2010 Annual Report

Minnesota Department of Transportation

RESEARCH SERVICES

Office of Policy Analysis, Research & Innovation

LRRB
LOCAL ROAD RESEARCH BOARD

Your Destination...Our Priority

The purpose of this report is to meet the requirements set forth by the Code of Federal Regulations, *Part 420—Planning and Research Program Administration—420.117 2(e):*

"Suitable reports that document the results of activities performed with FHWA planning and research funds must be prepared by the State DOT or subrecipient and submitted for approval by the FHWA Division Administrator prior to publication. The FHWA Division Administrator may waive this requirement for prior approval. The FHWA's approval of reports constitutes acceptance of such reports as evidence of work performed but does not imply endorsement of a report's findings or recommendations. Reports prepared for FHWA-funded work must include appropriate credit references and disclaimer statements."

For more information, please visit:

Minnesota Department of Transportation: **www.dot.state.mn.us**

Mn/DOT Research Services Section: **www.research.dot.state.mn.us**

Mn/DOT Library: **www.dot.state.mn.us/library**

Minnesota Local Road Research Board: **www.lrrb.org**

Connect with us on Facebook, Twitter and LinkedIn:

www.facebook.com/MnDOTResearch

www.twitter.com/MnDOTResearch

www.linkedin.com
(Search "Groups" for "MnDOT Research – Minnesota Department of Transportation")

Minnesota Department of Transportation

RESEARCH SERVICES

2010 Annual Report

Prepared by CTC & Associates LLC and shu shu design
Cover and many interior photos: David Gonzalez, Mn/DOT
Direction: Linda Taylor and Ben Worel
Mn/DOT project manager for technical transfer activities: Jake Akervik
Additional project management for At-A-Glance and Technical Summaries: Sandy McCully
Additional contributors: Sheila Hatchell, Rose Keller, Deb Fick

Acknowledgments

The Minnesota Department of Transportation's research and implementation efforts involve many researchers and transportation practitioners throughout Minnesota and other states. We would like to recognize their ongoing efforts toward improving Minnesota's transportation system.

Thank you to the following individuals for contributing their time and knowledge to the project Technical Summaries and other elements in the *Minnesota Department of Transportation Research Services 2010 Annual Report*.

Minnesota Department of Transportation

Jeanne Aamodt
Office of Customer Relations

Farideh Amiri
Office of Maintenance Operations

Janelle Anderson
Office of Traffic, Safety and Technology

Lisa Austin
Office of Transit

Rabinder Bains
Formerly Office of Investment Management

Jerry Baldwin
Formerly Mn/DOT Library

Tom Behm
District 8

Lynne Bly
Office of Statewide Multimodal Planning

Scott Bradley
Engineering Services Division

Tom Burnham
Office of Materials and Road Research

Ken Buckeye
Office of Policy Analysis, Research & Innovation

Dave Christianson
Office of Freight & Commercial Vehicle Operations

Tim Clyne
Office of Materials and Road Research

Paul Czech
Mn/DOT Metro District

Shongtao Dai
Office of Materials and Road Research

Moises Dimaculangan
Office of Bridges and Structures

Robert Edstrom
Office of Environmental Services

Mike Elle
Office of Technical Support

Glen Ellis
Mn/DOT Metro District

David Engstrom
Office of Traffic, Safety and Technology

Brian Gage
Office of Capital Programs and Performance Measures

Robert Gale
Office of Freight & Commercial Vehicle Operations

William Gardner
Office of Freight & Commercial Vehicle Operations

Jerry Geib
Office of Materials and Road Research

Kenneth Graeve
Office of Environmental Services

Todd Haglin
Office of Administration

Andrea Hendrickson
Office of Bridges and Structures

Gene Hicks
Office of Transportation Data and Analysis

Joe Huneke
Office of Maintenance Operations

Ed Idzorek
Office of Statewide Multimodal Planning

Cassandra Isackson
Office of Traffic, Safety and Technology

Bernard Izevbekhai
Office of Materials and Road Research

Jon Jackels
Office of Traffic, Safety and Technology

Eddie Johnson
Office of Materials and Road Research

Julie Johnson
Office of Environmental Services

Lowell Johnson
Office of Bridges and Structures

Marilyn Jordahl-Larson
Office of Environmental Services

Brian Kary
Regional Traffic Management Center

Jerry Kotzenmacher
Office of Traffic, Safety and Technology

Jim Kranig
Regional Traffic Management Center

Jonette Kreideweis
Intermodal Policy and Planning Section

Ernest Lloyd
Office of Maintenance

Curtis Pape
Office of Maintenance Operations

Tom Peters
Office of Maintenance Operations

Tom Ravn
Office of Construction and Innovative Contracting

Paul Rowekamp
Office of Bridges and Structures

Christopher Roy
Office of Aeronautics

John Siekmeier
Office of Materials and Road Research

Ray Starr
Intelligent Transportation Systems

Sarma Straumanis
Office of Environmental Services

Curt Turgeon
Office of Materials and Road Research

Mark Vizecky
State Aid Division

City and County

Lee Amundson
Lincoln County

Deb Bloom
City of Roseville

John Brunkhorst
McLeod County

Gary Danielson
Kandiyohi County

Mike Eastling
City of Richfield

John Grindeland
Fillmore County

Mark Maloney
City of Shoreview

Rich Sanders
Polk County

Michael Sheehan
Olmsted County

Kelvin Smith
District 3

Tim Stahl
Jackson County

Rick West
Otter Tail County

CONTENTS

Maintenance Operations & Security

Materials & Construction

Multi-Modal

Policy & Planning

Policy & Planning, continued

Traffic & Safety

Administration

List of Figures

Director's Message

We are pleased to present the *Minnesota Department of Transportation Research Services 2010 Annual Report*. In this document, you will find information about our projects, products and services, including highlighted accomplishments from the past year. This report supports Mn/DOT's goal of greater transparency and fulfills a federal requirement to account for the research program's finances, progress and results. It also represents our accountability to Commissioner Thomas K. Sorel, Mn/DOT's leaders and district offices, the Local Road Research Board, state government, the Legislature and Minnesota taxpayers. We hope that this information will promote sound research investments and continued improvement of the state's transportation system.

Our research, implementation and technology transfer activities are used to change policies and standards, identify technologies that enhance our programs, provide guidance on new construction methods and procedures, establish best practices and help guide the Department on operational procedures. Research Services supports Mn/DOT and local governments in the stewardship of the funds they receive. The innovations we facilitate help maintain Minnesota's transportation infrastructure, including its highway and bridge system, local roads and other modes of transportation.

The *Annual Report* continues to evolve with input from customers and continuous re-evaluation of our program. Key elements of this publication include the following:

- Mn/DOT's research program and library services are presented, including a staff listing, an overview of our goals and activities, and a description of our partnerships and programs.
- Also included is an At-A-Glance table, sorted by topic area, of all completed and ongoing research in 2010 supported by Mn/DOT, LRRB and Minnesota State Planning & Research funds.
- The bulk of the *Annual Report* is composed of Technical Summaries, which are two-page summaries of most of the research projects that were completed in 2010. We have arranged these according to newly assigned subject-area categories for ease of perusal.
- Reporting on the Transportation Pooled Fund/SP&R program additionally includes descriptions and status updates on all projects led by Mn/DOT and Technical Summaries covering highlighted ongoing multi-state pooled funds.

Strategic Vision, Strategic Research

2010 brought a change in management to Mn/DOT's Research Services. Ben Worel joined as Research Management Engineer on a two-year leadership exchange from MnROAD/Office of Materials and Road Research. This change brought about a new direction and philosophy, with retention of core functions in-house, increased program accountability and transparency, and an effort to make the research program more dynamic and responsive to changing Department needs.

Our services support and align with the Department vision and strategic plan. Commissioner Sorel values research and promotes innovation and technology; he is a strong supporter of the Library and promoted the Commissioner's Reading Corner.

As director of Research Services, my goals for 2011 are to:

- Expand Mn/DOT's capacity for delivering cutting-edge research by increasing the diversity of our research partners.
- Enhance customer service by taking a marketing approach to better understanding customer needs.
- Increase funding transparency and accountability.
- Sustain a high-performing organization by reducing barriers to communication and cooperation.
- Expand our marketing efforts to promote and educate our customers on how to better use our services.

**Linda Taylor,
Director, Mn/DOT Research
Services Section**

"Research and technological innovation are very high priorities to the Minnesota Department of Transportation, and the Library performs a critical service in advancing them."

**—Thomas K. Sorel,
Mn/DOT Commissioner**

2010 Program Highlights

- The **Mn/DOT Library** was remodeled to create a more user-friendly environment with Wi-Fi capabilities. The Library also created new marketing materials—including brochures, bookmarks and banners—and redesigned both its Web site and *New Library Materials* publication.
- A **Commissioner's Reading Corner** was established to promote and broaden staff knowledge in leadership techniques. Mn/DOT managers host monthly discussions of leadership-related books as part of Commissioner Sorel's Servant Leadership philosophy.
- **Marketing and outreach activities** included the use of social media for educational and research purposes and plans for a new, collaborative research transportation innovation knowledge network Web site. Our *2009 Annual Report* won a Minnesota Association of Government Communicators Award of Merit.
- The **Next Generation Automated Research Tracking System**, or ARTS-NG, was expanded to increase its monitoring capabilities and produce automated budget reports, increasing program accountability.
- A **customer services approach was taken to improve research processes** through the development of process flowcharts, calendars and standardized forms.
- At the **Transportation Research Board annual visit**, TRB senior program officer Christine Gerencher and Research Services management discussed key functional areas for future research needs and Mn/DOT program highlights that could be shared with other states.
- Jake Akervik and Sandy McCully were nominated and featured **in the annual "We are Mn/DOT" video** for their "dedication to teamwork and continuous demonstration of innovation" for their work in research marketing, outreach and publishing.

Please feel free to contact me or any of the Research Services Section staff for additional information about our products or projects. We would be happy to help you identify research needs and implementation opportunities. I encourage everyone to take advantage of our updated library facilities and services. Our research program will continue to bring innovation to Mn/DOT and to the state of Minnesota with the support and contributions of Mn/DOT staff, the LRRB, Federal Highway Administration, and our partners at universities and other public and private organizations. We welcome your comments, questions and suggestions.

Linda Taylor
Director, Mn/DOT Research Services Section
Linda.Taylor@state.mn.us

Research Services Overview

In 2010 Research Services managed a $9.6 million statewide transportation research program. The charts below (figures 1 and 2) illustrate the source of the research funding and how research dollars were spent. Figure 1 identifies the state, federal and local funding sources that make the research possible, followed by an explanation of each funding source. Figure 2 shows how research funds were invested across the different areas of transportation.

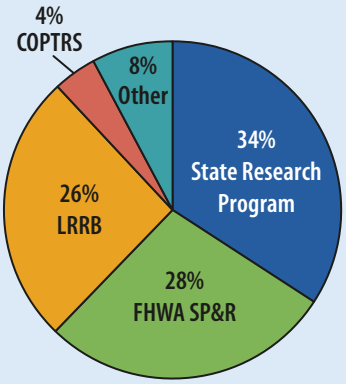
Mn/DOT's research program is extremely diverse and touches nearly every activity of the Department. Not only do projects address Minnesota's need for a well-maintained roadway system, but research efforts have expanded into a full range of transportation modes as well as policy, planning and environmental issues. Policy and planning research addressed sensitive issues facing Mn/DOT, such as tolling, full closure for major construction projects, unpaving roads and listening to customers. Mn/DOT's "Hear Every Voice" directive has impacted both the state's current transportation practices and the evolution of our transportation system. Our research has broadened to include other modes of transportation, including trucks, bikes, pedestrians, transit, high-speed rail and more.

New Environmental Protection Agency (EPA) requirements have spurred further investigations into ways to mitigate the negative effects of the transportation system on Minnesota's natural resources. Additional information on our method of research categorization can be found in the "Mn/DOT's State Research Program Overview" section of this report.

Our Mission

Mn/DOT Research Services supports Minnesota's transportation industry by meeting the innovation and information needs of transportation practitioners and the transportation community.

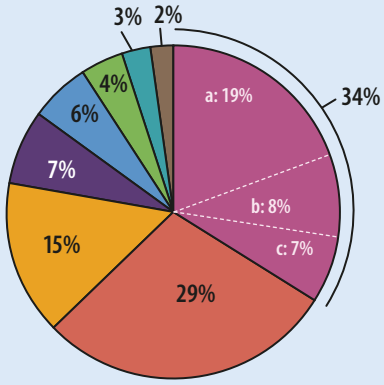
Figure 1. FY2010 Research Funds by Funding Source



State Research Program	$3,245,222
FHWA State Planning and Research (Part II)	$2,742,215
Local Road Research Board	$2,525,135
Cooperative Program for Transportation Research and Studies	$357,929
Other*	$773,752
Total	**$9,644,253**

*Includes contributions from other Mn/DOT offices (Maintenance, Traffic, Materials, Investment Management and Policy Analysis, Research & Innovation) and districts along with the Twin Cities Metropolitan Council and the University of Minnesota Intelligent Transportation Systems Institute.

Figure 2. FY2010 Research Funds Allocated by Topic Area*



Administrative	
a: Dedicated Programs (CTS & LTAP)	$ 1,603,792
b: Research Administration	$ 716,836
c: LRRB/RIC Administration	$ 577,852
	$ 2,898,480
Materials & Construction	$ 2,519,990
Traffic & Safety	$ 1,249,022
Policy & Planning	$ 566,197
Maintenance Operations & Security	$ 535,646
Environmental	$ 324,005
Bridge & Structures	$ 288,774
Multimodal	$ 171,864
Total**	**$ 8,553,978**

*Includes only projects with contracts maintained by Mn/DOT Research Services.
**Available funds not yet allocated: $1,090,275.

Research Services provides leadership, financial management, information services and administrative support to the following programs:

State Planning and Research Program (SP&R). These funds come from the Federal Highway Administration (FHWA), and at least 25 percent of the money goes to state-specific research needs. This amount, referred to as SP&R Part II funding, constituted 28 percent of the 2010 research funds Mn/DOT administered (as shown in the chart above). These funds are used for participation in cooperative research efforts with other stakeholders (states, universities, industry and other public agencies) through FHWA's pooled fund program.

Mn/DOT currently is involved in 54 multi-state pool fund projects and leads 13 of these studies. SP&R funds also are used to support local, statewide, regional, national and international research activities, committees and organizations such as the American Association of State Highway and Transportation Officials (AASHTO), National Cooperative Highway Research Program (NCHRP), Transportation Research Board (TRB) and the Research Advisory Committee (RAC). Mn/DOT's participation in these programs ensures that Minnesota's interests are well-represented and that Mn/DOT

staff members are made aware of the latest innovations and best practices for improving safety, exceeding customer expectations and saving taxpayer money. For more information about this program, including 2010 SP&R Research Highlights, see the "FHWA State Planning and Research Reporting" sections of this report.

Mn/DOT's State Research Program (SRP). These funds, representing 34 percent of the research dollars managed in 2010, come from Minnesota state government to ensure that agency research needs are addressed and to support Mn/DOT's strategic directions: safety, mobility, innovation, leadership and transparency. Research Services assists Mn/DOT and other public agencies in identifying and developing need statements, manages and provides technical assistance and support for research projects, assists in the implementation and deployment of research results, and promotes technology transfer and marketing of research products and services.

SRP funds are often used to match dollars from other funding sources including FHWA State Planning and Research and the University of Minnesota's Center for Transportation Studies (CTS) and Intelligent Transportation Systems Institute (ITS). These funds are also used to promote, support and complement Mn/DOT's other research programs: Guidestar, NTREC/MOR Program and MnROAD. For more information about this program, see the "Mn/DOT State Research Program Overview" section of this report.

Local Road Research Board (LRRB). Research Services administers the budget and research program for the LRRB, an organization created to facilitate transportation research and information sharing among Minnesota city and county engineers. LRRB funds constituted 26 percent of the research funds we managed in 2010. Services include developing contract documents, amendments and agreements; overseeing and facilitating out-of-state travel requests; and managing and approving invoices, purchase orders and expense reports. For more information, see the "LRRB Overview" section of this report.

Cooperative Program for Transportation Research and Studies (COPTRS). In addition to these three major programs, 4 percent of Mn/DOT's budget is dedicated to the University of Minnesota through COPTRS. This program, whose level of funding is determined by legislative action, was

established in 1983 to foster cooperation in basic and applied sciences and engineering to solve transportation problems, speed technology transfer, and stimulate new ideas and areas of research.

Other Funding. As the chart indicates, a full 8 percent of Mn/DOT's research budget comes from funding sources other than those listed above. These funds are contributed by other public agencies as well as Mn/DOT offices and districts. These contributions clearly demonstrate the commitment and support for Mn/DOT's statewide research programs.

Research Services receives assistance from several internal and external stakeholders in pursuing practical innovations that will be useful to transportation practitioners throughout Minnesota: FHWA; Consultant Agreements; Business Services; Finance; Capital Programs and Performance Measures; other departments of transportation; and agency, university and consultant partners. We have provided information about our research partners in the "Research Services and LRRB Partnerships and Programs" section of this report.

Research Services Organization

As the diagram below illustrates, Research Services is responsible for the management of individual research projects, the financial and contract services involved in supporting the contracts necessary to carry out these projects, and management of Mn/DOT's Transportation Library.

Figure 3

For a directory of current employees and their roles, please see the "Research and Library Services Staff" section of this report (page 18). Funding for staff comes from the Mn/DOT operating budget, the LRRB program and the SP&R program.

The SP&R Part II program provides funding for two staff positions: one in Research Management and the other in Financial and Contract Services. The LRRB provides funding support to Research Services to administer the program and to the Library for new materials and technical support.

The Research Management unit within Research Services consists of project managers, administrative liaisons and marketing/technology transfer staff.

The Financial and Contract Services unit includes financial and accounting staff, IT support staff and the office's administrative assistant.

The Library includes librarians and library technicians. The position of contract librarian within this group is a shared resource with the University of Minnesota Center for Transportation Studies.

Research Services Managers and Vision

Mn/DOT Research Services, under Linda Taylor's leadership, is responsible for the day-to-day management of the statewide research programs and the Mn/DOT Library. As director of Research Services, Taylor is the liaison to upper management and to other Mn/DOT divisions, offices and sections. She is also responsible for transparency and efficiency in research operations and communications, providing leadership in shaping communications and reporting strategies, and organizing Research Services staff and their priorities to continually improve the stewardship of state, federal and local transportation dollars.

Taylor is Mn/DOT's representative to the TRB and to the AASHTO RAC, and serves as board member/secretary on the LRRB board. She is also a member of many other steering and advisory committees, including the ITS and Local Technical Assistance Program (LTAP) boards, and chairs the Transportation Research Innovation Group (TRIG). TRIG is the governing board charged with providing guidance and funding recommendations for the statewide research program.

Guiding Principles

In 2010, Research Services management developed an operating plan for fiscal years 2011-2013 to redefine the key services provided and state the specific values and goals that will define its activities through the coming years. These principles and commitments were formulated to further Mn/DOT's strategic directions for improving transportation in Minnesota.

Our Vision:

Research Services fosters a professional and productive environment that leads to innovative research through global and regional collaboration.

Mn/DOT's Strategic Directions

Mn/DOT's leaders have defined the following strategic directions to elaborate the Department's core values. (More information is available at http://www.dot.state.mn.us/strategicvision/directions.html.)

Safety—Promote and maintain a safe, reliable and modern transportation system.

- Reduce transportation-related fatalities and injuries through the use of new and improved technology and safety measures.
- Monitor the condition of existing infrastructure in order to maintain a reliable and efficient transportation system.

Mobility—Improve access and enhance the movement of people and freight.

- Ease congestion, reduce commute times and improve the quality of life and economic well-being of all Minnesotans.
- Promote mass transit and use all modes for improving mobility and accessibility in metro and in greater Minnesota.
- Maximize operational efficiency of Interregional Corridors.

Innovation—Promote a culture of innovation in the organization.

- Foster innovation and collaborative partnerships within the transportation community in delivering 21st century transportation solutions.
- Develop ground-breaking, multi-modal transportation practices that will accommodate the diverse needs of all individuals and communities.
- Encourage research and build capacity to develop, implement and sustain solutions that balance preservation needs and address congestion issues.

Leadership—Become the transportation leader and employer of choice for Minnesota's diverse population.

- Mobilize in-house talent, public input and external partnerships to deliver value to the public.
- Value service, excellence and diversity to be an employer of choice.
- Provide development and advancement opportunities for all employees.
- Empower all employees to be leaders and ambassadors for Mn/DOT.

Transparency—Build public trust in Mn/DOT.

- Develop a simple, yet comprehensive tool for measuring performance across functions that is efficient, accurate, cost-effective and will show accountability to the public.
- Build relationships within local communities and encourage public involvement in developing transportation solutions.
- Effectively tie the strategic vision to Mn/DOT's long-range transportation plan, strategic plan and investment objectives, and serve as an ethical compass for decision-making at all levels.

Mn/DOT's methodology in managing its projects, funds and staff is designed to align with the Department core values:

- Maintaining safety as a priority.
- Enhancing trust with transparency and accountability.
- Promoting collaboration, research and innovation.
- Valuing diversity and cultural capital through inclusion and opportunity.
- Committing to employee well-being, development and success.
- Recognizing that employees are integral to Mn/DOT's success.

In 2010, Research Services managers participated in a risk assessment process to develop a strategic plan and vision. The assessment identified critical issues, challenges and barriers that could impede the goals of its research programs. As a result of this exercise, operations plans were formulated to address five strategic goals:

- Promoting high-quality, cutting-edge research through strategic partnerships with academic institutions.
- Enhancing customer service through research into customer needs and development of an enhanced service delivery process.
- Providing transparency and accountability in the stewardship of funds by more clearly defining funding criteria reflecting Mn/DOT and LRRB goals.
- Advancing Research Services as a high-performing organization through further definition of staff roles, responsibilities and projects to increase accountability, boost performance and foster cohesiveness.
- Promoting trust in Department work by communicating efforts and engaging stakeholders.

Efforts are currently under way to establish working committees to address each of the strategic areas.

Research Management

Mn/DOT Research Services works with state and local agencies to help identify research needs that can be addressed either through existing research efforts, through action within the office or state, or by developing and managing a new research contract. A state or local champion leads the process to develop an identified research need into a contract, and the effort needs to be approved by either Mn/DOT's TRIG or the LRRB.

Beyond management of SP&R, LRRB and SRP, Research Services can approve smaller projects as needed. These include Technical Summaries (TSs), which are performed for most completed projects; Transportation Research Synthesis (TRS) reports, which sum up the state of practice in some area of transportation research; and smaller projects to help meet research needs quickly and efficiently. Minnesota works with its customers along with industry and academia to achieve its research goals. Mn/DOT has developed a number of contracting processes to effectively hire appropriate contractors to help meet customers' needs. These methods include:

- Master agreements with prequalified universities.
- Transportation Research Assistance Program (TRAP), which establishes a list of preapproved consultants. TRAP research categories include technical writing and editing, outreach and education, event coordination, data information analysis and program/project coordination.
- Requests for proposals are used to contract both consultants and universities.

RESEARCH MANAGEMENT	
Total active contracts for research and implementation managed by Mn/DOT	152
Active pooled fund studies	54
Completed reports	40
Implementation products	4
Technical Summaries	56
Transportation Research Synthesis reports	9
Research and Innovation Series presentations	2
Transportation research videos	1 prototype
Research Services Web site hits	11,000+

Identifying Research Needs

Mn/DOT Research Services staff helps to identify research and innovation needs throughout the Department and the LRRB using completed research findings and communication with customers. Mn/DOT project managers use information collected to develop key roadmaps that help guide Mn/DOT's research investment throughout the year, ensuring that Mn/DOT and LRRB priorities are adhered to and that parallel efforts within a given area are not duplicative or in conflict. Staff members also coordinate efforts with state and national cooperative research programs, including the Transportation Pooled Fund Program, which is the chief target of FHWA SP&R funds. Research staff members also acquire research ideas and direction by participating in key research groups throughout the state, including research councils and local, state and national organizations.

Customers can also request research support through Mn/DOT's Project-Builder Web site, located on the Research Services site (**www.research.dot.state.mn.us**). This newly implemented tool allows users to submit ideas, review other idea submissions, and vote and comment on their priority. These methods help promote communication between stakeholders and ensure that the views of Mn/DOT managers, engineers and others will be considered when choosing a course of research in any particular area.

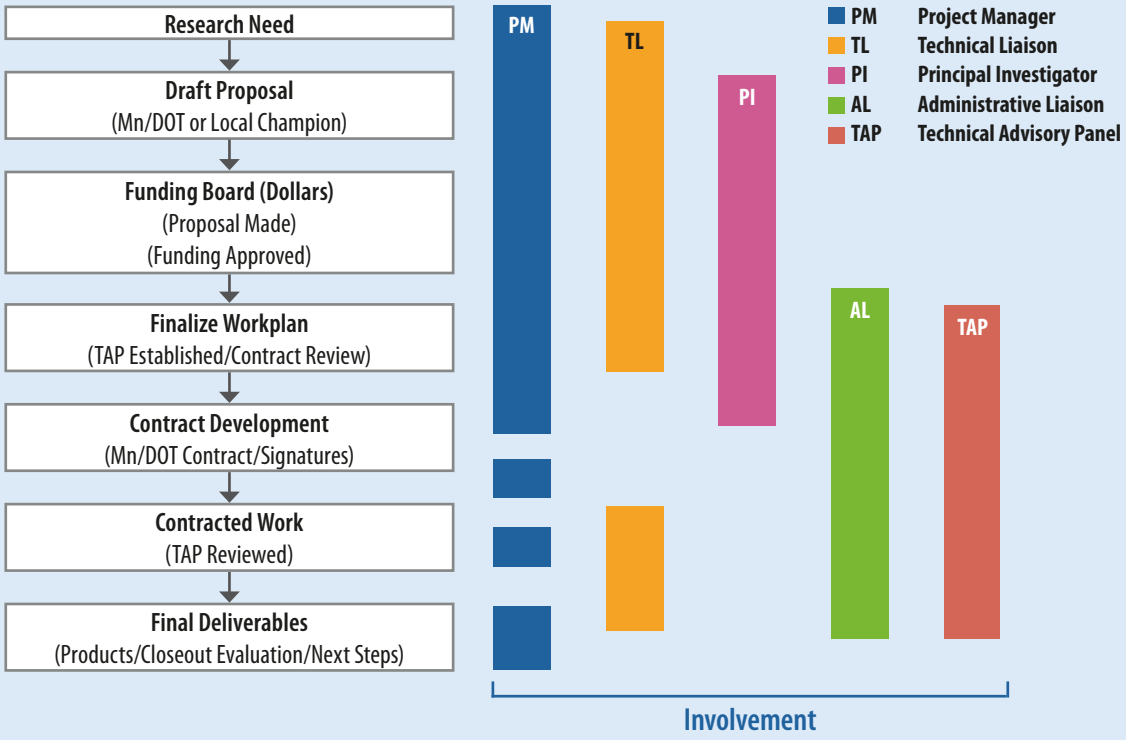
The Department solicits proposals for research projects in the fall and implementation projects in the spring of each year. Needs are not pursued without a state or local champion because without this leadership, projects are less likely to be incorporated into practice once the project is completed. Participation in national research efforts (NCHRP) and multiple funding sources (SP&R) also allows Mn/DOT to pool its research efforts with others around the country that have similar research needs.

Project Management Methodology

Research Services plays an important role throughout the development, coordination and evaluation of each research contract. The Department's research management process, described in the table and diagram below, is the product of many years of effort from a number of people. The table describes the roles of key personnel assigned to each project. These individuals may include state, local or industry representatives, depending on the topic. The diagram shows the steps involved in the development and completion of a successful research/implementation effort, indicating which roles are involved in each step. The progress of each contract is documented in Mn/DOT's computerized Automated Research Tracking System (ARTS), which is also used for the Department's financial program documentation.

Project Manager (PM):	The PM works with customers to develop needs into research contracts. Once a contract has been developed, the PM monitors the progress of the study and conducts the final closeout when it is complete. Sometimes the PM is referred to as the roadmap manager because the PM is always looking for research needs and how the various research efforts within a given area fit together to obtain desired products.
Technical Liaison (TL):	The TL is the Mn/DOT or local agency champion who guides the overall direction of the contract. The TL is involved in developing the initial need into a contract and helps the PI develop deliverables.
Administrative Liaison (AL):	An AL is assigned to each contract to ensure that contract provisions are followed and that deliverables are submitted and approved. The AL works with the TL to help manage projects throughout their life cycle. The AL also coordinates the activities of projects' Technical Advisory Panels.
Principal Investigator (PI):	The PI is the contractor working with Mn/DOT. The PI completes tasks as they are outlined in the contract.
Technical Advisory Panel (TAP):	The TAP helps to guide the research and review/approve the deliverables that are developed by the PI. Typically four to six people serve on each TAP.

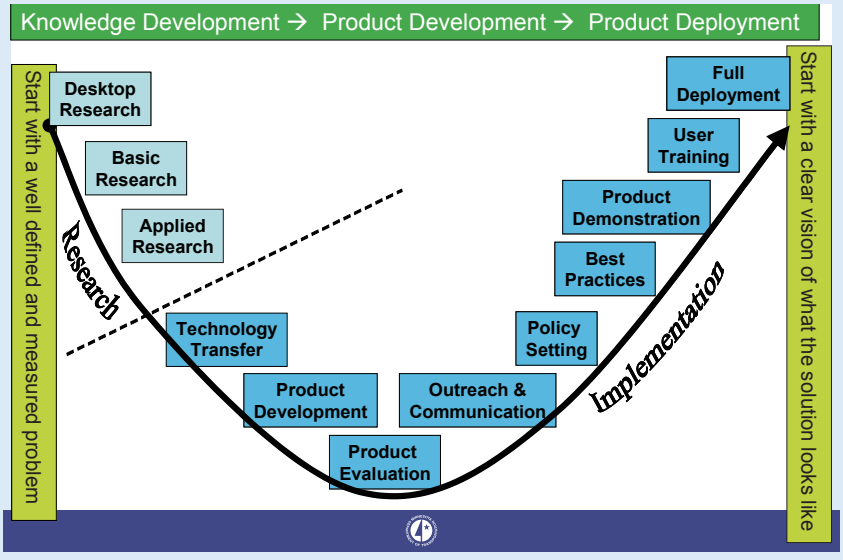
Figure 4. Research Project Management Process



Research Implementation

Implementation is a key component of Research Services' contribution in managing a project. Minnesota focuses on implementation projects each spring (new research is initiated in the fall) to gain the full benefits of past research investments, not only by Mn/DOT and LRRB but by other states and national programs. The following chart shows the overall development of ideas into research implementation for customers.

Figure 5. Innovation Roadmap



This diagram illustrates the cycle of innovation activities from research to deployment. Research is only the first step in ensuring deployment of a usable end-user product with a measurable benefit to transportation in Minnesota.

Research is only the first step in ensuring deployment of a usable product with a measurable benefit to transportation in Minnesota. During the project and roadmap planning processes, Research Services staff members determine measures required for successful implementation and ensure that these are built into research contracts. When a research contract ends, we evaluate the results to determine the most appropriate actions to take given the progress of the research. These may include additional work to further develop usable products such as specifications or manuals. It may also include demonstrations, training and technology transfer activities to inform potential users of research findings and enable them to make the best use of developed resources. Administrative liaisons for implementation contracts identify the impacts of research investments and measure the performance of individual projects and of Mn/DOT's research program as a whole.

Marketing, Outreach and Technology Transfer

Research Services communications staff is responsible for promoting program services and research project results by planning and coordinating communication and publishing through a variety of channels.

Publications, Multimedia and Web

Publications such as research project reports, the annual report, Transportation Research Synthesis reports, brochures, manuals, videos and research presentations are disseminated on an ongoing basis via Web sites, online database and e-mail.

In 2010, Research Services produced 56 two-page project Technical Summaries, our flagship communication product. Please see the "2010 Technical Summaries" section of this report.

Annual Report and Awards

In addition to ongoing publications that are disseminated throughout the year, a federally mandated and funded annual report (the one you are reading now) gives a yearly overview of the research program, services and results. The *Mn/DOT Research Services 2009 Annual Report* won a 2010 Award of Merit from the Minnesota Association of Government Communicators.

Communications staff members Jake Akervik and Sandy McCully received 2010 Certificates of Appreciation for their "dedication to teamwork and continuous demonstration of innovation in [their] work" after being featured in Mn/DOT's 2010 annual "We Are Mn/DOT" video.

Research Services received the CTS 2010 Research Partnership Award and the 2010 Best of ITS Rural Award in the category Best New Practice for its leadership of the multi-state pooled fund TPF-5(190): Northwest Passage, administered by SP&R Coordinator Deb Fick.

Social Media and Strategic Directions

Social media became another communications tool in 2010 as the program began publishing its research news and information on Facebook, Twitter and LinkedIn. These new, free channels allow Research Services to expand its reach in a manner that aligns with Mn/DOT's strategic directions of innovation and transparency.

Education and Outreach

While the Internet and social media are powerful and useful tools, research communications is also active in grass-roots stakeholder outreach through a number of organizations, committees, panels and conferences, including:

- CTS Education and Outreach Council
- CTS Research Conference Planning Committee
- LRRB meetings and Outreach Committee
- The Toward Zero Deaths Conference Planning Committee
- The Mn/DOT Tech Connections Flagship Initiative
- Maintenance Expo
- Minnesota LTAP and National LTAP Annual Conference

Technology Transfer

As part of the research program's research management and technology transfer efforts, communications staff helps research and other Mn/DOT staff with idea gathering, crowd sourcing and market research via collaboration tools like Web forms, UserVoice and IdeaScale, and through surveys and survey tools such as Mn/DOT's Online Community and SurveyMonkey.

Research Services hosted two Research and Innovation Series presentations in 2010: "Comparison of Dual-Phase and Static Changeable Message Signs to Convey Airline Information on Interstate Freeways" (January) and "Rumble StripEs and Strips for Rural High Speed Trunk Highways" (July). Documents related to these presentations are available at **www.dot.state.mn.us/research/2010-RIPS.html**.

According to Mn/DOT Research Project Supervisor Tom Wood, shown here in a technology transfer video created by Research Services on recreational trail preventive maintenance (http://www.youtube.com/watch?v=w0BZvuiQDxQ), "The best research in the world has no value unless you share it with the people who need to know the information."

Financial and Contract Services

Research Services' Financial Services staff members provide contractual and financial management to the federal, state and local road research programs, and the Mn/DOT Library. The staff coordinates research contracts and agreements; workflow and funding processes, including contract creation; budget management; and local, state and national research funding coordination.

Financial and Contract Services staff handled 177 purchase orders for facilities, equipment and commodities; created 59 new contracts and 57 amendments; and closed out 64 contracts. These staff members oversee and facilitate travel, lodging, food and meeting arrangements. This unit prepares, processes and monitors the University Master Contracts and Transportation Research Assistance Program (TRAP). It develops and facilitates 22 partnership, interagency and intra-agency, and joint powers agreements with other departments, public agencies, and other offices or districts to support the research program.

Financial and Contract Services staff also serve as experts on available funding sources for research, and help Mn/DOT and local practitioners and managers to determine the most appropriate contracting method and funding source.

This unit administers the LRRB and Research Implementation Committee (RIC) budget and programs. Research Services tracks partnership contributions; prepares, monitors and tracks contract documents, amendments and invoices; facilitates the out-of-state travel requested for LRRB-sponsored trips and processes expense reports; and develops purchase orders for equipment, food, lodging, outreach materials and other commodities needed to support LRRB and RIC programs.

FINANCIAL AND CONTRACT SERVICES	
Contract closeouts	64
New contracts	59
Contract amendments	57
Interoffice agreements	13
Interagency or partnership agreements	9
Purchase orders	177

Research and Library Services Staff

Linda Taylor
Director
Research Services Section
Linda.Taylor@state.mn.us
(651) 366-3765

Ben Worel
Research Management Engineer
Ben.Worel@state.mn.us
(651) 366-3757

Sheila Hatchell
Mn/DOT Library Director
Sheila.Hatchell@state.mn.us
(651) 366-3733

Rose Keller served as Contract and Financial Manager for a portion of 2010. The position will be filled in early 2011.

Jake Akervik
Communication Coordinator
Jake.Akervik@state.mn.us
(651) 366-3738

Jim Byerly
Electronic Resource Librarian
Jim.Byerly@state.mn.us
(651) 366-3739

Nelson Cruz
Information Technology Specialist
Nelson.Cruz@state.mn.us
(651) 366-3744

Debra Fick
Research SP&R Administrator
Debra.Fick@state.mn.us
(651) 366-3759

Pam Gonzalez
Periodicals and Acquisitions Technician
Pamela.M.Gonzalez@state.mn.us
(651) 366-3749

Judy Hartman
Office & Administrative Specialist
Judy.Hartman@state.mn.us
(651) 366-3780

Barb Hogan
InterLibrary Loan Technician
(Retired)

Bruce Holdhusen
Technology Development Engineer
Bruce.Holdhusen@state.mn.us
(651) 366-3760

Becky Lein
Financial Services Specialist
Rebecca.Lein@state.mn.us
(651) 366-3766

Sandy McCully
Technology Transfer Specialist
Sandra.McCully@state.mn.us
(651) 366-3768

Clark Moe
Research Evaluation and Implementation Manager
Clark.Moe@state.mn.us
(651) 366-3772

Karen Neinstadt
Reference and Outreach Librarian
Karen.Neinstadt@state.mn.us
(651) 366-3796

Alan Rindels
Research Development Engineer
Alan.Rindels@state.mn.us
(651) 366-3779

Anne Shelley
Librarian
Anne.Shelley@state.mn.us
(651) 366-3797

Shirlee Sherkow
Marketing Librarian/ Research Project Coordinator
Shirlee.Sherkow@state.mn.us
(651) 366-3783

Debbie Sinclair
Accounting Officer Principal
Debbie.Sinclair@state.mn.us
(651) 366-3746

Qin Tang
Technical Services Librarian
Qin.Tang@state.mn.us
(651) 366-3784

Dan Warzala
Research Project Coordinator
Dan.Warzala@state.mn.us
(651) 366-3786

Carole Wiese
Financial Services Specialist
Carole.Wiese@state.mn.us
(651) 366-3788

Mn/DOT Library Overview

Commissioner Thomas K. Sorel speaks to Mn/DOT staff about the value of the Mn/DOT Library at the celebration of its newly redesigned space.

Beyond its vast collection of materials, the Mn/DOT Library offers the services of trained staff, who are experts in helping customers find the information they need on the entire range of transportation-related subjects, from engineering and construction to management and training. Services include:

- **Research assistance**, providing customers with requested facts, data or other information.
- **Literature searches**, providing customers with summaries of pertinent books, reports, journal articles and other materials related to a requested topic or area of practice.
- **Document delivery and interlibrary loan services**, providing materials for customers from libraries worldwide.
- **Periodicals routing**, maintaining a database of every magazine or journal received by the Library and loaning them to customers upon request.
- **Online catalog access**, providing access via a searchable online database of all titles held by the Library.
- ***New Library Materials***, producing a newsletter that informs customers of titles newly added to the Library collection.
- **Ask a Librarian**, serving customers who request research assistance or materials using a simple online form.

By providing these services, the Library plays a vital role in helping Mn/DOT personnel build, improve and maintain Minnesota's transportation system. "Mn/DOT Library staff performs the literature searches required by the annual NCHRP problem solicitation to make sure that a problem statement being considered for submission hasn't already been solved or isn't being studied," said Tim Henkel, director of the Modal Planning & Program Management Division. "This invaluable service helps ensure that all Mn/DOT research proposals to NCHRP are original."

LIBRARY STATISTICS

Estimated for Calendar Year 2010

Library materials circulated	17,000
New materials acquired	402
Questions answered	1,100
Literature searches	529
Interlibrary loans	948
Library Web site hits	336,400

New Initiatives

The Mn/DOT Library, now in its 54th year, continued its tradition of excellent service in 2010 while engaging in a number of new initiatives, including:

- The remodeling of the Library space to make it more comfortable and easier for customers to use.
- The inclusion of a Wi-Fi area—a customer-friendly place to work with a fast wireless connection and access to social networking sites for work purposes.
- A marketing and communications plan that includes new brochures, bookmarks, posters and banners; a redesign of the Library Web site; and the *New Library Materials* publication.
- A Commissioner's Reading Corner—a forum for discussing leadership-related books.
- The digitization of Minnesota State Highway maps and Commission reports.
- The purchase of many new materials.
- Continued marketing and outreach efforts to make Mn/DOT staff aware of Library services.

The remodeled Mn/DOT library.

Remodeling by Repurposing

On December 15, 2010, the Library had a grand reopening to celebrate its first complete remodeling after 12 years at its current location. Library staff played an important role in this process, participating in a series of space redesign meetings and using customer focus group feedback to set priorities for improving the Library's floor plan and usability. Funded with the support of the Mn/DOT Commissioner and his leadership team, the new space makes librarians more accessible to customers, offers a comfortable work area for Library users, increases the space available for collections and capitalizes on new technologies to provide value-added services.

In preparation for the remodeling process, staff moved and re-sorted collections, not only to help facilitate the redesign but to ensure space for periodicals and other materials through 2020. Next, they focused on maximizing existing resources, or remodeling by repurposing. For example, chairs were reupholstered and study carrels were converted into tables. The Library also purchased some new furniture, including soft seating for customers and a service desk for Library and Research staff.

A significant benefit of the redesign included the creation of a Wi-Fi area for Mn/DOT staff and external customers and partners. "We wanted to provide a landing space for district staff members who have no place to work when they arrive early for meetings or between meetings," said Library Director Sheila Hatchell. "The Wi-Fi area provides tables and chairs as well as comfortable seating for customers, and the router provides a clear, strong signal with fast data transmission."

The remodel also included improvements to computer network security, better accessibility and security for the Research office and additional shelving, including future expansion space for collections that had been crowded for several years. Finally, the Library gained a locked storage area, combined the reference and circulation desks into one Library service desk, installed better signage both within the Library and in the adjoining hall, and created a private office for the Library director.

Commissioner's Reading Corner

In support of Commissioner Sorel's servant leadership philosophy, the Library instituted a Commissioner's Reading Corner by creating a physical space where leadership books recommended by the Commissioner are displayed and people can read in quiet near the natural light of windows. Each month, a book is selected for Departmentwide reading, and a manager is interviewed by Technical Services Librarian Qin Tang about the book. The manager also leads a live discussion for the book of the month. Mn/DOT employees may participate in these discussions in person or via Adobe Connect, allowing for remote participation by district and regional employees. Because of the high demand for leadership books, the Library also provides many of them in an e-book reader format.

Customer Access to Social Networking

Prior to opening core social networking sites throughout the Department, the Library made available streaming media and access to Mn/DOT-approved social networking tools, including Facebook, Twitter, YouTube, LinkedIn and WordPress, for work purposes such as viewing videos that feature newly developed engineering techniques and downloading audio files for inclusion in presentations.

A New Marketing and Communications Plan: Moving Knowledge

Following up on recommendations from focus groups, the Library applied for and Mn/DOT awarded funds to hire consultants to develop a marketing communications plan. Law Library Consultants conducted staff interviews and other exercises to develop a new tagline for the Library: *Moving Knowledge*. The Library also developed several new marketing materials, including a new logo, brochure, bookmark, posters and banners that can be used at presentations and conferences.

Web Site Redesign

The Library's new logo and tagline were included in a redesign of its Web site by team leader Jim Byerly with the assistance of Karen Neinstadt and Anne Shelley. The redesign also included moving frequently used tools and databases to the home page, making them easier to find and more efficient to use. The new pages require less scrolling now that everything is within eyesight, and were updated to be more ADA-compliant. The new Web site also allows Library customers to offer feedback via a survey so the site can continue to be fine-tuned to accommodate customers' needs.

New Library Materials

The Library's monthly publication *New Library Materials* was redesigned to make it easier to request Library materials and services, leading to a significant increase in requests. The publication features newly purchased and catalogued materials and other useful information such as tips and tricks.

Marketing and Outreach

This year the Library engaged in a variety of efforts to make Mn/DOT staff aware of Library services:

Karen Neinstadt explains how to search the Library catalog to Pat Kienitz of Mn/DOT's Eden Prairie Construction Office during Metro District Employee Days.

- Library staff conducted 20 tours for new employees, sent 100 letters introducing them to the Library and sent 100 letters introducing them to the Library's periodicals routing service.
- Library staff presented at the Bridge Office's annual meeting and exhibited at the Toward Zero Deaths Conference and Metro District Employees annual meeting.
- The new Library brochure, bookmark and a letter highlighting Library services and materials were sent to 500 city and county engineers.

Digitizing Minnesota State Highway Maps and Commission Reports

During 2010, the Mn/DOT Library completed its third digitization project in partnership with the Minnesota Digital Library (MDL). In this project, the Minnesota state highway maps from 1950 to 2009/2010 were digitized, making all Minnesota state highway maps available on the Web.

Also included in this digitization project were the annual reports of the Minnesota State Highway Commission (predecessor of the Minnesota Highway Department) from 1906 to 1915/1916 and the annual reports of the Minnesota Highway Department from 1917 to 1923.

Two previous digitization projects completed in 2006 and 2007 included Minnesota highway maps from 1919

to 1949 and Registered Minnesota Auto Trails. Registered Minnesota Auto Trails is a collection of historic forms used to register the names, symbols and general location of auto trails during the first half of the 20th century. These trails were established to direct motorists along the best routes to popular destinations.

To view digital images of all of Mn/DOT Library's contributions to the Minnesota Digital Library, visit the Minnesota Reflections Web site at **http://reflections.mndigital.org/cdm4/browse.php?CISOROOT=%2Fmdt**.

New Materials Purchased

This year the Library purchased books to support departmental interest in social networking and updated its collection of engineering manuals and related resources. Pam Gonzalez, who manages the Library's periodicals collection, secured the inclusion of:

- *Accident Analysis and Prevention*, which supports traffic engineering and the Toward Zero Deaths initiative.
- *RMA Journal*, the journal of the Risk Management Association, which supports the Department's risk management processes.
- The *Journal of Airport Management*, a publication for Mn/DOT's aeronautics specialists.

The Library also purchased many new books related to all six of the "B" campaign Shared Competencies: technical ability, teamwork, responsibility, leadership, innovation and character.

Future Plans

In the near future, the Library plans to:

- Further investigate the use of e-books to meet customer needs, including those of graduate engineers.
- Initiate digitization projects to make collections more accessible for current customers and preserve them for future customers.
- Continue to explore new technologies and introduce them to Mn/DOT staff to help enhance work performance.
- Explore the possibility of embedding librarians within various offices around the Department, or assigning them as information liaisons to special interest committees and projects.

The Library will also continue its active involvement in library networks and partnerships, including the Capitol Area Library Consortium, the Midwest Transportation Knowledge Network, the Special Libraries Association Transportation Division, the Transportation Library Connectivity Pooled Fund Study, the Transportation Research Board's Library and Information Science for Transportation Committee, the Minnesota Transportation Libraries partnership with the University of Minnesota Center for Transportation Studies (CTS) and the Minnesota Local Road Research Board. Through the CTS partnership, Anne Shelley is contracted with the Mn/DOT Library half-time to support various projects and initiatives.

Satisfied Customers

"I don't know how to adequately thank the Library for the wonderful job that it does for my department."

—Marj Ebensteiner, Management Analyst
Office of Traffic Safety & Technology

"It has been a pleasure to work with Pam Gonzalez and other Mn/DOT Library staff over the years. Their thoughtful, thorough and professional support has been most helpful to me in my work. The Library is a great asset and resource."

—Robert Gale, Freight Planning Manager
Office of Freight, Rail & Waterways

The Library saves me a great deal of time by conducting product and software searches, freeing me up for other projects. The Library services are an extremely valuable resource that I plan to use on future projects."

—Brian DeBlieck, IT Specialist
Architect & Analyst Services
Office of Information & Technology Services

Research Services and LRRB Partnerships and Programs

Research Services maintains partnerships with Mn/DOT offices and staff as well as with academia, industry, federal and local government agencies, other state transportation agencies, AASHTO and TRB. Regular communication with our partners keeps us abreast of both the critical issues facing transportation practitioners and the solutions already under development across the country. This awareness helps us develop research priorities for the Department and deliver high-quality research results and implementation products while ensuring that our efforts complement federal, state and local programs.

