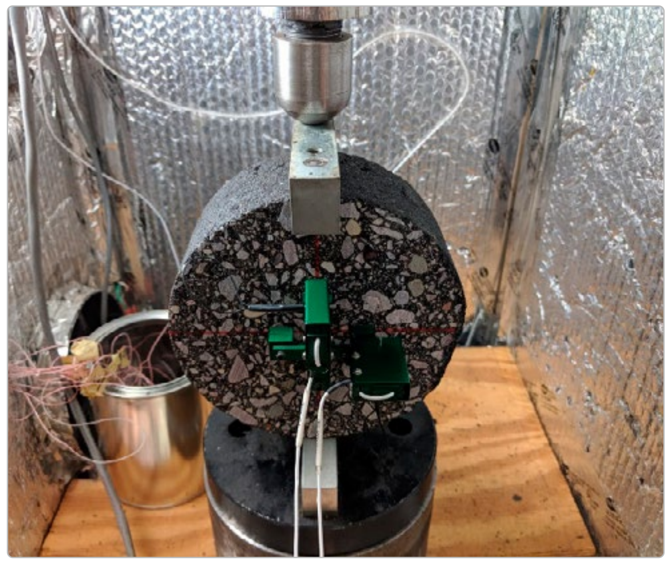
Each tested sealer yielded extension of pavement service life. Laboratory tests showed sealer effectiveness decreased with years of service; however, joints with sealers still outperformed joints without sealers, even after more than eight years.

This research affirms WisDOT's practice of applying penetrating sealers to saw-cut faces. Increasing the durability of these joints will extend the service life of concrete pavements and reduce future repair costs by an estimated $1 million per lane mile.

Enhanced Moisture Sensitivity Study

(WHRP 0092-18-06)

Project Brief and Final Report
http://wisconsindot.gov/Pages/about-wisdot/research/flex-pave.aspx



Asphalt pavements suffer moisture damage through loss of adhesion between asphalt and aggregate and due to cohesive failure of the binder. Both phenomena lead to pavement distress. Accurately predicting and mitigating moisture damage is difficult due to the wide variety of mixture design differences that impact performance such as aggregate type, construction practices, environmental conditions and traffic loads. This study aimed to identify and rank suitable test protocols readily available to contractor and agency laboratories for assessing moisture damage sensitivity.

Results showed there is not a "one size fits all" solution to moisture damage. Each test method ranked moisture performance differently. Design solutions to prevent moisture damage also depend on the aggregate and asphalt materials used in design.

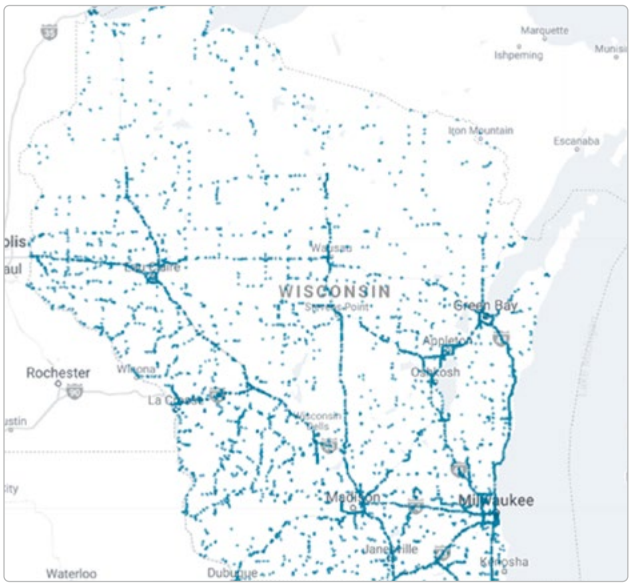
The research team developed an agency specification framework and recommended a risk-based approach that requires more prescriptive specifications for higher traffic roadways.

Featured research (continued)

Protocols for Concrete Bridge Deck Protections and Treatments

(WHRP 0092-18-03)

Project Brief and Final Report:
https://wisconsindot.gov/Pages/about-wisdot/research/structures.aspx



Cold-weather states like Wisconsin face challenges in preserving bridge decks that are subject to harsh winter conditions and chemical deicers. WisDOT applies different preservation strategies depending on deck condition, daily traffic and other factors. This research evaluated current WisDOT preservation practices and offered recommendations for improving them.

The research team created an archive of preservation strategies; deicer, traffic and bridge-condition data; and other factors. The team then contrasted deck-treatment plans for performance and cost to develop life-cycle profiles using Monte Carlo simulation.

