Wisconsin Department of Transportation

Research Program

Annual *2016* Report

Forward

This report highlights the department's dedication to upholding its mission to, "provide leadership in the development and operation of a safe and efficient transportation system." By aligning research with the department's strategic priorities and culture of data-driven decision-making, we aim to accelerate rapid implementation of research results. We do this by leveraging research recommendations to implement promising materials and technologies, and associated policies and procedures to show accountability to our transportation stakeholders and the public.

Over the past year, WisDOT's $4.2 million research program completed eight state-sponsored projects conducted through the Wisconsin Highway Research Program (WHRP) and the Policy Research Program. We also began implementation of our 2016–2020 WHRP Strategic Plan. This document, which was developed with input from internal and external partners and transportation stakeholders, lays out four key goals and associated actions to focus our efforts to: streamline the research cycle; ensure timely implementation of valid research findings; develop and strengthen partnerships; and leverage funding resources.

In addition to state-sponsored research, the department led three state pooled fund research projects and participated in 42 others. The department 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. Research and Library staff completed 11 synthesis reports and 30 literature searches, handled 887 customer inquiries, circulated over 2,165 items and added 1,007 records to the library. Throughout the entire department, approximately 130 staff serve at least one role on nearly 300 research committees and panels at the national and state levels. Their expertise and guidance are critical to the success and implementation of research.

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This is a report of research and technology transfer activities carried out by the Wisconsin Department of Transportation through the Part 2 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 2016, covering October 1, 2015 through September 30, 2016.

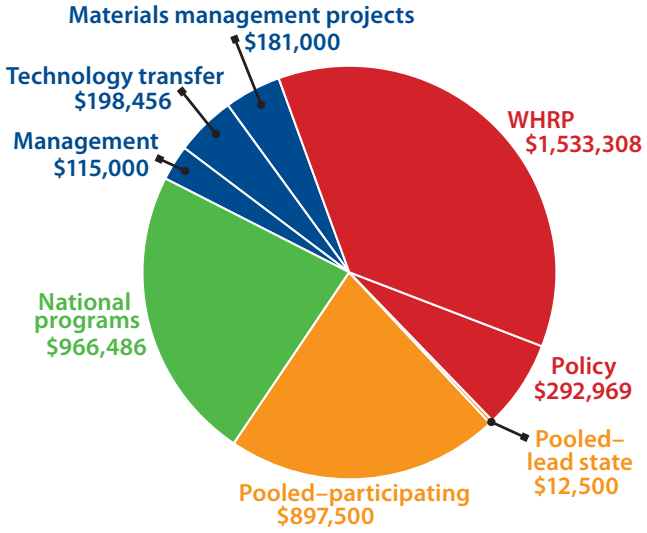
Common acronyms used in this document

AASHTO	American Association of State Highway and Transportation Officials
DOT	U.S. Department of Transportation
DBM	(WisDOT) Division of Business Management
DMV	(WisDOT) Division of Motor Vehicles
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
MAPSS	**M**obility, **A**ccountability, **P**reservation, **S**afety and **S**ervice
NCHRP	National Cooperative Highway Research Program
OPFI	Office of Policy, Finance and Improvement
SHRP2	The Second Strategic 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 $4.2 million program for research, library and technology transfer services during federal fiscal year (FFY) 2016. The State Planning and Research Part 2 (SPR2) federal program funded 89 percent ($3.73 million) of the program, while state funds covered the remaining 11 percent.

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. It focuses on geotechnics, structures and flexible and rigid pavements. Policy research addresses non-engineering issues such as planning, operations and safety. See pages 8–10 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 2016, WisDOT research led three pooled fund projects and provided support for 42 others. These projects ranged in scope from advances in engineering methods and materials to safety and performance management. For a full list of pooled fund projects, see pages 11–13.

National research

The department helps sustain national research initiatives on topics of broad national interest through the Transportation Research Board (TRB), the National Cooperative Highway Research Program (NCHRP) and Strategic Highway Research Program 2 (SHRP2). Approximately 130 WisDOT staff play at least one role in over 300 research committees including: 152 positions on WHRP and WisDOT Policy project and technical oversight committees; 73 positions on national research committees through TRB and AASHTO; 46 positions on transportation pooled funds (as technical representatives for the research); and 38 positions on national research project panels through the Cooperative Research Program, AASHTO and other national initiatives.

Staff functions and technology transfer

Effcient management of the program contributes to continuous performance improvement. The research program funds 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) projects are also included in the research program.

Featured research

The Department's MAPSS Performance Improvement program focuses on the five core goal areas of: **M**obility, **A**ccountability, **P**reservation, **S**afety and **S**ervice. Examples of research that contribute to achieving the department's strategic mission are listed below. The realized or anticipated impact to the state of practice is included for each project, to reaffirm the department's commitment to support data-driven decision-making through agile implementation of applied research recommendations.

Accountability

MAPSS goal: To use public dollars in the most efficient and cost-effective way.

0092-13-03

Understanding and Complying with Storm Water Mitigation Guidelines from the EPA

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

Researchers evaluated the effectiveness of various best management practices (BMPs) for monitoring and controlling erosion and sediment discharge.