Mn/DOT Internal Partnerships

Research Services solicits innovation needs statements from the Mn/DOT districts and from various Mn/DOT offices and works with them to develop a project that will address the problem. Research Services also looks at the needs of other offices that may be affected by the project.

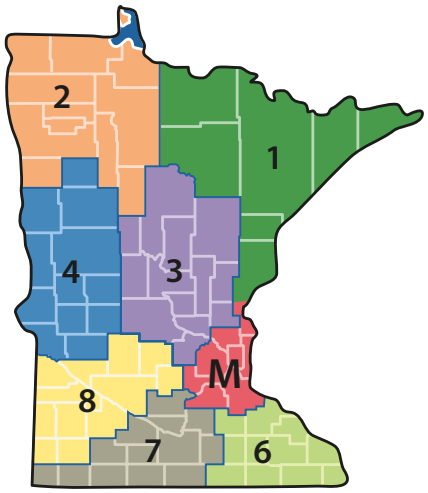


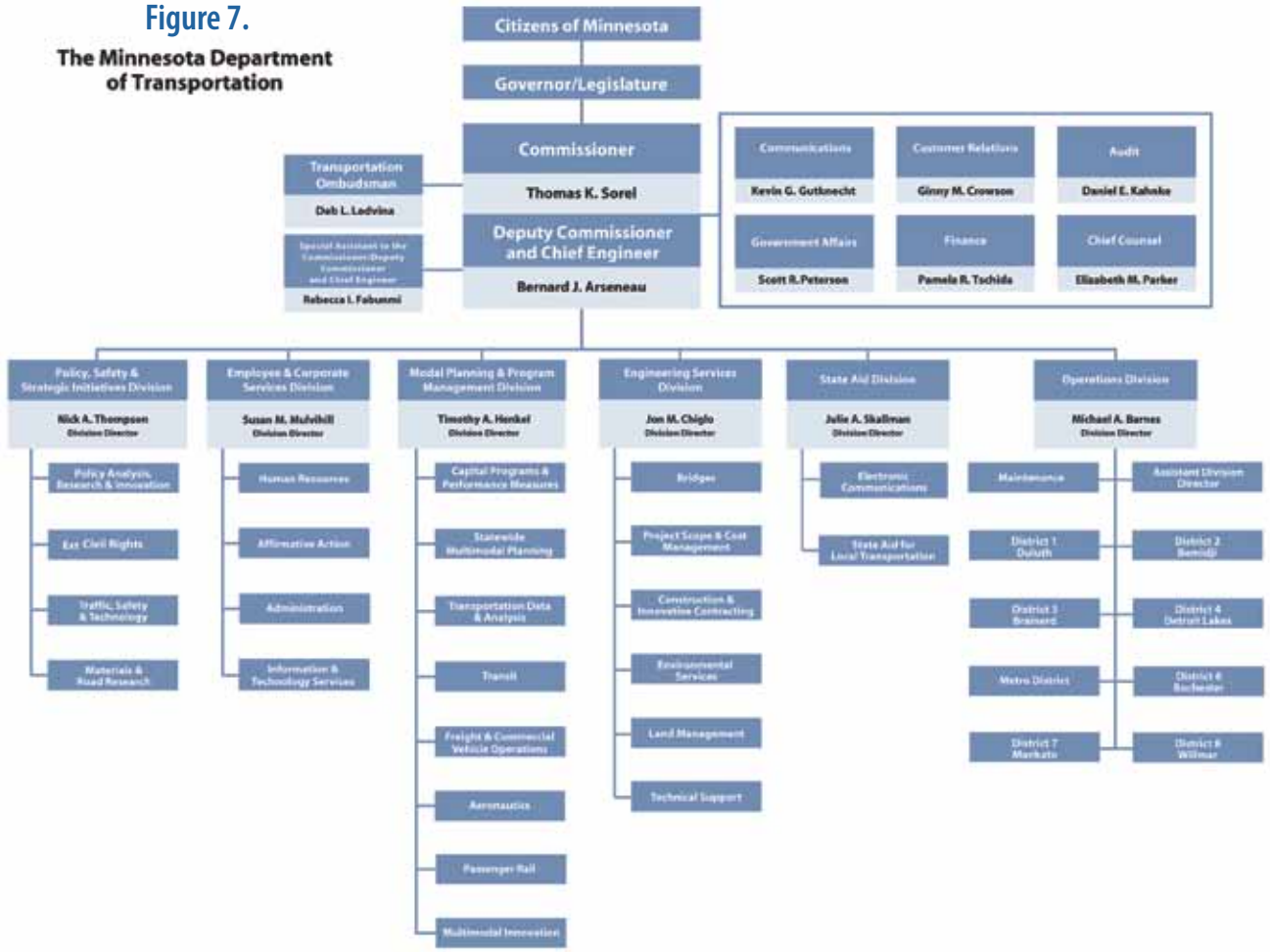
Figure 6. Mn/DOT Districts

- District 1: Duluth
- District 2: Bemidji
- District 3: Brainerd
- District 4: Detroit Lakes
- District 6: Rochester
- District 7: Mankato
- District 8: Willmar
- Metro District

Mn/DOT Offices

The many offices involved in requesting and facilitating research are presented here grouped according to their Mn/DOT Divisions on Mn/DOT's organizational chart. Research Services falls under the Policy, Safety & Strategic Initiatives Division.

Figure 7.
The Minnesota Department of Transportation



Research Programs at Other Mn/DOT Offices

A few Mn/DOT offices have research programs of their own. Research Services works in various ways to support these programs, as described below.

Minnesota Road Research—Office of Materials

Minnesota Road Research is Minnesota's Local and National Research and Technology Center. Located near Albertville, Minn., the facility is an outdoor cold-region pavement testing laboratory consisting of six miles of pavement sections with embedded electronic sensors. Researchers around the world use the MnROAD facilities and data. **www.dot.state.mn.us/mnroad**

Minnesota Guidestar—Office of Traffic, Safety and Technology

Minnesota Guidestar performs a broad range of intelligent transportation systems activities to assist in advancing ITS technology and programs to help achieve statewide and local transportation objectives. Its success is attributed to the strong partnerships developed with the public and private sectors and with academia. **www.dot.state.mn.us/guidestar**

Maintenance Operations Research—Office of Maintenance

Mn/DOT's Maintenance Operations Research Section has an active, applied "on-the-road" research program. Its purpose is to promote innovations in Mn/DOT operations and maintenance by stimulating and conducting research in winter maintenance, road and bridge maintenance, building maintenance, operations management, roadside maintenance, general maintenance, work zone safety and technology transfer. While on-the-road research is its focus, the program also supports laboratory research. The New Technology Research and Equipment Committee, or NTREC, approves funding for project proposals exceeding $12,000 and reviews the success of conducted research. **www.dot.state.mn.us/maintenance/research/index.html**

Mn/DOT External Academic Partnerships

University of Minnesota

The University of Minnesota Twin Cities campus is among the largest research universities in the country. Mn/DOT research is also performed on the Duluth campus. **www1.umn.edu/twincities/index.php**

Center for Transportation Studies (CTS)

Located on the Twin Cities campus, CTS addresses the need for closer cooperation between university faculty and state and federal departments of transportation. CTS also strengthens the university's role in transportation research, outreach and education. The mission of Mn/DOT's partnership with CTS is to bring together Minnesota's primary transportation agency and its major research and education university to advance transportation knowledge and foster innovations that improve Minnesota's transportation systems and services. **www.cts.umn.edu**

Humphrey School of Public Affairs

The Humphrey School of Public Affairs ranks among the top professional schools of public affairs at public universities in the country. Its expert researchers work with Mn/DOT and the LRRB on a variety of policy projects to improve Minnesota's multi-modal infrastructure and transportation planning practices. **www.hhh.umn.edu**

"By increasing the range of our research partners and taking advantage of their diverse strengths, Research Services will be able to use a broader knowledge base to continue to produce cutting-edge transportation research."

—Phil Barnes, Assistant Director, Mn/DOT Office of Policy Analysis, Research & Innovation

CTS spearheaded the Access to Destinations project (www.cts.umn.edu/access-study/publications), a series of studies to measure and improve accessibility in the Twin Cities area that ran from 2006 through 2010 and produced 10 Mn/DOT reports, including 2010-09, "Access to Destinations Phase 3: Measuring Accessibility by Automobile," and 2010-12, "Access to Destinations: Arterial Data Acquisition and Network-Wide Travel Time Estimation (Phase II)." A Web site was also created, http://atd.houstoneng.net (pictured above), where users can create accessibility, mobility and travel time maps for any locations in the area.

Center for Excellence in Rural Safety (CERS)

CERS is a joint program between CTS and the Humphrey School of Public Affairs that works with the LRRB to provide citizen-centered research, training and outreach to enhance rural safety and to meet the online and seminar training needs of rural transportation practitioners and policymakers. **www.ruralsafety.umn.edu**

Intelligent Transportation Systems Institute (ITS)

The ITS Institute is a federally funded University Transportation Center, conducting activities that further the mission of the U.S. DOT's UTC program: to advance U.S. technology and expertise in transportation through education, research and technology transfer activities. **www.its.umn.edu**

ITS programs and dedicated laboratories include:

- HumanFIRST Program
- Intelligent Vehicles Laboratory
- Minnesota Traffic Observatory
- Northland Advanced Transportation Systems Research Laboratories
- PTechPlan: Planning and Policy for ITS

Minnesota State University

Minnesota State University, Mankato

Minnesota State University, Mankato recently created the Minnesota Center for Transportation Research and Implementation. This center addresses the needs of Minnesota and the nation by bridging the gap between research and practice in the critical areas of transportation construction and materials. **www.mnsu.edu**

Other Minnesota State Colleges and Universities—37 Public Institutions

Additional Minnesota university partners work at other institutions in the MSCU system. **www.mnscu.edu**

Out-of-State University Partners

- Iowa State University
- Michigan State University
- Michigan Technological University
- Pennsylvania State University
- University of Illinois
- University of North Dakota
- University of Northern Iowa
- University of Wisconsin—Madison

Other Mn/DOT External Partnerships

Federal Highway Administration (FHWA)

FHWA provides financial support for Mn/DOT research activities through the SP&R program. Efforts and organizations within FHWA work with Mn/DOT in other specific ways.

Turner-Fairbank Highway Research Center (TFHRC)

TFHRC is a federally owned and operated research facility in McLean, Va. It is the home of FHWA's Office of Research, Development and Technology. TFHRC provides FHWA and the world highway community with the most advanced research and development related to new highway technologies. The research focuses on providing solutions to complex technical problems through the development of more economical, environmentally sensitive designs; more efficient, quality-controlled construction practices; and more durable materials. The end result is a safer, more reliable highway transportation system. **www.fhwa.dot.gov/research/tfhrc/**

FHWA Minnesota Division Research/Technology Transfer

The Minnesota Division of FHWA is responsible for overseeing FHWA's SP&R Program and the Minnesota LTAP. **www.fhwa.dot.gov/mndiv/programs/research.htm**

FHWA Transportation Pooled Fund Program (TPF)

The TPF Program, sponsored by FHWA, TRB and AASHTO, allows federal, state and local agencies and other organizations to combine resources to support transportation research studies. The TPF Program has been in operation for more than 20 years, with nearly 200 projects currently active, valued at more than $130 million of pooled investment. Mn/DOT makes good use of this program to pursue joint research on subjects of interest to other states and FHWA. **www.pooledfund.org**

Transportation Research Board (TRB)

TRB is a division of the National Research Council, which serves as an independent adviser to the federal government and others on scientific and technical questions of national importance. The mission of TRB is to provide leadership in transportation innovation and progress through research and information exchange, conducted within a setting that is objective, interdisciplinary and multi-modal.

TRB also administers a number of major research programs sponsored by other organizations, including NCHRP. **www.trb.org**

National Cooperative Highway Research Program (NCHRP)

NCHRP is sponsored by the member departments (individual state DOTs) of AASHTO in cooperation with FHWA. NCHRP was created in 1962 as a means to conduct research in acute problem areas that affect highway planning, design, construction, operation and maintenance nationwide. **www.trb.org/CRP/NCHRP/NCHRP.asp**

American Association of State Highway and Transportation Officials Research Advisory Committee (AASHTO RAC)

AASHTO created the RAC—along with its Standing Committee on Research—in 1987 to provide advice about transportation research matters, rate each year's problem statements for the National Cooperative Highway Research Program, share state-sponsored research to avoid duplication and perform other duties. The Research Services director is Mn/DOT's representative on RAC. **research.transportation.org**

Transportation Engineering and Road Research Alliance (TERRA)

Funded through SP&R project TPF-5(215), TERRA was introduced in 2004 to foster a comprehensive road research program. TERRA brings together government, industry and academia in a dynamic partnership to advance innovations in road engineering and construction. TERRA's partnering efforts reach beyond Minnesota to include transportation organizations in other states and in Europe. One of TERRA's main focus areas is to expand utilization of the MnROAD test facility. **www.terraroadalliance.org**

Operational Research Assistance Program (OPERA)

OPERA aims to promote innovations in operations and maintenance methods, materials and equipment for a safer, more efficient and environmentally sound statewide transportation system.
www.cts.umn.edu/Research/ProjectDetail.html?id=2008034

The MnROAD test facility, which is promoted by TERRA through pooled fund study TPF-5(215), consists of 3.5 miles of working interstate freeway and a 2.5-mile closed loop for low-volume traffic to simulate rural road conditions. These pavements are equipped with electronic sensors to support a wide range of tests to investigate new pavement construction methods and materials.

Research Services and the LRRB partnered with the Minnesota LTAP to host a booth at the 2010 Spring Maintenance Expo, an event focusing on the latest practices and technologies in spring and summer roadway maintenance. ***Pictured (from left): Kathleen Schaefer of the Circuit Training and Assistance Program (CTAP), the mobile arm of the LTAP, and Sandy McCully of Mn/DOT Research Services.***

Minnesota Local Technical Assistance Program (LTAP)

The Minnesota LTAP is part of the LTAP formed in 1982 by the FHWA to provide local agencies with information and training programs that address the maintenance of local roadways and bridges. The Tribal Technical Assistance Program was formed in 1991. Minnesota's LTAP, administered by CTS, conducts workshops and seminars, conferences, customized training, demonstrations and distance learning. In addition, Minnesota LTAP publishes newsletters and maintains a Web site with extensive resources. **www.mnltap.umn.edu**

The LRRB supports the local OPERA effort and Minnesota LTAP.

LRRB Overview

Since 1959, the LRRB has facilitated both new transportation research and the sharing of the latest knowledge among Minnesota city and county engineers. In the last 15 years, it has sponsored more than 200 projects in areas ranging from cold in-place recycling with foamed asphalt to the use of pervious concrete for stormwater management. In 2010, LRRB funds represented 26 percent ($2,525,135; see figure 1 on page 9) of the funds Research Services administers.

LRRB-Sponsored Research

The LRRB has helped local communities offer pavement management, rural safety and snowplow sander calibration workshops; update their crash analysis software; explore the environmental benefits of porous pavements; and evaluate the performance of stormwater treatment technology.

Recent research sponsored by the LRRB helps to improve the quality of Minnesota's transportation systems. The impact of this research multiplies as more and more engineers see the potential applications through the LRRB Research Implementation Committee's technology transfer efforts.

How the LRRB Works

Each year, the LRRB's 10-member board, including city and county engineers and key Mn/DOT decision-makers, approves and funds the most innovative research projects addressing the needs of local transportation practitioners.

The LRRB is continually on the lookout for new technologies for communicating results more cost-effectively and efficiently and welcomes research ideas from the transportation practitioners responsible for maintaining Minnesota's city and county roads, bridges, trails and other elements of its transportation infrastructure. Please submit your research needs to the LRRB at **www.lrrb.org/submitidea.aspx**.

Once approved, research is conducted by investigators from Mn/DOT, regional universities and consulting firms, with the LRRB monitoring its progress and Mn/DOT providing administrative support and technical assistance.

LRRB Mission

The mission of the LRRB is to serve local road transportation practitioners through the development of new initiatives, the acquisition and application of new knowledge, and the exploration and implementation of new technologies.

LRRB Strategic Goals

The LRRB sponsors research projects that improve Minnesota's local government road system with regard to:

1. **Design—the determination of the need for and nature of a proposed road system project**
2. **Construction—the implementation of the plans and specifications from the road system design process**
3. **Maintenance/Operations—the operation and maintenance of the road system investment**
4. **Environmental Compatibility—the integration of the local road system into the community to minimize adverse environmental impacts while contributing to economic and social well-being**

Benefiting Transportation Practitioners

Transportation practitioners involved with LRRB projects have benefited by:

- **Networking outside of the office and working with those who share similar interests.**
- **Keeping up-to-date on current topics within their area of expertise and learning about cutting-edge technologies.**
- **Working on real problems they otherwise wouldn't have the resources to address.**

Sharing the Results

Once research projects have been completed, the Research Implementation Committee (**www.lrrb.org/ric.aspx**) communicates its results and facilitates their practical application. The RIC uses a variety of methods to reach engineers and others with new developments, including presentations, videos, written reports, pamphlets, seminars, workshops, field demonstrations, Web-based technologies and on-site visits.

2010 LRRB Research Highlights

A key focus area for 2010 research was in helping local governments comply with federal regulations in areas such as:

- **Traffic Sign Management**. Recent FHWA regulations require all traffic signs to meet new minimum standards for nighttime visibility. Report **2010RIC02, "Sign Retroreflectivity: A Minnesota Toolkit,"** provided materials to help make Minnesota local agencies aware of these requirements and to establish agency-optimized retroreflectivity maintenance programs. Report **2010RIC10, "Minnesota's Best Practices for Traffic Sign Maintenance and Management,"** provided guidance to reduce sign management costs by devising and implementing a policy to remove unnecessary signs.
- **Pavement Marking**. Report **2010-05, "Minnesota Local Agency Pavement Marking Practices—Phase 1"** served to facilitate compliance with proposed FHWA standards for the design and maintenance of pavement markings by surveying local transportation agencies regarding their current procedures in this area and recommending best practices.
- **Stormwater Maintenance**. To meet state and federal environmental regulations, the LRRB invests in projects to help minimize the impact of anti-icing chemicals and other pollutants through stormwater control. Recent projects include Report **2010-10, "Hydrodynamic Separator Sediment Retention Testing,"** and Report **2010-16, "Drainable Pavements at MnROAD Pervious Concrete and Porous Concrete Overlay Cells 39, 85, and 89."**

Maintaining guardrails and other infrastructure features that keep drivers safe is a key focus of Report 2010RIC03, "Toward Zero Deaths: Maintaining a Safer Roadway Workshop," which involved developing a workshop on best practices that local agency maintenance forces can use to improve the safety of Minnesota roads, including practices related to on-road issues such as roadway obstructions, and off-road issues such as vegetation control and drainage.

For more information about LRRB activities, go to **www.lrrb.org**. The LRRB Web site lists LRRB members, provides news and events information, explains more about the LRRB's mission and plans, and provides links to a variety of Web-based tools to help in areas such as pavement design, management and rehabilitation; geosynthetics design; crash data analysis; and connecting with local and national resources.

LRRB Board Members

Rick West (Chair in 2011), Otter Tail County Engineer
(218) 998-8470, rwest@co.ottertail.mn.us

Deb Bloom (Chair in 2010), City of Roseville Engineer
(651) 792-7000, deb.bloom@ci.roseville.mn.us

Linda Taylor, Director, Mn/DOT Research Services
(651) 366-3765, Linda.Taylor@state.mn.us

Mitch Anderson, Stearns County/Engineer
(320) 255-6180, mitch.anderson@co.stearns.mn.us

Bruce Hasbargen, Beltrami County Engineer
(218) 333-8180, bruce.hasbargen@co.beltrami.mn.us

Steve Koehler, City of New Ulm/Engineer
(507) 359-8245, steve.koehler@ci.new-ulm.mn.us

Laurie McGinnis, CTS Director
(612) 625-3019, mcgin001@cts.umn.edu

Sue Miller, Freeborn County Engineer
(507) 377-5188, sue.miller@co.freeborn.mn.us

Thomas Ravn (Starting in 2011)
Construction & Innovative Contracting
(651) 366-4228, Tom.Ravn@state.mn.us

Keith Shannon, Mn/DOT Materials Director (Departing in 2011)
(651) 366-5590, Keith.Shannon@state.mn.us

Julie Skallman, State Aid for Local Transportation
(651) 366-4831, Julie.Skallman@state.mn.us

Report 2010RIC02, "Sign Retroreflectivity: A Minnesota Toolkit," included guidance on the use of control signs, which are signs representative of a part of an agency's inventory. These are monitored, and when a sign fades enough to fall short of retroreflectivity standards, then all signs in the field associated with the control sign are replaced.

In Report 2010-10, "Hydrodynamic Separator Sediment Retention Testing," investigators simulated a heavy storm event by piping water from a fire hydrant into a sewer equipped with a stormwater treatment device that filters sediment which would otherwise pollute the environment.

LRRB Completed Project Technical Summaries

This report contains technical summaries of the following LRRB-sponsored reports completed between November 2009 and December 2010:

Mn/DOT's State Research Program Overview

Mn/DOT's mission is to improve access to markets, jobs, goods and services, and to improve mobility by focusing on priority transportation improvements and investments that help Minnesotans travel safer, smarter and more efficiently. **Mn/DOT State Research Program funds**, which in 2010 comprised 34 percent ($3,245,222) of the research funds we administer, are allocated to serve Mn/DOT's strategic directions. In many cases this involves matching dollars from other funding sources, including FHWA State Planning and Research and the University of Minnesota's Center for Transportation Studies (CTS) and Intelligent Transportation Systems Institute (ITS).

"Mn/DOT has a long history as a leader in research and innovation, devoting significant amounts of funding and personnel to its various research programs, including Research Services, MnROAD, NTREC, Minnesota Guidestar and the Toward Zero Deaths initiative."

—Nick Thompson
Director, Mn/DOT Division of Policy, Safety & Strategic Initiatives

TRIG BOARD MEMBERS

Name	Current Title	Phone Number	E-mail Address
Linda Taylor	Director, Research Services (Chair)	(651) 366-3765	Linda.Taylor@state.mn.us
Sue Groth	State Traffic Engineer	(651) 234-7004	Sue.Groth@state.mn.us
Keith Shannon	State Materials Engineer	(651) 366-5590	Keith.Shannon@state.mn.us
Nick Thompson	Director, Policy Analysis, Research & Innovation	(651) 366-4838	Nick.Thompson@state.mn.us
Kathy Hofstedt	Information Systems Director	(651) 366-4048	Kathy.Hofstedt@state.mn.us
Abby McKenzie	Director, Capital Programs & Performance Measures	(651) 366-3770	Abby.Mckenzie@state.mn.us
Jonette Kreideweis	Director, Transportation Data & Analysis	(651) 366-3854	Jonette.Kreideweis@state.mn.us
Dan Dorgan	State Bridge Engineer	(651) 366-4501	Dan.Dorgan@state.mn.us
Jon Chiglo	Director, Technical Support	(651) 366-4826	Jon.Chiglo@state.mn.us
Steve Lund	State Maintenance Engineer	(651) 366-3566	Steven.Lund@state.mn.us
Mike Robinson	District 1 District Engineer	(218) 725-2704	Mike.Robinson@state.mn.us
Lee Berget	District 4A District Engineer	(218) 846-3603	Lee.Berget@state.mn.us
Jim Swanson	District 7 District Engineer	(507) 304-6101	James.Swanson@state.mn.us
Amr Jabr	Metro District—Operations & Maintenance Office Director	(651) 234-7801	Amr.Jabr@state.mn.us

NEW MEMBERS—2011

Name	Current Title	Phone Number	E-mail Address
Phil Forst	FHWA; New member 2011	(651) 291-6110	Phil.Forst@fhwa.dot.gov
Frank Pafko	Director, Environmental Services; New member 2011	(651) 366-3602	Frank.Pafko@state.mn.us
Nancy Daubenberger	State Bridge Engineer; Replaces Dan Dorgan in 2011	(651) 366-4504	Nancy.Daubenberger@state.mn.us
Mike Ginnaty	Director, Technical Support; Replaces Jon Chiglo in 2011	(218) 846-3604	Mike.Ginnaty@state.mn.us
Nelrae Succio	District 6 District Engineer; Replaces Mike Robinson in 2011	(507) 286-7501	Nelrae.Succio@state.mn.us
TBD	Multimodal Representative; New member 2011	TBD	TBD
TBD	Director, Policy Analysis, Research & Innovation	(651) 366-3152	TBD

Research Topic Areas

This year, with input from TRIG, Research Services managers updated the topic area designations we use to categorize research projects to better align them with Department offices and functions. These new research topics areas have been applied to all Mn/DOT research contracts. For simplicity's sake, Research Services now uses these categories to manage all of its projects, including those funded by the LRRB and FHWA State Planning and Research. The intent of this organization is to allow our customers to better understand and access information related to specific topic areas.

Administrative

- Program Administration
- Research Management
- Technology Transfer

Bridge & Structures

- Structures Management
- Structural Design & Analysis
- Structural Materials
- Bridge Rails & Transitions
- Geotechnical Issues
- High Mast Illumination Poles
- Hydraulics & Hydrology
- Overhead Sign Bridges
- Structures Construction

Environmental

- Cultural Resources
- Social and Economic Issues & Impacts
- Noise Analysis
- Erosion Control
- Wetlands
- Air & Water Quality
- Contaminated Properties
- Regulated Materials & Waste
- Forestry
- Wetlands
- Wildlife & Fisheries

Maintenance Operations & Security

- Vegetation Management
- Rest Areas
- Winter Operations
- Pavement Maintenance
- Maintenance Contracting
- Emergency Management
- Pavement Preservation

Materials & Construction

- Geotechnical
- Pavement Design
- Construction Materials
- Construction Operations
- Innovative Contracting
- Pavement Management

Multimodal

- Aviation
- Multi-Modal & Inter-Modal Freight
- Public/Mass Transit
- Ports & Waterways
- Railroads
- Airport
- Commercial Vehicles
- Bicycles

Policy & Planning

- Right of Way Planning, Acquisition & Management
- Statewide Regional & Local Transportation System Planning
- Roadway Planning
- Traffic Data Collection/WIM
- Twin Cities Mobility Modal Plans

Traffic & Safety

- Geometric Design
- Signal Operations
- Pavement Marking
- Railroad Crossing Safety
- Roadside Safety Roadway
- Signing & Delineation

2010 Mn/DOT State Research Highlights

Mn/DOT State Research funds went to support advances across our research topic areas:

- **Bridge & Structures**: Report **2010-39, "Development of an Advanced Structural Monitoring System for Fracture Critical Steel Bridges,"** detailed development of an advanced continuous monitoring system for steel bridges that would provide a distress warning in the event of imminent collapse.
- **Environmental**: Report **2010-20, "Site-Specific Native Grassland Seed Mix Design Methodology for Minnesota,"** created a guide to design site-specific native grassland seed mixes for roadsides, which will help native vegetation thrive while minimizing erosion and maintenance costs.
- **Maintenance Operations & Security**: Report **2010-13, "Evaluation of the SafeLane Overlay System for Crash Reduction on Bridge Deck Surfaces,"** searched for a way to protect bridges from the deteriorating effects of anti-icing chemicals.
- **Materials & Construction**: Report **2010-23, "Construction Report for a Thin Unbonded Concrete Overlay on Minnesota TH 53,"** tested the use of a concrete overlay thinner than those currently used to rehabilitate a pavement; this design could help make pavement maintenance more economical.
- **Multimodal**: Report **2010-34, "Minnesota Truck Parking Study: Phase 2,"** surveyed our state's truck parking capacity problems and identified specific, low-cost opportunities to expand capacity in the places where it is needed most.
- **Policy & Planning**: Report **2010-33, "Hear Every Voice Public Engagement Initiative,"** developed and administered a training curriculum for Mn/DOT employees' public participation in construction planning.
- **Traffic & Safety**: Reports **2010-04, "TH-36 Full Closure Construction: Evaluation of Traffic Operations Alternatives,"** and **2010-21, "Traffic Flow, Road User Impacts of the Collapse of the I-35W Bridge Over the Mississippi River,"** studied optimal methods of traffic diversion during construction.

Report 2010-39, "Development of an Advanced Structural Monitoring System for Fracture Critical Steel Bridges," studied tiered-arch bridges like the Cedar Avenue Bridge. These bridges lack redundancy: The failure of a structural member could lead to collapse. They are consequently particularly important to monitor.

In Report 2010-02, "Comparison of Dual-Phase and Static Changeable Message Signs to Convey Airline Information on Interstate Freeways," researchers used a driving simulator to compare the use of overhead dual-phase to multiple static Changeable Message Signs for effectiveness in conveying airline information to drivers approaching the Minneapolis-St. Paul International Airport by highway.

Transportation Research Syntheses

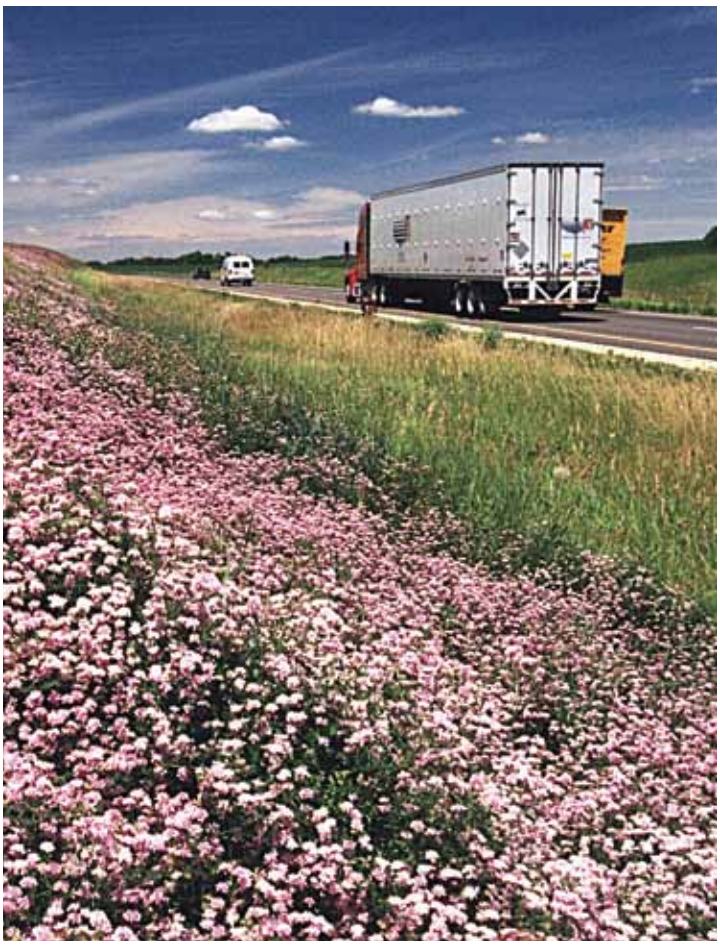
In 2010, Mn/DOT Research Services conducted nine Transportation Research Syntheses. TRSs are low-cost, short-turnaround, targeted reviews of literature and/or current practices in an area of interest to Mn/DOT management or researchers. TRSs allow our customers and staff to better understand research under way, to identify research gaps and implementation opportunities, and to leverage existing research to improve our programs.

TRSs can be requested by any Mn/DOT staff member, subject to supervisor and Research Services approval. All of the TRSs listed below, plus documents generated in past years, can be found at **www.dot.state.mn.us/research/transportation-research-syntheses.html**. For more information about requesting a TRS, contact Shirlee Sherkow at **Shirlee.Sherkow@state.mn.us**.

TRS1001 Effects of Major Traffic Generators on Local Highway Systems
TRS1002 Effectiveness of Traffic Signs on Local Roads
TRS1003 Developing a Culture of Innovation
TRS1004 ADA Compliance Reference and Training Materials
TRS1005 State DOT Experiences with Primavera P6 Project Management Software
TRS1006 Cadastral and Right of Way Data Sharing
TRS1007 Decision Tree for Unpaving Roads
TRS1008 Potential Benefits to the Freight Industry of Distance-Based Road User Fees
TRS1009 Effects of 24-Hour Headlight Use on Traffic Safety

Mn/DOT State Research Program Completed Project Technical Summaries

This report contains Technical Summaries of the following SRP-sponsored reports completed between November 2009 and December 2010:



The seed mix design manual created for Report 2010-20, "Site-Specific Native Grassland Seed Mix Design Methodology for Minnesota," includes instructions for seeding prairie smoke flowers, an example of roadside vegetation native to Minnesota.

FHWA State Planning and Research Reporting

State Planning and Research (SP&R) funds, which comprised 28 percent ($2,742,215; see figure 1 on page 9) of Mn/DOT's 2010 budget, are received from the Federal Highway Administration (FHWA) for Mn/DOT planning and research activities. The most recent transportation authorization act—the Safe, Accountable, Flexible, Efficient Transportation Equity Act—requires that a minimum of 25 percent of these funds are to be used specifically for research (designated SP&R Part II) to address state-specific research needs, with the remaining portion going to planning, administration and other needs (SP&R Part I). This publication covers only Part II funds, though it should be noted that unlike most state research programs, Mn/DOT Research Services oversees Part I spending as well.

SP&R Part II funds can be used for participation in multi-state pooled fund efforts, in single-state efforts and research program support. Multi-state pooled funds allow Mn/DOT to leverage its research dollars to facilitate more in-depth studies. Mn/DOT makes maximum use of this opportunity, participating in 54 pooled fund studies. Minnesota is the lead state in 13 of these efforts. (See figure 8.)

Leading Multi-State Collaborations

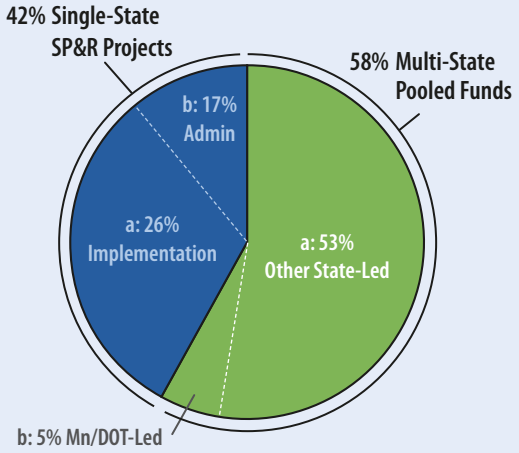
Mn/DOT has been a leader in multi-state pooled fund efforts, spearheading 13 pooled funds including the Clear Roads Winter Highway Operations Pooled Fund (TPF-5(218)), Investigations of Non-Intrusive Traffic Detection Technologies (TPF-5(171)), and Loop and Length Based Classification (TPF-5(192)).

SP&R funds enable Mn/DOT to invest in and pursue long-range strategies and research into innovative new technologies that might not otherwise be feasible. Some highlights of these efforts involve new pavement design testing at the MnROAD facility, intelligent compaction of soils, optimization of maintenance and construction techniques, and projects geared toward meeting regional (that is, the Midwest) and local needs. SP&R funds are often used to fund implementation and technology transfer efforts to ensure that developed innovations are understood and used by Mn/DOT districts and offices.

As figure 8 illustrates, 58 percent of the SP&R Part II budget goes to multi-state pooled funds and 42 percent to single-state projects. $927,000 of our funding goes to program administration, while $786,307 is used to support federal programs (NCHRP and TRB). In 2010, Mn/DOT allocated $774,614 toward implementation efforts.

As figure 9 shows, SP&R funds are invested across all of Mn/DOT's research topic areas (described in the "Mn/DOT's State Research Program Overview" section of this report), with particular emphasis on maintaining and improving Minnesota's infrastructure, from foundational elements like pavements and bridges to elements like rumble strips, signage and roadside barriers that help improve the safety of Minnesota drivers.

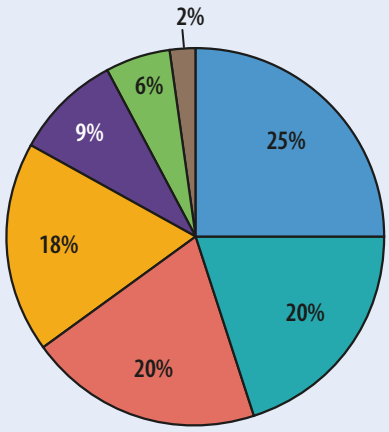
Figure 8. 2010 SP&R Part II Funding Distribution*



Multi-State Pooled Funds		
a: Participation in Pooled Funds Led by Other States	$	1,599,879
b: Mn/DOT-Led Pooled Funds	$	152,500
	$	1,752,379
Single-State SP&R Projects		
a: Implementation	$	774,614
b: Program and Administrative Support	$	512,000
	$	1,286,614
Total	$	3,038,993

*Includes SP&R funds rolled over from previous years.

Figure 9. 2010 SP&R Part II Nonadministrative Funding Distribution by Topic Area



Maintenance Operations & Security	$	300,800
Bridge & Structures	$	240,600
Materials & Construction	$	240,000
Traffic & Safety	$	216,700
Policy & Planning	$	108,214
Environmental	$	66,667
Multimodal	$	25,000
Total	**$**	**1,197,981**

Program Administration: $927,000

Federal Program Support (NCHRP and TRB Core Services): $786,307

Research Services is responsible for the administration of the SP&R program. Deb Fick serves as the SP&R program administrator, managing funding requests from other offices for new and ongoing projects, monitoring program expenditures and developing an annual work program that includes research project updates to meet FHWA requirements. She and other staff members serve as Administrative Liaisons for all SP&R projects.

2010 SP&R Research Highlights

- Minnesota made use of the MnROAD test facility through several projects to improve the surface characteristics of Minnesota's roads. For instance, Report **2010-40, "Influence of Pavement on Traffic Noise—Statistical Pass-By Measurements of Traffic on Several Interstate Pavements,"** funded through SP&R projects TPF-5(134), MPR-6(029) and MPR-6(021), used MnROAD test sections to evaluate pavement surface finishes to see which was the quietest.
- **TPF-5(190): Northwest Passage III**, an eight-state pooled fund effort led by Minnesota, received the 2010 Best of ITS Rural Award, in the category "Best New Practice." The pooled fund study works to integrate traveler information systems and coordinate maintenance operations across state borders along the I-90/I-94 corridor from Wisconsin to Washington.
- **TPF-5(148): The Effects of Implements of Husbandry "Farm Equipment" on Pavement Performance** is an ongoing MnROAD study led by Mn/DOT and supported by four states, the Local Road Research Board (LRRB) and the Professional Nutrient Applicators Association of Wisconsin that studies pavement response to various types of agricultural equipment, which may have additional axles and different-size tires, to support policy and design decisions.

In Report 2010-40, "Influence of Pavement on Traffic Noise—Statistical Pass-By Measurements of Traffic on Several Interstate Pavements," investigators monitored pavement noise for test sections using microphones placed at distances of 100 feet, 500 feet and directly adjacent to the road.

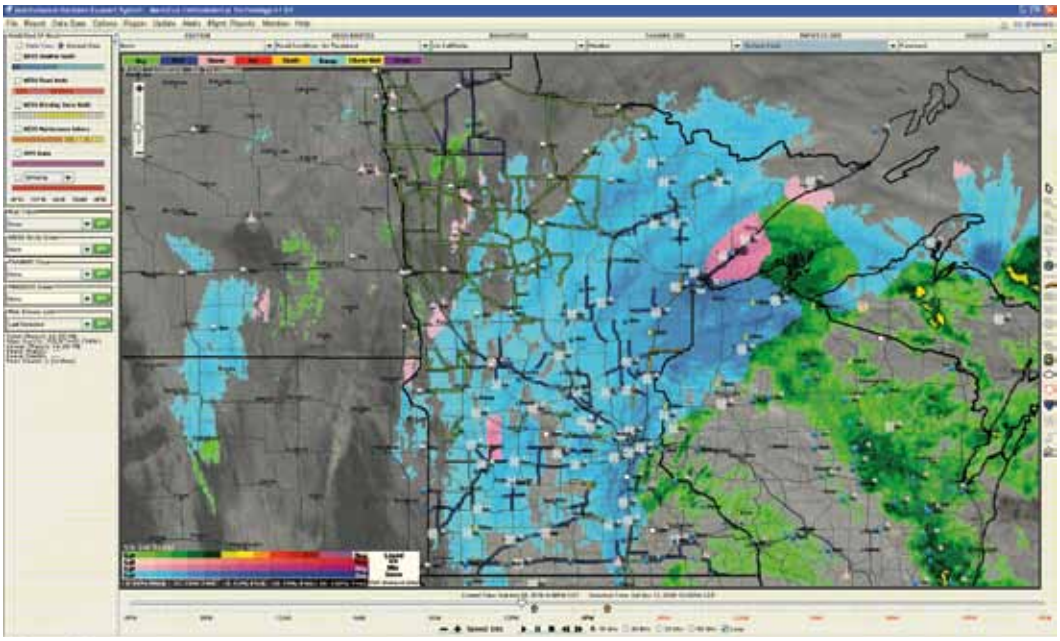
The National Cooperative Highway Research Program

The National Cooperative Highway Research Program (NCHRP) receives 5.5 percent of all states' SP&R Part II funding to fund the national need for research into highway planning, design, construction, operations and maintenance. This research includes the evaluation of fundamental new technologies and techniques, and sharing of best practices between states. These reports have direct effects on Minnesota; for example, Report 641, "Guidance for the Design and Application of Shoulder and Centerline Rumble Strips," was used in 2010 to help establish a new Mn/DOT technical memorandum requiring centerline rumble strips and helped address concerns regarding this low-cost safety measure from Mn/DOT's Maintenance personnel.

Mn/DOT staff actively participates on many NCHRP technical panels (31 in 2010) as well as on panels for other cooperative programs such as the Transit Cooperative Research Program and the Strategic Highway Research Program 2. A list of these memberships can be found in this report on page 58.

Pooled Fund Study Technical Summaries

A new effort was launched in 2010 to communicate the focus and benefits of Mn/DOT's investments in multi-state pooled fund studies. Technical Summaries on the following multi-state pooled funds can be found in this document on the page numbers listed:



TPF-5(054): Development of Maintenance Decision Support System (MDSS) Pooled Fund has developed and is deploying an automated software tool to provide real-time winter maintenance treatment recommendations. This MDSS image shows a recent storm in Minnesota; users can select a variety of views of this event, including a timeline of its progression, to support maintenance decisions.

SP&R Single-State Project Technical Summaries

In addition, this report contains Technical Summaries of the following reports completed in 2010 (or late 2009) that were sponsored using SP&R funding:

Completed SP&R Reports

The following reports were published through Mn/DOT in 2010 or late 2009. They include multiple MnROAD products and some projects cooperatively funded with Mn/DOT's State Research Program.

2009-42: TPF-5(165): Asphalt Mixture and Binder Fracture Testing for 2008 MnROAD Construction

Project Cost: $55,000
Performed by: University of Minnesota
PI: Mihai Marasteanu
TL: Timothy Clyne **AL:** Bruce Holdhusen
Description: Researchers evaluated the low-temperature fracture properties of 12 asphalt mixtures and nine asphalt binders used in the 2008 MnROAD reconstruction project. Results will help departments of transportation choose materials that are fracture-resistant in cold weather and provide baseline data for several other low-temperature cracking research efforts.

2010-04: TH-36 Full Closure Construction: Evaluation of Traffic Operations Alternatives

Project Cost: $109,890
Performed by: University of Minnesota **PI:** John Hourdos
TL: Christopher Roy, Colleen VanWagner
AL: Bruce Holdhusen
Description: Researchers evaluated the impact of the first large-scale full closure construction project in Minnesota. They found full closure to be a viable, cost-saving construction alternative under these circumstances and gained valuable knowledge of the tools used to evaluate future project alternatives.

2010-08: Incorporation of Recycled Asphalt Shingles in Hot Mix Asphalt Pavement Mixtures

Project Cost: N/A
Performed by: Iowa State University **PI:** Chris Williams
TL: Roger Olson **AL:** Deb Fick
Description: Researchers investigated the effect of asphalt binder grade and content, RAP source and content, and different shingle sources and proportions on HMA mixture properties, and made recommendations for a comprehensive shingle specification including the option of using tear-off scrap shingles.

2010-13: Evaluation of the SafeLane Overlay System for Crash Reduction on Bridge Deck Surfaces

Project Cost: $35,400
Performed by: University of Minnesota–Duluth
PI: John Evans
TL: Farideh Amiri **AL:** Nelson Cruz
Description: Researchers investigated the effectiveness of the Cargill SafeLane™ anti-icing overlay system on bridge decks and found that while it significantly increased traction and reduced crash rates, it was subject to rapid wear from traffic and snowplows.

2010-15: Mn/DOT Combined Smoothness Specification

Project Cost: $43,000
Performed by: Minnesota State University, Mankato
PI: W. James Wilde
TL: Thomas Nordstrom **AL:** Bruce Holdhusen
Description: Investigators unified Mn/DOT asphalt and concrete pavement smoothness specifications using the International Roughness Index, added new requirements to improve the profiling process and developed a certification training program for profiler operators.

2010-20: Site-Specific Native Grassland Seed Mix Design Methodology for Minnesota

Project Cost: $123,840
Performed by: Scale Tec LTD **PI:** L. Peter MacDonagh
TL: Kenneth Graeve **AL:** Shirlee Sherkow
Description: Researchers worked with experts from every aspect of the seed community to produce a step-by-step guide to designing site-specific native grassland seed mixes for use along roadsides in Minnesota.

2010-25: MPR-9(003): Design of Turn Lane Guidelines

Project Cost: $37,512
Performed by: CH2M Hill, Inc. **PI:** Howard Preston
TL: Glen Ellis **AL:** Shirlee Sherkow
Description: Investigators assembled a guide that identifies and analyzes the primary factors influencing turn lane design. The new design guidelines provide a detailed, step-by-step process to calculate safe and effective turn lane length based on the specific characteristics of each intersection.

2010-26: MnROAD Data Mining, Evaluation and Quantification—Phase I

Project Cost: $72,000
Performed by: University of Minnesota **PI:** Randal Barnes
TL: Thomas Burnham **AL:** Shirlee Sherkow
Description: Researchers created a procedure to flag questionable, erroneous and unreliable data in the MnROAD temperature record database. They also created summary tables and graphs of the resulting reliable data, which can be used by researchers worldwide to develop, test and ultimately improve road designs. The system developed in this project can also be used for ongoing filtering of temperature data as it is collected at MnROAD.

2010-28: Air Voids Testing for MnROAD Cells

Project Cost: $14,800
Performed by: University of Minnesota
PI: Mihai Marasteanu
TL: Timothy Clyne **AL:** Nelson Cruz
Description: Researchers evaluated the air void content of different asphalt mixtures by testing core samples extracted from various MnROAD cells. Analysis of the data was not part of this study.

2010-30: Construction Report for MnROAD Thin Unbonded Concrete Overlay Test Cell 5 (Sub-Cells 105-405)

Project Cost: $126,100
Performed by: Mn/DOT Office of Materials
PI: Mark Watson
TL: Bernard Izevbekhai **AL:** Bruce Holdhusen
Description: Researchers instrumented MnROAD Cell 5, which had recently received a thin unbonded concrete overlay, with electronic sensors for collecting environmental and load response data over the following year. The report includes a description of the physical characteristics of the test cell, construction plans, and a summary of initial material tests and various surface characteristic measurements.

2010-32: 2008 MnROAD Unbound Quality Control Construction Report

Project Cost: $49,656
Performed by: CNA Consulting Engineers, Inc.
PI: D. Lee Petersen
TL: John Siekmeier **AL:** Bruce Holdhusen
Description: Researchers used field and laboratory tests to refine quality control and assurance procedures for intelligent compaction and to further establish its relationship to mechanistic-empirical pavement design.

2010-33: Hear Every Voice Public Engagement Initiative

Project Cost: $230,798
Performed by: University of Minnesota **PI:** Jim Grothaus
TL: Scott Bradley **AL:** Rebecca Lein
Description: Investigators developed and administered a training curriculum on the core principles of Mn/DOT's public involvement guidance, designed to assist employees in the planning, implementation and evaluation of public and stakeholder participation.