The research team developed a life-cycle guide for addressing progressive strategies and treatments as well as transition points in bridge deck criteria. For each strategy, it details optimal application frequencies and pinpoints the time in a deck's life cycle that a treatment is no longer an effective or economical strategy. The results of this research will augment WisDOT's approach to data-driven asset management with inclusion in applicable chapters of the WisDOT Bridge Manual beginning with the January 2021 edition.

Monitoring Lateral Earth Pressures and Movements of Cut Retaining Walls

(WHRP 0092-17-08)

Project Brief and Final Report:
http://wisconsindot.gov/Pages/about-wisdot/research/geotech.aspx

Retaining walls protect roads, rights-of-way, utilities and structures from lateral soil movement. This project focused on cut retaining walls, constructed in a top-down manner, where complex soil-structure interactions affect the lateral earth pressure against the wall, lateral wall movement and vertical movement behind the wall. Understanding this complex soil-structure interaction is necessary to evaluate the strength and service limit states and predict horizontal and vertical movement. The main project objectives were to evaluate current cut-wall design methodologies and recommend potential improvements.

Results showed that current design methodologies are adequate for cut-wall design, but the critical loading conditions must be carefully considered. Cut-wall design predictions can be improved if additional site-specific testing is performed, and alternative analysis methods may improve predictions of vertical movement behind the wall. Instrumentation can monitor cut-wall performance in unusual or critical cases to confirm design assumptions or to inform design or construction modifications.

These findings and the guidance provided by the research team will enable WisDOT to refine its design procedures and construct more cost-effective, better-performing earth retaining structures.

Technology Transfer and Library Activities

The Division of Budget and Strategic Initiatives' Research and Library Services Unit provides information services for WisDOT staff and supports implementation of research results.

Synthesis reports

A synthesis report is an evaluation of other state transportation agencies' policies and procedures made by comparing, contrasting and combining information gathered from agencies' websites or through electronic surveys. Five synthesis reports were completed in FFY 2020 on a range of topics, including: single-bid contracts, Title VI training resources, and paving temperatures. Most synthesis reports can be found on the AASHTO Research Advisory Committee website.

Literature searches

A literature search is a systematic and thorough search of all types of published literature to identify a breadth of quality references relevant to a specific topic. Customers apply the collected information to decision making for funding and crafting research efforts and for general policy improvement. Sixteen literature searches were completed in FFY 2020.

Topics included: access management near roundabouts; pathogen transmission on disposable mouthpieces; and aggregate conversion factors.

WisDOT library services

Library staff handled 348 information requests, delivered 569 digital items (books, reports, periodicals and articles) and added 744 digital items to the Wisconsin Digital Archives.

Access options for library users

The WisDOT Library provides staff access to its growing digital collection through its online catalog. Wisconsin transportation documents, both scanned and born-digital, are stored either in an in-house database or archived as part of a partnership with other Wisconsin state agencies in the Wisconsin Digital Archives (WDA). The WDA offers permanent and public full-text access to over 18,000 official Wisconsin state documents, including close to 4,000 WisDOT documents.

Completed research projects

PROGRAM	PROJECT ID	PERFORMING ORGANIZATION	PRINCIPAL INVESTIGATOR	PROJECT BUDGET	WISDOT PROJECT MANAGER	PROJECT TITLE	COMPLETION DATE
WHRP – Geotechnics	0092-17-08	Geocomp Corporation	Allen Marr	$149,971	Andrew Zimmer	Monitoring of Lateral Earth Pressure and Movements of Cut Retaining Walls	12/2019
WHRP – Rigid Pavements	0092-18-01	University of Wisconsin–Platteville	Danny Xiao	$125,000	Myungook Kang	Evaluation of Penetrating Sealers Applied to Saw Cut Faces in Concrete Pavement Joints	3/2020
WHRP – Structures	0092-18-03	Iowa State University	Katelyn Freeseman, Başak Bektaş	$180,872	Ryan Bowers	Protocols for Concrete Bridge Deck Protections and Treatments	8/2020
WHRP – Flexible Pavements	0092-18-05	Temple University	Ahmed Faheem	$165,000	Erik Lyngdal	Investigation of In-Service Pavement Performance	10/2019
WHRP – Flexible Pavements	0092-18-06	Pennsylvania State University	Mansour Solaimanian	$150,000	Erik Lyngdal	Enhanced Moisture Sensitivity Study	12/2019