Results confirmed that current BMPs are effective and demonstrated that automatic monitoring of storm water runoff turbidity is easier and more cost-effective than monitoring total suspended solids directly.

WisDOT will be better prepared if the U.S. Environmental Protection Agency reinstates numerical limits on pollutants or imposes mandatory testing at construction sites.

Preservation

MAPSS goal: To protect, maintain and operate Wisconsin's transportation system efficiently by making sound investments that preserve and extend the life of our infrastructure, while protecting our natural environment.

0092-12-06

Evaluation of Thin Polymer Deck Overlays and Deck Sealers

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

Researchers explored the effectiveness and durability of thin polymer overlays in restoring and protecting bridge decks, improving safety and extending service life.

Benefits of thin polymer overlays include lower deadweight and lane closure times compared to concrete overlays, and increases in surface friction, skid resistance and life expectancy.

WisDOT can extend bridge deck life expectancies to seven to 15 years from this procedure that only requires approximately eight hours of lane closure.

Featured research *(continued)*

Preservation

MAPSS goal: To protect, maintain and operate Wisconsin's transportation system efficiently by making sound investments that preserve and extend the life of our infrastructure, while protecting our natural environment.

0092-13-04

Laboratory Study of Optimized Concrete Pavement Mixtures

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

This project aimed to improve the performance and environmental sustainability of concrete paving mixtures used in Wisconsin.

Results showed that optimized concrete mixtures inclusive of aggregate gradation and superplasticizers can greatly reduce cement content and permeability while improving workability and strength.

WisDOT can reduce its use of cementitious materials by 18 percent in a step towards a more sustainable transportation network.

MAPSS
Performance
Improvement

TPF-5(270)

Recycled Materials Resource Center – Third Generation

Lead Agency: WisDOT
http://www.pooledfund.org/Details/Study/499

The goal of the third generation Recycled Materials Resource Center (RMRC-3) is to provide the resources for applied research and outreach to increase utilization of recycled materials and industrial byproducts in transportation applications. This year's activities included two research efforts and the development of a web application

Research on the benefits of recycled materials in road construction gathered direct information on sustainability assessment characteristics. Greenhouse gas emissions, energy and water consumption and waste generation were reduced by 70 to 99 percent when states used recycled industrial byproducts such as fly ash, recycled concrete aggregate (RCA) and recycled asphalt pavement (RAP). The cost analysis indicated potential savings of up to $17 million.

RCA and RAP were examined as more cost efficient and environmentally friendly alternatives to traditional backfill sources in mechanically stabilized earth (MSE) walls. Results showed RCA is an adequate alternative, while RAP is not.

The online Geographic Information System (GIS) web application that was developed connects producers and consumers of recyclable material to help engineers and contractors make the best use of recycled materials in transportation projects.

Service

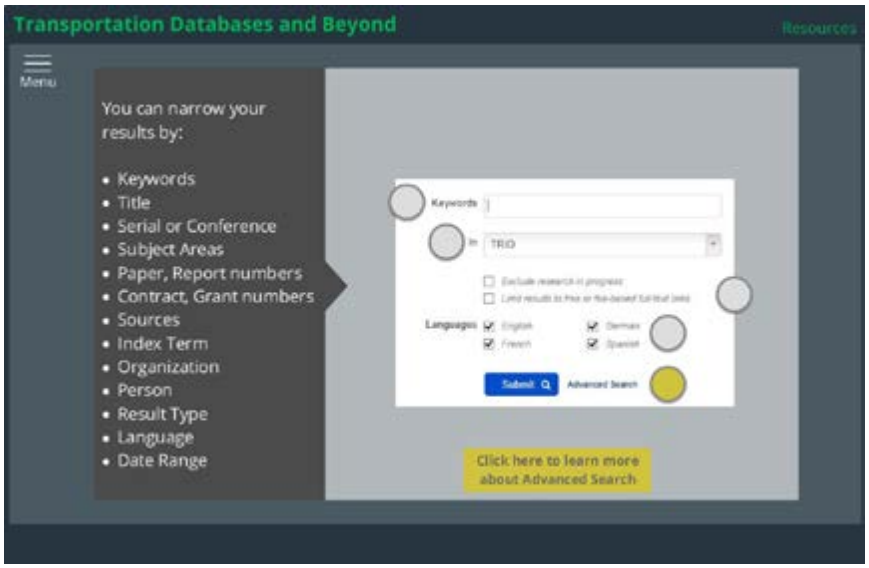
MAPSS goal: To be a professional and proactive workforce that delivers high-quality and accurate products and services in a timely fashion.

WisDOT library services

Library staff handled 887 customer inquiries, circulated 2,165 items (books, reports, periodicals and articles) and added 1,007 records to the library database over the past year.

Transportation database training

The WisDOT Research and Library Services Unit launched an online training module aimed at familiarizing WisDOT staff with transportation research resources. The *Transportation Databases and Beyond* training has an interactive format that is intended to be a starting point for self-directed researchers to begin their own quests to search for information on relevant transportation topics. The training employs concepts developed from the Transportation Research Board's most recent and comprehensive literature search on the topic to provide an overview of transportation research and engages users with basic learning exercises.