2010-36: Evaluation of Non-Intrusive Technologies for Traffic Detection

Project Cost: $185,020
Performed by: SRF Consulting Group, Inc.
PI: Erik Minge
TL: Jerry Kotzenmacher **AL:** Deb Fick
Description: Continuing with research that began in 1994, this project evaluated the accuracy of the newest generation of nonintrusive traffic detection technologies that collect speed and volume data, and have the added capability of gathering classification data.

2010-40: Influence of Pavement on Traffic Noise—Statistical Pass-By Measurements of Traffic on Several Interstate Pavements

Project Cost: $62,957
Performed by: HDR Engineering **PI:** Tim Casey
TL: Bernard Izevbekhai **AL:** Nelson Cruz
Description: Researchers compared the relative loudness of several pavement surface finishes by evaluating several test sections on MnROAD and the regional freeway system in Minnesota. Results showed the innovative/ultimate diamond grind to be the quietest, followed by the burlap drag, conventional diamond grind and transverse tine.

Single-State SP&R Projects

This section provides basic information on single-state SP&R Projects with active contracts in 2010, or in some cases, funds were committed in 2010 but have not yet resulted in a contract.

MPR-0(002): Culvert Repair Best Practices, Specifications and Special Provisions

Funded by: SP&R/SRP
Total Cost: $80,000 **Paid to Date:** $0
MN 2010 Commitment: $40,000
Performed by: TBD **PI:** TBD
TL: Jane Butzer **AL:** Bruce Holdhusen
Description: This study will develop a user's manual for culvert replacement or rehabilitation for typical highway maintenance and improvement projects. The manual should provide concise guidance regarding advantages and disadvantages of the previous three options commonly considered for centerline culvert replacement or rehabilitation. It will also include recommended methods and products for joint repair of concrete centerline culverts along with advantages and disadvantages of various methods of repair, cost comparisons, and applicable standard details and special provisions for construction.
Status: This project has just been undertaken; a contract has not yet been finalized.
Start Date: TBD **Projected End Date:** TBD

MPR-0(003): Reporting Capabilities for Continuous Vehicle Class and WIM Data

Funded by: SP&R
Total Cost: $35,268 **Paid to Date:** $0
MN 2010 Commitment: $28,214
Performed by: University of Minnesota, Duluth
PI: Teak Kwon
TL: Benjamin Timerson **AL:** Daniel Warzala
Description: In the previous project, data warehouse and reporting utilities for weigh-in-motion and vehicle classification binary data were successfully developed. The goal of this project is to develop new reporting functions and also modify existing functions to add more capabilities and improve utility. The main upgrade to Bullconverter would be error code translation and nearest 0.01-second time stamp for each vehicle record. Eight new reporting functions in Bullreport will be implemented along with several modifications to existing functions. Bullpiezo will add new functions to recognize FHWA .cla formats and produce reports directly from FHWA-formatted data. Extensive tests on the new software will be conducted.
Status: A kickoff Technical Advisory Panel meeting was held December 7.
Start Date: 11/18/2010 **Projected End Date:** 6/30/2012

MPR-0(004): Scour Monitoring Technology Implementation

Funded by: SP&R/SRP
Total Cost: $87,000 **Paid to Date:** $0
MN 2010 Commitment: $69,600
Performed by: TBD **PI:** TBD
TL: Andrea Hendrickson **AL:** Shirlee Sherkow
Description: Bridge scour causes the loss of material around bridge foundations and can result in bridge failure. Scour-critical bridges are monitored to identify when unacceptable scour is occurring. Two types of monitoring are available: portable and fixed. While fixed instrumentation may be preferred in some cases, Mn/DOT currently uses only portable monitoring devices. This project would install fixed monitoring equipment at two to three bridge sites. Several device options will be analyzed for installation and performance.
Status: This project has just been undertaken; a contract has not yet been finalized.
Start Date: TBD **Projected End Date:** TBD

MPR-6(003): Business Assessment of RSS Processes and Tools

Funded by: SP&R/SRP
Total Cost: $75,000 **Paid to Date:** $16,680
Performed by: Trissential **PI:** Steve Beise
TL: Rose Keller **AL:** Benjamin Worel
Description: Research Services has been redesigning the way services are provided. The primary goal of this project is to

analyze and document the remaining business processes and detail all business flows.
Status: This task is ongoing, with contract work proceeding according to plan.
Start Date: 11/4/2009 **Projected End Date:** 6/30/2011

MPR-6(003): Strategic Program Development

Funded by: SP&R/SRP
Total Cost: $50,000 **Paid to Date:** $28,890
MN 2010 Commitment: $200,000
Performed by: David Johnson **PI:** David Johnson
TL: Benjamin Worel **AL:** Linda Taylor
Description: This project involves working with Research Services to determine and document the workflows and handoff points for managing research contracts involving numerous roles and project phases to optimize the new ARTS database to support Research Services activities.
Status: No tasks were completed in 2010.
Start Date: 12/22/2009 **Projected End Date:** 6/30/2011

MPR-6(004): Investigation and Evaluation of Closeout Memo Data for the Development of Additional Performance Measures

Funded by: SP&R/SRP
Total Cost: $78,490 **Paid to Date:** $78,490
MN 2010 Commitment: $120,000 total for MPR-6(004)
Performed by: William Bunde **PI:** William Bunde
TL: Cory Johnson **AL:** Clark Moe
Description: This project provided expertise and resources to help Research Services review current procedures and processes for evaluating Mn/DOT research and implementation programs; develop, track and report performance and process measures; and where necessary, recommend and develop new research processes and outcome measures.
Status: This project finished in 2010. Researchers developed the state's 2007 and 2008 Research Services and Library measures reports; evaluated closeout memos to determine cost-saving implications; developed additional performance and process measures focusing on selection, research and implementation; participated as an advisor to the Research Management System (ARTS replacement/enhancement); and prepared a monthly activity report and final report.
Start Date: 1/30/2008 **End Date:** 3/31/2010

MPR-6(004): Implementation Plan Development, Closeout Memos and Implementation Communication Products

Funded by: SP&R/SRP
Total Cost: $39,600 **Paid to Date:** $28,380
MN 2010 Commitment: $120,000 total for MPR-6(004)
Performed by: Darlene Gorrill **PI:** Darlene Gorrill
TL: Jake Akervik **AL:** Benjamin Worel
Description: Research Services is developing a streamlined technology transfer process to support a more strategically focused research program that integrates high-level strategies with operational-level goals. Activities will include communications and outreach with other technology transfer efforts; departmentwide training; and creation of roadmaps that identify gaps in research and implementation.
Status: This project finished in 2010. Completed tasks included writing implementation plans and closeout memos, and writing communication materials that support communications and outreach.
Start Date: 4/28/2008 **End Date:** 8/31/2010

MPR-6(004): Implementation and Closeout Program Administration Support

Funded by: SP&R/SRP
Total Cost: $97,500 **Paid to Date:** $97,500
MN 2010 Commitment: $120,000 total for MPR-6(004)
Performed by: Micky Ruiz **PI:** Micky Ruiz
TL: Shirlee Sherkow **AL:** Alan Rindels
Description: Research Services is transitioning from a system that determines research and implementation needs annually to a strategic system of developing roadmaps that determine needs based on research and implementation gaps. The new initiative comprises consultant contracts that will establish a foundation for managing the Mn/DOT Research Program in the future.
Status: This project finished in 2010. Completed tasks included program administration support by evaluating 2010 completed projects and assisting Research Services in transitioning to a roadmap/end user product format for evaluations; training, including the creation of the Guide for Post Project Evaluations; consultant coordination; and contract administration support.
Start Date: 5/30/2008 **End Date:** 8/31/2010

MPR-6(005): Next Generation of ARTS Tech Support and Maintenance Services

Funded by: SP&R/SRP
Total Cost: $108,540 **Paid to Date:** $56,650
MN 2010 Commitment: $40,000
Performed by: ArchWing Innovations, LLC
PI: Ryan Anderson
TL: Nelson Cruz **AL:** Benjamin Worel
Description: The primary goals of this project are to provide technical support and maintenance services for three Web-based applications of the current Next Generation of Automated Research Tracking System. Project activities include training and knowledge transfer to Mn/DOT staff.
Status: This project is now in the ongoing maintenance mode. The consultant will continue to troubleshoot any problems and make minor changes along with enhancements to the new ARTS program.
Start Date: 5/13/2009 **Projected End Date:** 4/30/2011

MPR-6(008): Maintenance Decision Support System (MDSS)

Funded by: SP&R/SRP/Other State Funds
Total Cost: $626,200 **Paid to Date:** $0
MN 2010 Commitment: $140,800
Performed by: TBD **PI:** TBD
TL: Curtis Pape **AL:** Debra Fick
Description: The objective of the Maintenance Decision Support System project is to prototype an advanced decision support capability that would serve as a springboard for further development and implementation by the private sector for state DOT clients. The MDSS prototype capitalizes on existing road and weather data sources, fuses data to make an integrated and understandable presentation of current and predicted road weather conditions, and provides a decision support tool that generates recommendations on road treatment strategies with anticipated consequences of action or inaction. The system also allows users to analyze alternative courses of action.
Status: This project has just been undertaken; a contract has not yet been finalized.
Start Date: TBD **Projected End Date:** TBD

MPR-6(012): Development of New Test Roller Equipment and Construction Specs for Subgrade Compaction Acceptance

Funded by: SP&R/SRP
Total Cost: $253,300 **Paid to Date:** $86,684
Performed by: Minnesota State University, Mankato
PI: Aaron Budge
TL: Tim Anderson **AL:** Daniel Warzala
Description: The purpose of this project is to develop a more effective test roller system. New specifications will be developed that improve the existing test roller specs and account for variations in projects (such as the type of subgrade or the thickness of the base material).
Status: Difficulty in implementing a resilient modulus testing system has extended the time needed to collect data with which to relate stiffness and strength from lab tests. A test roller system has been developed that functions well. Additional time is needed to show that the deflection model developed in an earlier study works appropriately, and to validate the construction specification through field personnel. A Technical Advisory Panel meeting was held August 4.
Start Date: 1/24/2008 **Projected End Date:** 6/30/2011

MPR-6(019): Technology Transfer Material Development—Phase II

Funded by: SP&R/SRP
Total Cost: $99,949 **Paid to Date:** $99,949
MN 2010 Commitment: $400,000
Performed by: CTC & Associates LLC **PI:** Patrick Casey
TL: Cory Johnson **AL:** Jake Akervik
Description: Mn/DOT supports the continued development of outreach materials that market the products and services of the Research Services Section and the Local Road Research Board. Through various publications, reports and technical transfer materials, Research Services communicates the findings of research results and conveys the services it provides.
Status: In 2010, the contractor delivered the 2009 Annual Research Report, the 2009 Research Services and LRRB At-A-Glance documents, the SPR work plan appendix, 2009 Minnesota TRB Guide, Technical Summaries and other technical transfer materials.
Start Date: 4/29/2008 **End Date:** 1/31/2010

MPR-6(019): Technology Transfer Material Development—Phase IV

Funded by: SP&R/SRP
Total Cost: $99,954 **Paid to Date:** $88,640
Performed by: CTC & Associates LLC **PI:** Patrick Casey
TL: Jake Akervik **AL:** Benjamin Worel
Description: The focus of this project is to produce materials created for 2009's year-end reporting. It also provides Research Services and the Local Road Research Board with additional technical transfer materials to communicate the results of Mn/DOT's federal- and state-funded research efforts to department staff, city and county employees, and other stakeholders.
Status: In 2010, the contractor delivered the 2009 Annual Research Report, 2009 Research Services and LRRB At-A-Glance documents, the 2009 Minnesota TRB Guide, pooled fund support and other technical transfer materials.
Start Date: 9/24/2009 **Projected End Date:** 4/30/2011

MPR-6(019): Technology Transfer Material Development—Phase V

Funded by: SP&R/SRP
Total Cost: $99,848 **Paid to date:** $99,581
Performed by: CTC & Associates LLC **PI:** Patrick Casey
TL: Jake Akervik **AL:** Benjamin Worel
Description: Mn/DOT supports the continued development of outreach materials that market the products and services of Research Services and the Local Road Research Board. Through various publications, reports and technical transfer materials, Research Services communicates the findings of research results and conveys the services it provides.
Status: In 2010, the contractor delivered Technical Summaries, Transportation Research Syntheses and other technical transfer materials.
Start Date: 2/8/2010 **End Date:** 10/31/2010

MPR-6(019): Technology Transfer Material Development—Phase VI

Funded by: SP&R/SRP
Total Cost: $99,825 **Paid to Date:** $26,221
Performed by: CTC & Associates LLC **PI:** Patrick Casey
TL: Jake Akervik **AL:** Benjamin Worel
Description: This project will develop outreach materials to market products and services provided by Research Services and the Local Road Research Board, and distribute these materials to current and potential customers.
Status: In 2010, the contractor delivered Technical Summaries, Transportation Research Syntheses and other technical transfer materials.
Start Date: 9/17/2010 **Projected End Date:** 9/30/2011

MPR-6(020): Crash Mapping and Analysis Tool (MnCMAT)

Funded by: SP&R/Other State Funds
Total Cost: $162,720 **Paid to Date:** $162,720
Performed by: Great Arc Technologies, Inc.
PI: Michael Scanlon
TL: Richard Kjonaas, Mark Vizecky **AL:** Clark Moe
Description: In this study, researchers will implement the Crash Mapping and Analysis Tool (CMAT) crash analysis software for Mn/DOT-provided maps and data, and provide training for analyzing highway safety data.
Status: Tasks completed in 2010: 1) Phase 1: Detail Design 2) Phase 2: Proof of Concept/Prototype 3) Phase 3: Development 4) Phase 4: Implementation
Start Date: 9/21/2009 **End Date:** 8/31/2010

MPR-6(022): INV 864: Recycled Asphalt Pavements

Funded by: SP&R/LRRB/Other State Funds
Total Cost: $200,000 **Paid to Date:** $25,000
Performed by: Mn/DOT Office of Materials
PI: Eddie Johnson
TL: Roger Olson **AL:** Bruce Holdhusen
Description: This project will study the performance of recycled asphalt pavement under controlled testing conditions. The asphalt concrete test sections will have similar structural designs and contain 30 percent RAP but vary by binder grade and fractionated RAP content. In 2009 three new mix designs were added: warm mix with RAP, Superpave with no RAP and Superpave with 20 percent RAP.
Status: Researchers performed lab tests on construction samples to assess if and how the RAP is affecting the mix properties, and the results will be summarized. The annual reports for years one and two will be combined.
Start Date: 1/4/2008 **Projected End Date:** 12/31/2012

MPR-6(029): INV 868: HMA Surface Characteristics

Funded by: LRRB/SP&R/Other State Funds
Total Cost: $326,632 **Paid to Date:** $84,625
Performed by: Mn/DOT Office of Materials
PI: Timothy Clyne
TL: Greg Johnson **AL:** Bruce Holdhusen
Description: This study focuses on key pavement surface characteristics like noise and friction while also studying their relationship to ride quality, texture and mixture durability. Researchers will conduct statistical pass-by noise monitoring and data analysis to make relative comparisons of pavement surfaces on the Interstate test sections at the Minnesota Road Research Facility.
Status: Researchers performed additional surface characteristic measurements including statistical pass-by (noise), effective flow resistivity (sound absorption), Robotex (3-D surface texture) and rolling resistance (fuel efficiency). In addition, consultants were hired to perform advanced data analysis on certain surface characteristic measurements (such as the effect of texture on sound absorption). The first-year performance of various HMA surfaces was summarized. Surface characteristics (noise, texture, friction, ride, durability) were measured seasonally, and comparisons were made across both time and test section for each measure.
Start Date: 9/18/2007 **Projected End Date:** 6/30/2013

MPR-6(031): Concrete Pavement Optimization: Determining the Lower Threshold of Slab Thickness for High Volume Roadways

Funded by: SP&R/Other State Funds
Total Cost: $126,100 **Paid to Date:** $0
Performed by: Mn/DOT Office of Materials
PI: Thomas Burnham
TL: Bernard Izevbekhai **AL:** Bruce Holdhusen
Description: This project will develop better distress and life prediction models for more optimized (thinner) concrete pavements. Secondary objectives include understanding the behavior of these pavements with regard to maturity, slab warp and curl, thermal expansion and repair techniques. Researchers will conduct seasonal load response testing and monitor the field performance of an instrumented variable thickness concrete pavement test cell.

Status: This project is ongoing; reporting will begin when a pavement fails. Seasonal monitoring and performance reporting will take place each year.
Start Date: 1/3/2008 **Projected End Date:** 7/31/2014

MPR-6(033): TRACS Research and Implementation Project

Funded by: SP&R/SRP/Other State Funds
Total Cost: $310,000 **Paid to Date:** $268,319
Performed by: Project Information Services
PI: L. Tim Malagon
TL: Thomas Wiener **AL:** Clark Moe
Description: This project will evaluate available construction project management software with a focus on TRACS software. Stakeholder interviews will identify barriers to its implementation and use. A detailed review of the software and its capabilities will be conducted, and the project team will assist in developing and delivering training and presentations to Mn/DOT and state industry groups.
Status: Researchers made revisions and enhancements, created a migration plan for data and documented changes to TRACS.
Start Date: 3/12/2008 **Projected End Date:** 6/30/2011

MPR-6(033): Construction Project Management Software Evaluations

Funded by: SP&R/SRP/Other State Funds
Total Cost: $138,697 **Paid to Date:** $12,168
Performed by: Minnesota State University, Mankato
PI: W. James Wilde
TL: Thomas Wiener **AL:** Clark Moe
Description: This project will evaluate available construction project management software with a focus on TRACS software. Stakeholder interviews will identify barriers to its implementation and use. A detailed review of the software and its capabilities will be conducted, and the project team will assist in developing and delivering training and presentations to Mn/DOT and state industry groups.
Status: In 2010, researchers reviewed existing literature and software.
Start Date: 9/24/2008 **Projected End Date:** 10/31/2011

MPR-8(002): Vehicle Telematics for Novice Teenage Driver Support System—Smartphone Based Novice Teenage Driver Support

Funded by: SP&R
Total Cost: $500,000 **Paid to Date:** $391,184
Performed by: University of Minnesota **PI:** Max Donath
TL: Susan Sheehan **AL:** Daniel Warzala
Description: This project will develop a Teenage Driver Support System demonstration based on smart-phone technology that will prevent vehicle operation when alcohol is detected or seat belts are unfastened. Various on-board technologies will communicate with in-vehicle subsystems to provide real-time feedback to teen drivers about unsafe or illegal activities such as speeding and stop sign noncompliance.
Status: In 2010, researchers developed the Teenage Driver Support System, set up a usability review protocol and conducted a usability review protocol.
Start Date: 12/9/2008 **Projected End Date:** 5/31/2011

MPR-8(004): Development of a Concrete Maturity Test Protocol

Funded by: SP&R/SRP
Total Cost: $113,952 **Paid to Date:** $61,944
Performed by: Minnesota State University, Mankato
PI: W. James Wilde
TL: Robert Golish **AL:** Sandy McCully
Description: The overall objective of this project is to develop strength-maturity relationships in concrete that will allow contractors, field personnel and materials engineers to estimate the strength of high-pozzolan/SCM and low-w/c concrete pavement mixes in the field, with reduced sampling and testing of concrete. Specific goals are to test strength-maturity relationships in the laboratory, develop a standard test method for maturity testing and reduced physical testing in the field, and establish field strength-maturity relationships.
Status: Researchers conducted field validation for year one goals and developed a procedure for the sensor placement and specimen preparation for field sites. They also developed a lab testing plan and matrix for establishing strength-maturity curves.
Start Date: 4/2/2009 **Projected End Date:** 9/30/2012

MPR-8(006): Anti-Icing Technology Implementation

Funded by: SP&R/SRP
Total Cost: $98,348 **Paid to Date:** $98,348
Performed by: EVS **PI:** Paul Keranen
TL: Sue Lodahl **AL:** Bruce Holdhusen
Description: The goals of this project are to develop an anti-icing implementation plan that assesses the current state of anti-icing within each district; identifies resource gaps and needs; and creates a plan for a uniform, more consistent level of anti-icing statewide. Guidelines for effective anti-icing based upon research and the experience of other DOTs and districts will be created.
Status: The contractor conducted a user assessment, which helped identify districts' anti-icing best practices currently in place and established practices at other DOTs. The contractor also developed a guide that documents best practices and lessons learned, and identifies gaps and barriers to implementing an effective anti-icing program.
Start Date: 6/12/2009 **End Date:** 10/19/2010

MPR-9(001): Stabilized Full Depth Reclamation (SFDR) Implementation

Funded by: SP&R/SRP
Total Cost: $50,111 **Paid to Date:** $35,000
Performed by: American Engineering Testing, Inc.
PI: Dave Rettner
TL: John Hager, Steven Adamsky **AL:** Clark Moe
Description: This project will generate two mix designs for full depth reclamation projects to be constructed during 2010. These designs will use three asphalt emulsions and will, if successful, aid in the standardization of Mn/DOT's FDR procedures.
Status: In 2010, sources for samples were selected, and coarse aggregate and bituminous samples were selected. Researchers performed three FDR mix designs, meeting the requirement of 2331-FDRE for TH70 in District 1.
Start Date: 9/18/2009 **Projected End Date:** 2/28/2011

MPR-9(002): Concrete Bridge Deck Crack Sealant Evaluation and Implementation

Funded by: SP&R/SRP
Total Cost: $80,918 **Paid to Date:** $5,899
Performed by: Braun Intertec Corporation
PI: Mathew Oman
TL: James Lilly **AL:** Daniel Warzala
Description: This study will examine the performance of the best candidate crack-repair materials in Mn/DOT bridges. The scope of work includes field testing, evaluation of crack sealant products, depth of penetration, product effectiveness and performance validation. A best practices manual will be created for Mn/DOT practitioners.
Status: During a Technical Advisory Panel meeting held in June, the group discussed the best methods for evaluating the performance of the 11 crack sealers being tested. Researchers tested a water pressure device to assess the ability of crack sealers to prevent water ingress. They also selected a bridge for testing but the tests were delayed until spring 2011.
Start Date: 9/30/2009 **Projected End Date:** 3/31/2013

MPR-9(004): Load and Resistance Factor Design (LRFD) Pile Driving Static Load Test Data Collection (LRFD Implementation)

Funded by: SP&R
Total Cost: $96,000 **Paid to Date:** $0
MN 2010 Commitment: $96,000
Performed by: TBD **PI:** TBD
TL: Derrick Dasenbrock **AL:** Bruce Holdhusen
Description: Several states, including Minnesota, have recently completed research to develop new pile design formulas using the LRFD mandated by AASHTO. This project will collect Minnesota static load test data and PDA/CAPWAP data for calibrating the LRFD model.
Status: This project has just been undertaken; a contract has not yet been finalized.
Start Date: TBD **Projected End Date:** TBD

MPR-9(006): Research Implementation of the SMART Signal System on TH13

Funded by: SP&R/SRP
Total Cost: $239,000 **Paid to Date:** $0
Performed by: University of Minnesota **PI:** Henry Liu
TL: Steven Misgen **AL:** Shirlee Sherkow
Description: The SMART-Signal (Systematic Monitoring of Arterial Road Traffic and Signals) system generates both intersection and arterial performance measures in real time. At single intersection level, SMART-Signal can monitor the maximum queue length, intersection delay and level of service. At arterial level, it can report travel time, speed and average number of stops. In this project, researchers will design hardware for the TS-2 controller cabinet using Bus Interface Unit connection, and user-friendly graphical interface for system installation and day-to-day traffic management. The redesigned system hardware and software will be tested on TH13 at 14 intersections between Yankee Doodle Road and TH101.
Status: No tasks were completed in 2010.
Start Date: 12/17/2009 **Projected End Date:** 2/2/2012

LAB 878: Porous Asphalt Pavement Performance in Cold Regions

Funded by: SP&R/LRRB/Other State Funds
Total Cost: $71,000 **Paid to Date:** $22,400
Performed by: Mn/DOT Office of Materials
PI: Mathew Lebans
TL: Larry Matsumoto **AL**: Bruce Holdhusen
Description: The objectives of this research are to evaluate the durability, hydrologic characteristics and environmental effects of porous asphalt pavement when used on a low-volume roadway in a cold climate. Appropriate construction and maintenance procedures will be documented.
Status: Researchers conducted continuous pavement and environmental monitoring and maintenance. They also prepared a midpoint hydrological and environmental report.
Start Date: 7/26/2007 **Projected End Date:** 4/30/2012

LAB 878: Investigation of High Performance (60-Year Design) Concrete Pavement MnROAD

Funded by: SP&R/Other State Funds
Total Cost: $113,300 **Paid to Date:** $0
Performed by: Mn/DOT Office of Materials
PI: Ryan Rohne
TL: Thomas Burnham **AL:** Bruce Holdhusen
Description: Increased traffic congestion and reduced highway construction budgets are placing an emphasis on designing and constructing long-life pavements. The new goal for Minnesota's urban high-volume concrete highways is a 60-year design life. This study will develop an improved service life prediction model for Mn/DOT's current 60-year concrete pavement designs. Secondary objectives include understanding the behavior of these pavements with regards to maturity, slab warp and curl, and thermal expansion.
Status: No tasks were completed in 2010.
Start Date: 12/29/2008 **Projected End Date:** 2/28/2012

Mn/DOT-Led Multi-State Pooled Fund Projects

This section provides basic information on Mn/DOT-led SP&R Projects funded by multiple states that were active in 2010. In some cases, state financial commitments ended prior to 2010, but these funds are still being spent.

TPF-5(070): International Conference on Accelerated Pavement Testing

Number of Participating States: 8
URL: http://www.pooledfund.org/projectdetails.asp?id=298&status=4
Funded by: SP&R/SRP **Total Cost:** $130,000
Total MN Commitments: $15,000 **MN 2010 Commitment:** $0
Performed by: Mn/DOT **PI:** Ben Worel
TL: Ben Worel **AL:** Debra Fick
Description: The International Conference on Accelerated Pavement Testing provides a forum for the exchange of technical information on accelerated pavement testing and associated topics. Scheduled for fall 2012 at the University of California, Davis, the next conference will include technical sessions, technical field trips and exhibits.
Status: Three successful conferences have been held: in Reno, Nev. (1999); Minneapolis (2004); and Madrid, Spain (2008).
MN Commitment End Date: 2003

TPF-5(129): Recycled Unbound Pavement Materials (MnROAD Study)

Number of Participating States: 6
URL: http://www.pooledfund.org/projectdetails.asp?id=361&status=4
Funded by: SP&R/SRP **Total Cost:** $882,352
Total MN Commitments: $75,000
MN 2010 Commitment: $15,000
Performed by: UW–Madison **PI:** Tuncer Edil
TL: Andrew Eller **AL:** Nelson Cruz
Description: This study will monitor the performance of several test cells constructed with recycled materials in the granular base layers, including blended with virgin materials and 100 percent recycled asphalt and concrete pavement materials. Material properties will be used to verify mechanistic-empirical design inputs, especially variations with changing seasons and moisture regimes.
Status: Seventeen recycled materials samples were received: Four were related to the MnROAD test facility; seven RAP/RPM samples and six RCA samples were received from pooled fund member states and sources in Colorado, Ohio and New Jersey. Researchers completed particle size distributions, moisture density relationships, bench-scale resilient modulus, specific gravity, absorption and impurity content testing. Researchers also evaluated the scaling effects between laboratory and field conditions.
MN Commitment End Date: 2011

TPF-5(132): Investigation of Low Temperature Cracking in Asphalt Pavements, Phase II

Number of Participating States: 7
URL: http://www.pooledfund.org/projectdetails.asp?id=395&status=4
Funded by: SP&R/SRP **Total Cost:** $420,000
Total MN Commitments: $100,000
MN 2010 Commitment: $20,000
Performed by: University of Minnesota
PI: Mihai Marasteanu
TL: Timothy Clyne **AL:** Bruce Holdhusen
Description: Phase I of this study looked at developing a fracture mechanics-based specification for a better selection of asphalt binders and mixtures with resistance to crack formation and propagation. In Phase II, researchers will validate the laboratory test procedures, models and pavement design procedures from Phase I by monitoring two new test sections at MnROAD.
Status: A TAP meeting was held November 23 at Mn/DOT. University of Illinois and University of Minnesota research groups finalized mixture testing and are analyzing data. The University of Wisconsin research group has delivered the subtask on physical hardening of binders. Modifications to the current SCB method were analyzed; more data was gathered and analyzed for low-temperature specification development; and researchers investigated whether creep compliance can be obtained from other current test methods. Researchers also made significant progress on software code integration, debugging and verification of the TC Model. FEM analyses are being performed to investigate the effect of the spatial distribution of aggregates on the thermal-volumetric behavior of mixtures after thermal cycles. Testing has started on the mixtures used for the validation study.
MN Commitment End Date: 2011

TPF-5(134): PCC Surface Characteristics—Rehabilitation (MnROAD Study)

Number of Participating States: 3
URL: http://www.pooledfund.org/projectdetails.asp?id=363&status=4
Funded by: SP&R/SRP **Total Cost:** $275,000
Total MN Commitments: $75,000
MN 2010 Commitment: $15,000
Performed by: Mankato State University **PI:** W. James Wilde
TL: Bernard Izevbekhai **AL:** Bruce Holdhusen
Description: To create smooth pavements, researchers need to quantify the effects of pavement performance parameters. This project will provide data that will optimize pavement quietness, friction, texture and ride. Researchers will determine to what degree total noise is generated by tire-pavement interactions, and they will develop a prediction of noise level based on grinding techniques.
Status: Researchers completed statistical pass-bys testing, issued a draft report and conducted on-board sound intensity testing for ride and texture.
MN Commitment End Date: 2010

TPF-5(148): The Effects of Implements of Husbandry "Farm Equipment" on Pavement Performance (MnROAD Study)

Number of Participating States: 4
URL: http://www.pooledfund.org/projectdetails.asp?id=375&status=4
Funded by: SP&R/SRP **Total Cost:** $433,000
Total MN Commitments: $105,000 **MN 2010 Commitment:** $0
Performed by: University of Minnesota
PI: W. Lev Khazanovich
TL: Shongtao Dai **AL:** Bruce Holdhusen
Description: This study will compare pavement response under various types of agricultural equipment (including the impacts of different tires and additional axles) to the response under a typical five-axle tractor-trailer, allowing policy and design decisions to be driven by direct experimental results rather than by models.
Status: Researchers performed peak-pick analysis on all data collected during spring and fall 2008 and 2009, and spring 2010. Additional Tekscan measurements were collected for vehicles T7 and R6 equipped with radial and flotation tires, and the Tekscan report is currently being revised. Preliminary simulations of pavement response using layered elastic analysis, Tekscan contact area measurements and an optimization software are under way.
MN Commitment End Date: 2008

TPF-5(153): Optimal Timing of Preventive Maintenance for Addressing Environmental Aging in HMA Pavements

Number of Participating States: 4
URL: http://www.pooledfund.org/projectdetails.asp?id=380&status=4
Funded by: SP&R/SRP **Total Cost:** $335,000
Total MN Commitments: $332,205 **MN 2010 Commitment:** $0
Performed by: Asphalt Institute **PI:** Mike Anderson
TL: Tom Wood **AL:** Bruce Holdhusen
Description: The purpose of this study is to determine the proper timing of preventive maintenance treatments to optimize life-cycle costs and pavement performance. Researchers will seek to better understand the aging mechanism and how it can be reduced through pavement preservation. Work will be performed on newly built test sections at MnROAD.
Status: The PI discussed field evaluations and sampling of test sections at a September 10 meeting. Mn/DOT will core and prepare samples to ship to the Asphalt Institute for testing. The next section of fog seal was applied to test cell 24 on September 1. An off-site location was reviewed October 6 for possible inclusion in the project. Sampling was conducted at all Minnesota sites in October and November.
MN Commitment End Date: 2011

TPF-5(165): Development of Design Guide for Thin and Ultrathin Concrete Overlays of Existing Asphalt Pavements

Number of Participating States: 6
URL: http://www.pooledfund.org/projectdetails.asp?id=389&status=4
Funded by: SP&R/SRP **Total Cost:** $360,000
Total MN Commitments: $60,000 **MN 2010 Commitment:** $0
Performed by: University of Pittsburgh
PI: Julie Vandenbossche
TL: Tom Burnham **AL:** Nelson Cruz
Description: The primary purpose of this project is to create a unified national design guide for thin and ultrathin concrete overlays of existing asphalt pavements. In these guidelines, researchers will use existing validated performance models as well as new analytical models that address design aspects not considered in existing methods.
Status: In July, researchers evaluated and adopted the most favorable performance prediction/damage accumulation and structural response models. They will determine if it is beneficial to establish a seasonal resilient modulus value for hot-mix asphalt based on temperature. A draft final report was completed in November.
MN Commitment End Date: 2008

TPF-5(171): Evaluation of Non-Intrusive Traffic Detection Technologies, Phase III

Number of Participating States: 13
URL: http://www.pooledfund.org/projectdetails.asp?id=398&status=4
Funded by: SP&R/SRP **Total Cost:** $210,000
Total MN Commitments: $15,000 **MN 2010 Commitment:** $0
Performed by: SRF Consulting Group **PI:** Erik Minge
TL: Jerry Kotzenmacher **AL:** Debra Fick
Description: The objective of this project is to conduct field tests of the latest generation of non-intrusive traffic sensors to assess the capabilities and limitations in detecting traffic under a variety of conditions. The needs of participating state agencies will determine specific test conditions.
Status: This study was completed in 2010. Researchers completed field testing, data acquisition and data analysis, and prepared a final report.
MN Commitment End Date: 2007

TPF-5(215): Transportation Engineering and Road Research Alliance

Number of Participating States: 5
URL: http://www.pooledfund.org/projectdetails.asp?id=443&status=4
Funded by: SP&R/SRP **Total Cost:** $157,500
Total MN Commitments: $37,500
MN 2010 Commitment: $7,500
Performed by: N/A. TERRA supervises and funds a number of different research projects.
TL: Maureen Jensen **AL:** Debra Fick
Description: The Transportation Engineering and Road Research Alliance was formed in 2004 by a task force of government, industry and academic representatives. TERRA's mission is to develop, sustain and communicate a comprehensive research program on pavement, materials and related transportation engineering challenges, including issues related to cold climates.
Status: In 2010, administrative support was contracted through the University of Minnesota. No payments have been made to date. All subcommittees met. Researchers conducted an annual solicitation for problem statements/proposals and received 22 submittals. They also surveyed TERRA members for interest in 2009 proposals.
MN Commitment End Date: 2014

TPF-5(190): Northwest Passage, Phase III

Number of Participating States: 8
URL: http://www.pooledfund.org/projectdetails.asp?id=412&status=4
Funded by: SP&R/SRP **Total Cost:** $325,000
Total MN Commitments: $50,000
MN 2010 Commitment: $25,000
Performed by: Athey Creek Consultants **PI:** Dean Deeter
TL: Matthew Gjersvik **AL:** Debra Fick
Description: This series of projects will continue to integrate traveler information systems and coordinate maintenance operations across state borders along the I-90/I-94 corridor from Wisconsin to Washington.
Status: In September, researchers completed the second phase of the Northwest Passage travel information Web site and the center-to-center communications concept of operations. A TAP annual meeting was held in March. The project received 2010 Best of ITS Rural Award, in the category "Best New Practice."
MN Commitment End Date: 2010

TPF-5(192): Loop and Length Based Classification Pooled Fund

Number of Participating States: 14
URL: http://www.pooledfund.org/projectdetails.asp?id=416&status=4
Funded by: SP&R/SRP **Total Cost:** $405,000
Total MN Commitments: $40,000
MN 2010 Commitment: $10,000
Performed by: SRF Consulting Group, Inc.
PI: Erik Minge
TL: Gene Hicks **AL:** Debra Fick
Description: Many states are collecting length-based classification data but few are collecting it using the same criteria. Agencies need to know the variability in their collection programs. Field-test installation methods for loops are needed to determine the most cost-effective and best-performing procedures and materials. The number of bins and the length spacing for each bin must be determined. Calibration standards for vehicle length-based measurements must also be established.
Status: The Technical Advisory Committee met in April to finalize the work plan, and held its annual meeting in June. Researchers conducted a literature review and developed testing methodologies to guide the field testing of both loop and non-loop detection approaches.
MN Commitment End Date: 2010

TPF-5(218): Clear Roads Winter Highway Operations Pooled Fund (continued from TPF-5(092))

Number of Participating States: 19
URL: http://www.pooledfund.org/projectdetails.asp?id=446&status=4
Funded by: SP&R/SRP **Total Cost:** $1,955,000
Total MN Commitments: $150,000
MN 2010 Commitment: $25,000
Performed by: CTC & Associates LLC
PI: Patrick Casey
TL: Tom Peters **AL:** Debra Fick
Description: This project emphasizes state agency needs along with technology transfer and implementation in advancing national winter highway operations. Member states will evaluate new tools and practices in both lab and field settings, develop industry standards and performance measures, provide technology transfer and cost/benefit analysis, and support winter highway safety.
Status: In 2010 six research projects were completed, one project is in progress and one is being scoped. The Technical Advisory Committee met twice to review its budget; rate contractor proposals for the new projects; and discuss the results of the latest product experience survey, where states weigh in on their experience with winter maintenance products.
MN Commitment End Date: 2011

Other Active Multi-State Pooled Fund Projects

Number of Participating States excludes FHWA but in some cases includes Canadian provinces.

Study Number	Title	Technical Liaison	Admin. Liaison	Lead State or Agency	Number of participating states	Current MN Commitment End Date	Total Cost	Total MN Commitment	MN 2010 Commitment
SPR-2(207)	Transportation Management Center Pooled Fund Study	Brian Kary	Debra Fick	FHWA	28	2012	$4,912,267	$350,000	$50,000
SPR-3(017), TPF-5(193)	Midwest States Pooled Fund Crash Test Program	Michael Elle	Debra Fick	NE	16	2011	nearly $12,000,000	$1,320,863	$66,700
SPR-3(020)	IVHS Study (ENTERPRISE)	Ray Starr	Debra Fick	IA	9	2009	$1,295,000	$120,000	$0
SPR-3(042)	Aurora Program	Curtis Pape	Debra Fick	IA	18	2011	$3,122,500	$375,000	$25,000
SPR-3(049), TPF-5(198)	Urban Mobility Study	Paul Czech	Debra Fick	TX	13	2010	$1,375,000	$165,000	$70,000
SPR-3(074)	Pavement Research and Technology	Roger Olson	Debra Fick	WA	4	2010	$625,000	$280,000	$15,000
TPF-5(004)	Long—Term Pavement Performance (LTPP) Specific Pavement Study (SPS) Traffic Data Collection	Matthew Oman	Debra Fick	FHWA	24	2009	$14,676,285	$175,000	$0
TPF-5(029)	High Occupancy Vehicle	Janelle Anderson	Debra Fick	FHWA	11	2010	$1,865,000	$150,000	$25,000
TPF-5(035)	Pacific Northwest Snowfighters	Susan Lodahl	Debra Fick	WA	10	2009	$45,000	$30,000	$0
TPF-5(037)	Southeast Superpave Center	Jerry Geib	Debra Fick	AL	20	2009	$1,822,326	$21,500	$0
TPF-5(039)	Falling Weight Deflectometer (FWD)	David Bullock	Debra Fick	FHWA	18	2006	$1,003,825	$55,000	$0
TPF-5(054)	Maintenance Decision Support System (MDSS)	Curtis Pape	Debra Fick	SD	18	2012	$3,069,222	$200,000	$25,000
TPF-5(069)	Core Program Services for a Highway Research, Development and Technology Program	Linda Taylor	Debra Fick	FHWA	20	2010	$6,675,025	$383,115	$127,705
TPF-5(099)	Evaluation of Low Cost Safety Improvements.	David Engstrom	Debra Fick	FHWA	28	2007	$2,670,000	$195,000	$0
TPF-5(105)	Transportation Library Connectivity	Sheila Hatchell	Debra Fick	WI	24	2009	$1,290,000	$100,000	$0
TPF-5(109)	Core Program Services for a Highway Research, Development and Technology Program (TRB)	Linda Taylor	Debra Fick	FHWA	22	2010	$17,500,000	$383,115	$127,705
TPF-5(114)	Roadside Safety Research Program	Michael Elle	Debra Fick	WA	8	2011	$1,000,000	$400,000	$50,000
TPF-5(120)	Deer Vehicle Crash Information and Research (DVCIR) Center	Sue Sheehan	Debra Fick	FHWA	10	2006	$260,000	$50,000	$0
TPF-5(127)	Consortium of Accelerated Pavement Testing (CAPT) and Technical Exchange Partnership	Timothy Clyne	Debra Fick	FHWA	9	2007	$225,000	$25,000	$0
TPF-5(128)	Accelerated Implementation of Intelligent Compaction Technology for Embankment Subgrade Soils Aggregate Base	Tom Ravn	Debra Fick	FHWA	13	2008	$725,000	$75,000	$0
TPF-5(135)	Tire Pavement Noise Research Consortium	Bernard Izevbekhai	Debra Fick	WA	9	2009	$163,000	$25,000	$0
TPF-5(139)	PCC Surface Characteristics: Tire-Pavement Noise Program, Part 3	Bernard Izevbekhai	Debra Fick	IA	8	2008	$690,000	$55,000	$0
TPF-5(144)	Use of Video Feedback in Urban Teen Drivers	Ray Starr	Debra Fick	IA	2	2010	$0	$80,000	$0

Other Active Multi-State Pooled Fund Projects, Cont.

Study Number	Title	Technical Liaison	Admin. Liaison	Lead State or Agency	Number of participating states	Current MN Commitment End Date	Total Cost	Total MN Commitment	MN 2010 Commitment
TPF-5(154)	Census Transportation Planning Products (CTPP) from the American Community Survey	Jonette Kreideweis	Debra Fick	FHWA	10	2007	$1,609,704	$102,546	$0
TPF-5(156)	Mississippi Valley Freight Coalition Pooled Fund	John Tompkins	Debra Fick	WI	10	2010	$1,050,000	$100,000	$25,000
TPF-5(159)	Technology Transfer Concrete Consortium	Maria Masten	Debra Fick	IA	20	2010	$535,000	$25,000	$5,000
TPF-5(164)	Fish Passage in Large Culverts with Low Flows	Petronella DeWall	Debra Fick	FHWA	8	2008	$315,000	$30,000	$0
TPF-5(174)	Construction of Crack-Free Bridge Decks, Phase II.	Paul Kivisto	Debra Fick	KS	14	2011	$995,000	$75,000	$15,000
TPF-5(177)	Improving Resilient Modulus (MR) Test Procedures for Unbound Materials	Shongtao Dai	Debra Fick	FHWA	10	2010	$300,000	$40,000	$20,000
TPF-5(179)	Evaluation of Test Methods for Permeability (Transport) and Development of Performance Guidelines for Durability	Bernard Izevbekhai	Debra Fick	IN	11	2011	$883,000	$87,000	$25,000
TPF-5(187)	Precipitation Frequency Estimates for the Midwestern Region	Andrea Hendrickson	Debra Fick	FHWA	8	2010	$1,236,580	$200,001	$66,667
TPF-5(197)	The Impact of Wide-Base Tires on Pavement Damage: A National Study	Shongtao Dai	Debra Fick	FHWA	7	2012	$60,000	$100,000	$25,000
TPF-5(198)	Urban Mobility Study, 2009 continuation	Paul Czech	Debra Fick	TX	9	2010	$590,000	$165,000	$70,000
TPF-5(202)	HY-8 Culvert Analysis Program—Phase Three of Development Efforts	Petronella DeWall	Debra Fick	FHWA	8	2011	$110,000	$30,000	$10,000
TPF-5(209)	Support of the Transportation Curriculum Coordination Council (TCCC)	Catherine Betts	Debra Fick	FHWA	10	2012	$750,000	$75,000	$15,000
TPF-5(213)	Performance of Recycled Asphalt Shingles in Hot Mix Asphalt	Roger Olson	Debra Fick	MO	9	2010	$765,000	$85,000	$42,500
TPF-5(221)	Accelerated Bridge Construction (ABC) Decision Making and Economic Modeling Tool	Kevin Western	Debra Fick	OR	7	2010	$110,000	$10,000	$10,000
TPF-5(224)	Investigation of Jointed Plain Concrete Pavement Deterioration at Joints and the Potential Contribution of Deicing Chemicals	Bernard Izevbekhai	Debra Fick	IA	7	2013	$390,000	$60,000	$15,000
TPF-5(225)	Validation and Implementation of Hot-Poured Crack Sealant	Jim McGraw	Debra Fick	VA	10	2013	$775,000	$10,000	$25,000
TPF-5(231)	ITS Pooled Fund Program (ENTERPRISE)	Jon Jackels	Debra Fick	MI	10	2011	$1,355,000	$60,000	$30,000
TPF-5(410)	National Cooperative Highway Research Program (NCHRP)	Linda Taylor	Debra Fick	FHWA	All	Ongoing	N/A	N/A	$658,602

Active NCHRP Projects with Mn/DOT Panel Membership

Project Number	Project Title	Mn/DOT Panel Member	Division	Role	Start Date	End Date
D0146	Handbook for Pavement Design, Construction, and Management	Curt M. Turgeon	Policy, Safety & Strategic Initiatives	Member	2009	2011
D0148	Incorporating Pavement Preservation Into the MEPDG	Roger C. Olson	Policy, Safety & Strategic Initiatives	Member	2010	2012
D0362	Guidelines for Accessible Pedestrian Signals	Beverly Farraher	Operations	Member	2001	2012
D0391	Left-Turn Accommodations at Unsignalized Intersections	Brian K. Gage	Modal Planning & Program Mgt	Chair	2008	2010
D0836	Research for the AASHTO Standing Committee on Planning	Timothy A. Henkel	Modal Planning & Program Mgt	Member	1998	Ongoing
D0855	Developing a Logical Model for a Geo-Spatial Right-Of-Way Land Management System	Kevin F. Leonard	Engineering Services	Member	2007	2010
D0868	Citizen's Guide and Discipline-Specific Professionals' Guide for Context-Sensitive Solutions in Transportation	Scott D. Bradley	Engineering Services	Member	2008	2010
D0871	Methodology for Estimating Life Expectancies of Highway Assets	Mark B. Nelson	Modal Planning & Program Mgt	Chair	2009	2011
D0873	Road Pricing, Public Perceptions and Program Development	Kenneth R. Buckeye	Policy, Safety & Strategic Initiatives	Member	2009	2010
D0875	Guidelines for Evaluation and Performance Measurement of Congestion Pricing Projects	Kenneth R. Buckeye	Policy, Safety & Strategic Initiatives	Chair	2009	2011
D0879	Producing Transportation Data Products from the American Community Survey that Comply with Disclosure Rules	Jonette Kreideweis	Modal Planning & Program Mgt	Member	2010	2011
D0885	The Comprehensive Costs of Highway-Rail At-Grade Crossing Crashes	Susan H. Aylesworth	Modal Planning & Program Mgt	Member	Pending	Pending
D0930A	Calibration of Rutting Models for HMA Structural and Mix Design	Shongtao Dai	Policy, Safety & Strategic Initiatives	Member	2005	2011
D0940	Optimization of Tack Coat for HMA Placement	Roger C. Olson	Policy, Safety & Strategic Initiatives	Member	2005	2010
D0943	Mix Design Practices for Warm Mix Asphalt	Timothy R. Clyne	Policy, Safety & Strategic Initiatives	Member	2007	2011
D1071	Evaluation of CIP Reinforced Joints for Full-Depth Precast Concrete Bridge Decks	Daniel L. Dorgan	Engineering Services	Chair	2006	2011
D1077	Use of Automated Machine Guidance (AMG) within the Transportation Industry	Louise K. Barrett	Engineering Services	Member	2009	2011
D1084	Modulus-Based Construction Specification for Compaction of Earthwork and Unbound Aggregate	John A. Siekmeier	Policy, Safety & Strategic Initiatives	Chair	2010	2012
D1085	A Guidebook for Construction Manager-at-Risk Contracting for Highway Projects	Jay J. Hietpas	Engineering Services	Member	Pending	Pending
D1283	Calibration of LRFD Concrete Bridge Design Specifications for Serviceability	David Dahlberg	Engineering Services	Member	2009	2011
D1284	Guidelines for the Load and Resistance Factor Design and Rating of Riveted, Bolted, and Welded Gusset-Plate Connections for Steel Bridges	Kevin Western	Engineering Services	Member	2008	Not Specified
D1533	Guide for Transportation Landscape and Environmental Design	Scott D. Bradley	Engineering Services	AASHTO Monitor	2006	2011
D1539	Superelevation Criteria for Horizontal Curves on Steep Grades	James Rosenow	Engineering Services	Member	2010	2011
D1749	Guide for Effective Tribal Crash Reporting	Linda Aitken	Government Affairs	Member	Pending	Pending

Active NCHRP Projects with Mn/DOT Panel Membership, Cont.