Ongoing research projects

PROGRAM	PROJECT ID	PERFORMING ORGANIZATION	PRINCIPAL INVESTIGATOR	PROJECT BUDGET	WISDOT PROJECT MANAGER	PROJECT TITLE
WHRP – Rigid Pavement	0092-17-07	Behnke Materials Engineering, L.L.C.	Signe Reichelt	$275,000	Myungook Kang	Evaluation of Current WI Mixes Using Performance Engineered Mixtures Testing Protocols
WHRP – Geotech	0092-18-07	University of Wisconsin–Madison	William Likos	$150,000	Jeff Horsfall	Mechanically Stabilized Earth (MSE) Wall Backfill Water Infiltration
WHRP – Structures	0092-19-01	Clemson University	Brandon Ross	$180,000	David Kiekbusch	Textured Epoxy Coated and Galvanized Reinforcement to Reduce Cracking in Concrete Bridge Decks and Components
WHRP – Structures	0092-19-02	CTL Group - Materials & Mechanics	Jose Pacheco	$194,555	Oliva William	Internal Curing of Bridge Decks and Concrete Pavement to Reduce Cracking
WHRP – Rigid Pavement	0092-19-03	University of Wisconsin–Madison	Pavana Prabhakar	$150,000	Myungook Kang	Roadway Concrete Barrier Design and Performance – Material Durability Issue
WHRP – Flexible Pavement	0092-19-04	NCAT at Auburn University	Carolina Rodezno	$200,000	Erik Lyngdal	Recycled Asphalt Binder Study
WHRP – Flexible Pavement	0092-19-05	Behnke Materials Engineering, L.L.C.	Signe Reichelt	$165,000	Daniel Kopacz	Rubber Asphalt Study for Wisconsin
WHRP – Geotech	0092-19-06	University of Wisconsin–Milwaukee	Rani, Elhajjar	$100,000	Andrew Zimmer	Comparison of ASTM Standards for the Evaluation of Geogrid Strength
WHRP – Structures	0092-20-01	Iowa State University	Brent Phares	$220,000	Alex Pence	Analytical and Testing Methods for Rating Longitudinal Laminated Timber Slab Bridges
WHRP – Rigid Pavement	0092-20-02	Applied Research Associates, Inc.	Shreenath Rao	$200,000	Myungook Kang	Evaluation of Concrete Pavement Buckling in Wisconsin
WHRP – Flexible Pavement	0092-20-03	Applied Research Associates, Inc.	Harold Von Quintus	$215,000	Erik Lyngdal	Expansion of AASHTOWare ME Design Inputs
WHRP – Flexible Pavement	0092-20-04	NCAT at Auburn University	Randy West	$150,000	Steven Hefel	Balanced Mixture Design Implementation Support
WHRP – Geotech	0092-20-05	University of Wisconsin–Milwaukee	Hani Titi	$175,000	Erik Lyngdal	Quality Testing of Wisconsin Aggregates

Pooled fund participation

PROJECT NUMBER	TITLE	FFY 2019 FUNDING AMOUNT	WISDOT TECHNICAL REPRESENTATIVE	LEAD AGENCY/ STATE
TPF-5(176)	Traffic Analysis and Simulation	N/A	Vicki Haskell	FHWA
TPF-5(183)	Improving the Foundation Layers for Concrete Pavements	N/A	Jeff Horsfall	Iowa
TPF-5(255)	Highway Safety Manual Implementation	N/A	Brian Porter	FHWA
TPF-5(267)	Accelerated Testing for the NCAT Pavement Test Track	N/A	Steve Krebs Barry Paye	Alabama
TPF-5(281)	Center for the Aging Infrastructure: Steel Bridge Research, Inspection, Training and Education Engineering Center – SBRITE (Purdue)	N/A	Scot Becker	Indiana
TPF-5(283)	The Influence of Vehicular Live Loads on Bridge Performance	N/A	Alex Pence	FHWA
TPF-5(305)	Regional and National Implementation and Coordination of ME Design	N/A	Tirupan Mandal	FHWA
TPF-5(316)	Traffic Control Device Consortium	N/A	Jay Hille	FHWA
TPF-5(317)	Evaluation of Low Cost Safety Improvements	$10,000	Brian Porter	FHWA
TPF-5(319)	Transportation Management Center Pooled Fund Study	$50,000	Stacey Pierce	FHWA
TPF-5(335)	2016-2020 Biennial Asset Management Conference and Training on Implementation Strategies	$12,000	Scot Becker Justin Shell	Iowa
TPF-5(341)	National Road Research Alliance (NRRA)	$150,000	Barry Paye	Minnesota
TPF-5(346)	Regional Roadside Turfgrass Performance Testing Program	N/A	Christa Schaefer	Minnesota
TPF-5(347)	Development of Maintenance Decision Support System (MDSS)	$30,000	Mike Adams	South Dakota
TPF-5(351)	Self De-icing LED Signals	N/A	Donald Schell	Kansas
TPF-5(352)	Recycled Materials Resource Center (RMRC – 4th Generation	N/A	Barry Paye	Wisconsin
TPF-5(353)	Clear Roads Phase II	$25,000	Allan Johnson	Minnesota
TPF-5(359)	Evaluating New Technologies for Roads Program Initiatives in Safety and Efficiency (ENTERPRISE) Phase 2	$30,000	David Karnes	Michigan
TPF-5(368)	Performance Engineered Concrete Paving Mixtures	$15,000	Chad Hayes	Iowa
TPF-5(370)	Fostering Innovation in Pedestrian and Bicycle Transportation Pooled Fund Study	$25,000	Jill Mrotek-Glenzinski	FHWA
TPF-5(372)	Building Information Modeling (BIM) for Bridges and Structures	N/A	Scot Becker	Iowa
TPF-5(374)	Accelerated Performance Testing on the 2018 NCAT Pavement Test Track with MnROAD Research	$125,000	Barry Paye	Alabama