Technology transfer

The Office of Policy, Finance and Improvement (OPFI), Research and Library Services Unit provides information services for WisDOT staff and supports implementation of research results. Services provided in FFY 2016 include:

Transportation synthesis reports

A Transportation Synthesis Report (TSR) 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. Eleven TSRs were completed in FFY 2016. The topics covered included: ridesharing optimization; traffic microsimulation models; intersection control alternatives; wood fiber noise barriers; and thrie beam bullnose guardrail design.

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. Thirty literature searches were completed in FFY 2016. Topics included: proofrolling; type E overlays; thermal integrity profiling; concrete poured under water; and road user fee policies.

Completed research projects

Program	Project ID	Performing organization	Principal investigator	Project budget	WisDOT project manager	Project title	Completion date
WHRP – Geotech	0092-09-05	UW – Madison	Dante Fratta	$109,893	Robert Arndorfer	Evaluation of the Foundation Movements of Transportation Structures	2/24/2016
WHRP – Structures	0092-12-06	UW – Milwaukee	Habib Tabatabai	$199,696	David Bohnsack	Evaluation of Thin Polymer Deck Overlays and Deck Sealers	6/28/2016
WHRP – Geotech	0092-12-08	University of Illinois	James Long	$125,000	Jeff Horsfall	Static Pile Load Tests on Driven Piles into Intermediate-Geo Materials	9/14/2016
WHRP – Geotech	0092-13-03	UW – Milwaukee	Qian Liao	$74,998	Jeff Horsfall	Understanding and Complying with Storm Water Mitigation Guidelines from the EPA	5/5/2016
WHRP – Rigid Pavement	0092-13-04	UW – Milwaukee	Konstantin Sobolev	$199,185	Andrea Breen	Laboratory Study of Optimized Concrete Pavement Mixtures	6/15/2016
WHRP – Structures	0092-13-06	Michael Baker, Incorporated	Jose Aldayuz	$174,983	Shiv Gupta	Development and Implementation of the Next Generation Bridge Management System for Wisconsin – Phase 1 & 2	5/18/2016
WHRP – Structures	0092-15-01	UW – Madison	Michael Oliva	$75,000	Dave Kiekbusch	Precast/Prestressed Concrete Bridge Girder Cracking Phase II	7/12/2016
WHRP – Structures	0092-15-02	Iowa State University	Brent Phares	$64,959	Joshua Dietsche	Evaluation of Performance of Innovative Bridges in Wisconsin	9/14/2016

Ongoing research projects

Program	Project ID	Performing organization	Principal investigator	Project budget	WisDOT project manager	Project title
WHRP – Geotech	0092-12-07	UW – Milwaukee	Hani Titi	$94,989	Daniel Reid	Predicting Scour of Bedrock in Wisconsin
WHRP – Structures	0092-13-05	UW – Milwaukee	Al Ghorbanpoor	$120,000	Bill Dreher	Aesthetic Coatings for Concrete Bridge Components
WHRP – Structures	0092-14-01	Western Michigan University	Upul Attanayake	$84,999	William Oliva	Reflective Cracking between Precast Prestressed Box Girders
WHRP – Rigid Pavement	0092-14-05	UW – Madison	Steven Cramer	$249,918	Kevin McMullen	Comparison of Fresh Concrete Air Content Test Methods & Analysis of Hardened Air Content in Wisconsin Pavements
WHRP – Flexible Pavement	0092-14-06	Advanced Asphalt Technologies, L.L.C.	Ramon Bonaquist	$224,992	Carl Johnson	Critical Factors Affecting Asphalt Concrete Durability
Policy	0092-14-14	Internal WisDOT Study	WisDOT	$14,425	Matt Rauch	Copper Naphthenate Treatment Usage in Wood Sign Posts (WisDOT study)
WHRP – Structures	0092-15-03	South Dakota State University	Junwon Seo	$74,875	Steve Doocy	Self-Consolidating Concrete for Prestressed Bridge Girders
WHRP – Flexible Pavement	0092-15-04	UW – Madison	Hussain Bahia	$247,528	Barry Paye	Analysis and Feasibility of Asphalt Pavement Performance-Based Testing Specifications for the WisDOT
WHRP – Flexible Pavement	0092-15-05	Temple University	Ahmed Faheem	$100,000	Erv Dukatz	Evaluation of WisDOT Quality Management Program (QMP) Activities and Impacts on Pavement Performance
WHRP – Geotech	0092-15-06	UW – Milwaukee	Hani Titi	$119,997	Andrew Zimmer	Eval of the Long-Term Degradation and Strength Characteristics of In-situ Wis Virgin Base Aggregates under HMA Pavements
WHRP – Geotech	0092-15-07	UW – Milwaukee	Rani Elhajjar	$59,945	Andrew Zimmer	Correlation of ASTM D4833 and D6241 Geotextile Puncture Test Methods and Results for Use on WisDOT Projects
WHRP – Rigid Pavement	0092-15-08	UW – Madison	Steven Cramer	$120,000	James Parry	Better Concrete Mixes for Rapid Repair in Wisconsin
WHRP – Flexible Pavement	0092-15-09	Behnke Materials Engineering, L.L.C.	Signe Reichelt	$99,899	Barry Paye	WisDOT Asphaltic Mixture New Specifications Implementation- Field Compaction and Density Validation
WHRP – Rigid Pavement	0092-15-10	UW – Milwaukee	Konstantin Sobolev	$49,990	Andrea Breen	Class F Fly Ash Assessment for Use in Concrete Pavement

*This project is in field pilot phase for a two-year period with inspection intervals every six months.