Project Number	Project Title	Mn/DOT Panel Member	Division	Role	Start Date	End Date
D1908	Costs of Alternative Revenue-Generation Systems	Norman S. Foster	Government Affairs	Member	2009	2010
D2036	Highway Research and Technology—International Information Sharing	Mukhtar Thakur	Modal Planning & Program Mgt	Member	1993	2011
D2082	Next Generation Transportation Pooled Fund (TPF) Web site	Susan J. Lodahl	Operations	Chair	2009	2012
D208307	Sustainable Transportation Systems and Sustainability as an Organizing Principle for Transportation Agencies	Robert Edstrom	Engineering Services	Member	2010	2013
D2085	Renewable Energy Guide for Highway Maintenance Facilities	Robert Miller	Operations	Member	2010	2012
D2432	Scour at Wide Piers and Long Skewed Piers	Andrea Hendrickson	Engineering Services	Member	2007	2010
D2433	Development of Design Methods for In-Stream Flow Control Structures	Petronella L. DeWall	Engineering Services	Member	2008	2011

Active NCFRP Projects with Mn/DOT Panel Membership

Project Number	Project Title	Mn/DOT Panel Member	Division	Role	Start Date	End Date
DF022	Applying Benefit-Cost Analysis to Freight Project Selection: Lessons from the Corps of Engineers	William D. Gardner	Modal Planning & Program Mgt	Member	2009	Not Specified
DF024	Preserving and Protecting Freight Infrastructure and Routes	William D. Gardner	Modal Planning & Program Mgt	Member	2009	2011
DF035	Multimodal Freight Transportation Within the Great Lakes-Saint Lawrence Basin	William D. Gardner	Modal Planning & Program Mgt	Chair	2010	2012

Active TCRP Projects with Mn/DOT Panel Membership

Project Number	Project Title	Mn/DOT Panel Member	Division	Role	Start Date	End Date
TB34	Guidebook for Commingling ADA-Eligible and Other Passengers on ADA-Complementary Paratransit Services	Sarah B. Lenz	Employee & Corporate Services	Member	2006	2010
TD13	A Guide for Implementing Bus-On-Shoulder (BOS) Systems	Jennifer Conover	Operations	Member	2006	2011

Active SHRP 2 Technical Expert Task Groups with Mn/DOT Membership

Project Number	Project Title	Mn/DOT Technical Expert Task Group Member	Division	Role	Start Date	End Date
FB026	Guide for the Process of Managing Risk on Rapid Renewal Contracts	Jay J. Hietpas	Engineering Services	Member	2007	2011
FB038	Real-Time Smoothness Measurements on Portland Cement Concrete Pavements During Construction	Bernard Izevbekhai	Policy, Safety & Strategic Initiatives	Member	2009	2011
FC020	Incorporating Reliability Performance Measures into the Transportation Planning and Programming Processes	Peggy A. Reichert	Modal Planning & Program Mgt	Member	2010	2012

Mn/DOT 2010 Research

THESE TABLES ARE ORGANIZED BY RESEARCH TOPIC AREA:

RESEARCH PROJECTS:

- Completed research reports, implementation products and transportation research syntheses that were released from November 2009 to December 2010
- Research contracts completed in 2010 that did not result in a final report
- Other research contracts active in 2010, including some tasks or contracts that are part of larger programs that Mn/DOT tracks individually

POOLED FUND TABLES*:

- Multi-state transportation pooled fund studies led by Mn/DOT
- Other multi-state transportation pooled fund studies in which Mn/DOT participates, either through a 2010 contribution or through past contributions that are still producing value for Minnesota

*Project titles are active hyperlinks in the online PDF version of this document.

FUNDING SOURCE KEY

COPTRS	Cooperative Program for Transportation Research and Studies
LRRB	Local Road Research Board
SRP	Mn/DOT State Research Program
SP&R	State Planning and Research (FHWA)

Click the blue "X" in the "TS" column for a PDF download of the Technical Summary for the project. Technical Summaries are also found in the 2010 Annual Report or at www.research.dot.state.mn.us.

Pooled Fund Studies titles link to pooledfund.org pages.

"Participating States" for some pooled funds includes Canadian provinces and agencies such as FHWA.

Bridges & Structures

Report Number	Project Number	Contract Number	Title	Contractor	Investigator	Technical Liaison	Administrative Liaison	Start Date	End Date	Funding Source	Total Cost	Amount Paid	% Paid	TS
2009-40	2006-015	89261 W011	INV 853: Development of Flexural Vibration Inspection Techniques to Rapidly Assess the Structural Health of Rural Bridge Systems—Phase II	University of Minnesota - Duluth	Brian Brashaw	Chris Morris	Debra Fick	9/12/06	12/31/09	LRRB	$52,980	$52,980	100%	X
2010-03	2006-030	89261 W015	Discrepancies in Shear Strength of Prestressed Beams with Different Specifications	University of Minnesota	Cathy French	Lowell Johnson	Shirlee Sherkow	12/30/08	2/28/10	SRP	$114,390	$114,390	100%	X
2010-14	2008-004	89261 W0112	Bridge Scour Monitoring Technologies: Development of Evaluation and Selection Protocols for Application on River Bridges in Minnesota	University of Minnesota	Jeff Marr	Andrea Hendrickson	Shirlee Sherkow	9/26/08	1/31/11	SRP	$60,000	$60,000	100%	X
2010-39	2009-022	89261 W0144	Development of an Advanced Structural Monitoring System	University of Minnesota	Arturo Schultz	Moises Dimaculangan	Shirlee Sherkow	6/25/09	12/31/10	SRP	$71,933	$71,933	100%	X
N/A	2007-030	96272	Load and Resistance Factor Design (LRFD) Pile Driving Project—Phase II Study	Minnesota State University, Mankato	Aaron Budge	Paul Rowekamp, Gary Person	Nelson Cruz	8/18/10	10/31/12	SRP	$120,000	$0	0%	
N/A	2009-017	89261 W0142	Full Depth Precast Concrete Bridge Deck System—Phase II (Inverted Tee)	University of Minnesota	Cathy French	Keith Molnau	Daniel Warzala	7/30/09	10/31/12	SRP	$165,000	$0	0%	
N/A	2009-022	89261 W0183	Development of an Advanced Warning System for Fracture Critical Steel Bridges—Phase II	University of Minnesota	Arturo Schultz	Moises Dimaculangan	Shirlee Sherkow	9/24/10	3/30/12	SRP	$68,000	$0	0%	
N/A	2009-023	89261 W0145	Wakota Bridge Monitoring Program	University of Minnesota	Arturo Schultz	Arielle Ehrlich	Shirlee Sherkow	6/19/09	5/31/12	SRP	$195,000	$111,697	57%	
N/A	2009-159	95439	MPR-9(002): Concrete Bridge Deck Crack Sealant Evaluation and Implementation	Braun Intertec Corporation	Matthew Oman	James Lilly	Daniel Warzala	9/30/09	3/31/13	SRP, SP&R	$80,918	$5,899	7%	
N/A	2010-009	89261 W0192	Inspection of In-Place Bridges Constructed with Grouted Post-Tensioning Ducts	University of Minnesota - Duluth	Andrea Schokker	Paul Kivisto	Shirlee Sherkow	7/8/10	5/31/12	SRP	$123,195	$0	0%	
N/A	2010-014	89261 W0200	Validation of Prestressed Concrete I-Beam Deflection and Camber Estimates	University of Minnesota	Cathy French	Brian Homan	Daniel Warzala	5/11/10	7/31/12	SRP	$100,000	$5,000	5%	
N/A	2010-017	96271	Synthesis of Bridge Approach Panel Best Practices	Minnesota State University, Mankato	Farhad Reza	Paul Rowekamp	Shirlee Sherkow	7/15/10	3/31/12	SRP	$25,000	$8,840	35%	
N/A	2010-041	97466	Implementing a Database Classification of Mn/DOT Steel Bridges with Fracture/Fatigue Critical Details	No Choice	Arturo Schultz	James Pierce	Bruce Holdhusen	8/31/10	5/31/11	SRP	$5,000	$0	0%	

Pooled Fund Studies

Study #	Title	Technical Liaison	Administrative Liaison	Lead State or Agency	Number of Participating States	Current MN Commitment End Date	Total Cost	Total MN Commitment	MN 2010 Commitment	TS
TPF-5(179)	Evaluation of Test Methods for Permeability (Transport) and Development of Performance Guidelines for Durability	Bernard Izevbekhai	Debra Fick	IN	11	2011	$883,000	$87,000	$25,000	
TPF-5(202)	HY-8 Culvert Analysis Program—Phase Three of Development Efforts	Petronella DeWall	Debra Fick	FHWA	8	2011	$110,000	$30,000	$10,000	
TPF-5(221)	Accelerated Bridge Construction (ABC) Decision Making and Economic Modeling Tool	Kevin Western	Debra Fick	OR	7	2010	$110,000	$10,000	$10,000	

Environmental

Report Number	Project Number	Contract Number	Title	Contractor	Investigator	Technical Liaison	Administrative Liaison	Start Date	End Date	Funding Source	Total Cost	Amount Paid	% Paid	TS
2010-10	2007-005	89261 W053	INV 874: Hydrodynamic Separator Sediment Retention Testing	University of Minnesota	Omid Mohseni	Mike Eastling	Shirlee Sherkow	5/30/07	3/31/10	LRRB	$123,000	$123,000	100%	X
2010-11	2006-027	89261 W014	Wetland Mitigation in Abandoned Gravel Pits	University of Minnesota - Duluth	Kurt Johnson	Sarma Straumanis	Debra Fick	10/9/06	3/31/10	SRP	$109,562	$109,562	100%	X
2010-20	2007-095	92929	MPR-6(032): Site-Specific Native Grassland Seed Mix Design Methodology for Minnesota	Scale Tec LTD	L. Peter MacDonagh	Kenneth Graeve	Shirlee Sherkow	10/23/08	9/30/10	SRP, SP&R, Partnership Funds, Other State Funds	$123,840	$123,840	100%	X
2010-22	2008-008	89261 W0104	Statistical Analysis of the Soil Chemical Survey Data	University of Minnesota	Vladimir Cherkassky, Sauptik Dhar	Robert Edstrom	Daniel Warzala	7/8/08	6/30/10	SRP	$55,000	$55,000	100%	X
2010-38	2007-006	89261 W054	INV 875: Improved Automatic Sampling for Suspended Solids	University of Minnesota	John Gulliver	Marilyn Jordahl-Larson	Shirlee Sherkow	12/4/07	2/28/11	LRRB	$55,000	$52,525	100%	X
2011-06	2007-034	89261 W061	Evaluation of Buffer Width on Hydrologic Function, Water Quality and Ecological Integrity of Wetlands	University of Minnesota	John Nieber	Kenneth Graeve	Shirlee Sherkow	12/11/07	12/31/10	SRP	$158,872	$144,722	91%	
N/A	2006-032	89421	The Utility of Wildlife Crossings in Minnesota	Minnesota State University, Mankato	John Krenz	Jason Alcott	Daniel Warzala	9/14/06	7/31/11	SRP	$79,937	$58,187	73%	
N/A	2008-005	89261 W0100	Assessment and Recommendations for the Operation of Standard Sumps as Best Management Practice for Stormwater Treatment (Vol. I)	University of Minnesota	Omid Mohseni	Barbara Loida	Shirlee Sherkow	7/8/08	5/31/12	SRP	$257,000	$146,000	57%	
N/A	2009-031	89261 W0207	INV 894: Assessing and Improving Pollution Prevention by Swales	University of Minnesota	John Gulliver	Barbara Loida	Bruce Holdhusen	7/30/10	9/30/13	LRRB	$312,000	$0	0%	
N/A	2009-034	89258 W02	Wetblade to Control Canada Thistle and Phragmites Along Roadways	Michigan Technological University	Catherine Tarasoff	Kenneth Graeve	Nelson Cruz	6/25/09	6/30/12	SRP	$139,966	$16,320	12%	
N/A	2009-036	89261 W0152	INV 891: Performance Assessment of Oversized Culverts to Accommodate Fish Passage	University of Minnesota	John Nieber	Petronella DeWall, Nicole Danielson-Bartelt	Nelson Cruz	8/7/09	8/31/11	SRP, LRRB, COPTRS	$83,428	$4,371	5%	
N/A	2009-074	93463, Task 1	INV 645: RIC: BPs for Stormwater Management	SRF Consulting Group, Inc.	Mike Marti	Michael Sheehan	Clark Moe	2/19/09	12/31/11	LRRB	$51,748	$25,874	50%	

Environmental [cont.]

Report Number	Project Number	Contract Number	Title	Contractor	Investigator	Technical Liaison	Administrative Liaison	Start Date	End Date	Funding Source	Total Cost	Amount Paid	% Paid	TS
N/A	2009-106	89261 W0187	INV 892: Develop Outreach Program for a Thoughtful Street Tree Master Plan	University of Minnesota	Gary Johnson	Daniel Gullickson	Debra Fick	4/8/10	9/30/11	LRRB	$20,000	$0	0%	
N/A	2010-001	96273	Concrete Slurry, Wash and Loss Water Mitigation	Minnesota State University, Mankato	Stephen Druschel	Dwayne Stenlund	Bruce Holdhusen	5/11/10	10/31/11	SRP	$86,300	$0	0%	
N/A	2010-016	96319	Salt Brine Blending to Optimize Deicing and Anti-Icing Performance and Cost-Effectiveness	Minnesota State University, Mankato	Stephen Druschel	Gordon Regenscheid	Daniel Warzala	7/12/10	11/30/11	SRP	$69,600	$0	0%	

Pooled Fund Studies

Study #	Title	Technical Liaison	Administrative Liaison	Lead State or Agency	Number of Participating States	Current MN Commitment End Date	Total Cost	Total MN Commitment	MN 2010 Commitment	TS
TPF-5(164)	Fish Passage in Large Culverts with Low Flows	Petronella DeWall	Debra Fick	FHWA	8	2008	$315,000	$30,000	$0	
TPF-5(187)	Precipitation Frequency Estimates for the Midwestern Region	Andrea Hendrickson	Debra Fick	FHWA	8	2010	$1,236,580	$200,001	$66,667	X

Maintenance Operations & Security

Report Number	Project Number	Contract Number	Title	Contractor	Investigator	Technical Liaison	Administrative Liaison	Start Date	End Date	Funding Source	Total Cost	Amount Paid	% Paid	TS
2009RIC08	2009-081, 2008-104	93463, 93853	INV 645: RIC: Local Government Snowplow Salt and Sander Controller Calibration Guide	SRF Consulting Group Inc., EVS Engineering Inc.	Mike Marti, Paul Keranen	Richard Sanders, Farideh Amiri	Clark Moe, Bruce Holdhusen	2/3/09	12/31/09	SRP, LRRB	$139,210	$139,210	100%	X
2010-07	2007-028	89261 W058	Automated Vehicle Location, Data Recording, Friction Measurement and Applicator Control for Winter Road Maintenance	University of Minnesota	Rajesh Rajamani	Gabriel Guevara	Daniel Warzala	12/18/07	2/28/10	SRP	$160,000	$160,000	100%	X
2010-13	2007-032	89261 W094	MPR-6(014): Evaluation of the SafeLane Overlay System for Crash Reduction on Bridge Deck Surfaces	University of Minnesota - Duluth	John Evans	Farideh Amiri	Nelson Cruz	2/29/08	8/31/10	SRP, SP&R	$35,400	$35,400	100%	X
2010RIC03	2009-076	93463, Task 3	INV 645: RIC: Best Management Practices for Promoting Maintenance Roadway Safety	SRF Consulting Group, Inc.	Mike Marti, Renae Kuehl	Rick West	Clark Moe	2/19/09	12/31/11	LRRB	$40,863	$40,863	100%	X
2011-03	2007-041	89795 W01	INV 880: Optimal Workforce Planning and Shift Scheduling for Snow and Ice Removal	St. Louis County	Diwakar Gupta	Jim Foldesi	Alan Rindels	7/17/07	4/30/10	LRRB	$45,000	$45,000	100%	
N/A	2008-070	94758	MPR-8(006): Anti-Icing Technology Implementation	EVS	Paul Keranen	Susan Lodahl	Bruce Holdhusen	6/12/09	4/30/11	SRP, SP&R	$98,348	$98,348	100%	
N/A	2006-101	95099	INV 863, TPF-5(153): Optimal Timing of Preventive Maintenance for Addressing Environmental Aging in HMA Pavements	Asphalt Institute	Mike Anderson	Thomas Wood	Bruce Holdhusen	3/30/10	11/30/13	SP&R, LRRB	$286,185	$3,528	1%	

Maintenance Operations & Security [cont.]

Report Number	Project Number	Contract Number	Title	Contractor	Investigator	Technical Liaison	Administrative Liaison	Start Date	End Date	Funding Source	Total Cost	Amount Paid	% Paid	TS
N/A	2008-041	93463	INV 645: RIC: Transportation Network Solutions/Right Road on the Right System	SRF Consulting Group, Inc.	Mike Marti	Rick West	Clark Moe	4/17/09	12/31/11	LRRB	$31,350	$0	0%	
N/A	2009-035	89261 W0157	Research and Assess the Farmer and Mn/DOT Economic and Environmental Costs and Benefits of Living Snow Fences Including Carbon Impacts	University of Minnesota	Gary Wyatt	Daniel Gullickson	Daniel Warzala	6/15/09	1/31/11	SRP, COPTRS	$99,000	$26,433		
N/A	2009-077	93463, Task 4	INV 645: RIC: Pavement DVD/Video	SRF Consulting Group, Inc./ Greer & Associates/ Minnesota State University, Mankato	Mike Marti, Richard Kronick, W. James Wilde	Gary Danielson	Clark Moe	2/19/09	12/31/11	LRRB	$47,752	$23,876	50%	
N/A	2009-078	93463, Task 5	INV 645: RIC: Best Practices for Recreation Trails	SRF Consulting Group, Inc.	Mike Marti	Tom Behn	Bruce Holdhusen	2/19/09	12/31/11	LRRB	$27,608	$0	0%	
N/A	2009-165	96037	TPF-5(218): Clear Roads Administration and Information Services	CTC & Associates LLC	Patrick Casey	Thomas Peters	Debra Fick	1/19/10	1/31/11	SP&R	$73,706	$57,214	78%	
N/A	2010-005	89261 W0211	Developing Salt-Tolerant Sod Mixtures for Use as Roadside Turf in Minnesota	University of Minnesota	Eric Watkins	Adam Popenhagen	Daniel Warzala	6/8/10	8/31/14	LRRB	$176,516	$3,530	2%	
N/A	2010-007	89261 W0199	Estimation of Winter Snow Operation Performance Measures with Traffic Flow Data	University of Minnesota	Eil Kwon	Curtis Pape	Daniel Warzala	8/20/10	6/30/12	SRP, COPTRS	$58,000	$0	0%	
N/A	2010-008	89261 W0191	Comparative Performance Study of Chip Seal and Bonded Wear Course Systems Applied to Bridge Decks and Approaches	University of Minnesota - Duluth	John Evans	Farideh Amiri	Bruce Holdhusen	7/8/10	8/31/14	COPTRS	$90,872	$0	0%	
N/A	2010-036	97321	Inventory of Ash Tree Attributes Along Mn/DOT Right of Way Within a 10-Mile Radius of TH280 and I-94	S&S Tree Specialists, Inc.	Gail Nozal	Daniel Gullickson	Sandra McCully	10/8/10	4/26/11	SRP	$56,639	$0	0%	

Pooled Fund Studies

Study #	Title	Technical Liaison	Administrative Liaison	Lead State or Agency	Number of Participating States	Current MN Commitment End Date	Total Cost	Total MN Commitment	MN 2010 Commitment	TS
TPF-5(092), TPF-5(218)	Clear Roads Winter Highway Operations—Phase 2	Tom Peters	Debra Fick	MN	19	2011	$1,955,000	$150,000	$25,000	X
TPF-5(153)	Optimal Timing of Preventive Maintenance for Addressing Environmental Aging in HMA Pavements	Thomas Wood	Bruce Holdhusen	MN	4	2011	$335,000	$332,205	$0	
SPR-3(042)	Aurora Program	Curtis Pape	Debra Fick	IA	18	2011	$3,122,500	$375,000	$25,000	X
TPF-5(035)	Pacific Northwest Snowfighters	Susan Lodahl	Debra Fick	WA	10	2009	$45,000	$30,000	$0	
TPF-5(054)	Maintenance Decision Support System (MDSS)	Curtis Pape	Debra Fick	SD	18	2012	$3,069,222	$200,000	$25,000	X
TPF-5(231)	ITS Pooled Fund Program (ENTERPRISE)	Jon Jackels	Debra Fick	MI	10	2011	$1,355,000	$60,000	$30,000	

Materials & Construction

Report Number	Project Number	Contract Number	Title	Contractor	Investigator	Technical Liaison	Administrative Liaison	Start Date	End Date	Funding Source	Total Cost	Amount Paid	% Paid	TS
2009-41	2007-002	89261 WO51	INV 871: Statistical Methods for Materials Testing	University of Minnesota	Diwakar Gupta	Curt Turgeon, Thomas Ravn	Alan Rindels	8/17/07	1/31/10	LRRB	$94,876	$94,876	100%	X
2009-42	2007-091	89261 WO105	TPF-5(165): Asphalt Mixture and Binder Fracture Testing for 2008 MnROAD Construction	University of Minnesota	Mihai Marasteanu	Timothy Clyne	Bruce Holdhusen	7/23/08	1/31/10	SP&R, Partnership Funds, Other State Funds	$55,000	$55,000	100%	X
2010-08	2009-121	Part of TPF-5(213)	TPF-5(213): Incorporation of Recycled Asphalt Shingles in Hot Mixed Asphalt Pavement Mixtures	Iowa State University	Chris Williams	Roger Olson	Debra Fick	10/1/09	10/31/10	SP&R	N/A	N/A	100%	
2010-15	2007-082	91978	MPR-6(035): Mn/DOT Combined Smoothness Specification	Minnesota State University, Mankato	W. James Wilde	Thomas Nordstrom	Bruce Holdhusen	11/9/07	5/31/10	SRP, SP&R	$43,000	$43,000	100%	X
2010-16	2007-022	LAB879	INV 879: Drainable Pavements at MnROAD Pervious Concrete and Porous Concrete Overlay Cells 39, 85 and 89	Mn/DOT Office of Materials	Bernard Izevbekhai	Mark Maloney	Bruce Holdhusen	7/30/07	9/30/11	LRRB	$50,000	$15,000	30%	
2010-17	2006-007	89219	INV 844: Update of Vehicle Classification for County Road Pavement Design	Minnesota State University, Mankato	W. James Wilde	Tim Stahl	Daniel Warzala	8/1/06	5/31/10	LRRB	$92,749	$92,749	100%	X
2010-18	N/A	N/A	Investigation of Joint Deterioration in MnROAD—Phase 1 Jointed Concrete Pavement Test Sections	Mn/DOT Office of Materials	Ryan Rohne, Tom Burnham	N/A	N/A	N/A	N/A	SRP	N/A	N/A	100%	
2010-19	N/A	N/A	Mesabi-Select Concrete Pavement Five-Year Performance Report	Mn/DOT Office of Materials	Ryan Rohne	N/A	N/A	N/A	N/A	SRP	N/A	N/A	100%	
2010-23	N/A	N/A	Construction Report for a Thin Unbonded Concrete Overlay on Minnesota TH 53	Mn/DOT Office of Materials	Mark Watson, Erland Lukanen, Steven Olson, Tom Burnham	N/A	N/A	N/A	N/A	SRP	N/A	N/A	100%	
2010-24	N/A	N/A	Use of Taconite Aggregates in Pavement Applications	Mn/DOT Office of Materials	Timothy Clyne	Eddie Johnson	Sandra McCully	N/A	N/A	SRP	N/A	N/A	100%	X
2010-26	2007-003	89261 WO52	INV 872, TFP-5(148): MnROAD Data Mining, Evaluation and Quantification—Phase I	University of Minnesota	Randal Barnes	Thomas Burnham	Shirlee Sherkow	4/7/08	7/31/10	SRP, SP&R, LRRB	$72,000	$72,000	100%	X
2010-28	2007-091	89261 WO171	TPF-5(165): Air Voids Testing for MnROAD Cells	University of Minnesota	Mihai Marasteanu	Timothy Clyne	Nelson Cruz	10/27/09	9/30/10	SP&R, Partnership Funds, Other State Funds	$14,800	$14,800	100%	
2010-30	2007-050	LAB016	MPR-6(016): Construction Report for MnROAD Thin Unbonded Concrete Overlay Test Cell 5 (Sub-Cells 105-405)	Mn/DOT Office of Materials	Mark Watson	Bernard Izevbekhai	Bruce Holdhusen	12/29/08	2/28/14	SP&R, Partnership Funds, Other State Funds	$126,100	$0	0%	
2010-31	2006-006	89218	INV 843-1: Predicting the Occurrence of Bumps in Overlays	Minnesota State University, Mankato	W. James Wilde	John Brunkhorst	Daniel Warzala	8/8/06	9/30/10	LRRB	$31,040	$31,040	100%	X
2010-32	2009-095	93627	TPF-5(148): 2008 MnROAD Unbound Quality Control Construction Report	CNA Consulting Engineers, Inc.	D. Lee Petersen	John Siekmeier	Bruce Holdhusen	3/30/09	8/31/10	SP&R	$49,656	$49,656	100%	
2010-35	2006-037	89423	INV 855: A Property-Based Specification for Coarse Aggregate in Pavement Applications	North Dakota State University	Magdy Abdelrahman	John Grindeland	Daniel Warzala	11/6/06	10/31/10	SRP, LRRB	$92,624	$92,624	100%	X

Materials & Construction [cont.]

Report Number	Project Number	Contract Number	Title	Contractor	Investigator	Technical Liaison	Administrative Liaison	Start Date	End Date	Funding Source	Total Cost	Amount Paid	% Paid	TS
2010-37	2008-072	GPSGPR	Incorporating GPS and Mapping Capability into Ground Penetrating Radar (GPR) Operations for Pavement Thickness Evaluations	Mn/DOT Office of Materials	Matthew Lebens	Shongtao Dai	Bruce Holdhusen	1/29/09	5/29/10	SRP	N/A	N/A	100%	
2010-40	2006-088	94527	TPF-5(134), MPR-6(029), MPR-6(021): Influence of Pavement on Traffic Noise – Statistical Pass-By Measurements of Traffic on Several Interstate Pavements	HDR Engineering	Tim Casey	Bernard Izevbekhai	Nelson Cruz	6/16/09	9/30/10	SP&R, Other State Funds	$62,957	$58,319	93%	X
2011-02	2006-014	89261 WO#9	INV 851: Allowable Axle Loads on Pavements	University of Minnesota	Lev Khazanovich	Gerard Geib	Clark Moe	11/14/06	1/31/11	LRRB	$126,042	$126,042	100%	
TRS1005	N/A	N/A	State DOT Experiences with Primaverya P6 Project Management Software	CTC & Associates LLC	Patrick Casey	N/A	Shirlee Sherkow	N/A	N/A	N/A	N/A	N/A	100%	
N/A	2005-005	LAB825	Performance Monitoring of Olmsted CR 117/104 and Aggregate Base Material Update	Mn/DOT Office of Materials	Matthew Lebens	Michael Sheehan	Alan Rindels	6/1/05	6/30/10	LRRB	$40,000	$40,000	100%	
N/A	2006-003	LAB840	INV 840-1: Performance of PG 52-34 Oil on Local Roads	Mn/DOT Materials Lab	Shongtao Dai	Brian Noetzelman	Daniel Warzala	6/22/06	7/31/11	LRRB	$56,200	$45,600	81%	
N/A	2006-081	INV 843	INV 843-2: Predicting the Occurrence of Bumps in Overlays	Mn/DOT Office of Materials	Eddie Johnson	None	Daniel Warzala	7/13/06	9/30/10	LRRB	$33,500	$25,401	76%	
N/A	2006-120	92107	MPR-6(012): Development of New Test Roller Equipment and Construction Specs for Subgrade Compaction Acceptance	Minnesota State University, Mankato	Aaron Budge	Timothy Andersen	Daniel Warzala	1/24/08	6/30/11	SRP, SP&R	$253,300	$86,684	34%	
N/A	2007-009	LAB878	INV 878: Porous Asphalt Pavement Performance in Cold Regions	Mn/DOT Office of Materials	Matthew Lebens	Larry Matsumoto	Bruce Holdhusen	7/26/07	4/30/12	SP&R, LRRB, Other State Funds	$71,000	$22,400	32%	
N/A	2007-091	89258 W01	TPF-5(165): Field Evaluation of Built-in Curling Levels in Rigid Pavements	Michigan Technological University	Jacob Hiller	Thomas Burnham	Bruce Holdhusen	5/14/09	6/30/11	SP&R, Partnership Funds, Other State Funds	$64,000	$30,000	47%	
N/A	2007-091, 2009-095	89261-A W0128, 89261 W0128	INV 854, TPF-5(148): Vehicle Position Tracking During Load Response Testing—Phase 2 & Automated Faultmeter Control Software Prgram	University of Minnesota	Ahmed Tewfik	Thomas Burnham	Bruce Holdhusen	12/9/08	5/31/10	SRP, SP&R, LRRB, Partnership Funds	$66,000	$66,000	100%	
N/A	2007-091, 2009-095	89261-A W052	INV 872, TPF-5(148): Mn/Road Data Mining, Evaluation and Qualification—Phase 1	No Choice	No Choice	Shongtao Dai	Bruce Holdhusen	4/7/08	7/31/10	SRP, SP&R, LRRB, Partnership Funds	$438,000	$8,500	2%	
N/A	2008-033	LAB676	INV 676: FY2010 Support of MnROAD Low Volume Roads	Mn/DOT Office of Materials	Keith Shannon	N/A	N/A	7/1/09	6/30/10	LRRB	$570,000	$570,000	100%	
N/A	2008-038	89261 W0165	INV 869: TERRA Board Support (FY2010)	University of Minnesota	Laurie McGinnis	Julie Skallman, Mark Maloney	Linda Taylor	7/13/09	7/31/10	LRRB	$25,000	$25,000	100%	
N/A	2008-072	95647	GPS Extension to Mn/DOT GPR Production	American Engineering Testing, Inc.	Joe Korzilius	Matthew Lebens	Bruce Holdhusen	10/27/09	7/31/10	SRP	$4,972	$4,972	100%	
N/A	2009-061	89450 W07	MPR-6(033): TRACS Research and Impementation Project	Project Information Services	Timothy Malagon	Thomas Wiener	Clark Moe	3/12/08	6/30/11	SRP, SP&R, Other State Funds	$310,000	$268,319	87%	
N/A	2009-117	95336	MPR-9(001): Stabilized Full Depth Reclamation (SFDR) Implementation	American Engineering Testing, Inc.	Dave Rettner	Steven Adamsky, John Hager	Clark Moe	9/18/09	2/28/11	SRP, SP&R	$50,111	$35,000	70%	

Materials & Construction [cont.]

Report Number	Project Number	Contract Number	Title	Contractor	Investigator	Technical Liaison	Administrative Liaison	Start Date	End Date	Funding Source	Total Cost	Amount Paid	% Paid	TS
N/A	2008-034	INV 885	INV 885: Research Test Section Tracking—Phase II	Mn/DOT Office of Materials	Benjamin Worel	Luane Tasa	Clark Moe	12/21/09	12/21/14	LRRB	$55,000	$5,000	9%	
N/A	2008-044	93028	TPF-5(134): PCC Surface Characteristics—Rehabilitation (Mn/ROAD Study)—Data Analysis	Minnesota State University, Mankato	W. James Wilde	Bernard Izevbekhai	Bruce Holdhusen	7/23/08	3/31/12	SP&R	$72,760	$5,000	7%	
N/A	2008-074	94262	MPR-8(004): Development of a Concrete Maturity Test Protocol	Minnesota State University, Mankato	W. James Wilde	Robert Golish	Sandra McCully	4/2/09	9/30/12	SRP, SP&R	$113,952	$61,944	54%	
N/A	2008-090	94288	INV 645: RIC: Integrated Tools for Pavement Design and Management	Minnesota State University, Mankato	W. James Wilde	Rich Sanders	Clark Moe	4/21/09	4/30/11	LRRB	$54,531	$29,248	54%	
N/A	2008-100	89261 W0173	Optimal Contract Mechanism Design for Performance-Based Contracts	University of Minnesota	Diwakar Gupta	Richard Kjonaas	Daniel Warzala	11/10/09	3/31/11	SRP	$30,000	$7,500	25%	
N/A	2009-008	94079	INV 886: Cost-Effective Pavement Preservation Solutions for the Real World	Minnesota State University, Mankato	W. James Wilde	Gregory Coughlin	Nelson Cruz	9/8/09	2/29/12	SRP, LRRB	$94,984	$3,411	4%	
N/A	2009-008	LAB886	INV 886: Cost-Effective Pavement Preservation Solutions for the Real World	Mn/DOT Office of Materials	Thomas Wood	Gregory Coughlin	Nelson Cruz	9/10/09	2/29/12	SRP, LRRB	$15,000	$0	0%	
N/A	2009-009	89261 W0156	INV 887: Structural Evaluation of Asphalt Pavements with Full-Depth Reclaimed Base	University of Minnesota	Joseph Labuz	Merle Earley	Daniel Warzala	6/4/09	11/30/12	LRRB, Other State Funds	$38,260	$1,000	3%	
N/A	2009-009	LAB887	INV 887: Structural Evaluation of Asphalt Pavements with Full-Depth Reclaimed Base	Mn/DOT Office of Materials	Shongtao Dai	Merle Earley	Daniel Warzala	10/5/09	3/31/13	LRRB, Other State Funds	$41,548	$8,960	22%	
N/A	2009-011	LAB889	INV 889: Performance of Recycled Asphalt and High RAP Asphalt Mix	Mn/DOT Office of Materials	Eddie Johnson	Gregory Coughlin	Daniel Warzala	2/22/10	2/28/13	LRRB	$60,000	$0	0%	
N/A	2009-014	89261 W0140	Mechanistic Modeling of Unbound Concrete Overlays	University of Minnesota	Roberto Ballarini	Shongtao Dai	Daniel Warzala	6/29/09	7/31/11	SRP	$110,000	$5,500	5%	
N/A	2009-053	89261 W0190	INV 896: Quantifying Moisture Effects in DCP and LWD Tests Using Unsaturated Mechanics	University of Minnesota	Kimberly Hill	John Siekmeier	Nelson Cruz	9/24/10	11/30/12	LRRB	$109,900	$0	0%	
N/A	2009-061	93263	MPR-6(033): Construction Project Management Software Evaluations	Minnesota State University, Mankato	W. James Wilde	Thomas Wiener	Clark Moe	9/24/08	10/31/11	SRP, SP&R, Other State Funds	$138,697	$12,168	9%	
N/A	2009-095	89261 W0101	TPF-5(148): Vibrating Wire and Horizontal Clip Data Analysis	University of Minnesota	Ahmed Tewfik	Thomas Burnham	Bruce Holdhusen	6/10/08	4/30/11	SRP, SP&R, LRRB, Partnership Funds	$70,000	$63,000	90%	
N/A	2009-095	89261 W079	INV 854, TPF-5(148): Effects of Implements of Husbandry on Pavement Performance	University of Minnesota	Lev Khazanovich	Shongtao Dai	Bruce Holdhusen	10/12/07	1/31/11	SRP, SP&R, LRRB, Partnership Funds	$275,239	$74,315	27%	
N/A	2009-120	97281	Lump Sum Estimating: Discovery and Simulation	Minnesota State University, Mankato	Brian Wasserman	Jay Hietpas	Shirlee Sherkow	7/30/10	5/31/11	SRP	$17,000	$0		
N/A	2009-162	96661	An Integrated Pavement Management System Loading Additional Data into Minnesota Pavement Management System	Stantec Consulting, Inc.	Khaled Helali	Shongtao Dai	Bruce Holdhusen	5/21/10	1/31/11	SRP	$9,544	$2,245	24%	

Materials & Construction [cont.]

Report Number	Project Number	Contract Number	Title	Contractor	Investigator	Technical Liaison	Administrative Liaison	Start Date	End Date	Funding Source	Total Cost	Amount Paid	% Paid	TS
N/A	2009-164	89261 WO189	TPF-5(215): TERRA Pooled Fund Support—Transportation Engineering and Road Research Alliance	University of Minnesota	Laurie McGinnis	Maureen Jensen	Linda Taylor	4/30/10	3/31/12	SP&R	$45,000	$0	$0	
N/A	2009-175	95937	INV 895: Traffic Generating Developments and Roadway Life Consumption	Minnesota State University, Mankato	W. James Wilde	Susan Miller	Clark Moe	1/22/10	5/31/12	LRRB	$37,038	$6,371	17%	
N/A	2009-192	96033	INV 901: Evaluation of Concrete Admixtures to Increase Delivery Time	American Engineering Testing, Inc.	Dan Vruno	Maria Masten	Shirlee Sherkow	3/29/10	2/28/11	SRP, LRRB	$99,998	$16,233	16%	
N/A	2010-027	96885	INV 902: Material Control Testing Rates for Low Volume Roads	Minnesota State University, Mankato	Brian Wasserman	Julie Skallman	Clark Moe	6/1/10	8/31/11	LRRB	$25,000	$0	0%	
N/A	2010-030	97388	Validation of DOT600 Soil Moisture Device	American Engineering Testing, Inc.	Dave Rettner	John Siekmeier	Daniel Warzala	8/26/10	7/31/11	SRP	$29,982	$0	0%	
N/A	2010-042	LAB904	INV 904: Stripping of Hot Mixed Asphalt Pavements under Chip Seals	Mn/DOT Office of Materials	Thomas Wood	Thomas Tesch	Daniel Warzala	7/19/10	9/30/12	LRRB	$40,000	$0	0%	

Pooled Fund Studies

Study #	Title	Technical Liaison	Administrative Liaison	Lead State or Agency	Number of Participating States	Current MN Commitment End Date	Total Cost	Total MN Commitment	MN 2010 Commitment	TS
TPF-5(070)	International Conference on Accelerated Pavement Testing	Benjamin Worel	Debra Fick	MN	8	2003	$130,000	$15,000	$0	
TPF-5(129)	Recycled Unbound Pavement Materials	Andrew Eller	Nelson Cruz	MN	6	2011	$882,352	$75,000	$15,000	
TPF-5(132)	Low Temperature Cracking in Asphalt Pavements (Phase II MnROAD Study)	Timothy Clyne	Bruce Holdhusen	MN	7	2011	$420,000	$100,000	$20,000	
TPF-5(134)	PCC Surface Characteristics—Rehabilitation (Mn/ROAD Study)	Bernard Izevbekhai	Bruce Holdhusen	MN	3	2010	$275,000	$75,000	$15,000	
TPF-5(148)	The Effects of Implements of Husbandry "Farm Equipment" on Pavement Performance (MnROAD Study)	Shongtao Dai	Bruce Holdhusen	MN	4	2008	$433,000	$105,000	$0	
TPF-5(149)	Design and Construction Guidelines for Thermally Insulated Concrete Pavements	Timothy Clyne	Nelson Cruz	MN	5	2011	$438,980	$538,918	$0	
TPF-5(165)	Development of Design Guide for Thin and Ultrathin Concrete Overlays of Existing Asphalt Pavements (MnROAD)	Thomas Burnham	Nelson Cruz	MN	6	2008	$360,000	$60,000	$0	
TPF-5(215)	TERRA Pooled Fund Support—Transportation Engineering and Road Research Alliance	Maureen Jensen	Debra Fick	MN	5	2014	$157,500	$37,500	$7,500	
SPR-3(074)	Pavement Research and Technology	Roger Olson	Debra Fick	WA	4	2010	$625,000	$280,000	$15,000	
TPF-5(037)	Southeast Superpave Center	Jerry Geib	Debra Fick	AL	20	2009	$1,822,326	$21,500	$0	X
TPF-5(039)	Falling Weight Deflectometer (FWD)	David Bullock	Debra Fick	FHWA	18	2006	$1,003,825	$55,000	$0	
TPF-5(127)	Consortium of Accelerated Pavement Testing (CAPT) and Technical Exchange Partnership	Timothy Clyne	Debra Fick	FHWA	9	2007	$225,000	$25,000	$0	
TPF-5(128)	Accelerated Implementation of Intelligent Compaction Technology for Embankment Subgrade Soils Aggregate Base	Tom Ravn	Debra Fick	FHWA	13	2008	$725,000	$75,000	$0	
TPF-5(135)	Tire Pavement Noise Research Consortium	Bernard Izevbekhai	Debra Fick	WA	9	2009	$163,000	$25,000	$0	
TPF-5(139)	PCC Surface Characteristics: Tire-Pavement Noise Program, Part 3	Bernard Izevbekhai	Debra Fick	IA	8	2008	$690,000	$55,000	$0	

Pooled Fund Studies [cont.]

Study #	Title	Technical Liaison	Administrative Liaison	Lead State or Agency	Number of Participating States	Current MN Commitment End Date	Total Cost	Total MN Commitment	MN 2010 Commitment	TS
TPF-5(159)	Technology Transfer Concrete Consortium	Maria Masten	Debra Fick	IA	20	2010	$535,000	$25,000	$5,000	
TPF-5(174)	Construction of Crack-Free Bridge Decks—Phase II	Paul Kivisto	Debra Fick	KS	14	2011	$995,000	$75,000	$15,000	
TPF-5(177)	Improving Resilient Modulus (MR) Test Procedures for Unbound Materials	Shongtao Dai	Debra Fick	FHWA	10	2010	$300,000	$40,000	$20,000	
TPF-5(197)	The Impact of Wide-Base Tires on Pavement Damage: A National Study	Shongtao Dai	Debra Fick	FHWA	7	2012	$60,000	$100,000	$25,000	
TPF-5(213)	Performance of Recycled Asphalt Shingles in Hot Mix Asphalt	Roger Olson	Debra Fick	MO	9	2010	$765,000	$85,000	$42,500	
TPF-5(224)	Investigation of Jointed Plain Concrete Pavement Deterioration at Joints and the Potential Contribution of Deicing Chemicals	Bernard Izevbekhai	Debra Fick	IA	7	2013	$390,000	$60,000	$15,000	
TPF-5(225)	Validation and Implementation of Hot-Poured Crack Sealant	Jim McGraw	Debra Fick	VA	10	2013	$775,000	$10,000	$25,000	

Multimodal

Report Number	Project Number	Contract Number	Title	Contractor	Investigator	Technical Liaison	Administrative Liaison	Start Date	End Date	Funding Source	Total Cost	Amount Paid	% Paid	TS
2010-06	2007-035	89261 WO62	Practical Methods for Analyzing Pedestrian and Bicycle Use of a Transportation Facility	University of Minnesota	Nikos Papan-ikolopoulos	Lisa Austin	Alan Rindels	10/15/07	2/28/10	SRP	$76,000	$76,000	100%	X
2010-34	2008-006	89256 WO5	Mn/DOT Truck Parking Study: Phase 2	Iowa State University	Omar Smadi	Robert Gale	Shirlee Sherkow	12/5/08	8/31/10	SRP	$79,441	$79,441	100%	X
N/A	2008-060	89264 WO3	TPF-5(190): North/West Passage Corridor-wide Commercial Vehicle Permitting	University of Wisconsin-Madison	Ernest Wittwer	Matthew Gjersvik, Bill Legg	Debra Fick	9/11/09	4/30/10	SP&R, Partnership Funds	$32,232	$32,232	100%	
N/A	2008-082	93332	Minnesota Urban Partnership Agreement (UPA)	University of Minnesota	Lee Munnich	Kenneth Buckeye	None	10/15/08	9/30/10	SRP	$200,000	$200,000	100%	
N/A	2008-099	89261 WO136	Procedures for Highway Cost Allocation and Determination of Heavier Freight-Truck Permit Fees	University of Minnesota	Diwakar Gupta	John Tompkins	Daniel Warzala	3/26/09	1/30/12	SRP, COPTRS	$179,752	$80,888	45%	
N/A	2010-006	89261 WO197	Economic Benefits of Telework for Employers	University of Minnesota	Adeel Lari	Kenneth Buckeye	Shirlee Sherkow	6/30/10	8/31/12	COPTRS	$145,600	$0	0%	
N/A	2010-012	89261 WO193	Bike, Bus and Beyond: Extending Cyclopath to Enable Multi-Modal Routing	University of Minnesota	Loren Terveen	Greta Alquist	Shirlee Sherkow	7/6/10	3/31/12	SRP	$60,627	$0	0%	
N/A	2010-023	89261 WO215	Viability and Benefits of Personal Rapid Transit (PRT) for Minnesota	University of Minnesota	Lee Munnich	Mukhtar Thakur	Rose Keller	6/8/10	9/30/11	Multi-modal PRT, Modal Planning & Program Mgmt.	$46,000	$0	0%	

Pooled Fund Study

Study #	Title	Technical Liaison	Administrative Liaison	Lead State or Agency	Number of Participating States	Current MN Commitment End Date	Total Cost	Total MN Commitment	MN 2010 Commitment	TS
TPF-5(156)	Mississippi Valley Freight Coalition Pooled Fund	John Tompkins	Debra Fick	WI	10	2010	$1,050,000	$100,000	$25,000	X

Policy & Planning

Report Number	Project Number	Contract Number	Title	Contractor	Investigator	Technical Liaison	Administrative Liaison	Start Date	End Date	Funding Source	Total Cost	Amount Paid	% Paid	TS
2010-01	2009-140	89261 W0161	Evaluation of Workforce Perceptions as a Means to Identify and Mitigate the Causes of Musculoskeletal Disorders	University of Minnesota - Duluth	Todd Loushine	Todd Haglin	Bruce Holdhusen	7/17/09	11/30/09	SRP	$10,546	$10,546	100%	X
2010-04	2007-063	89261 W0137	MPR-6(009): TH36 Full Closure Construction: Evaluation of Traffic Operations Alternatives	University of Minnesota	John Hourdos	Christopher Roy, Colleen VanWagner	Bruce Holdhusen	4/5/07	1/31/10	SRP, SP&R	$109,890	$109,890	100%	X
2010-09	2008-009	89261 W0108	Access to Destinations Phase 3: Measuring Accessibility by Automobile	University of Minnesota	David Levinson	Paul Czech, Brian Gage	Linda Taylor	8/5/08	3/31/10	SRP, COPTRS	$186,000	$186,000	100%	X
2010-12	2006-111	89261 W043	Access to Destinations: Arterial Data Acquisition—Phase II	University of Minnesota	Gary Davis	Gene Hicks	Linda Taylor	7/16/07	3/31/10	SRP	$150,000	$150,000	100%	X
2010-21	2008-021	89261 W0102	Traffic Flow and Road User Impacts of the Collapse of the I-35W Bridge Over the Mississippi River	University of Minnesota	David Levinson	Edward Idzorek	Alan Rindels	6/12/08	9/30/10	SRP	$200,502	$200,502	100%	X
2010-27	2009-062	89261 W0147	Study of Public Acceptance of Tolling with New Capacity and Credits/Concepts of FAST Miles and FEE Lanes	University of Minnesota	Adeel Lari	Kenneth Buckeye	Shirlee Sherkow	4/16/09	7/31/10	SRP, Fast Miles Pricing	$75,000	$75,000	100%	X
2010-33	2007-049	89261 W078	MPR 6(007): Hear Every Voice Public Engagement Initiative	University of Minnesota	Jim Grothaus	Scott Bradley	Rebecca Lein	7/16/07	8/31/10	SRP, SP&R, Other State Funds	$230,798	$230,798	100%	X
CTS 10-06	2008-012	89261 W0130	Impact of Twin Cities Transitways on Regional Labor Market Accessibility: A Transportation Equity Perspective	University of Minnesota	Yingling Fan	Robert Vockrodt	Daniel Warzala	1/20/09	6/30/10	SRP	$17,763	$17,763	100%	
TRS1003	N/A	N/A	Developing a Culture of Innovation	CTC & Associates LLC	Patrick Casey	N/A	Shirlee Sherkow	N/A	N/A	N/A	N/A	N/A	100%	
TRS1004	N/A	N/A	ADA Compliance Reference and Training Materials	CTC & Associates LLC	Patrick Casey	Kristie Billiar	Shirlee Sherkow	N/A	N/A	N/A	N/A	N/A	100%	
TRS1006	N/A	N/A	Cadastral and Right of Way Data Sharing	Darlene Gorrill	Darlene Gorrill	Rick Morey, Jonette Kreidweiss	Alan Rindels	N/A	N/A	N/A	N/A	N/A	100%	
TRS1007	N/A	N/A	Decision Tree for Unpaving Roads	CTC & Associates LLC	Patrick Casey	Sue Miller	Shirlee Sherkow	N/A	N/A	N/A	N/A	N/A	100%	
TRS1008	N/A	N/A	Potential Benefits to the Freight Industry of Distance-Based Road User Fees	Ferrol Robinson	Ferrol Robinson	Ken Buckeye	Shirlee Sherkow	N/A	N/A	N/A	N/A	N/A	100%	
N/A	2008-014	89261 W093	Access to Destinations Study, Administration 2008-2009	University of Minnesota	Gina Baas	Cory Johnson	Linda Taylor	2/15/08	4/30/10	SRP	$14,000	$14,000	100%	
N/A	2008-011	89261 W0114	Development of a Weigh-Pad Based Portable WIM System	University of Minnesota - Duluth	Taek Kwon	Benjamin Timerson	Nelson Cruz	12/30/08	5/31/12	SRP	$160,000	$98,550	62%	
N/A	2008-012	89261 W0209	Assessing Neighborhood and Social Influences of Transit Corridors	University of Minnesota	Yingling Fan	Robert Vockrodt	Daniel Warzala	5/18/10	1/31/12	SRP	$12,500	$0	0%	

Policy & Planning [cont.]