Pooled fund participation (continued)

PROJECT NUMBER	TITLE	FFY 2019 FUNDING AMOUNT	WISDOT TECHNICAL REPRESENTATIVE	LEAD AGENCY/ STATE
TPF-5(375)	National Partnership to Determine the Life Extending Benefit Curves of Pavement Preservation Techniques (MnROAD/NCAT Joint Study Phase 2)	$50,000	Barry Paye	Minnesota
TPF-5(377)	Enhanced Traffic Signal Performance Measures	$30,000	Jeremy Iwen	Indiana
TPF-5(379)	Technology Exchange on Low Volume Road Design, Construction and Maintenance	N/A	Rodney Taylor Justin Shell	Iowa
TPF-5(381)	Evaluation of Lateral Pile Resistance Near MSE Walls at a Dedicated Wall Site Phase 2	N/A	Jeff Horsfall	Utah
TPF-5(382)	Drivers Failing to Yield at Multi-Lane Roundabout Exits	N/A	Rebecca Szymkowski	FHWA
TPF-5(383)	2019 Innovations in Freight Data Workshop	N/A	Shaun Destrampe Dan Thyes	Iowa
TPF-5(388)	Developing Implementation Strategies for Risk Based Inspection (RBI)	$50,000	Scot Becker	Missouri
TPF-5(389)	Connected Vehicle Pooled Fund Study	$50,000	Anne Reshadi	Virginia
TPF-5(395)	Traffic Disruption-Free Bridge Inspection Initiative with Robotic Systems	$25,000	Rick Marz	Missouri
TPF-5(396)	Mid-America Freight Coalition Phase 3 (MAFC-3)	$37,000	Dan Thyes Matt Umhoefer	Wisconsin
TPF-5(399)	Improve Pavement Surface Distress and Transverse Profile Data Collection and Analysis, Phase 2	$20,000	Andrew Schilling	FHWA
TPF-5(430)	Midwest Roadside Safety Pooled Fund Program	$65,000	Erik Emerson	Nebraska
TPF-5(432)	Midwest Bridge Preservation Partnership	$20,000	Bill Oliva	Wisconsin
TPF-5(435)	Aurora Program	$25,000	Mike Adams	Iowa
TPF-5(437)	Technology Transfer Concrete Consortium	$8,000	Chad Hayes	Iowa
TPF-5(438)	Smart Work Zone Deployment Initiative	$25,000	Erin Schoon	Iowa
TPF-5(441)	No Boundaries Transportation Maintenance Innovations	$10,000	Chris Ohm	Colorado
TPF-5(442)	Transportation Research and Connectivity	$15,000	John Cherney	Oklahoma
Solicitation 1508	Integrating Construction Practices and Weather into Freeze Thaw Specifics	$20,000	Chad Hayes	Oklahoma

Committees and contacts

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Appendix (briefs for featured research)

Research Brief

Wisconsin Highway Research Program
Project 0092-18-01
July 2020

Evaluation of Penetrating Sealers Applied to Saw Cut Faces in Concrete Pavement Joints