Ongoing research projects *(continued)*

Program	Project ID	Performing organization	Principal investigator	Project budget	WisDOT project manager	Project title
Policy	0092-15-11	UW – Madison	Andrea Bill	$77,000	Sarah Buzzell	Motorcycle Licensing and Safety
WHRP – Rigid Pavement	0092-16-01	Marquette University	James Crovetti	$149,979	Myungook Kang	Joint Sawing Practices and Effects on Durability
WHRP – Flexible Pavement	0092-16-02	National Center for Asphalt Technology	Carolina Rodezno	$150,000	Andrew Hanz	Asphalt Binder Extraction Protocol for Determining Amount & PG Characteristics of Asphaltic Mixtures
WHRP – Geotech	0092-16-03	Clemson University	Amir Poursaee	$149,938	Jeff Horsfall	Evaluation of H-pile Corrosion Rates for WI Bridges Located in Aggressive Subsurface Environments
WHRP – Structures	0092-16-04	UW – Madison	Gustavo Parra-Montesinos	$140,000	William Oliva	Staged Concrete Bridge Deck & Overlay Pours Adjacent to Live Traffic
WHRP – Structures	0092-16-05	University at Buffalo	Pinar Okumus	$150,000	Philip Meinel	Design & Performance of Highly Skewed Deck Girder Bridges
WHRP – Flexible Pavement	0092-16-06	Auburn University	Randy West	$150,000	Steven Hefel	Regressing Air Voids for Balanced HMA Mix Design Study
WHRP – Geotech	0092-16-07	University of Missouri	Andrew Boeckmann	$110,000	Andrew Zimmer	Thermal Integrity Profiling for Detecting Flaws in Drilled Shafts
Policy	0092-16-10	Behnke Materials Engineering, L.L.C.	Signe Reichelt	$127,969	Emily Kuntz	Materials Laboratory Design Guidelines
Policy	0092-16-11	UW – Milwaukee	Xiao Qin	$100,000	Laura Vande Hey	Identifying Highly Correlated Variables Relating to the Potential Causes of Reportable Wisconsin Traffic Crashes
WHRP – Geotech	0092-17-01	UW – Milwaukee	Hani Titi	$99,990	Andrew Zimmer	Evaluation of Recycled Base Aggregates
WHRP – Structures	0092-17-02	UW – Milwaukee	Habib Tabatabai	$167,218	Aaron Bonk	Strength & Serviceability of Damaged Prestressed Girders
WHRP – Rigid Pavement	0092-17-03	UW – Platteville	Danny Xiao	$60,000	Chad Hayes	Evaluation of the Effects of Deicers on Concrete Durability
WHRP – Flexible Pavement	0092-17-04	UW – Madison	Hussain Bahia	$150,000	Stacy Glidden	Field Aging and Moisture Sensitivity Study

Pooled fund participation

Project number	Title	FFY 2016 funding amount	WisDOT technical representative	Lead agency/ state
TPF-5(063)	Improving the Quality of Pavement Profiler Measurement	$5,000	Bill Duckert – DTIM	FHWA
TPF-5(153)	Optimal Timing of Preventive Maintenance for Addressing Environmental Aging in HMA Pavements (MnROAD Study)	N/A	Steve Krebs – DTSD	Minnesota
TPF-5(176)	Traffic Analysis and Simulation	$35,000	Vicki Haskell – DTSD	FHWA
TPF-5(183)	Improving the Foundation Layers for Concrete Pavements	N/A	Jeff Horsfall – DTSD	Iowa
TPF-5(193)	Midwest States Pooled Fund Crash Test Program	$66,000	Erik Emerson – DTSD	Nebraska
TPF-5(206)	Research Program to Support the Research, Development, and Deployment of System Operations Applications of Vehicle Infrastructure Integration	$50,000	Anne Reshadi – DTSD	Virginia
TPF-5(210)	In-situ Scour Testing Device	N/A	Najoua Ksontini – DTSD	FHWA
TPF-5(215)	Transportation Engineering and Road Research Alliance (TERRA)	N/A	Steve Krebs – DTSD	Minnesota
TPF-5(218)	Clear Roads (Test and Evaluation of Materials, Equipment and Methods for Winter Highway Maintenance)	$25,000	Mike Sproul – DTSD	Minnesota
TPF-5(219)	Structural Health Monitoring System	N/A	Scot Becker – DTSD	Iowa
TPF-5(225)	Validation and Implementation of Hot-Poured Crack Sealant	N/A	Paulette Hanna – DTSD	Virginia
TPF-5(227)	Continued Advancements in Load and Resistance Factor Design (LRFD) for Foundations, Substructures and Other Geotechnical Features	N/A	Jeff Horsfall – DTSD	FHWA
TPF-5(232)	Study of the Impacts of Implements of Husbandry on Bridges	N/A	Travis McDaniel – DTSD	Iowa
TPF-5(233)	Technology Transfer Intelligent Compaction Consortium (TTICC)	$9,000	Girum Merine – DTSD	Iowa
TPF-5(238)	Design and Fabrication Standards to Eliminate Fracture Critical Concerns in Two Girder Bridge Systems	N/A	Alex Pence – DTSD	Indiana
TPF-5(242)	Traffic and Data Preparation for AASHTO MEPDG Analysis and Design	N/A	Laura Fenley – DTSD	Louisiana
TPF-5(243)	Motorcycle Crash Causation Study	N/A	Randy Romanski – DSP	FHWA
TPF-5(247)	Field Testing Hand-held Thermographic Inspection Technologies Phase II	N/A	Travis McDaniel – DTSD	Missouri