Report Number	Project Number	Contract Number	Title	Contractor	Investigator	Technical Liaison	Administrative Liaison	Start Date	End Date	Funding Source	Total Cost	Amount Paid	% Paid	TS
N/A	2008-094	95029	TPF-5(192): Loop and Length Based Classification Pooled Fund	SRF Consulting Group, Inc.	Erik Minge	Gene Hicks	Debra Fick	1/27/10	5/31/12	SP&R	$404,543	$80,880	20%	
N/A	2009-015	89261 WO141	Advancing the Public Interest in Public-Private Partnerships of State Highway Development	University of Minnesota	Zhirong Jerry Zhao	Kenneth Buckeye	Daniel Warzala	6/8/09	2/28/11	SRP	$74,966	$24,739	33%	
N/A	2009-079	93463, Task 6	INV 645: RIC: LRRB Product Evaluation/Roadmapping	SRF Consulting Group, Inc.	Mike Marti	Rick Kjonaas	Clark Moe	2/19/09	12/31/11	LRRB	N/A	N/A	N/A	
N/A	2009-140	89261 WO214	Review of Workplace Wellness Program Options to Reduce Musculoskeletal Disorders in Laborious Work	University of Minnesota	Robert Feyen	Todd Haglin	Bruce Holdhusen	5/28/10	4/30/11	SRP	$11,312	$0	0%	
N/A	2010-011	89261 WO198	Quality of Life: Assessment and Evaluation to Develop Transportation Performance Measures	University of Minnesota	Ingrid Schneider	Karla Rains	Shirlee Sherkow	7/14/10	8/31/12	SRP, COPTRS	$218,913	$0	0%	
N/A	2010-013	89261 WO196	Case Studies of Transportation Investment to Identify the Impacts on the Local and State Economy	University of Minnesota	Michael Iacono	Matthew Shands	Bruce Holdhusen	8/27/10	2/28/12	SRP, COPTRS	$89,378	$0	0%	
N/A	2010-015	89261 WO201	Using Twin Cities Destinations and Their Accessibility as a Multimodal Planning Tool	University of Minnesota	David Levinson	Brian Gage	Alan Rindels	9/24/10	2/28/12	COPTRS	$100,000	$0	0%	

Pooled Fund Studies

Study #	Title	Technical Liaison	Administrative Liaison	Lead State or Agency	Number of Participating States	Current MN Commitment End Date	Total Cost	Total MN Commitment	MN 2010 Commitment	TS
TPF-5(192)	Loop and Length Based Classification Pooled Fund	Gene Hicks	Debra Fick	MN	14	2010	$405,000	$40,000	$10,000	
SPR-3(020)	IVHS Study (ENTERPRISE)	Ray Starr	Debra Fick	IA	9	2009	$1,295,000	$120,000	$0	X
SPR-3(049), TPF-5(198)	Urban Mobility Study	Paul Czech	Debra Fick	TX	13	2010	$1,375,000	$165,000	$70,000	
TPF-5(154)	Census Transportation Planning Products (CTPP) from the American Community Survey	Jonette Kreideweis	Debra Fick	FHWA	10	2007	$1,609,704	$102,546	$0	X

Traffic & Safety

Report Number	Project Number	Contract Number	Title	Contractor	Investigator	Technical Liaison	Administrative Liaison	Start Date	End Date	Funding Source	Total Cost	Amount Paid	% Paid	TS
2009-36	2006-041	89261 W011	Responding to the Unexpected Development of a Dynamic Data-Driven Traffic Operation Model for Effective Evacuation	University of Minnesota	Henry Liu	Ernest Lloyd	Cory Johnson	9/27/06	12/31/09	SRP	$150,000	$150,000	100%	X
2009-39	2006-042	89261 WO23	INV 845-2: Benefit:Cost Analysis of In-Vehicle Technologies and Infrastructure Modifications as a Means to Prevent Crashes Along Curves and Shoulders	University of Minnesota	Craig Shankwitz	Glen Ellis	Shirlee Sherkow	8/6/07	3/31/10	LRRB	$45,400	$45,400	100%	X
2010-02	2009-018	89261 WO137	Comparison of Dual-Phase and Static Changeable Message Signs to Convey Airline Information on Interstate Freeways	University of Minnesota	Kathleen Harder	Cassandra Isackson	Daniel Warzala	2/13/09	1/30/10	SRP	$99,500	$99,500	100%	X

Traffic & Safety [cont.]

Report Number	Project Number	Contract Number	Title	Contractor	Investigator	Technical Liaison	Administrative Liaison	Start Date	End Date	Funding Source	Total Cost	Amount Paid	% Paid	TS
2010-05	2009-001	89256 W06	INV 888: Minnesota Local Agency Pavement Marking Practices—Phase I	Iowa State University	Omar Smadi	Lee Amundson, Thomas Behm	Alan Rindels	4/9/09	2/28/10	LRRB	$18,720	$18,720	100%	X
2010-25	2009-155	95976	MPR-9(003): Design of Turn Lane Guidelines	CH2M Hill, Inc.	Howard Preston	Glen Ellis	Shirlee Sherkow	1/11/10	7/31/10	SRP, SP&R	$37,512	$37,512	100%	X
2010-36	2007-106	93097	TPF-5(171): Evaluation of Non-Intrusive Technologies for Traffic Detection	SRF Consulting Group, Inc.	Erik Minge	Jerry Kotzenmacher	Debra Fick	9/24/08	9/30/10	SP&R	$185,020	$185,020	100%	X
2010RIC02	2009-075	93463, Task 2	INV 645: RIC: Minnesota Sign Retroreflectivity Toolkit	SRF Consulting Group, Inc.	Mike Marti, Renae Kuehl	Michael Sheehan	Clark Moe	2/19/09	12/31/11	LRRB	$25,992	$25,992	100%	X
2010RIC10	2009-194	96011	INV 903: RIC: Best Practices for Traffic Sign Maintenance and Management	CH2M Hill, Inc.	Howard Preston	Mark Vizecky	Clark Moe	1/13/10	1/31/11	LRRB	$74,985	$45,546	61%	X
2010RIC13	2008-041, 2009-091	93463, Task 13	INV 645: RIC: Guardrail Replacement and Maintenance Guidelines	SRF Consulting Group, Inc.	Mike Marti, Renae Kuehl	Gary Danielson	Clark Moe	4/17/09	3/30/10	LRRB	$54,495	$54,495	100%	X
2011-04	2007-008	89261 W091	INV 877: Advanced Dynamic LED Warning Signs for Rural Intersections Powered by Renewable Energy	University of Minnesota - Duluth	Taek Kwon	Brian Boder	Alan Rindels	2/15/08	2/28/11	LRRB	$125,476	$71,440	57%	
TRS1001	N/A	N/A	Effects of Major Traffic Generators on Local Highway Systems	Minnesota State University, Mankato	W. James Wilde	N/A	Shirlee Sherkow	N/A	N/A	N/A	N/A	N/A	100%	
TRS1002	N/A	N/A	Effectiveness of Traffic Signs on Local Roads	CTC & Associates LLC	Patrick Casey	N/A	Shirlee Sherkow	N/A	N/A	N/A	N/A	N/A	100%	
TRS1009	N/A	N/A	Effects of 24-Hour Headlight Use on Traffic Safety	CTC & Associates LLC	Patrick Casey	Gordy Pehrson	Jake Akervik	N/A	N/A	N/A	N/A	N/A	100%	
N/A	2007-085	92751	MPR-6(020): Crash Mapping and Analysis Tool (MnCMAT)	Great Arc Technologies, Inc.	Michael Scanlon	Richard Kjonaas, Mark Vizecky	Clark Moe	9/21/09	8/31/10	SP&R, Other State Funds	$162,720	$162,720	100%	
N/A	2008-060	94522	TPF-5(190): North/West Passage: Project 4.1 Traveler Information Web Site—Phase 3 and Project 4.3 Center to Center Communications Concept of Operations	Open Roads Consulting	Jeffrey Adler	Matthew Gjersvik	Debra Fick	12/1/09	9/30/10	SP&R, Partnership Funds	$75,000	$75,000	100%	
N/A	2009-101	92452	TPF-5(093): OTSO North/West Passage Web Site	North Dakota State University	Ayman Smadi	Todd Kramascz	Debra Fick	2/26/09	3/1/10	SP&R	$3,195	$3,195	100%	
N/A	2008-041, 2009-175	93463, 95937	INV 895: RIC: Traffic Generator	SRF Consulting Group, Inc./ Minnesota State University, Mankato	Mike Marti, W. James Wilde	Gary Danielson	Clark Moe	4/17/09	5/31/12	LRRB	$79,062	$52,772	67%	
N/A	2008-057	89261 W0115	MPR-8(002): Vehicle Telematics for Novice Teenage Driver Support System—Smartphone Based Novice Teenage Driver Support	University of Minnesota	Max Donath	Susan Sheehan	Daniel Warzala	12/9/08	5/31/11	SRP, SP&R	$500,000	$391,184	78%	
N/A	2008-059	89261 W0116	ITS Institute Mn/DOT Match—FY09/10	University of Minnesota	Max Donath	Linda Taylor	Linda Taylor	12/5/08	1/31/11	SRP	$800,000	$600,000	75%	
N/A	2009-012	89261 W0139	INV 890: Speed Impacts of Occasional Hazard Residential Street Warning Signs	University of Minnesota	John Hourdos	Amy Marohn	Shirlee Sherkow	6/30/09	2/28/11	LRRB	$79,647	$58,939	74%	
N/A	2009-016	89256 W07	Pavement Marking Performance Under Challenging Pavement Surface Condition Chip & Seal Coat and Micro Surfacing	Iowa State University	Neal Hawkins	Mitchell Bartelt, Bradley Lechtenberg	Alan Rindels	3/1/10	10/31/11	SRP	$39,991	$0	0%	
N/A	2009-019	89261 W0143	Portable Non-Intrusive Advanced Warning Devices for Work Zones With or Without Flag Operators	University of Minnesota	John Hourdos	Randy Reznicek	Daniel Warzala	7/30/09	7/31/11	SRP	$61,986	$9,297	15%	

Traffic & Safety [cont.]

Report Number	Project Number	Contract Number	Title	Contractor	Investigator	Technical Liaison	Administrative Liaison	Start Date	End Date	Funding Source	Total Cost	Amount Paid	% Paid	TS
N/A	2009-021	89256 WO8	Implementation, Training and Outreach for Mn/DOT Pavement Marking Tool—Phase II	Iowa State University	Omar Smadi	Mitchell Bartelt	Alan Rindels	5/7/09	7/31/11	SRP	$86,970	$12,970	15%	
N/A	2009-098	89261 WO169	Development of Freeway Management and Operational Strategies with IRIS-In-LOOP Simulation	University of Minnesota - Duluth	Eil Kwon	Brian Kary	Alan Rindels	10/1/09	5/31/11	SRP	$86,000	$0	0%	
N/A	2009-101	91150	TPF-5(093): North/West Passage Program Support and Phase II Work Plan Projects	Athey Creek Consultants, LLC	Dean Deeter	Matthew Gjersvik	Debra Fick	9/14/07	8/31/12	SP&R	$256,358	$226,817	88%	
N/A	2009-151	89261 WO178	MPR-9(006): Research Implementation of the SMART Signal System on TH13	University of Minnesota	Henry Liu	Steven Misgen	Shirlee Sherkow	12/17/09	2/2/12	SRP, SP&R	$239,000	$0	0%	
N/A	2009-191	89256 WO9	Traffic Safety Analysis Software State of the Art	Iowa State University	Reginald Souleyrette	Bradley Estochen	Shirlee Sherkow	3/12/10	2/28/11	SRP	$28,403	$0	0%	
N/A	2009-193	89261 WO195	INV 898: Estimating the Crash Reduction and Vehicle Dynamic Effects of Flashing LED Stop Signs	University of Minnesota	Gary Davis	David Engstrom	Shirlee Sherkow	6/28/10	12/31/11	LRRB, plus ITS Institute ($37,333)	$74,667	$0	0%	
N/A	2010-004	96737	INV 900: Hennepin/Minneapolis LED Light Study	Hennepin County	Robb Luckow	Julie Skallman	Shirlee Sherkow	6/25/10	9/30/12	LRRB	$50,000	$45,000	90%	
N/A	2010-031	89261 WO224	Integration of New Ramp Metering Formula in RTMC IRIS System	University of Minnesota	John Hourdos	None	Alan Rindels	7/8/10	2/28/11	SRP, COPTRS, Imp	$17,662	$0	0%	
N/A	2010-058	89261 WO238	INV 645 RIC: Truck Weight Education Pilot Module	University of Minnesota, Alexandria Technical College	Jim Grothaus, Greg Hayes	Rick Kjonaas	Clark Moe	TBD	TBD	LRRB	$20,000	$0	0%	

Pooled Fund Studies

Study #	Title	Technical Liaison	Administrative Liaison	Lead State or Agency	Number of Participating States	Current MN Commitment End Date	Total Cost	Total MN Commitment	MN 2010 Commitment	TS
TPF-5(171)	Evaluation of Non-Intrusive Traffic Detection Technologies—Phase III (PNITDS); *see 2010-36 above*	Jerry Kotzenmacher	Debra Fick	MN	13	2007	$210,000	$15,000	$0	X
TPF-5(093), TPF-5(190)	North/West Passage—Phase 3	Matt Gjersvik	Debra Fick	MN	8	2010	$750,000	$200,000	$25,000	
SPR-2(207)	Transportation Management Center Pooled Fund Study	Brian Kary	Debra Fick	FHWA	28	2012	$4,912,267	$350,000	$50,000	X
SPR-3(017), TPF-5(193)	Midwest States Pooled Fund Crash Test Program	Michael Elle	Debra Fick	NE	16	2011	nearly $12,000,000	$1,320,863	$66,700	X
TPF-5(004)	Long-Term Pavement Performance (LTPP) Specific Pavement Study (SPS) Traffic Data Collection	Matthew Oman	Debra Fick	FHWA	24	2009	$14,676,285	$175,000	$0	
TPF-5(029)	High Occupancy Vehicle	Janelle Anderson	Debra Fick	FHWA	11	2010	$1,865,000	$150,000	$25,000	X
TPF-5(099)	Evaluation of Low Cost Safety Improvements	David Engstrom	Debra Fick	FHWA	28	2007	$2,670,000	$195,000	$0	X
TPF-5(114)	Roadside Safety Research Program	Michael Elle	Debra Fick	WA	8	2011	$1,000,000	$400,000	$50,000	X
TPF-5(120)	Deer Vehicle Crash Information and Research (DVCIR) Center	Sue Sheehan	Debra Fick	FHWA	10	2006	$260,000	$50,000	$0	
TPF-5(144)	Use of Video Feedback in Urban Teen Drivers	Ray Starr	Debra Fick	IA	2	2010	$0	$80,000	$0	X

Administrative

Report Number	Project Number	Contract Number	Title	Contractor	Investigator	Technical Liaison	Administrative Liaison	Start Date	End Date	Funding Source	Total Cost	Amount Paid	% Paid	TS
N/A	2007-039	94156	MPR-6(005): Next Generation of ARTS Tech Support and Maintenance Services	ArchWing Innovations, LLC	Ryan Anderson	Nelson Cruz	Benjamin Worel	5/13/09	4/30/11	SRP, SP&R	$108,540	$53,750	50%	
N/A	2007-075	96047	MPR-6(019): Technology Transfer Material Development—Phase V	CTC & Associates LLC	Patrick Casey	Jake Akervik	Benjamin Worel	2/8/10	10/31/10	SRP, SP&R	$99,848	$99,581	100%	
N/A	2007-092	91173	Research Services and Local Road Research Board Web Site Hosting and Maintenance, 2008-2009	MIS Sciences Corp	Jeff Willis	Jake Akervik	Jake Akervik	12/3/07	3/31/10	SRP	$21,312.50	$21,313	100%	
N/A	2008-040	89261 WO162	INV 998: Operational Research Program for Local Transportation Groups, FY2010	University of Minnesota	Jim Grothaus	Mark Maloney	Clark Moe	6/19/09	11/30/10	LRRB	$90,000	$4,860	5%	
N/A	2008-051	89261 WO168	RSS Report Publication Services, 2010	University of Minnesota	Gina Baas	Jake Akervik	Sandra McCully	7/17/09	7/31/10	SRP	$49,597	$37,198	75%	
N/A	2009-059	93423	MPR-6(003): Innovation Program Development	David Johnson	Dave Johnson	Linda Taylor	Cory Johnson	10/1/08	11/30/10	SRP, SP&R	$100,000	$99,999	100%	
N/A	2009-093	92329	MPR-6(004): Investigation and Evaluation of Closeout Memo Data for the Development of Additional Performance Measures	William Bunde	Bill Bunde	Cory Johnson	Clark Moe	1/30/08	3/31/10	SRP, SP&R	$78,490	$78,490	100%	
N/A	2009-093	92724	MPR-6(004): Implementation Plan Development, Closeout Memos and Implementation Communication Products	Darlene Gorrill	Darlene Gorrill	Jake Akervik	Benjamin Worel	4/28/08	8/31/10	SRP, SP&R	$39,600	$28,380	72%	
N/A	2009-093	92843	MPR-6(004): Implementation and Closeout Program Administration Support	Micky Ruiz	Micky Ruiz	Shirlee Sherkow	Alan Rindels	5/30/08	8/31/10	SRP, SP&R	$97,500	$97,500	100%	
N/A	2009-115	95940	Execution of Library 2009 Library Business Plan	Donald G. Kelsey	Donald G. Kelsey	Sheila Hatchell	Linda Taylor	12/18/09	3/31/10	SRP	$500	$500	100%	
N/A	2009-125	94606	Project Portfolio Management	Trissential	Steve Beise	N/A	Ann McLellan	5/4/09	1/31/10	2010 OIM	$4,999	$4,999	100%	
N/A	2009-147	89261 WO166	INV 668: Local Technical Assistance Program (LTAP), FY2010	University of Minnesota	Jim Grothaus	Julie Skallman	Linda Taylor	9/29/09	10/31/10	LRRB, Other Federal Funds	$440,500	$440,500	100%	
N/A	2007-039	94156	MPR-6(005): Next Generation of ARTS Tech Support and Maintenance Services	ArchWing Innovations, LLC	Ryan Anderson	Nelson Cruz	Benjamin Worel	5/13/09	4/30/11	SRP, SP&R	$108,540	$56,650	52%	
N/A	2007-075	95283	MPR-6(019): Technical Transfer Material Development—Phase IV	CTC & Associates LLC	Patrick Casey	Jake Akervik	Benjamin Worel	9/24/09	4/30/11	SRP, SP&R	$99,954	$88,640	89%	
N/A	2007-075	97585	MPR-6(019): Technology Transfer Material Development	CTC & Associates LLC	Patrick Casey	Jake Akervik	Benjamin Worel	9/17/10	9/30/11	SRP, SP&R	$99,825	$26,221	26%	
N/A	2007-092	95501	Research Services and Local Road Research Board Web Site Hosting and Maintenance, 2010-2011	MIS Sciences Corp	Jeff Willis	Jake Akervik	Jake Akervik	3/17/10	1/31/12	SRP	$16,150	$3,500	22%	
N/A	2008-040	89261 WO210	INV 998: FY2011 Operational Research Program for Local Transportation Groups (OPERA)	University of Minnesota	Jim Grothaus	Mark Maloney	Clark Moe	9/9/10	9/30/11	LRRB	$90,000	$1,980	2%	
N/A	2008-041	93463	INV 645: RIC Implementation of Research Findings, FY2009-2011	SRF Consulting Group, Inc.	Mike Marti	Michael Sheehan	Clark Moe	4/17/09	12/31/11	LRRB	$497,697	$275,219	55%	
N/A	2008-051	89261 WO219	RSS Report Publication Services, FY2011	University of Minnesota	Arlene Mathison	Jake Akervik	Sandra McCully	7/15/10	8/31/11	SRP	$49,468	$11,971	24%	
N/A	2009-059	94376	MPR-6(003): Business Assessment of RSS Processes and Tools	Trissential	Steve Beise	Rose Keller	Benjamin Worel	11/4/09	6/30/11	SRP, SP&R	$75,000	$16,680	22%	
N/A	2009-059	95936	MPR-6(003): Strategic Program Development	David Johnson	Dave Johnson	Benjamin Worel	Linda Taylor	12/22/09	6/30/11	SRP, SP&R	$50,000	$28,890	58%	
N/A	2009-115	89261 WO184	Execution of 2009 Library Business Plan	University of Minnesota	Arlene Mathison	Sheila Hatchell	Linda Taylor	3/5/10	4/30/11	SRP	$30,414	$7,604	25%	

Administrative [cont.]

Report Number	Project Number	Contract Number	Title	Contractor	Investigator	Technical Liaison	Administrative Liaison	Start Date	End Date	Funding Source	Total Cost	Amount Paid	% Paid	TS
N/A	2009-139	89261 WO159	CTS Operations, FY2010-2011	University of Minnesota	Laurie McGinnis	N/A	Linda Taylor	7/31/09	6/30/11	SRP, PARI	$2,400,000	$1,800,000	75%	
N/A	2010-045	89261 WO225	INV 668: Local Technical Assistance Program (LTAP), FY2011	University of Minnesota	Jim Grothaus	Clark Moe	Clark Moe	8/30/10	10/31/11	LRRB, Other Federal Funds	$440,500	$0	0%	
N/A	2010-047	INV 675	INV 675: FY2011 Research Services Positions	N/A	N/A	N/A	Linda Taylor	7/1/10	6/30/11	LRRB	$160,000	$0	0%	
N/A	2010-047	INV 745	INV 745: FY2011 Library Services	N/A	Sheila Hatchell	N/A	Linda Taylor	7/1/10	6/30/11	LRRB	$70,000	$0	0%	

Pooled Fund Studies

Study #	Title	Technical Liaison	Administrative Liaison	Lead State or Agency	Number of Participating States	Current MN Commitment End Date	Total Cost	Total MN Commitment	MN 2010 Commitment	TS
TPF-5(069)	Core Program Services for a Highway Research, Development and Technology Program	Linda Taylor	Debra Fick	FHWA	20	2010	$6,675,025	$383,115	$127,705	
TPF-5(105)	Transportation Library Connectivity	Sheila Hatchell	Debra Fick	WI	24	2009	$1,290,000	$100,000	$0	X
TPF-5(109)	Core Program Services for a Highway Research, Development and Technology Program (TRB)	Linda Taylor	Debra Fick	FHWA	22	2010	$17,500,000	$383,115	$127,705	
TPF-5(209)	Support of the Transportation Curriculum Coordination Council (TCCC)	Catherine Betts	Debra Fick	FHWA	10	2012	$750,000	$75,000	$15,000	X
TPF-5(410)	National Cooperative Highway Research Program (NCHRP)	Linda Taylor	Debra Fick	FHWA	All	Ongoing	N/A	N/A	$658,602	

2010 Technical Summaries—Introduction

These project summaries, organized by topic area, were produced by Research Services with the help of participants on the projects described. They have been created for technology transfer purposes. You can access and download any of them from our Web site (**http://www.dot.state.mn.us/research/2010-technical-summaries.html**) for use as handouts at conferences, mailings to staff in an area that should be made aware of this research, information sheets for legislators or simply as quick-reference sheets.

For more information on any of these projects, you can contact the Administrative or Technical Liaison indicated on the summary. For more information about Technical Summaries, please contact Jake Akervik at **Jake.Akervik@state.mn.us**.

2009-40TS
Published October 2010

LRRB
LOCAL ROAD RESEARCH BOARD

TECHNICAL SUMMARY

Technical Liaisons:
Chris Morris, St. Louis County
morrisc2@co.st-louis.mn.us

Dave Conkel, Mn/DOT
Dave.Conkel@state.mn.us

Administrative Liaison:
Deb Fick, Mn/DOT
Deb.Fick@state.mn.us

Principal Investigator:
Brian Brashaw, University of Minnesota Duluth

LRRB PROJECT COST:
$52,980

Electric motors with offset weights are used to create vibrations in the wooden bridge deck that are detected with sensors elsewhere on the deck.

MINNESOTA DEPARTMENT OF TRANSPORTATION

RESEARCH SERVICES
OFFICE OF POLICY ANALYSIS, RESEARCH & INNOVATION

Developing Flexural Vibration Inspection Techniques for Wooden Bridges

Researchers improved and automated a vibration testing system for wooden bridges designed to identify changes in the structural health of a bridge over time by monitoring the resonant frequencies of the structure, extending the use of this technique to dowel-laminated bridges.

What Was the Need?

There are more than 50,000 timber bridges in the United States and more than 4,000 in Minnesota, nearly all of which are on rural roads and maintained by local or county transportation agencies. Current inspection procedures are mostly limited to visual inspection of the wooden components of the bridge; these inspections are sufficient for detecting advanced decay, but are inadequate for determining early-stage degradation or internal damage to bridge members. Such inspections are also intensive and time-consuming, leading to inspection intervals that are less frequent than desired by bridge owners.

Deterioration can progress rapidly in wooden bridges, and owners want to address it as quickly as possible to minimize needed maintenance and preserve overall safety for traffic use. In Phase I of this study, researchers investigated the initial promise of using forced-vibration techniques to nondestructively evaluate the health of wooden bridges.

These techniques involve applying a forced vibration to the bridge and examining the oscillations (small deflections of the structure) with instruments attached to the deck. The resonant frequencies of the vibrations reflect the physical characteristics of the bridge, such as the overall rigidity.

Further development of such assessment techniques would enhance the care and maintenance of wooden bridges, especially if they could be used by local personnel to provide timely, inexpensive evaluations of the health of the bridges.

What Was Our Goal?

The goals of this project were to improve and automate a vibration testing system of dowel-laminated bridges and to conduct vibration tests to better understand the potential for the technique in assessing the structural health and condition of Minnesota's wooden bridges.

What Did We Do?

In its early development, the vibration testing system had been limited to short-span timber bridges whose structural integrity is largely vertical, meaning that the main constraint to flexure is provided by the pilings supporting the bridge deck. In this project, researchers applied the vibration technique to dowel-laminated timber bridges, which are built with individual timbers connected side by side and held together with metal spikes, forming a deck much like a laminated butcher-block countertop. Such deck structures display horizontal as well as vertical integrity—behaving more like a plate than a beam—and, consequently, have vibration characteristics different from the previously examined girder-style bridges.

The testing procedure utilized a one-half horsepower DC motor rotating an unbalanced disc attached at the center of the bridge span to vibrate the deck. Accelerometers attached at midspan measured the amplitude of vibration of the deck over a range of frequencies as the revolutions per minute of the motor increased.

continued

"Vibration testing aids inspectors by identifying trends in the structural integrity of the timber that indicate early deterioration."

–Brian Brashaw,
Program Director,
National Resources
Research Institute,
University of Minnesota
Duluth

"Wood rots from the inside out. With vibration testing, we can get a heads-up before the response becomes a knee-jerk reaction."

–Chris Morris,
Bridge Engineer,
St. Louis County

Produced by CTC & Associates for:
Minnesota Department
of Transportation
Research Services Section
MS 330, First Floor
395 John Ireland Blvd.
St. Paul, MN 55155-1899
(651) 366-3780
www.research.dot.state.mn.us

Researchers examined the potential for using vibration testing to assess the structural health of dowel-laminated bridge systems—wooden bridges constructed with laminated timbers held together transversely by metal dowels and supported by a spreader beam.

Researchers tested the deck panels of Bridge 53 in St. Louis County prior to, during and after construction, measuring the vibration characteristics of the bridge members throughout the assembly process. They also tested 12 other existing dowel-laminated bridge spans in northern Minnesota of varying ages.

Earlier versions of the vibration testing system relied significantly on operator expertise, and many individual steps were required to obtain and analyze the data. Researchers improved and automated the system using a ruggedized laptop running LabVIEW Windows to control the testing equipment and acquire the data.

What Did We Learn?

The vibration testing showed that the system developed is an effective tool for conducting forced vibration tests. The data acquisition and analysis system easily found the three signature vibration frequencies during each stage of the construction of Bridge 53 and showed that these frequencies increase significantly over the stages of construction. This confirms and quantifies the expectation that vibration testing could probe the bridge's rigidity.

The automated system performed similarly well on the 12 other bridges tested, automatically identifying three peaks in vibration amplitude over a range of vibration frequencies from 14 to 35 Hz. Researchers expect that monitoring the vibration characteristics over time would reveal structural changes correlated with decreasing resonant frequencies that would indicate worrisome deterioration within the bridge. Precise correlation of the level of deterioration with a given set of resonant frequencies requires further study.

What's Next?

Researchers hope to correlate the vibration response of a bridge with various levels of deterioration by building a bridge and tracking the vibration characteristics while forcing rapid decay of the bridge. Additionally, researchers are trying to use advanced monitoring techniques to assess the pilings of the bridges for early decay and rot. Funding for these projects is under consideration.

This Technical Summary pertains to the LRRB-produced Report 2009-40, "Development of Flexural Vibration Inspection Techniques to Rapidly Assess the Structural Health of Rural Bridge Systems: Phase II," published December 2009. The full report can be accessed at http://www.lrrb.org/PDF/200940.pdf.

This study is a continuation of the Northland Advanced Transportation Systems Research Laboratory-funded project CTS 08-22, "Development of Flexural Vibration Inspection Techniques to Rapidly Assess the Structural Health of Rural Bridge Systems." The final report for this project can be accessed at http://www.cts.umn.edu/Publications/ResearchReports/reportdetail.html?id=1692.

2010-03TS
Published July 2010

RESEARCH SERVICES

OFFICE OF POLICY ANALYSIS, RESEARCH & INNOVATION

TECHNICAL SUMMARY

Technical Liaison:
Lowell Johnson, Mn/DOT
Lowell.Johnson@state.mn.us

Administrative Liaison:
Shirlee Sherkow, Mn/DOT
Shirlee.Sherkow@state.mn.us

Co-Principal Investigators:
Carol Shield, University of Minnesota
Cathy French, University of Minnesota

PROJECT COST:
$114,390

Mn/DOT cares for more than 1,200 prestressed concrete bridges built between 1929 and 2005.

Discrepancies in the Shear Strength of Prestressed Beams with Different Specifications

Previous studies have revealed discrepancies between load rating calculations and the expected carrying capacity based upon visual inspections of bridges. In this study, researchers investigated possible sources of these discrepancies and suggested some remedies.

What Was the Need?

The codes and standards for bridge design and load rating have changed significantly over the years. Nearly two-thirds of the 1,200 prestressed concrete bridges under Mn/DOT's care were designed using pre-1983 AASHTO Standard Specifications, which are now known to contain potential shear design flaws.

When older bridges are rated using current standards, it is not unusual for the shear capacity to reduce the overall rating, meaning that the exact same bridge design would not be permitted for new construction today. While this low rating correlates with reduced capacity, some bridges receiving such a rating show no signs of distress upon visual inspection. Consequently, this method of computing load ratings makes it difficult to discern which bridges actually need attention, maintenance and repair. This uncertainty leads to a backlog in scheduling detailed inspections as well as wasted time and money. In addition, a significant number of bridges in the Mn/DOT inventory have untapped capacity and load limits that are overly conservative, unnecessarily restricting them from carrying permit loads and making the regulation of truck weights on Minnesota's roads and bridges more difficult.

What Was Our Goal?

The primary goal of this research was to resolve the discrepancies among the various methods used to determine shear capacities of prestressed concrete girders. This would facilitate recommendations that would make bridge load ratings more precise and the selection process more robust for bridges in need of closer inspection.

What Did We Do?

Researchers conducted an analytical research program, exploring a variety of factors that regulate the calculation of the shear component of a bridge's inventory rating and operating rating levels, including the effect of girder end-blocks and increased concrete strength on the overall shear strength of the girders. The inventory rating level corresponds to a live load level that can be safely supported by a bridge an indefinite number of times, while the operating rating level corresponds to the maximum live load level that can be safely supported by the bridge. Both ratings are used in guiding judgments regarding the loads allowed on the bridges. The operating rating level is used to restrict legal and permit overloads on bridges.

Fifty-four bridges with a low inventory rating level (less than unity) for shear were selected and evaluated according to the 2002 AASHTO Standard Specifications. (Note that no Mn/DOT bridges have operating rating levels for shear that are less than unity.) Researchers used the *Virtis*-BRASS software rating tool for the study. They also evaluated the rating tool by comparing the results to detailed calculations done by hand.

continued

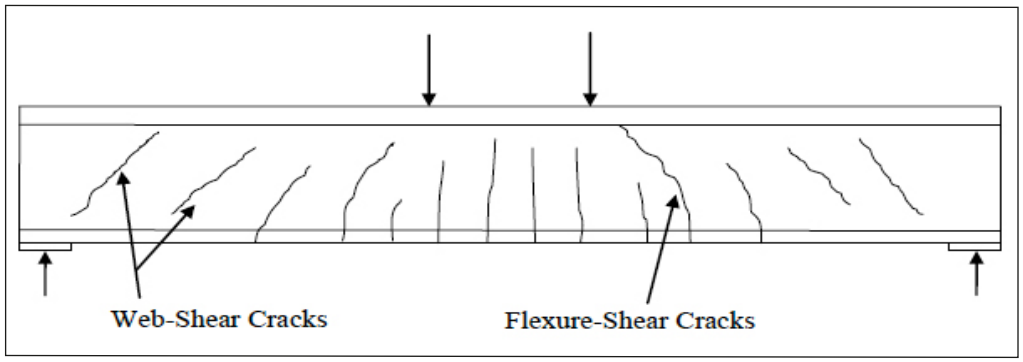
"Mn/DOT has a large number of prestressed concrete bridges built over 50 years. According to current rating methods, some of them rate low in shear, but these bridges are still performing well, and inspections have not detected problems."

–Lowell Johnson,
Load Rating Engineer, Mn/DOT Bridge Office Rating Section

"With the corrections, the software gives a good hierarchical ranking of the bridges."

–Carol Shield,
Professor, University of Minnesota Department of Civil Engineering

Produced by CTC & Associates for:
Minnesota Department
of Transportation
Research Services Section
MS 330, First Floor
395 John Ireland Blvd.
St. Paul, MN 55155-1899
(651) 366-3780
www.research.dot.state.mn.us



Excessive shear—the net force on a girder perpendicular to its length resulting from the pilings holding up the ends and the supported weight pushing down across the span—can crack the concrete of a girder, possibly compromising its strength.

What Did We Learn?

Researchers:

- Identified several errors in the *Virtis*-BRASS software. They notified the vendor about these errors, which have since been corrected. These corrections moved about 25 percent of the bridges that rated below unity for shear to above unity. With these corrections, bridge owners should continue to use the software to rate Mn/DOT bridges.
- Found that detailed calculations of end-block contributions to shear strength are unnecessary as they do not significantly change the shear ratings.
- Determined that compressive strengths of girders that are at least 20 years old can be assumed to increase by 20 percent from the nominal 28-day concrete compressive design strengths, producing a 2 percent to 5 percent increase in shear capacity and raising the load ratings by approximately 6 percent.
- Discovered that a number of girders in the inventory do not meet the requirements of the specification in effect at the time of design, making a simple specification-based selection impossible. Bridges with small span-to-spacing ratios (that is, $L/S_g < 10$) should receive further inspection.
- Found that shear rating in the critical section of $h/2$ from the face of the girder support is a good indicator of the overall shear rating throughout the girder and may be used as an indicator for whether further inspection is required.
- Determined that selection for further inspection should include consideration of heavy commercial average daily traffic counts.
- Found that heavy sand trucks should be used to load the bridge during inspection to reveal potential diagonal cracking due to shear. Such cracks may exist but be closed without the application of external load.

What's Next?

Though this research resolved a number of issues, questions remain about the relation between rating and performance of some Mn/DOT bridges. These questions will be resolved by more detailed on-site inspection. Researchers have also proposed a study to examine the effects of weight distribution on overall shear capacity, looking for further sources of reserve load capacity.

This Technical Summary pertains to Report 2010-03, "Discrepancies in Shear Strength of Prestressed Beams with Different Specifications," published January 2010. The full report can be accessed at http://www.lrrb.org/PDF/201003.pdf.

2010-14TS
Published September 2010

RESEARCH SERVICES

OFFICE OF POLICY ANALYSIS, RESEARCH & INNOVATION

TECHNICAL SUMMARY

Technical Liaison:
Andrea Hendrickson, Mn/DOT
Andrea.Hendrickson@state.mn.us

Administrative Liaison:
Shirlee Sherkow, Mn/DOT
Shirlee.Sherkow@state.mn.us

Principal Investigator:
Jeff Marr, University of Minnesota

PROJECT COST:
$60,000

Debris can damage monitoring equipment, limiting or eliminating its effectiveness.

Decision Support for Scour Monitoring on River Bridges

Bridge scour threatens bridge stability and the safety of the traveling public. Researchers developed a decision-making tool that uses the unique bridge and waterway characteristics of individual sites to help bridge operators successfully identify the best fixed scour monitoring methods.

What Was the Need?

Bridge scour occurs when rapidly moving water erodes the bed material from around bridge abutments or piers. This presents a major problem: Approximately 60 percent of bridge failures in the United States are due to bridge scour and stream instability.

Portable scour monitoring devices require inspectors to travel to bridge locations, which is often difficult due to the number of bridges and their locations across the state. Monitoring is particularly challenging during the annual snowmelt when most bridges are subject to high water flows. Fixed monitoring devices provide continuous monitoring, alerting personnel when the scour level becomes critical and requires attention.

A variety of fixed monitoring methods has been developed, ranging in complexity, cost, robustness and measurement resolution. Selecting the optimal device for a particular body of water and bridge can save money and time and can improve the accuracy of scour data. This in turn can lead to earlier detection of problems, which will allow for the timely closure and remediation of scour-critical bridges, potentially saving lives.

What Was Our Goal?

The primary objective of this project was to develop a scour monitoring decision framework, or SMDF, to assist bridge operators in choosing the best fixed monitoring tool appropriate for each situation.

What Did We Do?

Investigators first reviewed relevant research on scour monitoring methods, connecting existing technologies, experiences and techniques to challenges faced in Minnesota. They analyzed previous attempts in Minnesota and 37 other states that used fixed monitoring. Seven states were contacted and interviewed about their experiences with different monitoring methods.

Researchers then developed the SMDF, which employs an Excel workbook enabled with Visual Basic programming. The system accepts site-specific bridge and waterway information, compares it to critical scour monitoring technology characteristics, and then provides a ranking of the best tools for the site. To create this system, researchers first identified the critical bridge and waterway characteristics needed as inputs, including flow conditions, river flow habits, bridge geometry, bed material, and surface and subsurface material.

Eight fixed monitoring technologies were then characterized using categories and subcategories designed to identify strengths and weaknesses of each tool. The factors used for categorization are broad enough to evaluate any current and future monitoring options and to include sensor attributes, datalogger interface, personal interface, power, installation, cost, life span and serviceability.

Once the SMDF was complete, researchers tested it on five trunk highway bridges that

continued

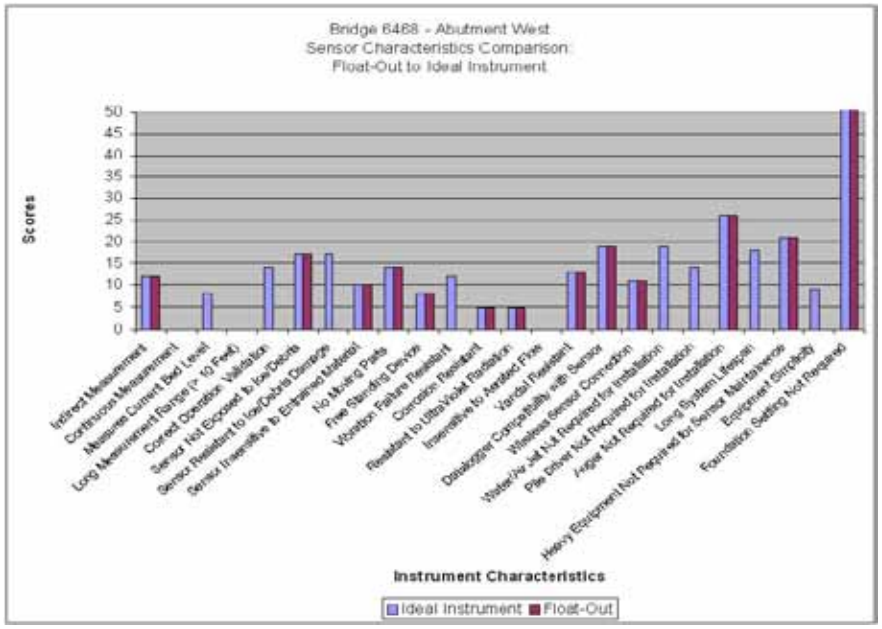
"The framework developed from this project will help bridge owners evaluate and select bridge fixed scour monitoring alternatives."

–Andrea Hendrickson,
Mn/DOT State Hydraulics Engineer

"This decision-making tool addresses one of the major problems with regard to fixed scour monitoring instrumentation: No single methodology can be used to solve scour measuring problems for every situation."

–Jeff Marr,
Associate Director of Applied Research, St. Anthony Falls Laboratory, University of Minnesota

Produced by CTC & Associates for:
Minnesota Department
of Transportation
Research Services Section
MS 330, First Floor
395 John Ireland Blvd.
St. Paul, MN 55155-1899
(651) 366-3780
www.research.dot.state.mn.us



The output of the SMDF can be viewed as a bar graph showing the importance of each characteristic and whether the selected tool satisfies the characteristic.

represented conditions found at most scour-critical bridge sites in Minnesota, inputting bridge and waterway data and generating monitoring tool recommendations.

Finally, researchers produced a user manual for the SMDF and detailed work plans for deployment of fixed monitoring equipment on two Minnesota bridges.

What Did We Learn?

States' experiences with monitoring devices showed that no single scour monitoring method can be used for all the different situations encountered in the field. For example, manual magnetic collar devices are low cost and easy to install but are very susceptible to debris. Sonar devices—the most popular technology currently in use—are more expensive but provide continuous monitoring, allow easy data transmission and are only somewhat susceptible to debris.

Evaluation of previous fixed monitoring devices in Minnesota revealed several key lessons. Debris is a major concern as it can destroy the fixed monitoring equipment or cause inaccurate scour measurements. Monitoring equipment should be installed during low water events and a review of available subsoil information should be performed before installation. A regular maintenance schedule also needs to be set, appropriate for the device in question.

Application of the SMDF to bridges in Minnesota produced results that were intuitive to those already familiar with the range of fixed scour monitoring practices and the selected sites. The most common and highly rated tools for monitoring piers and abutments, according to the SMDF, were sonar and float-out devices, respectively. The SMDF assists engineers in deciding which type of fixed scour monitoring instrumentation is best suited for a specific bridge site and how to mitigate potential problems that may occur with the user-selected tool as well as warning users of atypical scour at the bridge site.

What's Next?

Work plans developed as part of this research have been approved for funding. This implementation effort will involve the installation of several different types of fixed monitoring devices for further evaluation under real-world conditions.

This Technical Summary pertains to Report 2010-14, "Bridge Scour Monitoring Technologies: Development of Evaluation and Selection Protocols for Application on River Bridges in Minnesota," published March 2010. The full report can be accessed at http://www.lrrb.org/PDF/201014.pdf. *For information about the scour monitoring implementation effort, please contact* Andrea.Hendrickson@state.mn.us.

2010-39TS
Published December 2010

RESEARCH SERVICES

OFFICE OF POLICY ANALYSIS, RESEARCH & INNOVATION

TECHNICAL SUMMARY

Technical Liaison:
Moises Dimaculangan, Mn/DOT
Moises.Dimaculangan@state.mn.us

Administrative Liaison:
Shirlee Sherkow, Mn/DOT
Shirlee.Sherkow@state.mn.us

Principal Investigator:
Arturo Schultz, University of Minnesota

PROJECT COST:
$79,925

Waterproof housings allow for on-site installation of electronics necessary to power the sensors and acquire data.

Development of an Advanced Structural Monitoring System for Fracture-Critical Steel Bridges

What Was the Need?

While not inherently unsafe, fracture-critical bridges have at least one nonredundant structural component whose failure would lead to collapse of the bridge. As they age, such bridges require more frequent on-site inspections than other types, and these inspections are costly. Advanced monitoring of bridges using on-site sensing systems has the potential to provide more information about a bridge's health more quickly and at a lower cost, ensuring safer bridges and saving dollars.

Researchers developed an advanced continuous monitoring system for steel bridges that would provide a distress warning of likely imminent collapse.

Following the collapse of the I-35W bridge in August 2007, Mn/DOT adopted the goal of developing technology that could be used to effectively monitor fracture-critical bridges. Current commercial technologies for distress warning are triggered by the collapse of the bridge being monitored. Bridge caretakers would much prefer a system that warns of imminent collapse or other serious circumstances that could be addressed by immediate repair and/or closing of the bridge to traffic.

To fill this gap, Mn/DOT has funded an ongoing research effort aimed at developing and deploying a structural monitoring system to provide advance warning of distress. (After this project began, the Minnesota Legislature also passed a law requiring that all fracture-critical bridges be monitored.) The Mn/DOT report "Bridge Health Monitoring and Inspection: A Survey of Methods" (2009-29) describes researchers' work with Mn/DOT bridge engineers to generate criteria for the evaluation and selection of bridge monitoring systems and technologies, and to develop a spreadsheet-based program to aid in assessing which commercially available systems best fit the monitoring requirements of a given site.

A research gap that still needed to be filled was monitoring specific to steel tied-arch bridges, a specific class of fracture-critical bridges that have a history of problems with cracking in the welds and joints.

What Was Our Goal?

The objective of this project was to develop a detailed design for a monitoring scheme of a selected tiered-arch bridge with at least 10 years of remaining service life. This would involve determining the most appropriate monitoring technology and producing cost estimates and overall specifications for placement of monitoring equipment.