Research Objectives

- Evaluate the uniformity of sealer-application methods used on Wisconsin concrete pavement joints
- Determine the effectiveness of penetrating sealers in protecting concrete joints
- Develop standard specifications for applying penetrating sealers to concrete saw cuts

Research Benefits

- Demonstrated penetrating sealers' effectiveness in extending service life and improving performance of concrete pavement joints
- Affirmed the effectiveness of penetrating sealers in protecting bridge decks
- Provided guidance and specification updates on best practices in applying penetrating sealers

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Background

The biggest challenge to preserving concrete pavements in cold-weather climates is premature joint deterioration. The Wisconsin Department of Transportation (WisDOT) has applied sealers to the saw-cut faces of joints on several projects to reduce their susceptibility to damage and improve pavement performance; however, there has not yet been an investigation into the effectiveness and economy of the practice. The objectives of this study were to evaluate the uniformity of current sealer-application methods; determine the effectiveness of penetrating sealers in protecting concrete joints; and develop standard specification language for applying penetrating sealers to concrete pavement saw cuts.

Methodology

The research team conducted site visits to assess the performance of various sealers and sealer-application methods and rates on common Wisconsin concretes. Core samples were extracted from well- and poorly-performing joints and slabs at each site and tested for water absorption, contact angle and depth of penetration to evaluate the presence and effectiveness of sealers.

Additionally, concrete samples were produced and subjected to laboratory testing to determine the most effective sealer types, application methods and application rates. Based on these tests, sealers were applied to a section of highway and monitored for a year, after which core samples were taken and evaluated.

Results

Although there was no visual detection of the presence of sealers in in-service pavements (at two, six and eight years of service) previously treated with sealers, laboratory tests proved the presence and functionality through contact angle, absorption and penetration depth. Penetration depth ranged from 0.1'' to 0.5'', with an average of 0.2''. Penetration depth correlated with concrete strength; less penetration was associated with high-performance concrete. Effectiveness decreased with years of service; however, joints with sealers still outperformed joints without sealers after more than eight years.

The laboratory study found that all penetrating sealers applied to concrete samples resulted in decreased absorption and extension of time to critical (85%) saturation; these results can extend pavement service life. Time to critical saturation in A-FA grade concrete was eight and a half times longer when silane was applied in dry conditions.

Treatment	Final Degree of Saturation	Days to 85% Saturation	Lifespan change
Untreated control	100%	23	-
40% silane applied after 7 days	64%	218	↑ 850%
40% silane applied 30 min. after sawing	82%	102	↑ 340%
10% siloxane mixture applied after 7 days	77%	150	↑ 550%
7% siloxane mixture applied after 7 days	84%	97	↑ 320%
SME-PS applied after 7 days	76%	148	↑ 540%
PAM applied 30 min. after sawing	100%	8	↓ 65%

Table 1. Time to Critical Saturation of Wisconsin A-FA Concrete Applied with Different Sealers

Core samples from the field study section were hydrophobic, with contact angle exceeding 90 degrees. There was no difference in time to critical saturation and no sign of sealer in the penetration depth test. The absence of sealer in the field study section was attributed to three possibilities: (a) very low permeability of high-performance concrete; (b) hydrophobicity of polished concrete after saw-cutting; and (c) difficulty in effectively covering vertical surfaces. Penetrating sealers may not function properly for low permeability concrete or be practicably applied sufficiently to a vertical surface.

Recommendations for implementation

The results of this study demonstrate how penetrating sealers can extend service life and improve performance of concrete pavement joints when properly applied. The research team made several recommendations for best practices and specification updates.

- Sealer should be applied after at least seven days of curing.
- Surfaces should be washed to remove saw slurry and allowed time to dry.
- Product should be applied directly to the interior of the sawed joint, with additional passes after 10 to 15 minutes to achieve proper coverage rate; multiple applications of sealer will further reduce absorption.
- Contractors should use the masonry block setup to test their sprayer system and application method to verify the uniformity of coverage.

Among the four products tested in this study, silane and Soy Methyl Ester-Polystyrene (SME-PS) were more effective than siloxane and lithium silicate. Application of penetrating sealer on joints of regular concrete is effective; however, it does not seem effective on joints in high-performance concrete due to the difficulty of sufficient coverage and penetration. This study also affirms previous studies showing penetrating sealers are effective in protecting bridge decks.

"This study reveals the potential benefit of applying penetrating sealer in concrete pavement joints at the time of construction. It is a cost-effective method to increase the durability of the joints. WisDOT will continue to apply the penetrating sealer to the saw-cut face to extend the service life of concrete pavement."