Pooled fund participation *(continued)*

Project number	Title	FFY 2016 funding amount	WisDOT technical representative	Lead agency/ state
TPF-5(253)	Member-level Redundancy in Built-up Steel Members	N/A	Alex Pence – DTSD	Indiana
TPF-5(255)	Highway Safety Manual Implementation	N/A	Brian Porter – DTSD	FHWA
TPF-5(259)	Imaging Tools for Evaluation of Gusset Plate Connections in Steel Truss Bridges	N/A	Joshua Dietsche – DTSD	Oregon
TPF-5(264)	Passive Forced Displacement Relationships for Skewed Abutments	$15,000	James Luebke – DTSD	Utah
TPF-5(267)	Accelerated Performance Testing for the NCAT Pavement Test Track	$110,000	Steve Krebs & Barry Paye – DTSD	Alabama
TPF-5(270)	Recycled Materials Resource Center	N/A	Steve Krebs – DTSD	WisDOT
TPF-5(272)	Evaluation of Lateral Pile Resistance Near MSE Walls at a Dedicated Wall Site	N/A	Jeff Horsfall – DTSD	Utah
TPF-5(281)	Center for the Aging Infrastructure: Steel Bridge Research, Inspection, Training and Education Engineering Center	$50,000	Scot Becker – DTSD	Indiana
TPF-5(283)	The Influence of Vehicular Live Loads on Bridge Performance	$50,000	Scot Becker – DTSD	FHWA
TPF-5(290)	Aurora Program	$25,000	Mike Adams – DTSD	Iowa
TPF-5(292)	Assessing Roadway Traffic Count Duration and Frequency Impacts on AADT Estimations	N/A	Rhonda McDonald – DTIM	FHWA
TPF-5(295)	Smart Work Zone Deployment Initiative	$50,000	Travis Feltes – DTSD	Iowa
TPF-5 (297)	Improving Specification to Resist Frost Damage in Modern Concrete Mixtures	$17,500	Chad Hayes – DTSD	Oklahoma
TPF-5(302)	PG+/Modified Binder Quality Control Criteria	N/A	Barry Paye – DTSD	WisDOT
TPF-5(303)	2015 Performance Measures Technical Transfer Conference and Asset Management Peer Exchange	N/A	Lori Richter – EXEC	Iowa
TPF-5(308)	The Use of Bridge Management Software in the Network Analysis of Big Bridges	N/A	Shiv Gupta – DTSD	Michigan
TPF-5(313)	Technology Transfer Concrete Consortium	$8,000	Chad Hayes – DTSD	Iowa
TPF-5(315)	National Accessibility Evaluation	$40,000	Tonia Rice – DTIM	Minnesota
TPF-5(316)	Traffic Control Device (TCD) Consortium	N/A	Travis Feltes – DTSD	FHWA
TPR-5(317)	Evaluation of Low Cost Safety Improvements	$5,000	Brian Porter – DTSD	FHWA

Pooled fund participation *(continued)*

Project number	Title	FFY 2016 funding amount	WisDOT technical representative	Lead agency/ state
TPF-5(319)	Transportation Management Center Pooled Fund Study	$50,000	Paul Keltner – DTSD	FHWA
TPF-5(326)	Develop and Support Transportation Performance Management Capacity Development Needs for State DOTs	$10,000	Lori Richter – EXEC	Rhode Island
TPF-5(335)	2016–2020 Biennial Asset Management Conference and Training on Implementation Strategies	$12,000	Joe Nestler – DTIM; Scot Becker – DTSD	Iowa
TPF-5(340)	Axle and Length Classification Factor Analysis and Effect on Annual Average Daily Traffic (AADT)	$12,500	Susie Forde – DTIM	WisDOT
TPF-5(341)	National Road Research Alliance (NRRA)	$225,000	Steve Krebs – DTSD	Minnesota
TPF-5(346)	Regional Roadside Turfgrass Performance Testing Program	$20,000	Leif Hubbard – DTSD	Minnesota
TPF-5(351)	Self De-Icing LED Signals	$20,000	Don Schell – DTSD	Kansas

Note: N/A indicates that the pooled fund is ongoing, but no additional funds were required by participating agencies for FFY 2016.