What Did We Do?

In cooperation with the Mn/DOT bridge office, researchers selected the Cedar Avenue/MN 77 bridge for monitoring. The bridge is 30 years old and a major commuting thoroughfare in the Minneapolis-St. Paul area.

The designed system focused on monitoring vibrations from stress waves to detect the formation or growth of local fatigue cracks in the steel structural members: steel connections, box ties, floor beams and cables. The selection tool developed in 2009-29 was used to choose acoustic emission (AE) technology to monitor and analyze the development and propagation of fatigue cracks. AE sensors pick up vibrations in the material to which they are attached. These vibrations are characteristic of the underlying material

continued

"This research is part of Mn/DOT's ongoing effort to develop robust monitoring of fracture-critical bridges in Minnesota."

—Moises Dimaculangan,
Bridge Rating Engineer,
Mn/DOT Bridge Office

"One of the goals of advanced warning systems is to prevent the loss of life and property for both bridge users and bridge owners."

—Arturo Schultz,
Professor, University of Minnesota Department of Civil Engineering

Produced by CTC & Associates for:
Minnesota Department
of Transportation
Research Services Section
MS 330, First Floor
395 John Ireland Blvd.
St. Paul, MN 55155-1899
(651) 366-3780
www.research.dot.state.mn.us

Built about 30 years ago, the Cedar Avenue bridge carries MN 77 over the Minnesota River to connect Minneapolis to the southern suburbs. It is a steel tied-arch bridge that is considered fracture-critical: The design lacks redundancy such that failure of a structural member could lead to collapse. As such, it was selected for this project to develop advanced structural monitoring systems.

and structure, and computer analysis of the AE sensor output reveals these characteristics. AE sensors are permanent on-site devices that provide a continuous stream of monitoring information. Depending upon placement and position of the sensors, both local and global monitoring systems can be built.

In a local monitoring system, the sensors are placed at the location of known cracks and fractures. They can be used to monitor the growth of both surface and internal cracks, which would otherwise be missed by visual inspection. In a global monitoring system, the sensors are used to determine where cracks originate as well as to track how they propagate over time. In general, global monitoring systems require significantly more sensors and equipment, increasing their cost relative to local monitoring systems.

Researchers generated specifications for both the local and global systems using a finite-element model of the Cedar Avenue bridge. In the model, major structural components and connections of the bridge were included and the virtual bridge was then loaded and tested to identify locations of high-stress regions ("hot spots") optimal for sensor location.

Using these design specifications, researchers also developed an implementation plan for the monitoring system including pricing; an installation schedule and procedure; and plans for initial testing, verification and maintenance of the equipment.

What Did We Learn?

The components for both local and global bridge monitoring systems are commercially available, and the spreadsheet-based monitoring technology selection tool previously developed worked well. Ultimate evaluation of the capabilities of the monitoring system itself will occur after installation.

What's Next?

As part of a second phase of this study, researchers are currently deploying a reduced version of the local monitoring system developed in this project at the Cedar Avenue bridge. The goal of this second phase is to fine-tune the placement of the sensors in the complete system using data to be collected over a one-year period on the Cedar Avenue bridge.

This Technical Summary pertains to Report 2010-39, "Development of an Advanced Structural Monitoring System," published November 2010. The full report can be accessed at http://www.lrrb.org/PDF/201039.pdf. *This project uses the results of Report 2009-29, "Bridge Health Monitoring and Inspections—A Survey of Methods," which may be accessed at* http://www.lrrb.org/PDF/200929.pdf.

2010-10TS
Published July 2010

LRRB
LOCAL ROAD RESEARCH BOARD

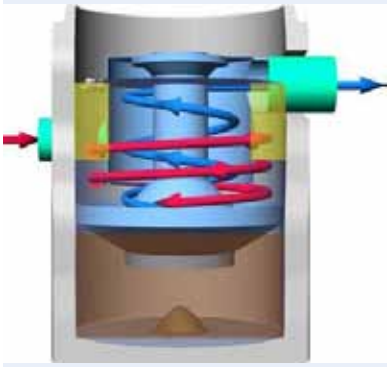
TECHNICAL SUMMARY

Technical Liaison:
Mike Eastling, City of Richfield
meastling@cityofrichfield.org

Administrative Liaison:
Shirlee Sherkow, Mn/DOT
Shirlee.Sherkow@state.mn.us

Principal Investigators:
Omid Mohseni, University of Minnesota
John Gulliver, University of Minnesota

LRRB PROJECT COST:
$123,000



Water enters a hydrodynamic separator, swirls and then exits with captured sediment settling at the bottom of the chamber.

MINNESOTA DEPARTMENT OF TRANSPORTATION

RESEARCH SERVICES
OFFICE OF POLICY ANALYSIS, RESEARCH & INNOVATION

Assessment of Underground Stormwater Management Devices Under High Flow Conditions

Researchers developed tests for measuring the amount of sediment washed out of hydrodynamic separators during high flow storm events. These tests have aided in creating computer models that will be used to predict efficiencies for any manufacturer's separator under varying conditions and environments.

What Was the Need?

Excess sediments in rivers and lakes can reduce sunlight penetration, interfere with fish-gill function and, in sufficient quantities, reduce waters available for aquatic species. In addition, a number of pollutants, including heavy metals and plant nutrients (fertilizers), can bind to sediments found on roadway surfaces. These sediments can be carried by stormwater to affect downstream water sources and other environmental features.

Various stormwater treatment devices are available to address this situation. Hydrodynamic separators are widely used in urban areas for this purpose due to the limited land availability for above-ground stormwater management installations. Hydrodynamic separators are used to pretreat stormwater runoff from the drainage basins they serve. Water enters a flow-through device where sediments and contaminants can then be captured. The sizes of hydrodynamic separators are based upon the rate of runoff expected from that area. Occasionally, a storm event will result in a flow rate that exceeds that device's maximum design treatment rate. During these high flow events, previously captured sediments and pollutants can be washed back out of the hydrodynamic separator when sediment resuspension and washout takes place. This occurs when the water enters the device at such a rate as to cause turbulence sufficient to overcome the resettling of resuspended sediments, dispersing them upward to the outlet of the device.

It is consequently useful to monitor the performance of a hydrodynamic separator under a wide range of actual hydraulic and pollutant loading conditions. However, traditional methods of estimating a device's performance have displayed only limited accuracy.

What Was Our Goal?

The researchers' goal was to study the potential for scour and washout of previously deposited sediments in the collection reservoir (sump) of hydrodynamic separators during atypical storm events. By doing this, researchers could not only predict the effectiveness of a particular hydrodynamic separator, but could also minimize the costs of maintenance by accurately predicting when a separator's sump would require emptying before pollutants begin to wash out of the device.

What Did We Do?

Researchers at the St. Anthony Falls Laboratory studied three types of hydrodynamic separators used in the Twin Cities: an Environment 21 V2B1 Model 4, an STC1200 Stormceptor and a 6-foot Downstream Defender. Researchers developed a new testing procedure to assess sediment resuspension and washout for these devices under flow rates exceeding maximum design treatment rates. The first of these devices was also tested in the field using a fire hydrant to provide controlled water supply at flow rates at and above the maximum design treatment rates; these field results matched those of the laboratory tests.

continued

"By using the testing methods developed at the St. Anthony Falls Laboratory, we determined that the separators tested in the field were in fact retaining a high degree of sediment during high flow storm events. One device in particular had no sediment washout."

–Mike Eastling,
Director of Public Works,
City of Richfield

"The data collected from this study will be instrumental in developing computer models that will predict the efficiency of any manufacturer's hydrodynamic separator under a variety of conditions."

–Omid Mohseni,
Adjunct Associate Professor, St. Anthony Falls Laboratory, University of Minnesota Department of Civil Engineering

Produced by CTC & Associates for:
Minnesota Department
of Transportation
Research Services Section
MS 330, First Floor
395 John Ireland Blvd.
St. Paul, MN 55155-1899
(651) 366-3780
www.research.dot.state.mn.us

For the field test, water was piped from a fire hydrant directly into a storm sewer catch basin with a valve to adjust the flow rate. From the catch basin, the water flowed through a storm sewer pipe under Rice Creek Road to another catch basin, and then into the V2B1 hydrodynamic separator. Water flow and washout sediment exiting the device were measured.

To further advance the understanding of the principal processes that govern sediment scouring, resuspension and washout, researchers built a 1:10 scale model of a swirl flow type 10-foot diameter separator. Multiple retention tests were run with sand particle sizes ranging from 180 to 250 microns, and then again with particle sizes ranging from 125 to 180 microns.

What Did We Learn?

Researchers discovered that the STC1200 Stormceptor performed well under high flow conditions, with almost no washout of sediments that the device could remove from stormwater runoff. This performance is primarily due to the bypass built inside the device and the flow patterns entering the sump. The other two devices displayed varying degrees of sediment washout.

The scale model tests showed that in general, swirl flow hydrodynamic separators are more prone to higher washout rates due to high flow velocities near the sediment inside these devices.

Researchers concluded that by using the data collected from this study, mathematical relationships could be developed that would accurately predict the efficiency of any manufacturer's hydrodynamic separator under a variety of conditions. These mathematical functions can be incorporated into computer models to aid local transportation agencies in selecting a separator for their particular environment. In addition, since efficiencies are directly impacted by how much sediment has collected in the sump, prediction models would allow maintenance schedules to be developed, which would reduce the number of scheduled cleanouts and save on maintenance costs.

What's Next?

While the mathematical relationships had not been worked out during the span of this project, researchers have since developed these functions and will soon incorporate them into computer models that will be available on the Internet. An additional report is in progress that will reference this study as the launching point for the development of these equations. Researchers hope that Minnesota transportation agencies will use these models for developing efficient maintenance schedules for existing installations, and for evaluating various manufacturers' hydrodynamic separators for the particular environments in which they will be installed.

This Technical Summary pertains to the LRRB-produced Report 2010-10, "Hydrodynamic Separator Sediment Retention Testing," published March 2010. The full report can be accessed at http://www.lrrb.org/PDF/201010.pdf.

2010-11TS
Published August 2010

RESEARCH SERVICES

OFFICE OF POLICY ANALYSIS, RESEARCH & INNOVATION

TECHNICAL SUMMARY

Technical Liaison:
Sarma Straumanis, Mn/DOT
Sarma.Straumanis@state.mn.us

Administrative Liaison:
Deb Fick, Mn/DOT
Deb.Fick@state.mn.us

Principal Investigator:
Kurt Johnson, University of Minnesota Duluth

PROJECT COST:
$109,562

Donor soil was spread by hand over the mitigation site. Because of the wet conditions of the site, soil was hauled using an ARGO amphibious off-road vehicle pulling an Otter sled.

Using Abandoned Gravel Pits for Wetland Mitigation

Researchers explored using abandoned gravel pits filled with soil displaced from road construction projects as sites for creating mitigation wetlands by establishing indigenous vegetation on these sites. This could be useful for creating wetlands in northern Minnesota where wetland restoration is not typically an option.

What Was the Need?

Wetland impacts are often an inevitable consequence of road construction. Federal and state "no-net-loss" wetland policies require compensatory mitigation for wetlands lost due to construction. The Minnesota Board of Water and Soil Resources predicts potential road construction related wetland impacts over the next two years to exceed 148 acres annually for the 18 counties of northeastern Minnesota. As just one example, recent reconstruction along U.S. Trunk Highway 53 resulted in approximately 84 acres of unavoidable wetland impacts. Affected vegetation included wet meadow, shrub swamp, wooded swamp, bog and other wetlands.

Wetland restoration, where the hydrology and vegetation of an impacted wetland is restored, is a common strategy to compensate for wetland losses. However, since northern Minnesota still retains more than 80 percent of the wetlands that existed prior to the European settlement of the area, this leaves few opportunities for restoration. Abandoned gravel pits seemed to have potential as sites for new wetlands, but the viability of this strategy had not been tested.

What Was Our Goal?

The goal of this project was to create pilot wetlands using gravel pits. These would be "in-kind" mitigation wetlands, meaning that they would be representative of the natural wetlands indigenous to the area that were impacted by the road construction.

What Did We Do?

In July 2007, two 2.5-acre wetland creation sites were established in abandoned gravel pits running adjacent to the U.S. Trunk Highway 53 reconstruction corridor. Researchers worked with Mn/DOT to evaluate a variety of techniques for wetland establishment. On one site, wet meadow and shrub swamp wetlands were attempted, while wooded swamp and bog wetlands were attempted on the other.

The reconstruction of Highway 53 had displaced an abundance of organic soil, which researchers were able to use in the wetland creation sites. Each site was broken up into treatment plots to determine the effect of soil amendments, direct seeding, tree and shrub plantings, and fertilizer. Plant species, percent vegetative cover, and tree/shrub survival and height were recorded for each plot in June and September of each year after establishment. SigmaPlot 11 software was used to conduct the statistical analyses on the collected data to determine the effects of these various treatments.

What Did We Learn?

For the two growing seasons that researchers observed these sites, vegetation in general progressed well, with increases over time in native species richness and in percent cover. With any wetland mitigation project, control of invasive species is a primary concern. Prominent invasives at these sites—reed canary grass, narrow-leaved cattail and purple loosestrife—were effectively controlled by hand pulling and spot herbicide treatments.

continued

"Though wetland creation is often thought to be less effective than wetland rehabilitation, I believe this project went a long way in demonstrating that abandoned gravel pits can serve as wetland mitigation sites."

–Sarma Straumanis,
Wetland Program Coordinator, Mn/DOT Office of Environmental Services

"We wanted to create in-kind replacement wetlands within the same watershed as those impacted by the road construction. This is in keeping with the regulatory agencies' goal of no net loss of wetland functions and values."

–Kurt Johnson,
Research Fellow, Natural Resources Research Institute, University of Minnesota Duluth

Produced by CTC & Associates for:
Minnesota Department of Transportation
Research Services Section
MS 330, First Floor
395 John Ireland Blvd.
St. Paul, MN 55155-1899
(651) 366-3780
www.research.dot.state.mn.us

As shown in this aerial photo taken after project completion, two gravel pit basins were used, one on each side of the road. This site was chosen for its proximity to existing shrub swamp, wooded swamp and bog wetlands as well as the organic donor soil used for this project.

Due to their ease of collection and preparation, native hardwood willow cuttings were planted on the wet meadow and shrub swamp site and showed promise of providing a shrub component to the wetland vegetation. Researchers did note, however, that the potential for restoring wooded swamp and bog wetlands is not as promising as wet meadow and shrub.

Unusually wet weather in the establishment year resulted in severe flooding on one of the sites. Researchers lowered the discharge culvert and installed a bypass ditch to reduce water levels and prevent future flooding. Despite high water levels continuing into the spring and fall, these remedial actions appear to have stabilized the site to a point where plant growth was not disturbed.

Researchers noted that although construction costs for these wetland creation sites were quite high ($34,109 per acre), integrating the restoration into an entire road construction project would lower the cost considerably. Researchers concluded that the use of abandoned gravel pits for wetland creation, when carried out in conjunction with a road construction project, is a potentially effective means of like-for-like wetland mitigation.

What's Next?

Drained wetlands are scarce in northeast Minnesota, so locating wetlands to restore is an ongoing challenge for local transportation agencies in this area. Abandoned gravel pits present a viable alternative for city and county engineers to address this problem. However, researchers recommended a 10-year observation period of the pilot restorations to ensure that the result is truly a wetland that will meet regulations.

Researchers also recommended that detailed cost studies be performed to determine the exact costs of wetland creation when integrated into a road construction project. Finally, researchers suggested that similar studies be conducted in other geographical areas within Minnesota.

This Technical Summary pertains to Report 2010-11, "Wetland Mitigation in Abandoned Gravel Pits," published March 2010. The full report can be accessed at http://www.lrrb.org/PDF/201011.pdf.

2010-20TS
Published October 2010

RESEARCH SERVICES

OFFICE OF POLICY ANALYSIS, RESEARCH & INNOVATION

TECHNICAL SUMMARY

Technical Liaison:
Ken Graeve, Mn/DOT
Kenneth.Graeve@state.mn.us

Administrative Liaison:
Shirlee Sherkow, Mn/DOT
Shirlee.Sherkow@state.mn.us

Principal Investigator:
L. Peter MacDonagh,
Kestrel Design Group, Inc.

PROJECT COST:
$111,743

These prairie smoke flowers, an example of vegetation native to Minnesota, were found along a roadside in the Minneapolis area.

Designing Site-Specific Roadside Prairie or Grassland Seed Mixes

Researchers worked with experts from every aspect of the seed community to produce a step-by-step guide to designing site-specific native grassland seed mixes for use along roadsides in Minnesota.

What Was the Need?

Vegetation along Minnesota's roads needs to accomplish several goals, from maintaining visibility and safety for travelers to minimizing erosion and maintenance costs. Research and experience demonstrate that native plants are particularly well-suited to these tasks. This primarily herbaceous native vegetation also has significantly greater wildlife habitat value on roadsides compared to non-native herbaceous species. For native vegetation to succeed and thrive, appropriate seed mixes must be used in each location. For instance, a seed mix might need to be designed for the unique soils or climate of a particular region, or it may need to be a more general collection, suitable for statewide use and more likely to succeed in degraded or harsh environments.

Currently, roadside vegetation managers choose from a variety of seed mixes that are designed to be used across the state, but these statewide mixes do not always fit the site conditions of a particular project. Poorly matched mixes can lead to erosion, weeds and other problems.

A standard process for designing site-specific seed mixes, uniform seed quality standards and core seed mixes for statewide use will lead to thriving roadside vegetation in different regions, less confusion and volatility in the pricing of seeds, a steadier supply of commonly agreed upon species, and a more effective and equitable substitution process.

What Was Our Goal?

The goals of the project were to develop a step-by-step manual for Minnesota agencies to design site-specific seed mixes and to provide guidelines for other states to develop their own mixes.

What Did We Do?

Researchers first conducted a comprehensive literature search of efforts to design site-specific native grassland seed mixes. Then they coordinated and conducted a series of stakeholder workshops and technical advisory panel meetings to bring together experts from Mn/DOT, Minnesota Department of Natural Resources, Minnesota Department of Agriculture, Board of Water and Soil Resources, the University of Minnesota, Natural Resources Conservation Service, U.S. Fish and Wildlife Service, and the Native Wildflower/Grass Producers Association. These meetings provided a forum for knowledgeable parties to determine how to develop a native seed mix design methodology suitable for the needs of Mn/DOT and other land management agencies.

In addition to six technical advisory panel meetings, researchers coordinated two large workshops that included members of the panel plus members of the seed community, including vendors, producers, installers, highway maintenance personnel, designers and researchers with knowledge and experience regarding the needs, challenges and effects of seed mixes.

The project also included a seed market survey to investigate the supply of and demand for native seed in Minnesota. Vendors, installers, Mn/DOT staff, researchers, planners and agencies were asked questions regarding available species, desired species, local origin and origin standards.

continued

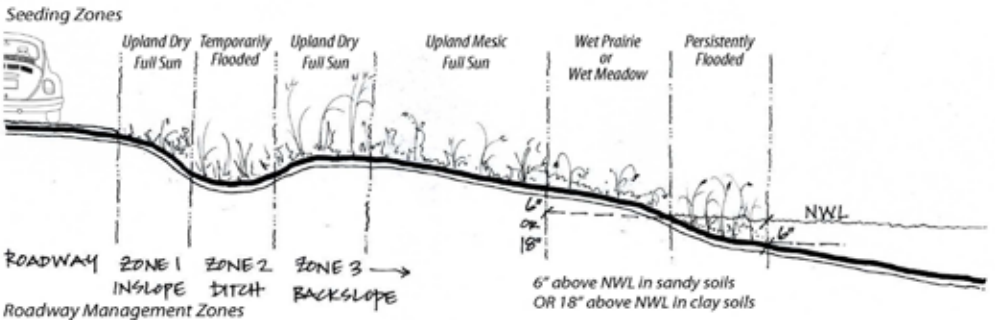
"This project was successful in bringing together experts from different perspectives to contribute to a much-needed document that can ultimately be used by various people, from project designers to seed vendors."

–Ken Graeve,
Botanist, Mn/DOT Office of Environmental Services

"Substitution of seeds based on availability has traditionally been very difficult and time-consuming. This system changes that dynamic by giving people the flexibility of having multiple species that provide the same ecological service for each unique site."

–L. Peter MacDonagh,
Director of Design and Science, Kestrel Design Group, Inc.

Produced by CTC & Associates for:
Minnesota Department
of Transportation
Research Services Section
MS 330, First Floor
395 John Ireland Blvd.
St. Paul, MN 55155-1899
(651) 366-3780
www.research.dot.state.mn.us



This is one example of typical native grassland seeding zone analysis for roadsides exposed to full sun in the Easter Broadleaf Forest, Prairie Parkland or Tall Aspen Parkland ecological provinces in Minnesota.

What Did We Learn?

Researchers produced a design manual that empowers users of various knowledge levels to design reliable, site-specific native grassland seed mixes. It allows for flexibility in species selection based on current seed availability and cost, and results in the most diverse possible species use statewide to maximize resilience and biodiversity on a landscape ecological scale.

The manual provides five steps to identify and design appropriate seed mixes, which incorporate project site characteristics, context, goals, seed availability and cost:

- Analyze site and establish goals. A site analysis checklist lists factors such as the ecological province, total acres to be seeded, types of crops used previously and potential invasive species adjacent to the site.
- Choose whether to use a standard or site-specific mix. Site-specific mixes are recommended for sites with more than 10 acres; in areas where wildlife habitat enhancement, conservation or beautification are the primary goals; and for wetland mitigation sites.
- Analyze seeding zones. Seed zones are determined and analyzed based on the amount of water, soil type, sun exposure and slope present at each site.
- Select seed mix design worksheet for each zone. Worksheets provide a list of species that are commercially available.
- Design seed mixes. The manual includes "recipes" for choosing the appropriate quantities of core species, selected species and cover species for each seeding zone.

What's Next?

Hard copies of the Native Seed Mix Design for Roadside manual will be distributed to agency staff, vendors and design firms; it is also available in CD format and online.

In the future, researchers aim to develop a computer program that will incorporate and expand upon the current manual to allow users to produce a complete, dynamic site restoration plan based on their local site conditions and project goals.

This Technical Summary pertains to Report 2010-20, "Site Specific Native Grassland Seed Mix Design Methodology for Minnesota," published May 2010. The full report can be accessed at http://www.lrrb.org/PDF/201020.pdf.

2010-22TS
Published November 2010

RESEARCH SERVICES

OFFICE OF POLICY ANALYSIS, RESEARCH & INNOVATION

TECHNICAL SUMMARY

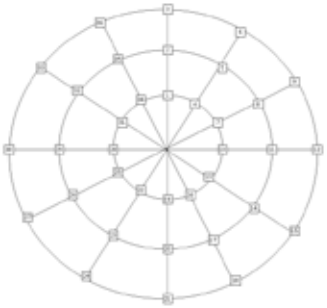
Technical Liaison:
Robert Edstrom, Mn/DOT
Robert.D.Edstrom@state.mn.us

Administrative Liaison:
Dan Warzala, Mn/DOT
Dan.Warzala@state.mn.us

Principal Investigators:
Vladimir Cherkassky, University of Minnesota

Sauptik Dhar, University of Minnesota

PROJECT COST:
$55,000



Metro 2001 Soil Survey data used concentric circles to define zones based on their proximity to the Minneapolis downtown area at the circle center.

Measuring Soil Contaminants Caused by Land Use

Researchers evaluated soil survey data to determine concentrations of potentially harmful chemicals in Minnesota soils while distinguishing the effects of human activity from those of native geology. They found that soils closer to roads and downtown areas had higher chemical concentrations.

What Was the Need?

After the completion of construction projects, the soils within the right of way may be subjected to chemicals contained in construction materials and recycled industrial byproducts used beneficially in the project. These chemicals include heavy metals such as arsenic and lead, and other contaminants that in large enough concentrations can be harmful to human health and the environment.

The Minnesota Pollution Control Agency determines the allowable concentrations of these chemicals. Determining these levels requires knowing the background levels of the chemicals in soils throughout Minnesota. In 2001 and 2003 Mn/DOT conducted statewide surveys to measure concentrations of 45 chemicals. To understand this data, analysis was required to distinguish chemical levels occurring naturally in Minnesota soils from those resulting from human activity.

What Was Our Goal?

The goal of this project was to analyze 2001 and 2003 statewide soil survey data to determine chemical concentration trends in soils within the Minneapolis metropolitan area and the state of Minnesota, distinguishing concentrations due to human activity from those existing in native geology.

What Did We Do?

Researchers analyzed three sets of data: 135 samples produced by the Metro 2001 Soil Survey, 200 samples produced by the Statewide 2003 Soil Survey and eight background soil samples collected by researchers near parking lots and minor city roads. Each sample was collected at a single location and contained 45 chemical measurements.

Researchers began by preprocessing data to develop strategies for dealing with outliers and sample measurements below known detection limits. Then they produced models consisting of self-organizing maps, which provide visual representations in two dimensions of data with a higher number of dimensions—in this case, a dimension for each of the 45 measured chemicals.

2001 data included samples collected at sites along Mn/DOT roads within the Minneapolis–St. Paul metropolitan area, including downtown, suburban and rural zones. Researchers modeled the way the concentrations of chemicals changed based on zone and distance from major highways both for the 2001 data and the background samples.

2003 data included samples collected throughout Minnesota that were representative of each of the state's terrain types as determined by historical geological processes shaping them, such as erosion, weathering, sedimentation and other factors. Researchers modeled the way in which chemicals were clustered within these terrain types.

Finally, researchers analyzed the relationship between 2001, 2003 and background samples to evaluate whether construction and other land usage were associated with increased chemical concentrations. Specifically, they analyzed data for high concentrations of chemicals that are dangerous to human health, taking care to use 2003 state-

continued

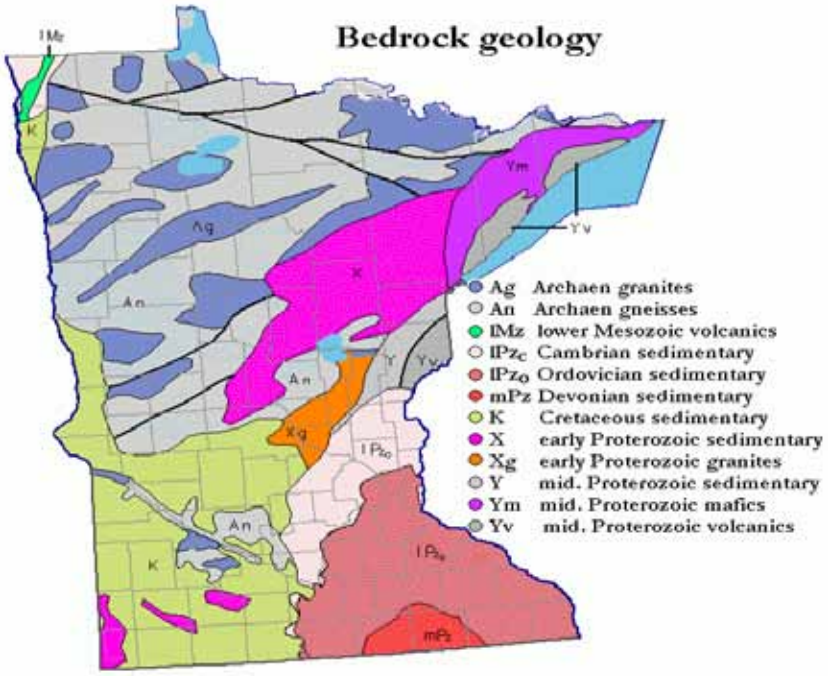
"These results can be used by engineers, toxicologists, planners and administrators at Mn/DOT and other state agencies to determine background levels of inorganic contaminants."

—Vladimir Cherkassky,
Professor, University of Minnesota Department of Electrical and Computer Engineering

"This study will help us assess the impacts of human activity on Minnesota soils and whether certain kinds of industrial byproducts are suitable to specific construction projects."

—Robert Edstrom,
Chief Toxicologist, Minnesota Office of Environmental Services

Produced by CTC & Associates for:
Minnesota Department
of Transportation
Research Services Section
MS 330, First Floor
395 John Ireland Blvd.
St. Paul, MN 55155-1899
(651) 366-3780
www.research.dot.state.mn.us



Important to evaluating the chemical profile of Minnesota soils is its bedrock geology. Because of its geological history, northeastern Minnesota has high concentrations of minerals that must be distinguished from chemicals caused by human activity.

wide data to distinguish those caused by human activity from those caused by native geology.

What Did We Learn?

Overall, the analysis indicated that chemical concentrations in soils adjacent to roads were higher for some elements such as lead, tungsten, zinc and copper. Chemical concentrations in soils generally decreased with distance from the road but not necessarily from the downtown areas.

Metro 2001 Soil Survey Data: Results showed that soil samples collected both in surveys and by researchers on the current project near roadways had higher concentrations of chemicals including lead, tungsten, zinc and copper than those farther away. These near-roadway chemical levels were consistent for soils with similar profiles, regardless of the distance of the collection site to downtown Minneapolis. These results suggest that concentrations of certain chemicals in metro area soils have been affected by local industrialization and that this effect is not easily discernable near major metropolitan roadways.

MN Statewide 2003 Soil Survey Data: Results showed that samples collected from northeastern Minnesota had higher concentrations of certain elements, including arsenic, chromium, copper, nickel and tungsten, than those collected from other parts of the state. Statewide concentrations were more similar to the background samples of the 2001 survey than the 2001 roadside samples.

What's Next?

Mn/DOT has defined the eventual end-user product of this ongoing research effort as an integrated data management plan for environmentally related information, and this project contributes to that goal. Its results will be helpful in determining the suitability of certain recyclable materials or products for use in construction or maintenance activities. The data gathered through this project provides a chemical baseline from which Mn/DOT will be able to detect trends in the chemical levels within soils throughout the transportation system. Participating agencies will be sent soil data via CD-ROM and a link for downloading the final report.

This Technical Summary pertains to Report 2010-22, "Statistical Analysis of the Soil Chemical Survey Data," published June 2010. The full report can be accessed at http://www.lrrb.org/PDF/201022.pdf.

2010-38TS
Published January 2011

LRRB
LOCAL ROAD RESEARCH BOARD

TECHNICAL SUMMARY

Technical Liaison:
Marilyn Jordahl-Larson, Mn/DOT
Marilyn.Jordahl@state.mn.us

Administrative Liaison:
Shirlee Sherkow, Mn/DOT
Shirlee.Sherkow@state.mn.us

Principal Investigator:
John Gulliver, University of Minnesota

LRRB PROJECT COST:
$55,000

Because flotation devices can be submersed at high velocities, researchers invented a wing that lifts the sampler when water flows across it.

RESEARCH SERVICES
OFFICE OF POLICY ANALYSIS, RESEARCH & INNOVATION

Improved Automatic Sampling for Suspended Solids

What Was the Need?

One common cause of water pollution is post-rain runoff from areas such as construction sites, highways and urban centers. This runoff can include sediments—silt and other solids suspended in the water—that can harm fish, plants and other aquatic organisms. Suspended solids can also lead to higher concentrations of other pollutants typically attached to sediment particles, including pesticides and heavy metals. Consequently, one important objective for Minnesota agencies managing stormwater is to monitor the concentrations of suspended solids in runoff water.

One method of conducting this monitoring involves the use of automated sampling devices, which often consist of a tube with an intake opening placed in the path of running water—typically facing downstream—and the other end attached to a compartment containing bottles for storing samples. When the device detects that the water level and flow are above preset thresholds, a pump is automatically activated to extract and store water samples at regular intervals.

Researchers dramatically increased the accuracy of the automatic sampling of suspended solids by creating a device that mixes equal volumes of samples collected from multiple locations in the water column, yielding a combined sample that more closely reflects the average for the water column as a whole.

However, using a single intake opening means that samples are only taken at one depth at a given time. Because larger sediment particles have a tendency to settle more rapidly, samples taken at a single depth will typically not reflect the average large sediment concentration for the water column as a whole, and so misrepresent suspended solids in the water. Consequently, automatic field samplers have been found to overestimate the concentrations of sediments in runoff water, especially for coarse silts and sands. Research was needed to improve the sampling process.

What Was Our Goal?

The objective of this project was to improve the performance of automatic water samplers for sampling coarse silts and sands.

What Did We Do?

Researchers began by evaluating a typical sampling device in the laboratory to test water flowing through an 18-inch sewer pipe before and after the addition of sediments of various sizes. Samplers were tested in various configurations reflecting combinations of the following options: with and without an intake manifold, facing upstream or downstream, and anchored to the sewer pipe or allowed to move freely within the flow.

For each configuration, automatic samplers substantially overestimated concentrations for coarse silts and sands. Consequently, researchers set out to increase the accuracy of sampling by using either a flotation device or a wing to hold the manifold up and keep it positioned across the water column. They also tested a modified manifold with holes of different sizes for different water column depths, designed to sample equal volumes of water and sediment from each part of the water column.

continued

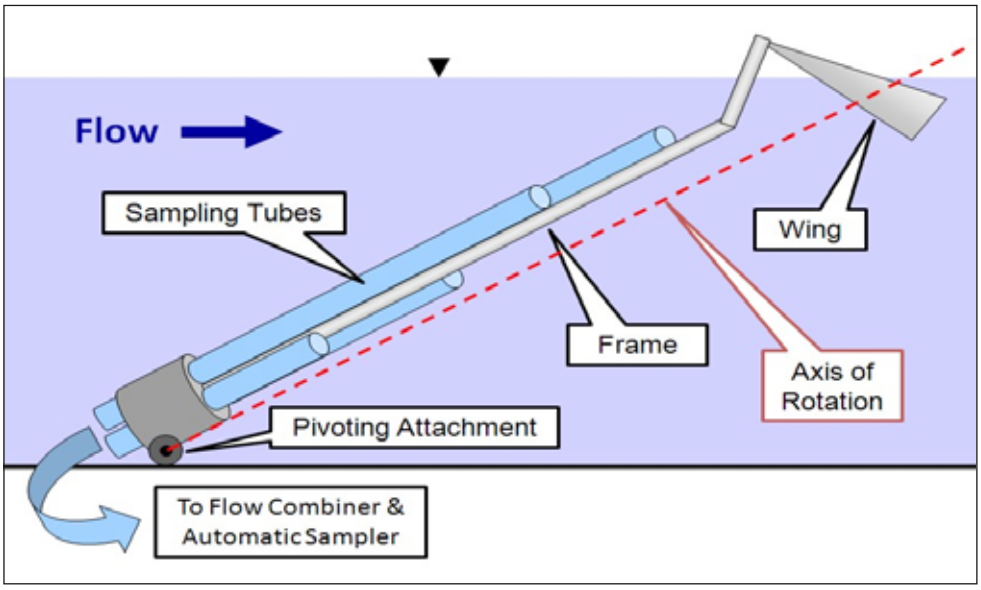
"We developed an automatic sampling device that dramatically increases the accuracy of sampling for suspended sediments, especially sands and coarse silt."

—John Gulliver,
Professor, University of Minnesota Department of Civil Engineering

"This project is an important starting point for developing technologies that make stormwater sampling more accurate and efficient."

—Marilyn Jordahl-Larson,
Unit Chief, Mn/DOT Environmental Modeling & Testing

Produced by CTC & Associates for:
Minnesota Department of Transportation
Research Services Section
MS 330, First Floor
395 John Ireland Blvd.
St. Paul, MN 55155-1899
(651) 366-3780
www.research.dot.state.mn.us



Researchers created the winged sampling arm—a design that replaces the intake manifold of typical sampling devices with four tubes that combine equal volumes of samples taken from different locations in the water column.

What Did We Learn?

The presence of the flotation device made the sampler prone to submersion under higher velocities by drag forces, making this design unsuitable for use in a sewer pipe. Consequently, researchers designed a wing that creates lift when water flows past it, allowing the sampler to maintain its position over a range of flow velocities.

While wing- and manifold-modified samplers displayed improved accuracy, these improvements were not consistent for all sediment sizes and flow rates. Researchers concluded that the manifold itself led to poor sampling, so they tested a design that eliminated it completely. This design used a wing attached to a frame holding four sampling tubes of different lengths and consequently different depths in the water column. These tubes were then combined using a device that ensures equal flow rates from each tube in order to mix the same volumes of samples from each level of the water column. The sampling mechanism was named the "winged sampling arm."

The winged sampling arm dramatically increased the accuracy of sampling by collecting subsamples of equal volume, from multiple locations in the water column and across a range of flow conditions, yielding a combined sample that more closely reflects the average for the water column as a whole.

What's Next?

Researchers will be presenting the results of this project over the next year in three journal articles, at conferences and through other communication venues. As engineers continue to improve their knowledge of the role of suspended sediments in stormwater management, technologies that increase the accuracy of sampling will play a critical role.

This Technical Summary pertains to the LRRB-produced Report 2010-38, "Improved Automatic Sampling for Suspended Solids," published November 2010. The full report can be accessed at http://www.lrrb.org/PDF/201038.pdf.

2010-TPF-5(187)TS
Published November 2010

TRANSPORTATION POOLED FUND PROGRAM

TECHNICAL SUMMARY

Mn/DOT Technical Liaison:
Andrea Hendrickson
Andrea.Hendrickson@state.mn.us

Mn/DOT Administrative Liaison:
Deb Fick
Deb.Fick@state.mn.us

TOTAL AGENCY CONTRIBUTIONS TO DATE:

$1,307,437

Mn/DOT AND CITY STATE AID CONTRIBUTIONS TO DATE:

$182,374

PARTICIPATING STATES:

CO, IA, KS, MI, MN, MO, NE, ND, OK, SD, WI

NOAA is updating precipitation frequency estimates by geographic region and, in some cases, for single states (such as California).

RESEARCH SERVICES

OFFICE OF POLICY ANALYSIS, RESEARCH & INNOVATION

Pooling Our Research: Updating Precipitation Frequency Estimates

Why a Pooled Fund Study?

Hydraulic engineers use precipitation frequency estimates to determine runoff and flow rate when designing storm drains, ponds, culverts and water quality devices to ensure they are adequately sized to handle the water quantity. If the structures are too small, flooding occurs; if they are too big, designers are wasting money.

In some parts of the country, including Minnesota, some precipitation frequency estimates used to design small drainage structures have not been updated for 50 years.

States like Minnesota without updated estimates use data from the 1961 publication Technical Paper No. 40 in equations to determine runoff. Information from the 1977 Tech Memo HYDRO-35 is used to create rainfall intensity-duration-frequency curves—graphical representations of the amount of water that falls within a given period of time—for typical design frequencies. These design frequencies are computed using the probability that a flood flow will be exceeded in a given year. For example, if a flood has a 2 percent chance of being equaled or exceeded each year, over a long period of time that flood will be equaled or exceeded on average once every 50 years.

TPF-5(187): Updating U.S. Precipitation Frequency Estimates for the Midwestern Region. *This multistate pooled fund study is updating decades-old precipitation frequency estimates that are used by practitioners to design small drainage structures such as inlets, storm drains and small culverts.*

There is some evidence—and this reflects widespread perception in the technical community—that rainfall patterns have been changing, and the precipitation data used by Minnesota transportation agencies is outdated. This means that the resulting hydraulic designs may not be as accurate as possible.

The National Oceanic and Atmospheric Administration, a recognized expert in precipitation analysis, has updated precipitation data for parts of the country in various volumes of NOAA Atlas 14, Precipitation-Frequency Atlas of the United States with funding from regional climatic centers and other pooled funding arrangements. In 2008, Minnesota helped create a new pooled fund study to generate precipitation frequency estimates for participating states using the same state-of-the-art statistical techniques NOAA has applied to updates for other regions of the country. Minnesota's share of this study is financially supported by Mn/DOT research funds, the Legislative-Citizen Commission on Minnesota Resources through the Minnesota Pollution Control Agency, and Minnesota cities with State Aid funds.

What is the Pooled Fund Study's Goal?

The goal of this pooled fund study is to review and process available rainfall data for participating states to update precipitation frequency estimates for durations ranging from 5 minutes to 60 days and for average recurrence intervals, or ARIs. An ARI is the long-term average number of years between the occurrence of a flood as big as or bigger than a selected event.

What Have We Learned?

During the first year of this three-year project, researchers evaluated a list of potential data sources, updated and formatted all data sets and conducted initial data quality con-

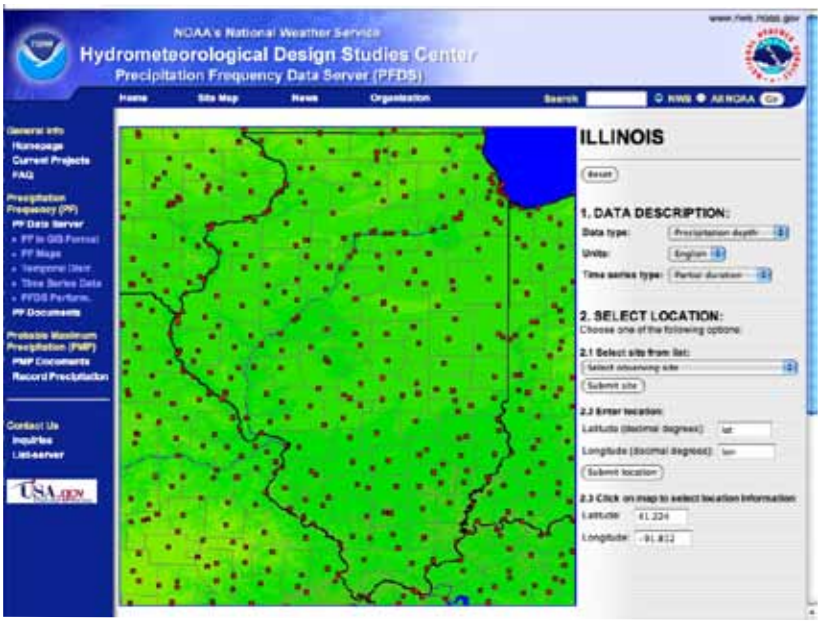
continued

"The precipitation frequency estimates used to design Minnesota's drainage infrastructure are, in some cases, 50 years old. The precipitation data developed in this study will use the best available data, helping us to make the best design decisions."

—Deb Bloom,
City Engineer, City of Roseville, Minnesota

"Mn/DOT's participation in this national project means that the same process and procedure for precipitation frequency estimates will be employed statewide."

—Andrea Hendrickson,
Mn/DOT State Hydraulics Engineer



This screen shot shows how users are prompted to gather precipitation frequency data from NOAA's Precipitation Frequency Data Server for Illinois, one of the states included in NOAA Atlas 14, Volume 2. Users will see a similar point-and-click, map-based screen of Minnesota when this pooled fund project is complete.

trol. Data sets for Minnesota included data from 344 Minnesota sites that provide one-day data sets, and data from the Metropolitan Council Environmental Services' metering and alarm rainfall database that includes 15-minute interval reporting from 22 stations. Additional quality control and data reliability tests included examining outliers, screening data for duplicate records and identifying candidates for merging reporting stations.

What's Going On Now?

Researchers are continuing with data analysis, which includes regional frequency analysis based on L-moments statistics—an alternative way of describing frequency distributions. Because L-moments are linear combinations of ranked observations, they are less subject to bias in estimation than other statistical methods. Other activities include the use of algorithms that test internal consistency at observing locations and the development of homogeneous regions—or sets of observing locations—that are expected to reduce the error associated with estimates.

What's Next?

Researchers estimate that study results will be published in May 2012 as a new Web-based volume of NOAA Atlas 14, with the Precipitation Frequency Data Server providing access to mapping, charts and related reporting. With data delivered via the Web, users can incorporate digital versions of the estimates directly in their applications, eliminating an expensive and error-prone digitizing step that was required in the past.

Precipitation frequency estimates will be presented in geographic information systems-compatible formats, including estimates at a given point on a map (after entering the latitude and longitude); distributions of heavy precipitation for durations of six, 12, 24 and 96 hours; charts of the seasonal distribution of the maximum 24-hour rainfall occurring annually; and cartographic maps of precipitation frequency estimates with 90 percent upper and lower confidence intervals for assorted durations.

Produced by CTC & Associates for:
Minnesota Department of Transportation
Research Services Section
MS 330, First Floor
395 John Ireland Blvd.
St. Paul, MN 55155-1899
(651) 366-3780
www.research.dot.state.mn.us

This Technical Summary pertains to the ongoing Pooled Fund TPF-5(187), Updating U.S. Precipitation Frequency Estimates for the Midwestern Region. Details of this study can be found at http://pooledfund.org/projectdetails.asp?id=410&status=4.

For more than 25 years, FHWA's Transportation Pooled Fund Program has been providing state DOTs and other organizations with the opportunity to collaborate in solving transportation-related problems. The TPF Program is focused on leveraging limited funds, avoiding duplication of effort, undertaking large-scale projects and achieving broader dissemination of results on issues of regional and national interest.

2009RIC08TS
Published June 2010

LRRB
LOCAL ROAD RESEARCH BOARD

TECHNICAL SUMMARY

Technical Liaisons:
Richard Sanders, Polk County Engineer
sanders.rich@co.polk.mn.us
Farideh Amiri, Mn/DOT
Farideh.Amiri@state.mn.us

Administrative Liaisons:
Clark Moe, Mn/DOT
Clark.Moe@state.mn.us
Bruce Holdhusen, Mn/DOT
Bruce.Holdhusen@state.mn.us

Principal Investigators:
Michael Marti, SRF Consulting Group Inc.
Gary Peterson, EVS Engineering Inc.
Paul Keranen, EVS Engineering Inc.

LRRB PROJECT COST:
$50,933

Mn/DOT PROJECT COST:
$88,277

Tying up the spinner before filling the auger is part of the process to calibrate a manual sander controller.

MINNESOTA DEPARTMENT OF TRANSPORTATION

RESEARCH SERVICES

OFFICE OF POLICY ANALYSIS, RESEARCH & INNOVATION

Putting Research into Practice: Snowplow Calibration Guides for Mn/DOT and Local Governments

Investigators created snowplow calibration guides to address the most common types of sander controllers used by Minnesota's cities and counties and by Mn/DOT districts. The guides include step-by-step calibration instructions, one-page quick sheets and other calibration aids.

What Was the Need?

Winter maintenance operations staff use trucks with manual or automated material delivery systems—referred to as sander controllers—to discharge road salt, sand and other anti-icing materials to the roadway. Manual sander controllers apply material at a consistent rate, meaning that more material will be applied if the truck is moving more slowly, and less when the truck speeds up. Automatic sander controllers adjust the application rate so the truck always applies the same amount of material to the road regardless of truck speed.

Regardless of the type of sander controller used, it is important to keep controller units well calibrated. Improperly calibrated sander controllers can fail to discharge the optimum amount of material to keep the road safe: Too much material can mean wasted resources and increased environmental impact, while too little application can necessitate wasted time from reapplication to meet the agency's desired level-of-service goals.

Before this project, calibration was not being performed routinely by most operators. Calibration guidance has often been limited to information from a technical equipment manual and vendor training provided when a sander controller is new. Winter operations staff at both Mn/DOT and local agencies needed a step-by-step approach to calibration that could be used to introduce new operators to the process and serve as a refresher for more seasoned staff.

What Was Our Goal?

This effort involved two related projects performed by the same investigators—one funded by the Local Road Research Board and one by Mn/DOT—to prepare calibration guides addressing the snowplow sander controllers most commonly used by cities and counties in Minnesota and by Mn/DOT district staff, and to conduct calibration training for winter maintenance staff from local agencies across the state.

What Did We Implement?

This project leveraged the practical experience of Mn/DOT and city and county winter maintenance staff in calibrating snowplow sander controllers. Information derived from surveys and follow-up contacts with experienced Minnesota winter maintenance professionals laid the groundwork for the development of the calibration guides and training sessions.

How Did We Do It?

First, investigators conducted surveys of winter maintenance staff in local agencies across Minnesota and in Mn/DOT districts to identify the calibration equipment currently used, current calibration practices and training needs. Investigators used these survey results to develop calibration guides for the sander controller equipment most commonly used by respondents, using input from sander controller vendors and winter

continued

"The calibration guides and workshops can help increase efficiencies in local governments' winter maintenance operations. By using the right amount of sand and salt at the right time, local agencies make better use of stretched budgets and limit environmental impacts."