– Myungook Kang, WisDOT

Interested in finding out more?

Final report is available at: WisDOT Research website

This brief summarizes Project 0092-18-01,
"Evaluation of Penetrating Sealers Applied to Saw Cut Faces in Concrete Pavement Joints"
Wisconsin Highway Research Program

Enhanced Moisture Sensitivity Study for Asphalt Concrete Pavements

Research Objectives

- Identify reliable methods for measuring asphalt pavement's sensitivity to moisture damage and the effectiveness of moisture susceptibility treatments
- Develop specifications for reducing the risk of moisture damage in asphalt pavements

Research Benefits

- Developed protocols for effectively inducing moisture damage in asphalt pavements to simulate field conditions under various traffic loads
- Established pass/fail criteria for moisture damage in asphalt pavements

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Background

Asphalt pavements suffer moisture damage through loss of adhesion between asphalt and aggregate (i.e., stripping of asphalt from aggregate) and due to cohesive failure of the binder. Both phenomena contribute to reductions in strength or stiffness of the asphalt concrete layer that lead to pavement distresses. Accurately predicting and mitigating moisture damage is difficult due to wide variance in aggregate types, construction practices, environmental conditions and traffic loads. The goal of this research was to identify suitable test protocols to assess the moisture damage sensitivity of asphalt concretes commonly used in Wisconsin under conditions typical to the state.

Methodology

Four mixes with aggregates sourced from different Wisconsin quarries were selected for this study based on laboratory tests and field performance. Two mixes had dolostone sources, one from Menasha with a low tensile strength ratio (TSR) and one from Waukesha with a high TSR. Two mixes had siliceous sources with marginal-to-poor field performance, one from Rock Springs and one from Olsen located in Chippewa Falls and Downing.

The research team performed four moisture conditioning schemes on each mix: vacuum saturation followed by freezing and hot water conditioning (AASHTO T 283); vacuum saturation followed by hot water conditioning (AASHTO T 283); Moisture-induced Stress Tester (MiST) conditioning (ASTM D7870); and submerged load-induced conditioning with a Hamburg Wheel Tracking Device (HWTD) (AASHTO T 324). Specific properties were measured before and after each test to evaluate the capability of each procedure in manifesting the susceptibility of the mix to moisture damage: indirect tensile strength; indirect tensile dynamic modulus; modulus from ultrasonic pulse velocity (UPV), and rut depth under repeated wheel passes.

Measuring dynamic modulus of asphalt concrete in indirect tensile mode

“This research shows the complexity of moisture damage in asphalt pavements. Results highlight the need to consider more advanced testing protocols for higher traffic level mixtures.”

– Erik Lyngdal, WisDOT

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Final report is available at: WisDOT Research website

Results

The various conditioning and test protocols produced different rankings of mixture moisture sensitivity. The rankings were combined to deliver a final moisture-sensitivity score for each mixture; scores in order from highest (the best mix in resisting moisture damage) to lowest (the worst mix in resisting moisture damage) were: Rock Springs (marginal performing, siliceous), Waukesha (high-TSR dolomite), Olsen (poorly performing, siliceous) and Menasha (low-TSR dolomite).

These rankings align closely with those given by the HWTD test, dynamic modulus ratio and UPV modulus ratio based on freeze-thaw conditioning. Rankings do not align with test results using current WisDOT acceptance methods (TSR without freeze-thaw). TSR defines the ratio of strengths before and after conditioning and does not directly address the strength level of the mixture. The HWTD test simulates load/water interaction with the mix under repeated loading, for which results are heavily strength dependent. Results suggest that a combination of wet strength and TSR should be used to more accurately capture moisture susceptibility.

Recommendations for implementation

The research team recommends using AASHTO T 283, HWTD and MiST to induce moisture damage; however, HWTD and MiST best simulate field conditions, since they induce suction and pressure in the mix through repeated cycles.

Load effects should be considered when establishing the damage criteria; therefore, the research team recommends a tiered approach based on traffic volume. MiST conditioning should be used for evaluating the effect of moisture conditioning on mixes’ engineering properties and changes in mixes’ dynamic modulus, as change in the modulus is a major input parameter in recently developed performance prediction models. HWTD testing should be used for medium- and high-volume roads, and AASHTO T 283 (with criterion on minimum required wet strength and minimum indirect TSR) should be used for low-volume roads.