Wisconsin Highway Research Program* (WHRP)

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WisDOT, EXEC, OPFI

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Wisconsin Earthmovers Association

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FHWA – Wisconsin

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WisDOT, DTSD, Bureau of Structures

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WisDOT, DTSD, North Central Region

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American Council of Engineering Companies of Wisconsin

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Matt Grove
Wisconsin Transportation Builders Association

Kevin McMullen
Wisconsin Concrete Pavement Association

Gustavo Parra-Montesinos
UW – Madison, National Center for Freight & Infrastructure Research & Education

Brandon Strand
Wisconsin Asphalt Pavement Association

WHRP technical support staff

Angela Pakes Ahlman
Co-Principal Investigator, UW-Madison

David Noyce
Principal Investigator, UW-Madison

WHRP Technical Oversight Committee chairs

FLEXIBLE PAVEMENTS

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(Co-chairs)
WisDOT, DTSD, Bureau of Technical Services

GEOTECHNICS

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Myungook Kang and Barry Paye
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WisDOT, DTSD, Bureau of Technical Services

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Bill Oliva
WisDOT, DTSD, Bureau of Structures

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**Rosters and staff as of June 1, 2016.*
The FFY 2017 Annual Report will provide updated rosters and reflect staffing updates after this date.

Research Brief

Wisconsin Highway Research Program
Project 0092-12-06
September 2016

Thin Polymer Overlays for Bridge Decks

Research Objectives

- Explore the effectiveness and durability of thin polymer overlays in restoring and protecting bridge decks, improving safety and extending service life
- Assess and compare performance of selected thin polymer overlay systems under laboratory test conditions
- Suggest appropriate bridge deck maintenance strategies related to this research

Research Benefits

Thin polymer overlays:

- Impose less deadweight than concrete overlays
- Can be rapidly applied, resulting in lane closure of eight hours or less
- Have life expectancies of seven to 15 years when properly installed
- Better preserve surface friction and skid resistance compared to concrete with no overlay

Principal Investigator

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Background

Deterioration of concrete bridge decks is a major maintenance concern, particularly in the northern snow-belt regions where deicing salt is used to treat roads and bridges during winter months. The salt that helps keep traffic moving safely in winter can also accelerate deterioration of bridge decks and corrode embedded steel components. Sealers and overlays are used to prevent corrosive chlorides from penetrating the concrete and improve skid resistance by mitigating the damaging effects caused by vehicles, deicing salts and freeze-thaw cycles. These practices have resulted in varying levels of success in preserving affected bridge decks in a cost-efficient manner. Application can be expensive, time consuming and result in traffic disruptions. Additionally, corrosion activity may continue unabated even after application if chloride contamination already exists. This research was performed to explore cost-efficient solutions to these prevailing problems.

Methodology

Based on the evaluation of available literature, surveys, and discussions with state DOTs and manufacturers, the research team proposed nine sets of different treatment systems for testing of polymer overlays. Laboratory tests were performed to compare the performance of the selected systems against each other and a control group of uncoated specimens. Reinforced 15 in. x 15 in. x 4 in. concrete slab specimens matching conventional WisDOT mix designs were subjected to accelerated corrosion, freeze-thaw cycling, heat/ultraviolet/rain cycles and tire wear tests, including “snow plow” application. Application of overlays on previously chloride-contaminated concrete was also studied through exposure of two sets of specimens to increasing chloride levels prior to application of overlays. Chloride testing was done using the rapid chloride test (RCT) procedures. Pull-out strength, friction, deformation due to tire passage and corrosion mass loss were also measured.

Rapid chloride exposure testing in progress.

"The addition of polymer overlays does not significantly reduce corrosion mass loss in bridge decks with high levels of chloride contamination prior to application."
– Habib Tabatabai, UW-Milwaukee

Interested in finding out more?

Final report is available at: WisDOT Research website.

Results

The overlay system with an epoxy resin and flint rock aggregate provided the best overall performance based on performance indices determined for friction coefficient, corrosion mass loss, pull-out strength and surface deformation due to tire passage. The polyester multi-lift overlay system delaminated from the concrete surface in all nine specimens utilizing that overlay type. The addition of polymer overlays does not significantly reduce corrosion mass loss in bridge decks with high levels of chloride contamination prior to application. Applying overlays may slightly reduce the initial friction of concrete surfaces, but retain surface friction longer than tined concrete with no overlay. Freeze-thaw testing resulted in gradual loss of aggregates that protect the polymer against deterioration due to ultraviolet (UV) radiation, suggesting that, in practice, there may be longer-term UV damage after loss of aggregate.