–Richard Sanders,
Polk County Engineer

"Development of the calibration guides and related training classes was done in partnership with expert agency snowfighters. Their expertise was used to develop and fine-tune a detailed guide and ensure it was user-friendly."

–Gary Peterson,
P.E., EVS Engineering Inc.

Produced by CTC & Associates for:
Minnesota Department
of Transportation
Research Services Section
MS 330, First Floor
395 John Ireland Blvd.
St. Paul, MN 55155-1899
(651) 366-3780
www.research.dot.state.mn.us

The weight box shown here is a simple-to-use tool that automatically weighs material for sander calibration. The weight box can collect approximately 500 pounds and requires a skid steer or forklift for positioning and emptying.

maintenance experts from Mn/DOT and local agencies. The two manuals were identical in most respects but were tailored to address the equipment typically used by each audience. Investigators then scheduled a series of workshops across the state to offer brief classroom instruction and extensive hands-on calibration training using the LRRB calibration guide as a course book, which was improved from session to session with input from the professionals who attended the course.

What Was the Impact?

The experience-based calibration guides capture tips and techniques learned by experienced calibrators. The guides include step-by-step instructions with images for calibrating the most common types of controllers used: ForceAmerica 5100 in the LRRB guide and DICKEY-john Control Point and ICS in the Mn/DOT guide. A separate document was produced covering Gresen GRS32 controllers for Mn/DOT. Also presented were less detailed instructions to calibrate manual and other automatic sander controllers; one-page quick sheets on calibration and weighing material tailored to more experienced staff; and other calibration aids, including a record to track key calibration settings, forms to verify calibration by weighing material and filling a container, guidance regarding manual sander controllers and troubleshooting tips.

The guides also provide recommendations about when to calibrate or verify that calibration is not required: at least annually, after truck repairs or modifications, on new trucks and after a change in anti-icing materials used.

During fall 2009, investigators conducted 10 workshops for participants from across the state, training Mn/DOT district personnel in the morning and local agency staff in the afternoon. Workshop participants learned practical calibrating tips and shared expertise with other winter maintenance professionals. Most of each three-hour session was spent working with trainers in a variety of hands-on activities—from practice in the cab adjusting calibration settings to monitoring material discharge at the back of the truck.

What's Next?

These guides have been distributed to all Mn/DOT district offices and made available to cities and counties. Last fall's training sessions were well-attended and well-received. Discussions are under way to develop a schedule for additional training later in 2010.

This Technical Summary pertains to the LRRB-produced Report 2009RIC08, "Local Government Snowplow Salt and Sander Controller Calibration Guide," and the Mn/DOT Snowplow Salt and Sander Controller Calibration Guide and Gresen GRS32 Calibration documents, published December 2009. These documents can be accessed at http://www.lrrb.org/PDF/2009RIC08.pdf, http://www.dot.state.mn.us/maintenance/research/files/MnDOT%20Salt%20and%20Sander%20Calibration%20Guide.pdf *and* http://www.dot.state.mn.us/maintenance/research/files/Gresen.pdf, *respectively.*

2010-07TS
Published July 2010

RESEARCH SERVICES

OFFICE OF POLICY ANALYSIS, RESEARCH & INNOVATION

TECHNICAL SUMMARY

Technical Liaison:
Farideh Amiri
Farideh.Amiri@state.mn.us

Administrative Liaison:
Dan Warzala
Dan.Warzala@state.mn.us

Principal Investigator:
Rajesh Rajamani
University of Minnesota

PROJECT COST:
$160,000

Researchers used a skid pad where the road surface transitions from dry asphalt to hard ice to examine the effects of acceleration, deceleration and steering maneuvers on the friction measurement system.

Automating Friction Measurement and Applicator Control for Snowplows

Researchers developed an automated system that continuously measures the friction coefficient of the pavement and quickly detects any change, activates/deactivates the snowplow applicator based on the friction measurement and applies the appropriate amount of deicing material on the road surface.

What Was the Need?

Transportation agencies are always looking for ways to make the most efficient use of limited resources. Using salt and deicing chemicals efficiently to treat winter roadways is often described as using the right amount of material in the right place at the right time.

One way agencies are increasing operating efficiencies is with the use of friction measurements. The friction coefficient is used to describe the grip of car tires to the roadway and can be used as a measure of a slippery road surface. Knowing the friction coefficient can help agencies identify the right time and place to apply a particular amount of deicing material, saving resources and limiting the impact on the environment.

Previous Mn/DOT research developed a prototype device for continuous, real-time measurement of tire-road friction coefficient by snowplows. This device is modular and compact, and consists of a small, redundant wheel located near the front axle of the snowplow. Mn/DOT wanted to know how the prototype device could be used to make decisions about applying deicing material with automated, real-time control of a snowplow's material applicator.

What Was Our Goal?

The objectives of this research included:

- Evaluating the ability of a friction measurement system to provide an accurate measure of road conditions.
- Assessing the ability of the friction measurement tool's closed-loop application control system to adequately apply anti-icing or deicing material on slippery spots on the roadway.
- Developing an interface between the applicator control system and a geographic information system that provides real-time information on problematic sections of the roadway.

What Did We Do?

Researchers tested a closed-loop controller applicator system that automatically applies deicing material whenever the friction measurement tool detects an icy spot on the road. The system consists of a Global Positioning System receiver to record the vehicle location, the friction measurement wheel, a microprocessor, an LCD touch screen and an interface to the DICKEY-john controller of the material applicator.

The rotating friction measurement wheel has no brake or other moving parts, and includes two sensors to filter the vibration "noise" coming from the roadway and to detect any loss of friction. A microprocessor then uses this data to generate a signal to start and stop the deicing applicator at the back of the snowplow when appropriate. The operator raises and lowers the friction measurement wheel with a switch in the snowplow's cab.

continued

"Snowplow operators have to deal with difficult conditions, from poor visibility to simultaneously controlling the snowplow blade and deicing applicator. The friction tool's automated control of the material spreader takes care of one of those tasks for the operator."

–Rajesh Rajamani,
Professor, University of Minnesota Department of Mechanical Engineering

"Friction tools can help us make more effective use of time and materials. The prototype developed in this project works very well to apply material at lower truck speeds, proactively treats problem spots and increases public safety."

–Farideh Amiri,
Research Engineer, Mn/DOT Office of Maintenance Operations

Produced by CTC & Associates for:
Minnesota Department
of Transportation
Research Services Section
MS 330, First Floor
395 John Ireland Blvd.
St. Paul, MN 55155-1899
(651) 366-3780
www.research.dot.state.mn.us

A small, redundant wheel located near the front axle of the snowplow uses sensors and unique technology to measure friction under a wide range of operating conditions.

First, researchers evaluated the device's ability to measure road conditions in experiments on a skid pad at the MnROAD testing facility that tested the system as the road surface changed from dry asphalt to ice. Next, researchers examined two types of delays associated with the applicator control system that could limit the friction tool's effectiveness: a hardware-related delay associated with movement of material away from the slippery spot after the applicator is deployed, and the time to process the signal from the device.

Finally, the research team tested an enhanced applicator control system that interfaces with vehicle location measurements using a GIS and the same GPS used by the Maintenance Decision Support System/Automated Vehicle Location technology currently being implemented by Mn/DOT.

What Did We Learn?

Researchers found that the wheel-based friction measurement tool can work reliably at truck speeds up to 25 mph; at higher speeds, the hardware delay can cause portions of the icy road to be missed. This can be mitigated with the use of zero velocity material spreaders that eject material at zero velocity relative to the roadway, which reduces the amount of material bouncing off the pavement. Researchers found the software-related delay in sending the signal from the device to the applicator to be negligible (less than 150 milliseconds).

Software to enhance the applicator control system proved to be effective in prescribing application of material on problematic roadway segments. First, the operator enters data for the GPS locations for the route and any road segments known to be problematic, such as bridges or shaded areas. The software then calculates road curvature and road grade angle and automatically adds these road sections to the manually identified segments for proactive treatment of trouble spots. By coupling the friction coefficient measurement system with a GPS-based GIS, operators can also generate a map of the road condition values over an entire snowplow route.

What's Next?

Deployment of the system has not yet been approved by Mn/DOT. Friction measurement devices may be piloted in real-world conditions in the future, depending primarily on budgetary considerations.

This Technical Summary pertains to Report 2010-07, "Automated Vehicle Location, Data Recording, Friction Measurement and Applicator Control for Winter Road Maintenance," published February 2010. The full report can be accessed at http://www.lrrb.org/PDF/201007.pdf.

The prior research referred to was Report 2007-37, "Automated Winter Road Maintenance Using Road Surface Condition Measurements," published September 2007 and available at http://www.lrrb.org/PDF/200737.pdf.

2010-13TS
Published May 2010

RESEARCH SERVICES

OFFICE OF POLICY ANALYSIS, RESEARCH & INNOVATION

TECHNICAL SUMMARY

Technical Liaison:
Farideh Amiri, Mn/DOT
Farideh.Amiri@state.mn.us

Administrative Liaison:
Nelson Cruz, Mn/DOT
Nelson.Cruz@state.mn.us

Principal Investigator:
John Evans, University of Minnesota

PROJECT COST:

$35,400

While the SafeLane system provided excellent traction, it wore quickly, including by debonding at expansion joints.

Making Roads and Bridges Resistant to Frost and Ice

Researchers investigated the effectiveness of the Cargill SafeLane anti-icing overlay system on bridge decks and found that while it significantly increased traction and reduced crash rates, it was subject to rapid wearing caused by traffic and snowplows.

What Was the Need?

Since the 1990s, Mn/DOT has been using anti-icing chemicals to help prevent frost and ice from building up on its roads and bridges. Unfortunately, chloride ions from deicing salts corrode the steel bars that reinforce bridge decks, causing premature deterioration. The anti-icing chemicals can also damage the environment, including surrounding soil, vegetation and water.

Consequently, Mn/DOT is interested in methods that prevent dangerous road and bridge icing while minimizing the damaging effects of deicing chemicals. One possible method is the Cargill SafeLane™ anti-icing overlay, said by its manufacturer to consist of a unique aggregate that absorbs and stores liquid deicing chemicals. This property allows the pavement overlay to resist icing while preventing the chemicals from seeping into and damaging the steel reinforcement within the pavement. Research was needed to test these claims and evaluate whether this anti-icing overlay system would be suitable for use in Minnesota.

What Was Our Goal?

The objective of this study was to evaluate the effectiveness of the Cargill SafeLane overlay system for reducing crashes, winter maintenance costs and the frequency of deicing chemical applications on bridge decks. Specifically, researchers evaluated its:

1. Performance as a sealcoat to reduce damage caused by the chloride in deicing chemicals used during the winter season.
2. Improvement of traction, retention of deicing chemicals between applications and reduction of vehicle crash rates.
3. Bond to the underlying concrete bridge deck.

What Did We Do?

Researchers applied the SafeLane overlay system—consisting of a mixture of epoxy and crushed aggregate—to the southbound lanes of four Minnesota bridge decks and evaluated their performance over two to three years against that of northbound control lanes.

Each installation was studied for rates of crashes attributable to winter conditions, while one installation in Hibbing, Minnesota, was also studied in more detail for traction properties, wear performance and maintenance costs. For the Hibbing installation, researchers conducted laboratory tests of how well SafeLane's system of crushed aggregate and epoxy bonded to the underlying concrete. Over the next three years, researchers periodically conducted visual inspections for cracking, wear in wheel paths and shearing from plows; tested core samples for the depth and concentration of chloride intrusion; and conducted skid testing by measuring the friction between the road surface and the skidding tire of a test trailer with a locked wheel. To test the ability of the overlay to retain deicing chemicals, researchers asked plow operators to fill out forms that summarized their observations concerning its performance by comparing road surface conditions for the southbound overlay lanes and northbound nonoverlay lanes.

continued

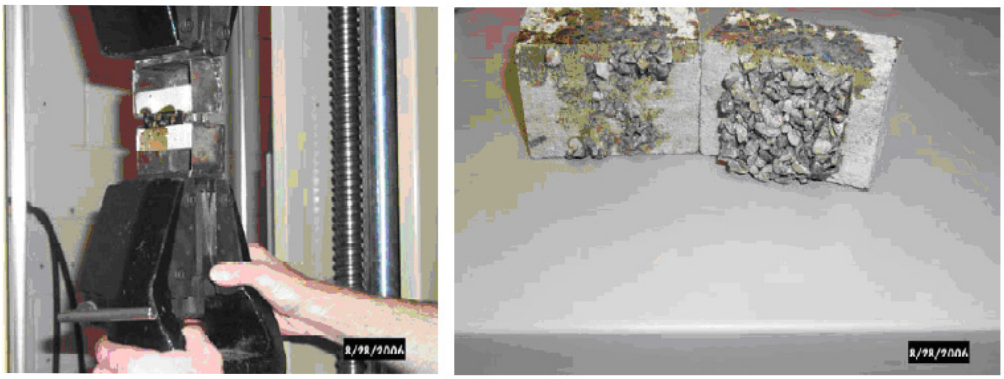
"This project is a starting point for finding innovative anti-icing technologies to make Minnesota roads safer and less expensive to maintain."

–Farideh Amiri,
Mn/DOT Maintenance Operations Research Engineer

"The SafeLane system initially offers outstanding traction for vehicles and seems to reduce crash rates, but wears rapidly. More research is required to find a cost-effective system."

–John Evans,
Professor, University of Minnesota Department of Chemistry and Biochemistry

Produced by CTC & Associates for:
Minnesota Department
of Transportation
Research Services Section
MS 330, First Floor
395 John Ireland Blvd.
St. Paul, MN 55155-1899
(651) 366-3780
www.research.dot.state.mn.us



To test the strength of the bond between the SafeLane aggregate-epoxy system and the underlying concrete, researchers used a bond pull-out machine (left) to measure the force required to pull them apart (right).

What Did We Learn?

Results indicated that while the SafeLane overlay shows promise for improving traction, reducing crash rates and protecting against the intrusion of chloride, it is subject to rapid wearing both from snowplows and normal traffic. Researchers noted that:

- The SafeLane system adhered well to the underlying pavement.
- Initially, the traction afforded by the coarse, rough aggregate was outstanding.
- Each installation showed a reduction in crash rates, which researchers inferred was the result of improved traction and the retention of deicing chemicals.
- As a sealcoat, the system afforded excellent protection against the intrusion of chloride and would likely decrease the corrosion of reinforcing steel over the service life of any bridge deck to which it was applied.
- The system is subject to significant, rapid wear, primarily due to plow blade shearing forces, but also from normal traffic in wheel paths. The observed shearing of the aggregate is consistent with loss of traction as measured by skid testing. Researchers predict that the service life of the overlay is limited to 3.5 to 5 years.

What's Next?

Because of the short duration of this study, researchers recommend that more thorough, longer-term studies be conducted to confirm the expected service life for the SafeLane overlay system predicted in this study. They also recommend investigation of other overlay systems with aggregates less susceptible to damage from snowplow blades, and Mn/DOT has initiated another study, "Comparative Performance Study of Polymeric Chip Seal and Ultra Thin Bonded Wear Course Systems Applied to Bridge Decks and Approaches," to analyze seven types of overlays on nine bridges in four Mn/DOT districts. Mn/DOT's ultimate goal is to deploy an end-user product that maintains friction on roadways and bridges during snow and ice events, while reducing chloride damage and maintenance costs.

This Technical Summary pertains to Report 2010-13, "Evaluation of the SafeLane™ Overlay System for Crash Reduction on Bridge Deck Surfaces," published March 2010. The full report can be accessed at http://www.lrrb.org/PDF/201013.pdf.

2010RIC03TS
Published September 2010

LRRB
LOCAL ROAD RESEARCH BOARD

TECHNICAL SUMMARY

Technical Liaison:
Rick West, Otter Tail County
rwest@co.ottertail.mn.us

Administrative Liaison:
Clark Moe, Mn/DOT
Clark.Moe@state.mn.us

Principal Investigators:
Mike Marti, SRF Consulting Group
Renae Kuehl, SRF Consulting Group

IMPLEMENTATION PROJECT COST:
$40,863

Maintenance activities critical to roadway safety include removing obstructions such as tree branches while implementing traffic control procedures.

MINNESOTA DEPARTMENT OF TRANSPORTATION

RESEARCH SERVICES
OFFICE OF POLICY ANALYSIS, RESEARCH & INNOVATION

Putting Research into Practice: Maintaining Safer Local Roadways

Investigators created a workshop on best practices that local agency maintenance forces can use to improve the safety of Minnesota roads, including practices related to on-road issues such as roadway obstructions and off-road issues such as vegetation control and drainage.

What Was the Need?

In 2008, 455 people died and 33,379 were injured in traffic crashes in Minnesota. To reduce these numbers as much as possible, transportation stakeholders in Minnesota established the Toward Zero Deaths campaign, a multiagency partnership focused on creating a culture in which traffic fatalities and serious injuries are no longer acceptable. Part of this mission involves fostering a culture of safety among local engineers by providing them with strategies for prioritizing safety problems, implementing solutions and increasing safety awareness among the public.

However, the need for a culture of safety does not end with engineers. Because Minnesota local agency maintenance forces are frequently in the field and have the opportunity to observe safety issues, they are the first line of defense for maintaining safe roadways. A training program was needed to help create a culture of safety among maintenance workers.

What Was Our Goal?

The purpose of this effort was to develop a training program to educate Minnesota local agencies in the best practices that maintenance workers can employ in their everyday jobs to create safer roadways.

What Did We Implement?

This project leveraged a previous Local Road Research Board implementation project, "Rural Road Safety Solutions Workshop Materials," in which investigators created a workshop to foster a culture of safety among engineers and provide them with the tools they need to identify problems and implement solutions. These tools included crash data resources, methods for securing funding and increasing the public's awareness of safety issues such as seatbelt use and drunk driving, and low-cost strategies such as rumble strips and pavement markings that improve roadway safety by reducing run-off-road accidents and head-on collisions on rural roads.

How Did We Do It?

Investigators used information from the materials created for the above project and augmented them with safety-improving practices specific to maintenance personnel that were gathered through a literature search, conversations with an advisory panel of Minnesota technical experts and an online survey of local maintenance departments concerning maintenance practices related to safety. Investigators then selected a number of key maintenance practices from this collection of information and gathered more details about them by conducting telephone interviews with the survey respondents who had suggested them. Finally, investigators selected the 10 practices most important to safety and created a presentation detailing them for use in a workshop.

What Was the Impact?

The resulting presentation was delivered to more than 200 people at the Minnesota Local Technical Assistance Program Spring Training Maintenance Expo in April 2010.

continued

"We wanted maintenance workers to know that a lot of what they already do in their daily jobs is critical to roadway safety and that they have an important role in Minnesota's Toward Zero Deaths campaign."

–Rick West,
Otter Tail County Engineer

"Reducing roadway fatalities and achieving [Toward Zero Deaths] will need everyone's efforts. Maintenance professionals play an integral role as the eyes and hands of safety on our state's rural roadway system."

–Mike Marti,
Principal, SRF Consulting Group

Produced by CTC & Associates for:
Minnesota Department
of Transportation
Research Services Section
MS 330, First Floor
395 John Ireland Blvd.
St. Paul, MN 55155-1899
(651) 366-3780
www.research.dot.state.mn.us

Maintenance workers should watch for damage to guardrails and median barriers, and when necessary follow agency procedures to have them repaired. Workers should also look for potential causes of the collision that may have caused the damage, such as a pothole in the road.

The workshop helps maintenance workers understand their role in the Toward Zero Deaths campaign, recognize maintenance tasks that impact safety, and recognize and respond to both on-road and off-road safety issues.

On-road issues addressed include:

- Obstructions in the roadway, which can cause drivers to engage in sudden evasive maneuvers and should be removed, such as loose gravel, branches, mud and debris.
- Shoulder drop-offs, which may cause drivers to overcorrect and steer into oncoming traffic, and may need to be paved.
- Signs and pavement markings, which lose visibility over time and need to be replaced.
- Work zone safety, which will be compromised if work zones are improperly marked.
- Pavement conditions such as rutting and potholes, which may be repaired temporarily or marked using a traffic control device until a permanent repair can be made.
- Traffic signals, which may malfunction and need to be replaced.

Off-road issues include:

- Vegetation control via trimming, mowing and tree removal so that vegetation does not obscure the visibility of signs and intersections.
- Roadside hazards in clear zones, including nonconforming mailboxes, nonapproved signs, head walls and retaining walls, planters, parked vehicles, culvert ends and driveway cross slopes, which can result in serious crashes.
- Drainage, which if insufficient can result in roadway flooding; this requires culvert maintenance, clearing debris from grates and reporting sedimentation.
- Winter maintenance, which includes plowing, establishing clear sight lines, and responding to drifts and snow dumped in rights of way.
- Guardrails and cable median barriers, which require regular damage assessments and repairs when necessary.

What's Next?

This workshop will be available in the near future from the Minnesota Local Technical Assistance Program and will help to create maintenance forces that proactively identify roadway issues affecting the safety of the traveling public.

This Technical Summary pertains to the LRRB-produced Report 2010RIC03, "Toward Zero Deaths: Maintaining a Safer Roadway Workshop," published April 2010. The full report can be accessed at http://www.lrrb.org/PDF/2010RIC03.pdf. *Information concerning workshop availability from the Minnesota Local Technical Assistance Program can be found at* http://www.mnltap.umn.edu.

The primary resource being implemented via this project can be found in the LRRB-produced implementation product 2008RIC03, "Rural Road Safety Solutions," published February/March 2008. This report can be accessed at http://www.lrrb.org/PDF/2008RIC03.pdf.

2010-SPR-3(042)TS
Published August 2010

TRANSPORTATION POOLED FUND PROGRAM

TECHNICAL SUMMARY

Mn/DOT Technical Liaison:
Curt Pape
Curt.Pape@state.mn.us

Mn/DOT Administrative Liaison:
Deb Fick, Mn/DOT
Deb.Fick@state.mn.us

TOTAL STATE CONTRIBUTIONS TO DATE:

$3,317,500

Mn/DOT CONTRIBUTIONS TO DATE:

$375,000

PARTICIPATING STATES AND REGIONS:

AK, IL, IN, IA, MI, MN, NV, NY, ND, OH, PA, UT, VA, WI, QUEBEC, ONTARIO AND SWEDEN

Roadway sensors measure conductivity to assess when road surface conditions change and the presence and concentrations of anti-icing chemicals.

RESEARCH SERVICES

OFFICE OF POLICY ANALYSIS, RESEARCH & INNOVATION

Pooling Our Research: Developing Technologies to Predict Winter Road Conditions

SPR-3(042): Aurora Program Pooled Fund Study. *Aurora is an internationally recognized leader in the research and development of road and weather information systems, including winter and pavement condition forecasting technologies. Mn/DOT has been a member of this program since its inception in 1996.*

Why a Pooled Fund Study?

Each winter, Mn/DOT and Minnesota's local transportation agencies protect drivers from the hazards of snowy and icy roads by pretreating pavements with anti-icing chemicals, deploying snowplows and other maintenance equipment, and alerting travelers via roadway warning systems. Effective protection of drivers requires proactive decisions by road agencies that are fine-tuned to current weather and road conditions, and these decisions depend in turn on a combination of technologies referred to as Road Weather Information Systems, or RWIS.

RWIS technologies include environmental stations around the state that collect atmospheric weather data such as temperature and humidity, and roadside sensors that collect information about pavement and underlying soil temperatures, water levels and icing. This data is processed and made available to transportation agencies and the traveling public.

To receive maximum benefit from these technologies, Mn/DOT joined an international partnership dedicated to their development. The Aurora Program was founded in 1996 to bring together transportation agencies, universities and weather services for collaboration on RWIS research, development, deployment and technology transfer. Seventeen state DOTs and other agencies each contribute $25,000 annually to this study. Agency representatives include international leaders in RWIS technologies, many of whom are also affiliated with AASHTO's Snow and Ice Pooled Fund Cooperative Program and related programs.

What is the Pooled Fund Study's Goal?

The goal of the Aurora Program is to develop RWIS technologies that significantly reduce the adverse impacts of inclement weather on mobility and public safety.

What Have We Learned?

Since the inception of Aurora, more than 30 research efforts have been completed, including two initiated by Mn/DOT:

- Support of the MDSS Pooled Fund Study, which provided funding to develop and test the Maintenance Decision Support System as an operational tool in member states.
- RWIS Equipment Monitoring System—Phase I, developed to provide Aurora member agencies with an automated means of identifying and reporting problems with their RWIS equipment. This Web-based solution was based on an existing Mn/DOT system and routes users to the right technician immediately, saving them significant amounts of time when it comes to maintaining their RWIS technologies.

Even those projects not initiated by Mn/DOT are often highly beneficial to Minnesota and typically include Mn/DOT participation of the project team. Two recently completed projects of particular interest to Mn/DOT were:

continued

"Many of Mn/DOT's improvements to its RWIS systems have come from Aurora projects or ideas, including the use of network cameras to provide cheap, reliable images at our sites."

–Curt Pape,
Mn/DOT Road Weather Information Systems Coordinator

"Aurora is internationally recognized as a leader in the snow and ice community, providing invaluable knowledge critical to efficient winter maintenance operations."

–Sue Lodahl,
Mn/DOT Assistant State Maintenance Engineer

Produced by CTC & Associates for:
Minnesota Department
of Transportation
Research Services Section
MS 330, First Floor
395 John Ireland Blvd.
St. Paul, MN 55155-1899
(651) 366-3780
www.research.dot.state.mn.us

RWIS technologies use weather stations to supply temperature, visibility and other data so agencies can inform the public and make decisions about winter maintenance operations.

- Pavement Temperature Sensor Accuracy, which was conducted at the MnROAD facility to evaluate the accuracy of various pavement temperature sensors.
- Computer-Based Training Development, an interactive training program for winter operations that included segments on RWIS, anti-icing, deicing chemicals and other related aspects of winter operations.

Mn/DOT RWIS coordinator Curt Pape sees the value in being a member of a national team that sets the agenda for winter maintenance and RWIS research, having used the opportunity to develop relationships with national and international leaders in RWIS equipment, decision support systems, standards and training. "We use their collective knowledge to help solve our issues and plan for the future," said Pape. "There is nowhere else you can go to get the kind of detailed road and weather knowledge available to Aurora participants."

What's Going On Now?

The following are among the more than 30 ongoing projects by Aurora:

- Benchmarking the Performance of RWIS Forecasts is reviewing the state of the art within the meteorological community with regard to measuring the performance of weather forecasting information.
- Support of the Clarus Initiative is helping to guide and implement the federal project that establishes a vision for leveraging local and regional road, rail and marine weather observations.
- Mobile Weather and Road Condition Reporting is developing an RWIS technology that collects data electronically from remote statewide locations for delivery in real time.

What's Next?

Each year, Aurora Program participants develop a number of new project ideas, which are then reviewed by the program members for areas of common interest. Through this process, an annual work plan is developed that outlines the projects to be funded in the coming year. As it moves ahead, the program is expected to remain an internationally recognized leader in RWIS and an important resource for Mn/DOT, improving the safety of Minnesota's roads and reducing the costs of winter maintenance and related activities for all of Minnesota's transportation agencies.

This Technical Summary pertains to the ongoing Pooled Fund SPR-3(042), Aurora Program. Details of this effort can be found at http://www.pooledfund.org/projectdetails.asp?id=189&status=4 *and* www.aurora-program.org/.

For more than 25 years, FHWA's Transportation Pooled Fund Program has been providing state DOTs and other organizations the opportunity to collaborate in solving transportation-related problems. The TPF Program is focused on leveraging limited funds, avoiding duplication of effort, undertaking large-scale projects and achieving broader dissemination of results on issues of regional and national interest.

2010-TPF-5(054)TS
Published December 2010

TRANSPORTATION POOLED FUND PROGRAM

TECHNICAL SUMMARY

Mn/DOT Technical Liaison:
Curt Pape
Curt.Pape@state.mn.us

Mn/DOT Administrative Liaison:
Deb Fick
Deb.Fick@state.mn.us

TOTAL AGENCY CONTRIBUTIONS TO DATE:

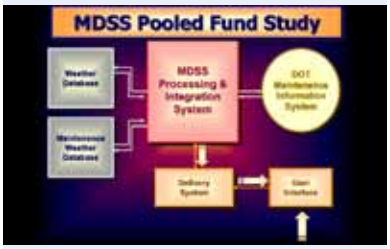
$4,400,000

Mn/DOT CONTRIBUTIONS TO DATE:

$325,000

PARTICIPATING STATES:

CO, ID, IN, KS, KY, MD, MN, NE, NH, NY, ND, PA, SD, VA, WI, WY



The MDSS works with weather databases and DOT maintenance systems to deliver needed information.

RESEARCH SERVICES

OFFICE OF POLICY ANALYSIS, RESEARCH & INNOVATION

Pooling Our Research: Automating Winter Maintenance Decision Support

TPF-5(054): Development of Maintenance Decision Support System Pooled Fund Study. *This study was launched to develop and implement an automated software tool that provides real-time winter maintenance treatment recommendations.*

Why a Pooled Fund Study?

Winter maintenance personnel often have to make quick decisions about maintenance strategies that involve the complex interplay of materials, equipment, scheduling, road reporting and changing weather conditions. For many agencies, these decisions have been largely based on the prior experience of maintenance staff and supervisors.

The Federal Highway Administration recognized the benefit of integrating information and technology to support winter maintenance treatment decisions and in 2001 began development of a functional prototype winter maintenance decision support system. An MDSS is an automated software tool that integrates information about weather, road conditions, maintenance practices and available resources to help winter maintenance personnel make proactive decisions about the best treatment to use before and during winter events. FHWA released its prototype MDSS software in September 2002. Interested in enhancing and implementing FHWA's functional prototype, Mn/DOT and four other state DOTs formed the MDSS pooled fund study in late 2002 in partnership with Meridian Environmental Technology Inc. Today 16 states and the FHWA participate in the study, with South Dakota DOT as the study's lead agency.

What is the Pooled Fund Study's Goal?

The goal of this pooled fund study is to develop and deploy a user-friendly MDSS that focuses on operations and tactics to provide weather and road condition forecasts and real-time treatment recommendations for specific road segments. State DOTs can use the MDSS as a guidance tool to maintain or improve levels of service; reduce operating costs by reducing the materials, equipment and labor used on winter maintenance; and make winter roadways safer for the motoring public.

What Have We Learned?

Researchers started by evaluating the FHWA MDSS prototype and used this evaluation to begin development of an MDSS that would optimally meet the needs of front-line maintenance supervisors. The interoperable design of an MDSS includes five systems: weather, pavement forecast, DOT operations and control, MDSS decision logic and the user interface. It also involves two interrelated applications: one predicts and portrays how road conditions will change due to forecast weather and the application of alternative maintenance treatments, and the other suggests optimal maintenance treatments based on agency resources.

First, an MDSS is provided with current road condition data via on-truck instrumentation, in-pavement sensors and manual entry of observations. If no observations are available, the MDSS assesses the road conditions using recent weather and reported maintenance. Next, continuously updated weather forecasts are uploaded in the MDSS, and actual maintenance treatments are entered by the operator or automatically recorded by instrumented snowplows. Computer modeling assesses past and present weather conditions and predicts short- and long-term storm weather. The MDSS uses this information to predict future road conditions with and without treatments. Finally, MDSS decision

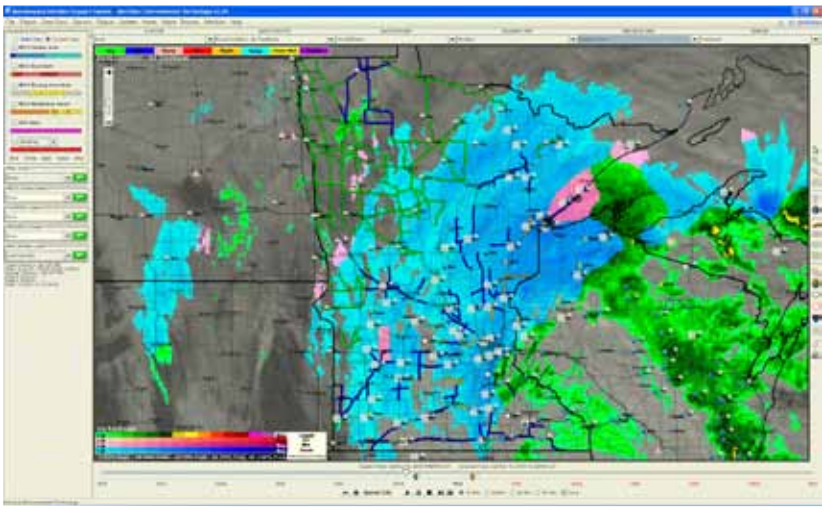
continued

"By optimizing the timing and selection of winter maintenance treatments, the MDSS can help Mn/DOT meet its desired level of service while using the minimum amounts of chemicals and resources."

—Curt Pape,
RWIS Coordinator,
Mn/DOT Office of Maintenance

"The MDSS pooled fund study has accomplished far more than any single state could have accomplished alone. The work is changing the world of winter maintenance."

—Dave Huft,
Program Manager,
SDDOT Office of Research



This MDSS image shows a recent storm in Minnesota, with color codes indicating conditions in each local area. Users can follow the timeline along the bottom to see the storm's progression or select a number of different views (such as a route or map view) and details (such as weather alerts) using the toolbar on the left.

logic considers an agency's available resources and applies agency-defined priorities for level of service and significance of road segments to provide continuously updated maintenance recommendations. Each maintenance alternative includes treatment type, application rate and optimal timing, and the expected effectiveness and costs. MDSS software is expected to improve the consistency and cost-effectiveness of Mn/DOT's snow and ice control operations. An Mn/DOT study that examined data generated from recent winter events concluded that the MDSS also has the potential to significantly reduce Mn/DOT's salt use, lessening environmental impacts while still meeting or exceeding existing performance targets.

What's Going On Now?

The pooled fund study continues to advance research and development of the MDSS software, provide training support and assist new participants in conducting field trials. Mn/DOT began preparing for its MDSS deployment in 2007 with the long-term goal of statewide deployment. Almost 20 percent of all plow routes in the state are entered in the MDSS. Mn/DOT is using Automated Vehicle Location technology to gather real-time information about current road conditions and maintenance activities for entry in the MDSS application. Today nearly 10 percent of all Mn/DOT plow trucks have AVL technology on board. While the MDSS and AVL initiatives are two separate projects, and the MDSS can be implemented without AVL technology, test sections in several areas of Minnesota have demonstrated that combining the MDSS with AVL will significantly enhance the effectiveness of each project.

What's Next?

As MDSS/AVL deployment continues, Mn/DOT is considering how these applications can be used to leverage other Mn/DOT systems. Possibilities include automating repetitive manual data entry of maintenance activities and material usage, and incorporating AVL/MDSS feedback into a roadway system map depicting driving conditions to enhance Minnesota's largely audio-based 511 system.

This Technical Summary pertains to the ongoing Pooled Fund TPF-5(054), Development of Maintenance Decision Support System Pooled Fund. Details of this effort can be found at http://pooledfund.org/projectdetails.asp?id=240&status=6 *and* http://www.meridian-enviro.com/mdss/pfs/.

For more than 25 years, FHWA's Transportation Pooled Fund Program has been providing state DOTs and other organizations with the opportunity to collaborate in solving transportation-related problems. The TPF Program is focused on leveraging limited funds, avoiding duplication of effort, undertaking large-scale projects and achieving broader dissemination of results on issues of regional and national interest.

Produced by CTC & Associates for:
Minnesota Department
of Transportation
Research Services Section
MS 330, First Floor
395 John Ireland Blvd.
St. Paul, MN 55155-1899
(651) 366-3780
www.research.dot.state.mn.us

2010-TPF-5(218)TS
Published June 2010

TRANSPORTATION POOLED FUND PROGRAM

TECHNICAL SUMMARY

Mn/DOT Technical Liaison:
Tom Peters
Tom.Peters@state.mn.us

Mn/DOT Administrative Liaison:
Deb Fick
Deb.Fick@state.mn.us

TOTAL STATE CONTRIBUTIONS TO DATE:

$1,955,000

Mn/DOT CONTRIBUTIONS TO DATE:

$150,000

PARTICIPATING STATES:

CO, IA, IL, MA, ME, MI, MN, MO, ND, NH, NY, OH, PA, VA, WA, WI, WY

Clear Roads funded the development of innovative prototype snowplows capable of tackling a range of winter road conditions using multiple plow blades.

RESEARCH SERVICES

OFFICE OF POLICY ANALYSIS, RESEARCH & INNOVATION

Pooling Our Research: Improving Winter Maintenance with New Technologies

Why a Pooled Fund Study?

New winter maintenance materials, methods and equipment are constantly being developed, and states need to know their effectiveness before they can be widely implemented. Prompt and rigorous identification and field testing of innovative solutions improve safety and save money.

The Clear Roads pooled fund study was established in 2004 to fulfill this need. The program annually funds research projects focused on identifying innovative solutions; evaluating winter maintenance materials, equipment and methods under real-world conditions; and assessing their practicality and ease of use within varied highway maintenance organizational structures.

TPF-5(218): Clear Roads Winter Highway Operations Pooled Fund. *Launched in 2004, this ongoing, multistate study is aimed at rigorous testing of winter maintenance materials, equipment and methods for use by highway maintenance crews.*

Participating agencies make a $25,000 annual commitment to Clear Roads; states may use 100 percent federal funds for their contribution. Mn/DOT took over leadership of the study from Wisconsin DOT in 2010.

What is the Pooled Fund Study's Goal?

As state DOTs aggressively pursue new technologies and practices for improving winter highway operations, Clear Roads supports their evaluation in both the laboratory and the field to develop industry standards, performance measures and cost-benefit analyses, practical field guides and training curricula. The scope of the effort is currently expanding to focus on state agency needs, technology transfer and implementation, including support for staff in the field.

What Have We Learned?

Every year, Technical Advisory Committee members propose projects for funding consideration and select one or two projects. To date, three projects have been completed; seven projects are under way or scheduled to begin soon.

One of the three completed research projects evaluated the accuracy of the automated systems used on winter maintenance trucks to deliver sand, salt and other deicing materials at a specified rate. The project's added bonus—a spreader calibration guide—provides general guidelines and procedures that can help winter maintenance programs save money by increasing efficiency and using material more effectively.

Farideh Amiri, Mn/DOT's Maintenance Operations research engineer, reports that the calibration project also proved beneficial to Mn/DOT in pursuing its own research agenda. "I used the Clear Roads project to gather background information and develop the work plan for a follow-up implementation project we completed at Mn/DOT," Amiri said. "In our project, we used Clear Roads' general calibration guide as a baseline and developed a step-by-step, user-friendly how-to manual that Mn/DOT and local governments can use to calibrate their material spreaders."

"We have a better handle on calibration now," said Joe Huneke, Mn/DOT Maintenance Operations winter coordinator. "Using the calibration guide has helped our operators to better manage the amount of material Mn/DOT uses for winter highway maintenance."

continued

"Mn/DOT finds great value in Clear Roads. We have sought to demonstrate our commitment to Clear Roads by taking over as the lead state starting this year."

–Tom Peters,
Research and Training Engineer, Mn/DOT Maintenance and Operations

"As a researcher, I use the Clear Roads Web site all the time to ensure that we do not duplicate Clear Roads research and to find contact information for my counterparts at other Clear Roads member agencies with similar research interests."

–Farideh Amiri,
Research Engineer, Mn/DOT Maintenance and Operations

Produced by CTC & Associates for:
Minnesota Department
of Transportation
Research Services Section
MS 330, First Floor
395 John Ireland Blvd.
St. Paul, MN 55155-1899
(651) 366-3780
www.research.dot.state.mn.us

The Clear Roads calibration guide advises operators to raise the truck bed to an operational elevation for calibration.

Solutions identified in a Clear Roads study of fogging and icing on truck windshields include plow deflectors and flaps, heated windshields, chemical glass treatments and winter-grade wipers.

What's Going On Now?

Five research projects are under way (all expected to conclude in 2010), including:

- Development of a Toolkit for Cost-benefit Analysis of Specific Winter Maintenance Practices, Equipment and Operations. Researchers will identify the costs and benefits associated with the top 10 winter maintenance practices, procedures and equipment. The new tool is expected to help Mn/DOT and other agencies justify new expenditures and assess overall program effectiveness.
- Development of Standardized Test Procedures for Carbide Insert Snowplow Blade Wear. Researchers will develop testing procedures that could be used by an independent testing laboratory to determine life expectancy of any carbide insert snowplow blade. Replacing carbide inserts only when necessary can save money, reduce snowplow downtime and protect equipment investment.

Clear Roads activities go beyond traditional research. Other supported projects include:

- Coordinating a national winter driver safety campaign, "Ice and Snow…Take It Slow," to educate drivers about the importance of driving safely in winter conditions.
- Supporting the efforts of the Snow and Ice Pooled Fund Cooperative Program to develop computer-based training modules that help train snowplow drivers, maintenance crews and others.
- Working with the Highway Maintenance Concept Vehicle pooled fund to conduct research on optimum snowplow design.

What's Next?

Two research projects will begin in 2010: Identifying the Parameters for Effective Implementation of Liquid-only Plow Routes will help researchers identify elements for the safe and effective use of liquid-only routes during winter storm events and assess the viability of field testing. Correlating Lab Testing and Field Performance for Deicing and Anti-icing Chemicals will lead to recommendations for how to proceed with laboratory testing to measure performance characteristics and the friction coefficient of deicing and anti-icing chemicals.

This Technical Summary pertains to the ongoing Pooled Fund TPF-5(218), "Clear Roads Winter Highway Operations Pooled Fund," continuing the project initiated under TPF-5(092). Details of this effort can be found at http://www.pooledfund.org/projectdetails.asp?id=446&status=4, http://pooledfund.org/projectdetails.asp?id=317&status=4 *and* http://www.clearroads.org/.

For more than 25 years, FHWA's Transportation Pooled Fund Program has been providing state DOTs and other organizations the opportunity to collaborate in solving transportation-related problems. The TPF Program is focused on leveraging limited funds, avoiding duplication of effort, undertaking large-scale projects and achieving broader dissemination of results on issues of regional and national interest.

2009-41TS
Published February 2010

LRRB
LOCAL ROAD RESEARCH BOARD

TECHNICAL SUMMARY

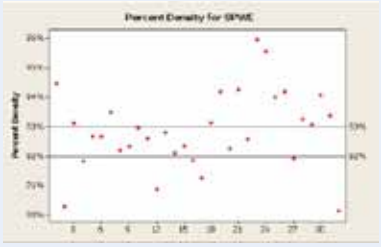
Technical Liaisons:
Tom Ravn, Mn/DOT
tom.ravn@state.mn.us

Curt Turgeon, Mn/DOT
curt.turgeon@state.mn.us

Administrative Liaison:
Alan Rindels, Mn/DOT
alan.rindels@state.mn.us

Principal Investigator:
Diwakar Gupta,
University of Minnesota

PROJECT COST:
$94,876



This scatter plot of percent density for two sample lots includes reference lines at the 100 percent pay factor limits. Densities at or above these reference lines indicate high-quality work for the pavement mix being tested.

MINNESOTA DEPARTMENT OF TRANSPORTATION
RESEARCH SERVICES SECTION

Statistical Methods for Materials Testing

What Was the Need?

State departments of transportation use a variety of testing protocols to assess the quality of contractors' work in the construction and rehabilitation of pavements. Mn/DOT uses one of these tests to determine the quality of compaction effort and provides incentives to contractors who achieve a high relative density in hot-mix asphalt pavement construction.

Mn/DOT's current density testing protocol for HMA divides the daily amount of pavement built by each contractor into a small number of lots. Core samples are taken from two locations in each lot, and lab tests are used to determine the relative density of each sample. The average of the two values is used as an estimate of the lot's relative density, which determines the lot's pay factor (the incentive or disincentive payments to the contractor based on the mean density of each lot). For example, a pay factor of 102 percent results in a 2 percent incentive per ton, and a 95 percent pay factor penalizes the contractor by 5 percent per ton.

It is important to employ the optimum number of tests for determining the accepted level of quality. Too few samples increase the probability of assessing an incorrect pay factor; too many samples increase testing costs and weaken the pavement. To make good payment decisions, Mn/DOT needed a reliable method to determine the number of test samples required to accurately apply the pay factors associated with the ranges of density values.

What Was Our Goal?

The goal of this study was to develop a testing protocol to determine the required number of samples that should be tested based on user-specified criteria to make more reliable pay factor calculations. A second aim was to develop guidelines for estimating key parameters needed to implement the testing protocol.

The project was not designed to propose changes to the way density values are themselves computed for a given sample or to evaluate current formulas for determining pay factors from relative density, but only to determine how many samples are needed to determine a pay factor.

What Did We Do?

Researchers reviewed current testing protocols and used Bayesian statistics to devise methods for determining how many core samples need to be evaluated using historical data about the contractor's work and reliability measures specified by the project owner as inputs.

In brief, the protocol requires dividing the range of relative densities into equal-sized intervals called bins so that each bin lies within a single pay factor range, then evaluating individual samples one by one, putting them into the appropriate bin, until the reliability measures have been met. A cutoff ratio of .6 and cutoff point of 2 means that the testing procedure will terminate when only two bins are at least 60 percent as likely as the most likely bin as calculated from the sample inputs.

Researchers developed two variations of this testing protocol to provide DOT project engineers with decision support:

- The first testing variation uses core samples, tested later in the lab, to determine pavement density where the number of tests must be known before any samples are

continued

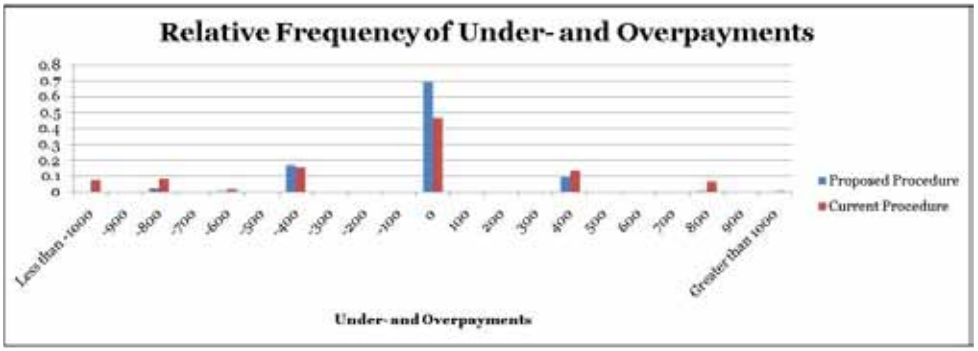
"This new approach to testing can help Mn/DOT apply more accurate incentive and disincentive payments and reward contractors that are doing more than just meeting the minimum specifications."

–Tom Ravn,
Director, Mn/DOT Office of Construction and Innovative Contracting

"With the new testing protocol, the project owner can set the criteria to determine how many samples should be taken to achieve a desired level of accuracy in identifying mean lot density."

–Diwakar Gupta,
Professor, University of Minnesota Institute of Technology, Industrial & Systems Engineering

Produced by CTC & Associates for:
Minnesota Department
of Transportation
Research Services Section
MS 330, First Floor
395 John Ireland Blvd.
St. Paul, MN 55155-1899
(651) 366-3780
www.research.dot.state.mn.us



This graph shows the relative frequency of under- and overpayments in the current and proposed testing procedures.

obtained. A computer program calculates the number of samples that should be tested for the lot based on the reliability criteria. Test results are entered in an Excel worksheet that determines the pay factor.

- The second variation addresses testing in the field, where density observations are available immediately, for example, with the use of a nuclear density gauge that records how gamma radiation interacts with the electrons in the pavement to determine pavement density. An Excel spreadsheet uses the same data used in the first variation, augmented by the observed relative density from each test as it is taken in the field. With each test, the Excel worksheet recommends whether at least one more sample is needed to achieve the desired reliability or the procedure should terminate.

Researchers also developed a procedure to determine the initial estimate of variance of density value for each new contractor and identify when that value should change based on actual contractor performance.

What Did We Learn?