This brief summarizes Project 0092-18-06,
“Enhanced Moisture Sensitivity Study”
Wisconsin Highway Research Program

Research Brief

Wisconsin Highway Research Program
Project 0092-18-03
November 2020

Protocols for Concrete Bridge Deck Protections and Treatments

Research Objectives

- Evaluate the effectiveness of current WisDOT practices and policies for preserving bridge decks
- Develop a cost-effective life-cycle treatment plan for preserving Wisconsin's bridge decks

Research Benefits

- Developed a life-cycle guide outlining progressive strategies and treatments for preserving concrete bridge decks under various conditions and factors
- Determined the most cost-effective default strategy for preserving concrete bridge decks
- Confirmed that all examined preservation strategies are more cost-effective than taking no action

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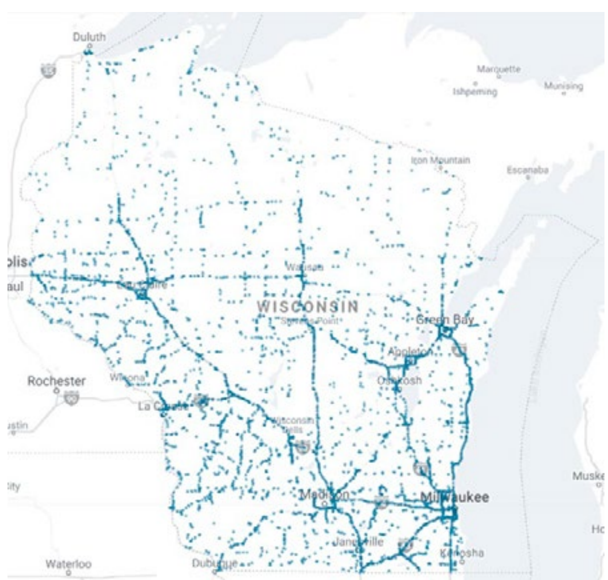
Background

Cold-weather states like Wisconsin face challenges in preserving bridges that are subject to harsh winter conditions and chemical deicers. Depending on a bridge deck's condition, daily traffic and other factors, the state applies different preservation strategies, including: concrete overlays, asphalt concrete overlays, polymer overlays, crack repairs, deck sealers or even deck replacement. Defining optimal methods and timing of preservation treatments is critical to maximizing deck service life and reducing life-cycle costs. The objective of this research was to evaluate current WisDOT preservation practices and to improve them through the development of a cost-effective life-cycle treatment plan.

Methodology

The research team gathered an archive of deck-preservation strategies used throughout the state and analyzed it in conjunction with historic bridge conditions and other factors, such as deicer usage and traffic data. Similar data sets from South Dakota and Minnesota were also analyzed for the same purpose. Using Monte Carlo simulation to develop life-cycle profiles and Equivalent Uniform Annual Cost (EUAC) values, the research team contrasted deck-treatment plans for performance and cost-effectiveness in order to identify the most cost-effective treatment options for different deck conditions and at different points throughout a deck's life cycle.



Wisconsin's 4,535 concrete bridge decks were mapped and archived.

"The results of this research will augment WisDOT's approach to data-driven asset management."

– Ryan Bowers, WisDOT

Interested in finding out more?

Final report is available at: WisDOT Research website

Results

The research team found that treated decks have consistently lower life-cycle costs than untreated decks, regardless which treatment strategy is applied. The team confirmed that sealing and overlaying decks early in the life cycle lead to lower life-cycle costs than if the treatment is delayed. It is also cost effective to apply multiple deck seals throughout a deck's life cycle, particularly on high-traffic corridors, as there is a significant difference in sealer performance depending on traffic volumes. Another product of the research was a series of deck performance and treatment impact models that can be utilized in WisDOT's bridge management system or decision support-tools.

Recommendations for implementation

Simulated life-cycle plans provide insight into the most cost-effective strategies available to WisDOT and, potentially, other Midwest transportation agencies. The research team developed a life-cycle guide for addressing progressive strategies and treatments as well as transition points in bridge deck criteria. For each strategy, it details optimal application frequencies and pinpoints when in a deck's life cycle a treatment is no longer an effective or economical strategy. The team also proposed updates to the WisDOT Bridge Manual's chapters related to bridge maintenance and rehabilitation and to the WisDOT Preservation Policy on Sealing and Thin Overlays. Other recommendations include:

- Treat decks as early as possible in their life cycles to lower EUACs.
- Apply sealers more frequently on high-traffic bridge decks.
- Seal average decks at General Condition Rating (GCR) 8 and again at GCR 7.
- Seal decks every three years on bridges with annual average daily traffic of 15,000 or higher.
- Consider life-cycle costs in conjunction with WisDOT's asset performance measure targets and incorporate treatment efficiency findings into bridge management systems and other decision-support tools to facilitate bridge-level decisions.