Recommendations for Implementation

Proper application of a 2-lift thin polymer overlay on decks that are in good repair (no significant chloride contamination, corrosion and/or deck surface defects) have a life expectancy of seven to 15 years. The main advantage of thin polymer overlays is the long-term preservation of friction coefficients as the deck ages. Therefore, for applications where friction enhancements are needed, the thin polymer overlays are recommended unless deck conditions preclude it.

If the purpose for the installation of the thin polymer overlay is to protect an uncontaminated deck against corrosion, a more cost effective approach may be to apply penetrating sealer instead shortly after construction, and repeating the sealer application every three to five years, depending on average daily traffic. On heavily-travelled roads, where routine reapplication can be particularly disruptive to traffic, the application of thin polymer overlays may be considered as an acceptable corrosion protection strategy when chloride contamination is not significant.

Timing is key to ensure that penetrating sealers are effective and have a long service life. All new bridge decks should receive their first application shortly after construction, to maximize benefits and guarantee harmful chlorides have not already migrated into the concrete beneath. If the first application of sealer is not done within the first five years of a deck's life, there may be little to no benefit.

The time of year that sealing should be performed matters as well; late spring and summer are ideal, especially in areas where deicers are used over the winter. Allowing rain to help wash the accumulated chloride off the deck will help to preserve the service life of the sealer or overlay.

This brief summarizes Project 0092-12-06,
"Evaluation of Thin Polymer Deck Overlays and Deck Sealers"
Wisconsin Highway Research Program

Research Brief

Wisconsin Highway Research Program
Project 0092-13-03
November 2016

Understanding and Complying with the EPA's Storm Water Mitigation Guidelines

Research Objectives

- Evaluate the effectiveness of various BMPs for controlling erosion and sediment discharge based on quantitative measures
- Better understand and comply with the EPA's new construction and development rules
- Help establish appropriate storm water runoff monitoring protocols for WisDOT projects

Research Benefits

- Determined BMPs are generally effective at reducing erosion and turbidity to acceptable levels
- Confirmed automatic monitoring of turbidity is cheaper and easier than monitoring TSS directly
- Confirmed the use of TSS turbidity relations from samples to predict turbidity in runoff events

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Background

In Wisconsin, the Environmental Protection Agency (EPA) delegates the regulation of storm water discharge associated with construction activities to the Wisconsin Department of Natural Resources (WDNR) through the Wisconsin Pollutant Discharge Elimination System (WPDES). Although the Wisconsin Department of Transportation (WisDOT) is exempt from these regulatory requirements, it follows the Wisconsin Administrative Code and a cooperative agreement with the WDNR to address construction site erosion control on its construction projects.

Major components of the erosion control plan that WisDOT follows are non-numeric best management practices (BMPs) that require erosion and sediment controls, but they do not require permittees to monitor turbidity or other measures of pollution. The EPA has not specified numeric limits on pollutants in the past because of technical limitations and prohibitively high costs for businesses; however, as automatic turbidity testing devices become more advanced and less costly, the EPA may revisit imposing numerical limits and mandatory testing. Therefore, there is a need to determine the effectiveness of existing storm water management practices and to develop other measurement strategies.

Methodology

An automated monitoring device was developed to collect time series of turbidity at the outfall locations of five sampling sites. At four sites, grab samples were also collected during or after storm events to quantify typical turbidity and other water quality parameters at various discharge points, specifically; conductivity, pH value and mass concentration of total suspended solids (TSS). Most grab samples were measured onsite with handheld meters, while some samples were taken back to the laboratory to be validated on a benchtop Nephelometer.

Laboratory experiments were also conducted to investigate the relationship between turbidity and the mass concentration of TSS. Soil was taken from the four sites where grab samples were collected and laboratory simulations of runoff were created. The resulting turbidity levels and other parameter measurements were compared to grab samples.

Handheld turbidity monitor used to collect data at runoff site.

"Conventional BMP measures are able to effectively protect soil from erosion, reduce runoff volume and speed and enhance infiltration, thereby reducing the total sediment entering the receiving water body."
– Qian Liao, UW-Milwaukee

Interested in finding out more?

Final report is available at: WisDOT Research website.

Results

Measured turbidity in grab samples during or after storms ranged from 20 to 2,300 Nephelometric Turbidity Units (NTU). These measurements are lower than those reported in the literature at typical construction sites, but comport with the 500 to 2,000 NTU range reported by the National Cooperative Highway Research Program for sites following conventional BMPs. This suggests that conventional BMP measures are able to effectively protect soil from erosion, reduce runoff volume and speed and enhance infiltration, thereby reducing the total sediment entering the receiving water body. However, some samples measured immediately at both sides of BMP controls, such as straw roll ditch checks and silt fences, did not show significant difference in turbidity.

TSS-turbidity relation for runoff from construction sites can be well characterized and predicted by analyzing soil samples collected on-site following a simple laboratory test.

The measured pH values of grab samples ranged from 7.2 to 9.2, and the conductivity values were between 380 and 3,200 μS/cm. No correlations were found among the pH value, conductivity and turbidity for grab samples.

Recommendations for Implementation

WisDOT should continue employing BMPs (minus straw roll ditch checks and silt fences) to keep turbidity to acceptable levels. Sedimentation basins or ponds with flocculation treatment are the only known methods to effectively settle out fine clay or silt sediments, thus reducing the turbidity level even further.

Reconstruction of the turbidity response function and observed statistical correlations suggest that it is possible to develop models to predict the daily maximum turbidity and the total turbidity load of effluent from construction sites for designed storm events. Models of this kind are valuable for future BMPs of WisDOT construction projects as well as for the EPA to evaluate new regulation policies.

If the EPA institutes numeric limits and monitoring mandates, automatic turbidity monitors should be used at appropriate distances from outfall to collect data that can be used to estimate TSS using a calibrated TSS-turbidity relation. This relation estimates TSS with a much simpler turbidity measurement, which allows continuous monitoring of the TSS concentration of effluents from construction sites to be done economically and accurately. Turbidity measured immediately from outfalls will likely be extremely high despite extensive BMP coverage.

This brief summarizes Project 0092-13-03,
"Understanding and Complying with Storm Water Mitigation Guidelines from the EPA"
Wisconsin Highway Research Program

Research Brief

Wisconsin Highway Research Program
Project 0092-13-04
November 2016

Lab Study of Optimized Concrete Pavement Mixtures

Research Objectives

- To support the development of concrete specifications inclusive of aggregate gradation and use of superplasticizers
- To improve the performance and environmental sustainability of concrete paving mixtures used in Wisconsin

Research Benefits

- Optimizing concrete mixture proportions can result in up to 18 percent reduction of cementitious materials content
- Supplementing portland cement with cementitious industrial by-products can potentially reduce the consumption of cement by up to 18 percent
- Optimized concrete has enhanced workability, strength and reduced permeability

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Background

The contribution of portland cement to the carbon footprint of concrete is a key factor that requires immediate improvement in order to reach the objective for a more sustainable paving material. One approach to combat concrete's environmental impact is to reduce cementitious materials in its mixture. Previous WisDOT research concluded that concrete mixtures with reduced cementitious material have adequate durability, but poor workability. Those findings prompted this research to identify a multi-faceted approach to optimizing mixture proportions for low-slump concrete.

Current proportioning standards have limited or no guidelines on the optimization or use of aggregate gradations, including ternary aggregate blends, supplementary cementitious materials (SCM), modern superplasticizers or air-entraining admixtures. The application of these alternative mixture strategies requires a deep knowledge of the materials' properties, behaviors and time-dependent interactions.

Methodology

The SCM and air-entraining admixtures were selected to comply with existing WisDOT performance requirements, and chemical (mid-range and high-range water reducing) admixtures were selected based on the optimization study. Concrete mixtures were batched and mixed, and the concrete specimens were cast, cured and tested according to the corresponding ASTM and AASHTO standards. The performance of different concrete mixtures was evaluated for workability (slump), air content, compressive and flexural strength ranging from one and up to 365 days, drying shrinkage, freeze-thaw resistance, and rapid chloride permeability.

Research results were obtained by testing three specimens for compressive strength, two for modulus of rupture, three for length change, two for rapid chloride permeability and three for freezing and thawing resistance.

Testing the workability of concrete mixture using a slump cone

"Using these research findings to optimize concrete mixtures will result in improved durability, economy and environmental sustainability of concrete pavements on WisDOT projects statewide."
– James Parry, WisDOT

Interested in finding out more?

Final report is available at: WisDOT Research website.

Results

It was demonstrated that concrete mixtures can be effectively designed by optimizing two essential phases comprising the material: aggregate blends and cement paste.

Improved aggregate packing can improve the compressive strength and enhance concrete performance, allowing for a reduction of up to 18 percent in the cementitious material content compared to current WisDOT specifications for concrete mixtures, while still satisfying all other performance requirements. The optimized, superplasticized concrete consisting of up to 30 percent fly ash (Class C) and up to 50 percent ground granulated blast furnace slag demonstrated exceptional mechanical and durability performance.

Air-entraining (AE) admixtures form the desired air-void structure of concrete and low spacing factors which, in turn, provide extra space for freezing water to expand, reducing the associated stresses and enhancing the concrete's freezing and thawing resistance. The use of polycarboxylate ether superplasticizing admixtures enabled up to a 10 percent reduction of the water-to-cement ratio and water content compared to commonly used water-reducing admixtures, resulting in better performance.

Recommendations for Implementation

The proposed concrete optimization strategy with optimal aggregate blends, superplasticizing admixtures and SCM reduces environmental impacts of pavement production while providing enhanced performance, durability, life-cycle and sustainability.

Although superplasticizers introduce remarkable advantages, there are some limitations. For example, the compatibility of superplasticizers with other admixtures such as air-entraining agents and SCM must be verified prior to application.

The developed concrete has better workability, flowability and durability than currently used portland cement concrete, while using 18 percent less cementitious material. Using concrete with SCM from industrial by-products such as slag or fly ash can reduce the overall cement consumption by up to 50 percent.

This brief summarizes Project 0092-13-04,
"Laboratory Study of Optimized Concrete Pavement Mixtures"
Wisconsin Highway Research Program

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