The most cost-effective preservation strategy overall is to seal decks at GCR 8 and again at GCR 7; apply two thin-polymer overlays when GCR drops to 7; apply a concrete overlay when GCR drops to 6; and to seal it again when GCR drops to 7. Therefore, this sequence of treatments is recommended as the default deck-preservation policy.

This brief summarizes Project 0092-18-03,
"Protocols for Concrete Bridge Deck Protections and Treatments"
Wisconsin Highway Research Program

Research Brief

Monitoring Lateral Earth Pressures and Movements of Cut Retaining Walls

Research Objectives

- Investigate the short-term and long-term performance of cut retaining walls
- Develop guidance to accurately predict horizontal and vertical earth movements behind cut retaining walls
- Obtain data for calibrating design methodologies for cut retaining walls

Research Benefits

- Identified methods for more accurately predicting earth movement and estimating strength and service limit states of cut retaining walls
- Recommended modifications to analysis and design methods that will improve cut retaining wall performance

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Background

Retaining walls are barriers built to protect roads, rights-of-way, utilities and structures from the lateral movement of soil. Cut retaining walls, such as soldier pile/lagging walls, sheet pile walls and tangent/secant pile walls, are constructed top down. Accurate estimates of complex lateral and vertical soil-structure interactions that determine earth pressure against these walls are necessary for evaluating strength and service limit states.

The objective of this project was to develop guidance to accurately predict horizontal and vertical movements; obtain data for calibration of specific design methodologies; and provide recommendations for limit states that can be used to control wall performance.

Methodology

Two cut retaining walls (one cantilevered wall and one anchored wall) on an active construction project were instrumented and remotely monitored over a 15-month period.

A Shaped Array Accelerometer secured at ground level.

Automated readings from strain gages, inclinometers using Shaped Array Accelerometers (SAA), survey points, vibrating wire piezometers (VWPZ) and load cells were collected to obtain measurements of each wall's displacement, strains in each wall's structural elements and pore pressures in the retained soil. The research team compared predicted design performance as computed by two programs (SPW-911 and PY-Wall) to the actual measured performance of each wall.

Results

Piezometers recorded positive pore pressures behind the walls after construction, indicating that the as-built walls may have been preventing lateral seepage. SAA readings showed seasonal outward movement that rebounded after the winter season, indicating that the movement was likely related to freezing and thawing of the

"WisDOT learned a lot about the behavior and performance of cut retaining walls through this research. This will allow us the ability to calibrate our design procedures, which will lead to more cost-effective structures."

– Andrew Zimmer, WisDOT

Interested in finding out more?

Final report is available at: [WisDOT Research website]

ground during the winter months. Wall movements measured with the SAAs were repeatable and consistent over time. Moments deduced from the wall movements measured with the SAAs were consistent with those deduced from strain gages. The SAA data were superior because they were able to capture the maximum moments. Back calculations of earth pressures from measured deformations using SAA readings were erratic and sensitive to small changes in the readings. Back-calculated earth pressures require careful consideration of reaction forces provided by slabs and anchors.

Recommendations for implementation

The research team provided the following recommendations for WisDOT to consider in its future design practices:

- Include all applicable load cases in design to ensure that worst case loading, or a combination of loading, is addressed.
- Develop standard details for protection against pore water pressure buildup and ground freezing behind the wall.
- Consider undrained and drained cases for each wall design to cover various possibilities that can develop in the field during construction and post construction.
- When using the PY-WALL method, obtain soil parameters for actual site conditions using appropriate site-specific testing rather than using the p-y curves internally generated by the software.
- Have specifications require performance testing of a representative number of anchors to reduce uncertainty in the actual anchor lock-off loads.
- Require contractors to conduct higher-quality documentation of their sequence of work to aid in interpreting retaining wall performance.
- For unusual cases, and cases where poor wall performance could create significant risks and costs, instrument and monitor representative wall sections to better understand and manage future performance.
- For cut walls where the zone of influence of construction might include existing utilities and/or buildings sensitive to ground movement, require alternative software to SPW911 and PY-Wall (such as Finite Element Analysis) to predict ground settlements, as neither program calculates ground settlement behind the wall.

This brief summarizes Project 0092-17-08,
"Monitoring Lateral Earth Pressures and Movements of Cut Retaining Walls"
Wisconsin Highway Research Program

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