Researchers compared current and proposed testing procedures and found that the proposed testing procedure resulted in more accurate pay factor calculations. Using an example based on historical data, accuracy increased from 47 percent to 70.6 percent, where accuracy is measured by the proportion of times that the correct pay factor is identified. This translated to a change from an average over- and underpayment of $109.60 and $287.33 per lot to $44.50 and $90.74 per lot, respectively.

What's Next?

Mn/DOT continues to look for ways to improve pavement quality, and this research provides an avenue for further discussion about possible changes to specifications for materials testing. Future activities may involve providing training to contractors on the use of the new testing protocol with nuclear density gauges in the field.

This Technical Summary pertains to Report 2009-41, "Statistical Methods for Materials Testing," published December 2009. The full report can be accessed at http://www.lrrb.org/PDF/200941.pdf.

2009-42TS
Published June 2010

RESEARCH SERVICES

OFFICE OF POLICY ANALYSIS, RESEARCH & INNOVATION

TECHNICAL SUMMARY

Technical Liaison:
Tim Clyne, Mn/DOT
Tim.Clyne@state.mn.us

Administrative Liaison:
Bruce Holdhusen, Mn/DOT
Bruce.Holdhusen@state.mn.us

Principal Investigator:
Mihai Marasteanu,
University of Minnesota

PROJECT COST:

$55,000

In the Semi-Circular Bend test, a load is applied to a halved asphalt mixture core sample while gages are used to record resulting cracks.

Reducing Cold-Weather Cracking in Asphalt Pavements

Researchers evaluated the low-temperature fracture properties of 12 asphalt mixtures and nine asphalt binders from a 2008 MnROAD reconstruction project. Results will help DOTs choose materials that are fracture-resistant in cold weather and provide baseline data for related research efforts.

What Was the Need?

In Minnesota and other cold-weather climates, low temperatures often cause asphalt pavements to contract and crack, weakening them and leading to a reduced service life, lower ride quality and increased maintenance requirements. Preventing cracking requires selecting asphalt mixtures with binders—the petroleum products that cement together crushed rock—that do not become too rigid and brittle at low temperatures, and are less capable of relaxing the built-up tensions that lead to cracks. To this end, binders are assigned performance grades listing the highest and lowest temperatures at which they have passed certain laboratory tests for durability.

To better understand binder performance at low temperatures, Mn/DOT recently participated in a cooperative study with several other states, TPF-5(080), Investigation of Low Temperature Cracking in Asphalt Pavements, which developed new, more informative laboratory tests of binder and mixture performance. To relate these and traditional laboratory tests to field performance, researchers developed a partner project to the 2008 large-scale reconstruction of the MnROAD pavement testing facility, which includes a traffic-bearing stretch of I-94. This study—TPF-5(132), Investigation of Low Temperature Cracking in Asphalt Pavements, Phase II—was provided with three MnROAD test cells, consisting of 500-foot road segments, to study low-temperature cracking in recycled asphalt. Researchers were also given a wide range of asphalt binder and mixture samples from test cells used by other projects focused on a variety of different areas, from roof shingle hot-mix asphalt mixtures to warm-mix asphalts.

What Was Our Goal?

The objective of this project was to conduct laboratory testing of the low-temperature fracture properties of asphalt binders and mixtures used in the 2008 MnROAD reconstruction project. By comparing these laboratory results from samples created during pavement construction to future field tests of sections that have been subjected to traffic and repeated freeze/thaw cycles, researchers will be able to determine which tests are most effective for predicting low-temperature pavement performance.

What Did We Do?

Researchers conducted laboratory testing of 12 asphalt mixtures and nine asphalt binders used on MnROAD. The sources of these samples included three primary MnROAD test cells from the TPF-5(132) study, which were paved with a nonwear course of 30 percent RAP. Two mixtures consisted of fractionated RAP, which had been split into fine and coarse fractions, then reconstituted into new hot mix. The binders for these mixtures had a performance grade of 58-28 and 58-34, respectively. The third mixture consisted of nonfractionated RAP with a binder graded at 58-28.

Researchers also analyzed mixtures from a number of other partner projects, including wear and nonwear courses using warm mixes, shoulder mixes, porous mixtures and mixtures containing roof shingles. Finally, researchers tested binders from partner projects with performance grades ranging from 58-28 to 70-28 as well as binders that

continued

"This study produced data that will help Mn/DOT improve the performance of its roads by identifying and using asphalt mixes and binders that resist low-temperature cracking."

–Tim Clyne,
MnROAD Operations Engineer

"The results of this project are vitally important to supporting current and future research efforts into the low-temperature cracking of asphalt pavements."

–Mihai Marasteanu,
Associate Professor, University of Minnesota Department of Civil Engineering

Produced by CTC & Associates for:
Minnesota Department
of Transportation
Research Services Section
MS 330, First Floor
395 John Ireland Blvd.
St. Paul, MN 55155-1899
(651) 366-3780
www.research.dot.state.mn.us

Low-temperatures cause asphalt pavements to contract, which may lead to cracking. Asphalt mixtures and binders that are not as rigid in cold temperatures are better able to relax stresses, making pavements less brittle and prone to fracture.

were extracted in the laboratory from RAP piles of differing consistencies, including standard, coarse and fine.

What Did We Learn?

This study did not include an analysis of results, but rather employs two tests developed in TPF-5(080) and provides data to be analyzed in its Phase II follow-up, TPF-5(132).

Researchers began laboratory testing of mixtures by compacting them to a typical target density for pavements. They evaluated these mixtures at three temperatures using the Indirect Tensile test to measure creep stiffness and tensile strength, and the Bending Beam Rheometer test to measure their stiffness and their ability to relax the stresses of contraction. They also performed the Semi-Circular Bend test to measure fracture toughness. In this test, a compacted, semicircular sample is cut from a cylindrical specimen and loaded from above at the apex of the curve; this load bends the sample while its base rests on two elevated supports, and a gage is used to measure the growth of cracks resulting from this bending.

Researchers analyzed binders using the Direct Tension test, which measures low-temperature stress and strain at failure, and is typically used in combination with the Bending Beam Rheometer test to determine an asphalt binder's low-temperature performance grade. They also performed the new Double Edge Notch Tension test, which is a modification of the Direct Tension test in which researchers weaken specimens prior to testing.

What's Next?

Researchers will analyze the data resulting from this project in TPF-5(132) to evaluate the effectiveness of typical binder performance tests as well as validate the new laboratory and pavement design procedures developed in TPF-5(080). If validated, these procedures will lead to improved binder selection and more durable, economical roads. They will also provide a methodology for future studies investigating the detrimental effects of aging and moisture on the fracture resistance of asphalt materials.

This Technical Summary pertains to Report 2009-42, "Asphalt Mixture and Binder Fracture Testing for 2008 MnROAD Construction," published December 2009. The full report can be accessed at http://www.lrrb.org/PDF/200942.pdf.

2010-15TS
Published July 2010

RESEARCH SERVICES

OFFICE OF POLICY ANALYSIS, RESEARCH & INNOVATION

TECHNICAL SUMMARY

Technical Liaison:
Tom Nordstrom, Mn/DOT
Tom.Nordstrom@state.mn.us

Administrative Liaison:
Bruce Holdhusen, Mn/DOT
Bruce.Holdhusen@state.mn.us

Principal Investigator:
W. James Wilde, Minnesota State University, Mankato

PROJECT COST:
$43,000

The new smoothness specification covers newly constructed concrete pavements like this one as well as asphalt pavements.

Putting Research into Practice: Establishing a Combined Smoothness Specification for Minnesota Pavements

Investigators unified Mn/DOT asphalt and concrete pavement smoothness specifications using the International Roughness Index; added new requirements to improve the profiling process; and developed a certification training program for profiler operators.

What Was the Need?

To build roads that are both cost-effective and comfortable for driving, Mn/DOT offers payment incentives and disincentives to contractors based on the smoothness of the pavements they construct. Until recently, Minnesota determined whether pavements earn bonuses or penalties by measuring their smoothness using the Profile Index method. This method involves rolling a 25-foot frame across a pavement and measuring the vertical displacements of a wheel located at its midpoint; these displacements, taken together, provide a profile of its smoothness.

However, the profile data provided by this method cannot be used to accurately determine ride quality or how comfortable a pavement will seem to drivers. Consequently, in 2002 Mn/DOT began exploring the use of a more advanced method for measuring roughness on asphalt pavements. Called the International Roughness Index, this method uses an algorithm to convert road profile data into an accurate measurement of ride quality. Because algorithm inputs must be precise, profiles are measured using laser sensors mounted on a profiling vehicle traveling at a typical highway speed of 60 mph.

After a series of pilot projects in 2004 and 2005 confirmed that IRI was more effective than PI, Mn/DOT began requiring its use on all new asphalt projects in 2006 and all new concrete projects in 2007. The two offices modified their current, separate specifications; consequently, contractors had to adhere to two sets of requirements, making the profiling process less efficient.

What Was Our Goal?

The objective of this project was to unify Mn/DOT asphalt and concrete pavement profiling specifications to make the evaluation of the ride quality of newly constructed pavements more efficient and effective. Investigators also set out to develop a certification program for training profile operators in using the combined specification.

What Did We Implement?

This study implemented project 2007-09, "Implementation of an International Roughness Index for Mn/DOT Pavement Construction and Rehabilitation," which developed a specification for using IRI to measure the smoothness of newly constructed portland cement concrete pavements. The current project combines this specification with a previous IRI specification developed for asphalt.

How Did We Do It?

Investigators began by reviewing past and present pavement smoothness practices in Minnesota and other states. Then they developed a combined smoothness specification detailing profiling equipment, surface testing methods and methods for adjusting contractor pay based on pavement smoothness. The specification also included the following additions for both asphalt and concrete:

continued

"Combining specifications will make the profiling process more consistent and efficient for contractors, leading to smoother pavements at a reduced cost."

–W. James Wilde,
Professor, Minnesota State University, Mankato

"Using continuous IRI to identify areas of localized roughness will enable contractors to better locate and quantify bumps and dips, which will improve the effectiveness of corrective work and result in smoother pavement surfaces."

–Tom Nordstrom,
Mn/DOT Pavement Management Analyst

Produced by CTC & Associates for:
Minnesota Department of Transportation
Research Services Section
MS 330, First Floor
395 John Ireland Blvd.
St. Paul, MN 55155-1899
(651) 366-3780
www.research.dot.state.mn.us

IRI algorithms for calculating ride quality from pavement profiles use data from inertial profilers, which use laser sensors to take precise measurements per inch of pavement.

- A requirement to profile both right and left roadway wheel paths. Previous specifications required that only right wheel paths be profiled.
- An improved method of identifying areas of localized roughness (roadway bumps and dips).
- The inclusion of segments that have undergone corrective work in adjustments to contractor pay.

Investigators then developed operator certification requirements and training workshops and solicited an external review of the new specification, including from participants in an industry forum in November 2009.

What Was the Impact?

Combining specifications will save Mn/DOT effort by ensuring that future specification changes will not have to be made twice. Further, contractors who construct both asphalt and concrete pavements will not need to conform to two sets of requirements.

Mn/DOT also used this project to implement the Profile Viewer and Analyzer software tool, or ProVAL, developed by the Federal Highway Administration as a new standard for pavement profile analysis. This software implements a uniform, standard computation method that also improves the accuracy and reliability of profile computation and reporting, and can import pavement profiles from a variety of profiling machines.

Finally, Mn/DOT changed its profiling certification requirements to cover equipment and operators; this will dramatically improve data collection and analysis on Mn/DOT pavement construction projects as well as quality control and assurance. Investigators created a workshop to train profiler operators on the combined smoothness specification, ProVAL software and best practices for minimizing measurement errors. A pilot workshop was conducted for Mn/DOT personnel and two full workshops for contractors and other pavement profiler operators. To be certified, participants must pass a written examination upon completion of the workshop.

What's Next?

In the 2010 construction season, Mn/DOT will conduct pilot projects using the new specification and plans to require its use on all asphalt and concrete paving projects by 2011. Going forward, investigators recommend:

- Periodic reviews of the specification's incentive/disincentive levels and thresholds for correcting areas of localized roughness.
- The development of an online certification workshop and examination.
- Continued assessment of changes in paving industry technologies and best practices.

This Technical Summary pertains to Report 2010-15, "Mn/DOT Combined Smoothness Specification," published April 2010. The full report can be accessed at http://www.lrrb.org/PDF/201015.pdf.

The research being implemented via this project can be found in Report 2007-09, "Implementation of an International Roughness Index for Mn/DOT Pavement Construction and Rehabilitation," published April 2007. This report can be accessed at http://www.lrrb.org/PDF/200709.pdf.

2010-17TS
Published October 2010

LRRB
LOCAL ROAD RESEARCH BOARD

TECHNICAL SUMMARY

Technical Liaison:
Tim Stahl, Jackson County
Tim.Stahl@co.jackson.mn.us

Administrative Liaison:
Dan Warzala, Mn/DOT
Dan.Warzala@state.mn.us

Principal Investigator:
W. James Wilde,
Minnesota State University

LRRB PROJECT COST:
$92,749

The proportion of five-axle semitrailers on county state aid highways has increased 340 percent.

MINNESOTA DEPARTMENT OF TRANSPORTATION

RESEARCH SERVICES
OFFICE OF POLICY ANALYSIS, RESEARCH & INNOVATION

Update of Vehicle Classification for County Road Pavement Design

Researchers conducted vehicle classification counts in 15 counties across the state. They discovered that the proportion of heavy trucks on the County State Aid Highway system is at least twice as high as the counts found in the latest Pavement Design Manual.

What Was the Need?

Traffic analysis is an essential component of proper pavement design and construction. Equivalent single axle load forecasts are one factor used to determine the type and durability of roadways. Accurate ESAL forecasts require accurate average annual daily traffic counts and vehicle classifications. It is vital to know, for instance, how many multi-axle semitrailers are expected to use a roadway as compared with the number of passenger cars. Since one five-axle semitrailer can be equivalent to thousands of passenger cars in terms of pavement damage, a dramatic impact on pavement design will result if heavy truck traffic increases by even a small percentage.

Mn/DOT has installed many permanent traffic classification sites on interstate and state highways throughout the state, resulting in continuously updated information. However, there are often long gaps of time between classification counts on the county road system. The default vehicle classification tables for county road systems from the most recent Pavement Design Manual were originally created in 1977 and last updated in 1997. Proper design and construction of roadways require accurate classification data based on up-to-date traffic analysis.

What Was Our Goal?

The primary goal of this project was to update the vehicle classification and distribution tables that counties use when designing pavement structures. Secondary goals included characterizing this data by region, season and Average Daily Traffic, or ADT, category, and developing a method for local agencies to determine appropriate vehicle classifications for use in the design of a particular roadway.

What Did We Do?

Fifteen county engineers from different counties with varied geography, demographics and commercial activities worked with the research team to select five roadways within each of their respective counties to conduct traffic classification counts. Roadways were selected that were representative of traffic within the county, including one roadway in each ADT category when possible, and were limited to those in the County State Aid Highway system and county system.

Each county then obtained traffic classifying equipment from local Mn/DOT State Aid offices or via purchase, including TimeMark Delta IIIL tube counters. These counters were installed on each of the selected roadways, with two tubes set exactly 16 feet apart; the counters determined the class of vehicle by calculating axle spacing using the speed of vehicles crossing the tubes. Each counter remained on the roadway for an average of 12 days, which is longer then the standard 48 hours generally used for vehicle classification counts.

From November 2006 through July 2009, 47 sets of classification counts were collected with approximately five roadways each, for a total of 239 individual roadway counts. This data included counts in spring, summer and fall for each participating county.

Researchers then analyzed the data to determine vehicle classification trends by vehicle

continued

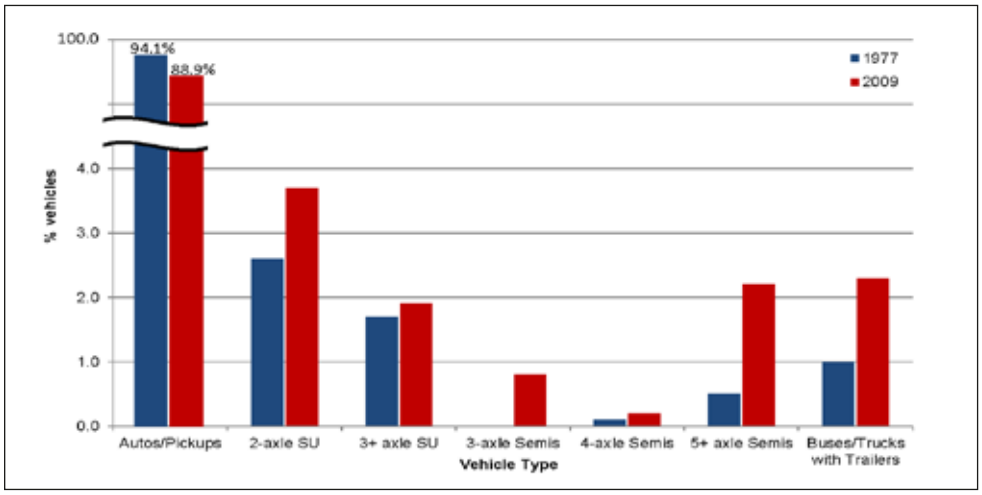
"We need to be designing roads based on up-to-date vehicle classification data. A large increase in the use of five-axle semitrailers has a significant impact on pavement damage and the types of roads we should build."

—Tim Stahl,
Jackson County Engineer

"We were able to address the need for accurate and updated vehicle classification data and go further by analyzing the data by region, season and ADT category."

—W. James Wilde,
Professor, Minnesota State University Center for Transportation Research and Implementation

Produced by CTC & Associates for:
Minnesota Department
of Transportation
Research Services Section
MS 330, First Floor
395 John Ireland Blvd.
St. Paul, MN 55155-1899
(651) 366-3780
www.research.dot.state.mn.us



Researchers analyzed data to capture traffic trends, including by vehicle category. This chart illustrates the difference between 1977 (blue) and 2009 (red) percentages of traffic for each category, showing the significant increase in larger vehicles that have a greater impact on pavements.

type distributions statewide, district/region, season, ADT category, weekend versus weekday, and combinations of these categories.

Finally, researchers produced a guide for local agencies to develop vehicle classification distributions using three different methods: the updated statewide classification tables, tables categorized by region/season/ADT, and hardware counts to conduct individual counts on specific roadways.

What Did We Learn?

The results of this study indicate the vehicle classification distributions on the County State Aid Highway system have changed since the classification tables were last updated. The changes are most prominent in the increase of large trucks on county roadways. A summary of statewide vehicle classification changes in the traffic mix by vehicle category follows:

- Autos and pickups decreased 5.5 percent.
- Single-unit trucks (two-axle, six-tire) increased 42 percent.
- Single-unit trucks (three-plus axle) increased 12 percent.
- Tractor semitrailers (four-axle) increased 100 percent.
- Tractor semitrailers (five-plus axle) increased 340 percent.
- Buses and trucks with trailers increased 130 percent.

Spring and fall seasons displayed the highest percentage of commercial vehicle traffic because of the increased numbers of farming and harvesting vehicles. Regional classification data showed the percentage of heavy truck traffic varies between districts. For instance, District 4 reported the highest proportion of heavy commercial vehicles at 18.4 percent, while District 5 reported only 6.8 percent. Researchers anticipated that roadways with lower ADT and in rural areas would experience a higher proportion of heavy truck traffic, but the data indicated only a small increase.

What's Next?

Researchers recommend providing additional guidance to counties in collecting, analyzing and interpreting traffic classification data. The results of this project should be formally presented to a full meeting of county engineers from across the state, and researchers are working with the Mn/DOT Office of State Aid to determine if the research will be used to update the Pavement Design Manual.

This Technical Summary pertains to the LRRB-produced Report 2010-17, "Update of Vehicle Classification for County Road Pavement Design," published April 2010. The full report can be accessed at http://www.lrrb.org/PDF/201017.pdf.

2010-24TS
Published October 2010

RESEARCH SERVICES

OFFICE OF POLICY ANALYSIS, RESEARCH & INNOVATION

TECHNICAL SUMMARY

Technical Liaison:
Eddie Johnson, Mn/DOT
Eddie.Johnson@state.mn.us

Administrative Liaison:
Sandy McCully, Mn/DOT
Sandra.Mccully@state.mn.us

Principal Investigator:
Tim Clyne, Mn/DOT
Tim.Clyne@state.mn.us

PROJECT COST:
N/A (Included in regular Mn/DOT operations)

MnROAD cell 31, now in place for six years, had two transverse cracks after the third winter of testing, but otherwise showed no signs of distress.

Recycling Mining Materials as Durable Aggregates

Researchers evaluated an iron mining byproduct called taconite for use in roads as a high-quality aggregate and found it to be durable. MnROAD test sections using taconite performed as well as or better than those using conventional aggregates.

What Was the Need?

Highway construction requires high-quality aggregates—crushed rock used in road foundations and pavements. Because these aggregates are becoming scarce in many parts of the country, new sources are needed. One possible source is taconite, a sedimentary rock consisting of iron mixed with various minerals. Each year, about 125 million tons of taconite waste are produced from Minnesota's Mesabi Iron Range as a byproduct of iron ore mining. Such mining requires blasting through very hard layers of taconite bedrock, called overburdens, to get to the more iron-rich minerals beneath them. Taconite byproducts include rocks of various sizes as well as tailings, which are sand-sized particles that result from crushing these rocks. The largest taconite rocks—2-inch stones with flat shapes and rounded edges—are sometimes used as railroad ballast, but until recently most taconite waste was landfilled.

However, there was little information available on taconite use in construction design specifications. Consequently, Mn/DOT began a partnership in 2004 with the Minnesota Department of Natural Resources to evaluate taconite aggregates for use in asphalt and concrete mixtures. Part of this evaluation included construction of test sections at MnROAD, a test facility for researching pavement materials that includes a traffic-bearing stretch of I-94. The current project is part of ongoing monitoring of these test sections.

What Was Our Goal?

The goal of this project was to assess taconite for use as an abundant and high-quality aggregate by evaluating the long-term performance of several MnROAD test sections using it.

What Did We Do?

Researchers evaluated the performance of five MnROAD test sections: two built in 2004 and three in 2008. The 2004 cells were constructed on MnROAD's Low Volume Road, or LVR, which tests an 80,000-pound truck traveling about 80 laps per weekday on the inside lane. These sections included cells 31 and 54, paved with asphalt and concrete mixtures incorporating taconite aggregate, respectively.

For the 2008 test sections, two cells were constructed on the MnROAD Mainline, which carries live I-94 traffic for all but three days each month. During the project, a third cell was added on the LVR. These included cell 6, constructed on the Mainline with a 2-inch layer of fine aggregate asphalt mixture incorporating two taconite tailing sources, placed over a 5-inch-thick concrete pavement; and cells 23 and 87, constructed on the Mainline and LVR, respectively, with a base consisting of taconite railroad ballast.

With the exception of cell 87, which did not successfully bear truck traffic for reasons unrelated to the taconite (the rock underneath failed), researchers monitored test sections regularly for performance, collecting data two to four times per year on cracking, rutting, ride quality, faulting and friction. They also tested pavement strength using a falling weight deflectometer and conducted laboratory tests on taconite materials used in cells 6 and 23, including evaluations of gradation and specific gravity.

continued

"Taconite could supply a high-quality aggregate for roadway use that would lead to cost savings for Mn/DOT and would benefit the environment."

—Tim Clyne,
MnROAD Operations Engineer, Mn/DOT Materials and Road Research

"Laboratory tests have shown taconite aggregates to be tough, durable materials, performing as well as or better than conventional aggregates."

—Eddie Johnson,
Research Project Engineer, Mn/DOT Materials and Road Research

Produced by CTC & Associates for:
Minnesota Department
of Transportation
Research Services Section
MS 330, First Floor
395 John Ireland Blvd.
St. Paul, MN 55155-1899
(651) 366-3780
www.research.dot.state.mn.us

The taconite used in this study was delivered via specialized trailers that can travel by rail or semi-tractor, demonstrating a promising option for future long-distance hauling of taconite aggregates to road construction projects where local aggregates are scarce.

Finally, researchers conducted a field experiment in Otsego, Minnesota, to evaluate the usefulness of microwave technology for heating materials while patching potholes. Researchers used non-taconite patching materials with a view to establishing a baseline for future testing of taconite as a more suitable patching material.

What Did We Learn?

Results showed that taconite aggregates can be used successfully to construct high-quality aggregate base, asphalt and concrete pavement layers.

The test sections constructed at MnROAD have performed as well as or better than those built using conventional aggregates. Skid resistance in particular has been exceptional in the taconite cells, and other parameters such as ride quality and the amount of rutting and cracking have been satisfactory. Laboratory tests showed that material properties of the taconite aggregates and mixtures have generally been as good as or better than those of traditional aggregates. Based on these results, Mn/DOT has developed standard specifications for the use of taconite materials in roads.

The pothole demonstration project showed that microwave technology can be used to patch potholes, with the test patch performing well over time. However, the patching operation will need to be made more efficient for this process to gain widespread use.

What's Next?

Researchers will continue to monitor test sections and will also evaluate the performance of thin lift hot-mix asphalt pavements using taconite via the recently initiated project "Performance of Taconite Aggregates in Thin Lift HMA." They will also continue to investigate the use of taconite aggregates for pothole patching and testing properties of the rock to make the process more efficient.

This Technical Summary pertains to Report 2010-24, "Use of Taconite Aggregates in Pavement Applications," published June 2010. The full report can be accessed at http://www.lrrb.org/PDF/201024.pdf.

2010-26TS
Published November 2010

LRRB
LOCAL ROAD RESEARCH BOARD

TECHNICAL SUMMARY

Technical Liaison:
Tom Burnham, Mn/DOT
Tom.Burnham@state.mn.us

Administrative Liaison:
Shirlee Sherkow, Mn/DOT
Shirlee.Sherkow@state.mn.us

Principal Investigator:
Randal Barnes, University of Minnesota

LRRB PROJECT COST:
$27,500

Mn/DOT CONTRIBUTION:
$36,000

TOTAL PROJECT COST:
$63,500

The MnROAD facility consists of two roadways instrumented with thousands of sensors that record traffic load response and environmental data.

MINNESOTA DEPARTMENT OF TRANSPORTATION

RESEARCH SERVICES
OFFICE OF POLICY ANALYSIS, RESEARCH & INNOVATION

Improving the Quality of MnROAD Pavement Temperature Data

Researchers created a procedure to flag erroneous data in the MnROAD temperature record database. They also created summary tables and graphs of the resulting reliable data, which can be used by researchers worldwide to develop, test and ultimately improve road designs.

What Was the Need?

Since 1994, Minnesota's MnROAD facility has been used by researchers worldwide to conduct cutting-edge research into road performance. Located outside Otsego, Minnesota, and 40 miles northwest of Minneapolis/St. Paul, MnROAD consists of two road segments in parallel to Interstate 94. A 3.5-mile mainline roadway carries live Interstate traffic, and a 2.5-mile loop road carries controlled trucks loaded to various weights to simulate conditions on low-volume rural roads.

These roads are divided into more than 50 test cells of up to 500 feet in length that are paved with different thicknesses and types of aggregates, concrete and asphalt. These pavements have varying combinations of surface, base, subbase, subgrade, drainage and compaction properties.

MnROAD test cells are instrumented with various surface and subsurface sensors to collect data related to traffic load response and environmental conditions. In 48 of these cells, pavement temperature measurements are taken using thermocouple sensors, which consist of a pair of dissimilar metal alloy wires connected near the point of measurement. The difference in the responses of these metals to heat creates an electrical voltage that can be measured and then correlated to temperature. Temperature changes are particularly important because they can contribute to substantial pavement damage. During its operation, MnROAD has produced a vast database of these temperature recordings, including more than 471 million data records from 1,313 thermocouple sensors taking readings every 15 minutes from January 1996 through October 2007. While this information is potentially of great value to pavement research studies worldwide, only small portions of the data have been extracted and analyzed. One reason for this limited use is that errors in the data—caused by equipment failures, miscalibration, power outages and other factors—make processing and analyzing it prohibitively labor-intensive. A method was needed to filter errors from both historical data and new data as it is collected going forward.

What Was Our Goal?

The objective of this project was to improve the effectiveness and quality of the MnROAD pavement temperature record database by identifying and flagging questionable, erroneous and unreliable data.

What Did We Do?

Researchers extracted data from the MnROAD database and identified possible patterns of error, including:

- Pavement temperatures not consistent with Minnesota's thermal extremes, or less than -50 degrees Celsius and more than 60 degrees Celsius
- Gaps or outliers in an otherwise continuous data stream
- Nonsensical data patterns indicating defective sensors
- Unrealistically abrupt changes in temperature

continued

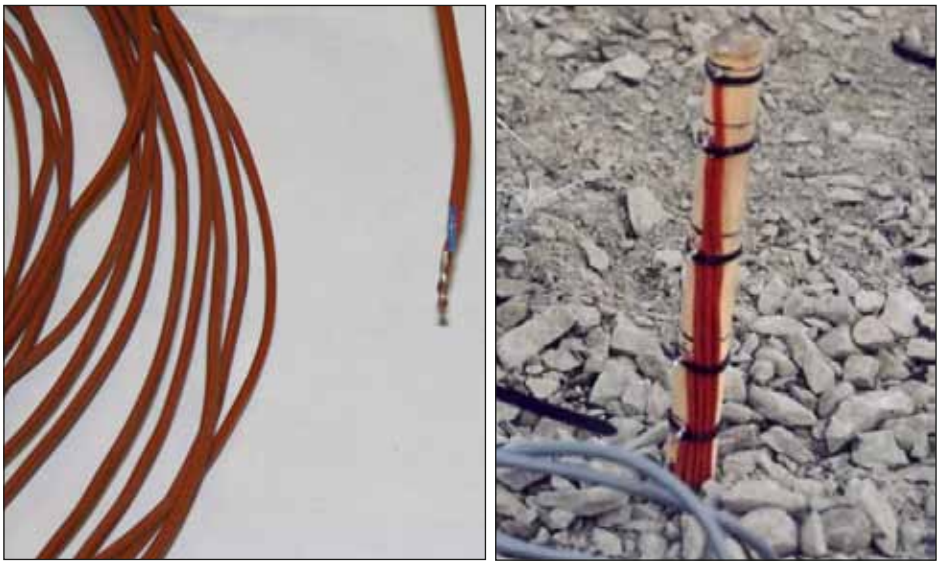
"The temperature data collected at Mn/ROAD will be a huge asset for optimizing road design both in Minnesota and those places around the world with similar climates. The filtering processes produced by this project make this data more usable."

—Randal Barnes,
Associate Professor,
University of Minnesota
Department of Civil
Engineering

"The size and impact of the MnROAD database affected by this project are comparable to the Long-Term Pavement Performance database, the premier information source in the United States for pavement performance data."

—Tom Burnham,
Mn/DOT Senior Road
Research Engineer

Produced by CTC & Associates for:
Minnesota Department
of Transportation
Research Services Section
MS 330, First Floor
395 John Ireland Blvd.
St. Paul, MN 55155-1899
(651) 366-3780
www.research.dot.state.mn.us



A thermocouple sensor (left) is typically mounted on a vertical tree (right) spanning surface and subsurface pavement layers, allowing temperature measurements at various depths. These vertical profiles are critical to fully relating pavement performance to temperature.

- Differences in data streams taken during the same period by similar sensors, or by sensors located in comparable pavement types and at approximately the same depths and cell locations

These patterns were used to create an algorithm and computer code that could be employed to filter the temperature database. This algorithm included 14 interdependent quantitative tests for flagging erroneous, questionable and exceptional data.

Researchers filtered out erroneous data and used the remaining accurate data to produce a wide variety of statistical tables and graphs. They also created a user's guide for researchers wishing to make use of this data along with the algorithms and computer code used to filter it.

What Did We Learn?

The majority of the pavement temperature sensors performed very well. Of the 1,282 operational sensors, 714 produced reliable data more than 99 percent of the time. Only 18 of 1,282 operational sensors produced reliable data less than 50 percent of the time. Only 31 of the original 1,313 sensors were wholly nonoperational.

What's Next?

The MnROAD temperature database contains information that is invaluable to in-depth research about the response of pavements to cold climates. Now that this data has been filtered, MnROAD can share it in a convenient digital format with researchers around the world, allowing them to develop and test new pavement designs that could improve road performance. Although this project focuses on an existing set of data, the system developed for it can also be used for ongoing filtering of temperature data as it is collected at MnROAD.

Because of the success of this project, researchers have not yet determined whether a second phase will be required. Ongoing related research includes the Vibrating Wire and Horizontal Clip Data Analysis project, in which researchers are analyzing MnROAD data from vibrating wire and horizontal clip sensors—used to measure pavement strain and structural changes—to flag anomalies and develop similar validation software.

This Technical Summary pertains to the LRRB-produced Report 2010-26, "MnROAD Data Mining, Evaluation and Quantification—Phase I," published July 2010. The full report can be accessed at http://www.lrrb.org/PDF/201026.pdf.

2010-31TS
Published November 2010

LRRB
LOCAL ROAD RESEARCH BOARD

TECHNICAL SUMMARY

Technical Liaison:
John Brunkhorst, McLeod County
John.Brunkhorst@co.mcleod.mn.us

Administrative Liaison:
Dan Warzala, Mn/DOT
Dan.Warzala@state.mn.us

Principal Investigator:
W. James Wilde, Minnesota State University, Mankato

LRRB PROJECT COST:
$31,040

Researchers recommend avoiding sealant overbanding on the sides of cracks.

MINNESOTA DEPARTMENT OF TRANSPORTATION

RESEARCH SERVICES
OFFICE OF POLICY ANALYSIS, RESEARCH & INNOVATION

Preventing the Occurrence of Bumps in HMA Overlays

Researchers identified construction methods and materials for preventing the occurrence of bumps in hot-mix asphalt overlays, finding that best practices include using specified rolling techniques during warmer weather, low-modulus sealants, and narrow and shallow crack sealant reservoirs while avoiding overbanding.

What Was the Need?

As pavements age, they are subject to cracking and other deterioration. To rehabilitate them without engaging in expensive reconstruction, Minnesota state and local highway agencies sometimes rehabilitate these pavements with one or more layers of asphalt after filling existing cracks with sealant.

An asphalt overlay can sometimes develop bumps near or directly above the sealed cracks in the original pavement, especially when the overlay consists of only one layer. If large enough, these bumps can significantly affect the ride quality of the road as experienced by motorists.

The Local Road Research Board supported a project to investigate the causes of these bumps. Researchers surveyed local agencies on bump prevention methods and theories, and then evaluated these methods in the laboratory, disconfirming a common hypothesis that bumps were caused by the thermal expansion of sealants. These results were used to develop a manual, *Common Practices for Avoiding Bumps in Overlays*, for predicting, preventing and mitigating the effects of overlay bumps by using specific crack sealants and construction methods. Because of this manual, local agencies are already reporting fewer bumps in overlays. However, because this project did not fully establish the causes of these bumps, additional research was needed to further investigate them and to refine prevention methods accordingly.

What Was Our Goal?

The objective of this project was to identify crack sealant types and construction methods for avoiding and mitigating the occurrence of bumps in hot-mix asphalt overlays, and to update the manual of practice for doing so.

What Did We Do?

Researchers evaluated the influence of the following factors on bumps in overlays:

- The type of sealant used, including its stiffness or elasticity.
- Crack geometry, or reservoir structure, the depth and width to which cracks are routed before they are filled with sealant. Traditionally, enough sealant is applied to overflow the crack and create an overband, or a layer of sealant on each side.
- Construction methods, including the speed, pattern and operation of the rollers used to spread and compact the asphalt layer, and the temperature of this layer during compaction.

Researchers conducted two experiments to monitor these factors; the first focused on sealant type and crack geometry, and the second on construction methods. For the first experiment, researchers monitored a site on CSAH 5 in Jackson County, Minnesota, consisting of 19 250-foot sections. Each section involved the same construction methods but a different combination of crack geometry and crack sealant type (such as hot-poured crumb rubber, hot-poured elastic and hot-poured extra-low modulus elastic). As

continued

"Thanks to the findings in this study, local and county agencies now have some great techniques to help reduce the occurrence of bumps in overlays."

—John Brunkhorst,
McLeod County Engineer

"We found that the occurrence of bumps can be significantly decreased by avoiding high air temperatures when placing overlays, using low-modulus sealants and using the right rolling techniques."

—W. James Wilde,
Professor, Minnesota State University, Mankato

Produced by CTC & Associates for:
Minnesota Department
of Transportation
Research Services Section
MS 330, First Floor
395 John Ireland Blvd.
St. Paul, MN 55155-1899
(651) 366-3780
www.research.dot.state.mn.us

Researchers often found bumps during the first field visit, including this 1/2-inch tall bump with hairline cracking, indicating that compaction equipment had been operated when the HMA temperature was not optimum.

a control, the cracks in some sections were not routed, and others were not filled with sealant.

For the second experiment, researchers monitored sites at four locations in Lincoln County, Minnesota, on CSAH 5 and CSAH 15. These sites received the same sealant and crack geometry treatment but were subject to different construction methods and conditions, including roller operation and air and pavement temperatures.

Researchers then monitored all of these sites over two years by measuring bump height with a level and ruler, recording bump locations with Global Positioning System equipment and collecting profile data using a lightweight profiler.

What Did We Learn?

Results showed that while the occurrence of bumps in overlays is directly related to sealant type and reservoir geometry, the more significant causes of bumps are rolling techniques and warmer air and pavement temperatures. The project report recommends the following methods for minimizing the occurrence of overlay bumps:

- Rolling when air and pavement temperatures are lower, below 80°F and 125°F, respectively, and possibly slightly delaying rolling operations so that the overlay mat cools while the underlying sealant material heats up.
- Using low-modulus and crumb rubber sealant types, and possibly allowing sealant materials to age at least one year before applying the overlay.
- Routing narrow and shallow crack reservoirs, avoiding sealant overbanding, and possibly leaving sealant material below the pavement surface or removing it before overlay construction.
- The use of pneumatic rollers for breakdown compaction through 200°F followed by a single steel finishing roller.
- The use of nonvibratory breakdown rollers.

What's Next?

Researchers used project results to update the manual *Common Practices for Avoiding Bumps in Overlays*. More research is required before the causes of bumps can be definitively identified, and future results may help further refine bump mitigation strategies.

This Technical Summary pertains to the LRRB-produced Report 2010-31, "Predicting the Occurrence of Bumps in Overlays," published August 2010. The full report can be accessed at http://www.lrrb.org/PDF/201031.pdf.

This project builds on the results detailed in a previous report, 2005-28, "Occurrence of Bumps in Overlays," which can be accessed at http://www.lrrb.org/PDF/200528.pdf.

2010-35TS
Published January 2011

LRRB
LOCAL ROAD RESEARCH BOARD

TECHNICAL SUMMARY

Technical Liaison:
John Grindeland, Fillmore County
jgrindeland@co.fillmore.mn.us

Administrative Liaison:
Dan Warzala, Mn/DOT
Dan.Warzala@state.mn.us

Additional Project Support:
Charles Howe, Mn/DOT
Charles.Howe@state.mn.us

Principal Investigator:
Magdy Abdelrahman, North Dakota State University

TOTAL PROJECT COST:
$92,624

LRRB COST:
$46,312

Coarse aggregate rocks are smaller than 3 inches but too large to pass through a sieve with 1/4-inch-diameter holes.

MINNESOTA DEPARTMENT OF TRANSPORTATION

RESEARCH SERVICES

OFFICE OF POLICY ANALYSIS, RESEARCH & INNOVATION

A Property-Based Specification for Coarse Aggregate in Pavement Applications

What Was the Need?

Building durable road bases and pavements requires the use of high-quality aggregates, or mixtures of sand, gravel and crushed rock. Aggregates are often obtained from local supplies of natural rock, which may then be crushed and blended to meet certain specifications, including size. Coarse aggregates are those that will pass through a screen with 3-inch diameter holes but not pass through a sieve with 1/4-inch diameter holes.

Minnesota has numerous sources of aggregates, including gravel pits and rock quarries. To ensure aggregates from these sources are of a high enough quality to produce well-performing pavements, they are tested annually against certain specifications for abrasion resistance (resistance to crushing and degradation), percent spalling materials (the amount of rock in an aggregate that is easily weathered, is highly absorptive or reacts chemically with other mixture materials) and soundness (resistance to weathering and freeze-thaw deterioration).

Researchers explored the possibility of improving and unifying Minnesota coarse aggregate specifications for asphalt and concrete mixes by including requirements for properties that more adequately predict pavement performance, such as compressive strength.

Minnesota's current aggregate specifications have been in use since the 1930s, and it is possible that they could be improved by requiring tests for properties more directly related to pavement performance. Further, basing requirements on performance properties might allow the use of unified specifications applicable to both concrete and asphalt mixtures. However, before specifications can be modified, researchers need to better understand how well Minnesota aggregates meet current specifications.

What Was Our Goal?

The objective of this study was to explore the possibility of improving and unifying Minnesota coarse aggregate specifications for asphalt and concrete by including additional requirements for properties that predict pavement performance.

What Did We Do?

Researchers began by performing a literature review of coarse aggregate testing procedures commonly used in Minnesota and other states. Then they conducted an electronic survey asking researchers, engineers and other pavement industry professionals to rank a list of physical, chemical and mechanical properties of coarse aggregates as well as associated methods for testing them in order of their importance as indicators of aggregate quality.

Researchers then analyzed district testing data for 76 Minnesota local aggregate sources contained in Mn/DOT databases from the year 2000 onward to determine for both asphalt and concrete applications:

- How well Minnesota local aggregates satisfy current specifications, including requirements for abrasion resistance, percent spalling materials and soundness.
- What other aggregate testing procedures are commonly being used in Minnesota districts, and how well on average they predict aggregate quality as measured by current specifications.

continued

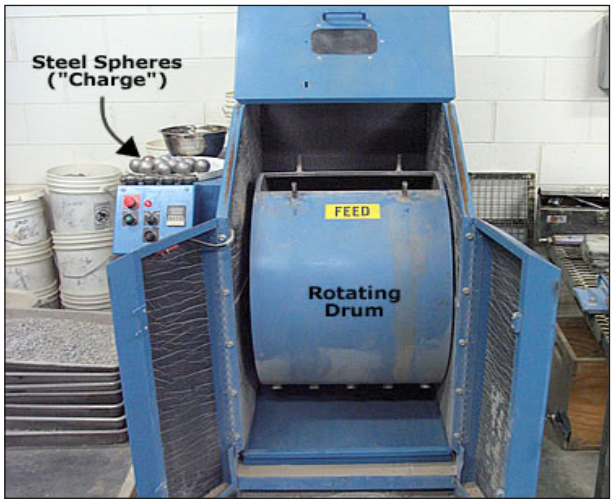
"This project created an important dialogue between asphalt and concrete engineers and geologists, including a discussion of the pros and cons of using various properties in coarse aggregate specifications."

—John Grindeland,
Fillmore County Highway Engineer

"Improvements in coarse aggregate specifications could eventually simplify construction processes and increase the use of local materials, saving Mn/DOT time and money."

—Magdy Abdelrahman,
Assistant Professor, North Dakota State University Department of Civil Engineering

Produced by CTC & Associates for:
Minnesota Department
of Transportation
Research Services Section
MS 330, First Floor
395 John Ireland Blvd.
St. Paul, MN 55155-1899
(651) 366-3780
www.research.dot.state.mn.us



A common test for measuring abrasion resistance is the Los Angeles abrasion test, used to evaluate how well aggregate stones remain intact when subjected to grinding in a rotating steel drum containing steel spheres.

Finally, researchers compared the quality of Minnesota aggregates to those of neighboring states with similar specifications, and discussed preliminary results with Mn/DOT engineers to examine their views on current coarse aggregate requirements.

What Did We Learn?

Results showed that aggregate specifications in Minnesota and other states do not include tests for those properties identified by survey respondents as most important for predicting pavement performance, suggesting that improvements are needed. The aggregate property identified as most important for both asphalt and concrete mixtures was compressive strength, or the capacity of a material to withstand a force applied to its axis. Respondents also identified solubility as an important aggregate property for concrete performance; and aggregate coatings, asphalt affinity and integrity as significant for asphalt applications.

The analysis of historical testing data showed that, on average, Minnesota aggregates met both concrete and asphalt specifications more than 90 percent of the time. Aggregates met the abrasion resistance requirement more than 92 percent of the time, percent spalling materials more than 67 percent of the time and soundness more than 70 percent of the time. However, these averages do not reflect the fact that aggregate quality varied significantly between Minnesota districts, especially for asphalt applications. Further, some aggregate sources that were compliant with specifications on average varied significantly from one measurement to another, reflecting a lack of consistency that can affect pavement performance. This variability was slightly higher in Minnesota than in other states.

What's Next?

This study, which resulted in three papers published in key transportation journals and conferences, comprises the first task in restructuring coarse aggregate specifications to be based more closely on the performance of asphalt and concrete mixes. A better understanding of available aggregate testing methodologies and those properties critical to evaluating aggregate quality will help maximize the use of local sources, which are sometimes rejected despite the fact that they may be suitable for low-volume applications even when not suitable for high-quality mixes. This will contribute to the sustainability of Minnesota's aggregate supply. Mn/DOT is receptive to modifying current specifications in the future, once better correlations are established between aggregate properties and pavement performance.

This Technical Summary pertains to the LRRB-produced Report 2010-35, "A Property-Based Specification for Coarse Aggregate in Pavement Applications," published October 2010. The full report can be accessed at http://www.lrrb.org/PDF/201035.pdf.

2010-40TS
Published December 2010

RESEARCH SERVICES

OFFICE OF POLICY ANALYSIS, RESEARCH & INNOVATION

TECHNICAL SUMMARY

Technical Liaison:
Bernard Izevbekhai, Mn/DOT
Bernard.Izevbekhai@state.mn.us

Administrative Liaison:
Nelson Cruz, Mn/DOT
Nelson.Cruz@state.mn.us

Principal Investigators:
Tim Casey, HDR Engineering, Inc.
Elliott Dick, HDR Engineering, Inc.

PROJECT COST:
$58,319

For each test section, researchers placed microphones at 100 feet from the road, 50 feet and very close to the pavement.

The Influence of Pavement Surface Texture on Traffic Noise

Researchers compared the relative loudness of several concrete pavement surface finishes by evaluating test sections. Results showed the innovative/ultimate diamond grind to be the quietest, followed by the burlap drag, conventional diamond grind and transverse tine.

What Was the Need?

Highway traffic noise is a common and expensive form of noise pollution, with the sound barriers used to mitigate it costing nearly $3 million per mile. Highway noise comes primarily from vehicle engines, exhaust systems and tires.

At highway speeds, tire-pavement contact is the most important contributor to road noise. The level of tire-pavement noise varies significantly with the texture of the pavement surface. In the case of concrete pavements, these surface textures are added during road construction to create friction and skid resistance, which are especially critical in wet weather. The textures are created by dragging various materials across the fresh concrete to create surface grooves or tines before it completely hardens. The width, depth and spacing of grooves affects not just skid resistance but also tire noise.

Three common types of concrete pavement surface textures follow:

- Transverse tine is produced by dragging a metal rake laterally across the width of the pavement. Tining is the most common texture on highways but was abandoned in 1988 by Mn/DOT due to noise levels.
- Burlap drag is typically used for lower speed streets and local roads, produced by dragging moistened coarse burlap over the pavement surface.
- Diamond grind is produced by cutting longitudinal grooves into a pavement using closely spaced, diamond-coated saw blades and shaving a thin layer off the top to smooth surface irregularities. Diamond grinding was originally developed to restore smoothness and skid resistance to aging pavements, but engineers found that it produced pavements with significantly less tire noise than tining, so Mn/DOT began using it on newly constructed pavements.

To further reduce tire-pavement noise, Purdue University's Institute for Safe, Quiet, and Durable Highways developed the innovative/ultimate diamond grind, which produces wider grooves with smoother peaks. Research was needed to evaluate this technique, comparing the noise produced by pavements developed this way to the other options available.

What Was Our Goal?

The purpose of this project was to compare the relative tire-pavement loudness of various pavement surface finishes by evaluating several test sections at Minnesota's MnROAD facility and the regional freeway system in Minnesota.

What Did We Do?

Researchers used digital audio and video recording equipment to make traffic noise measurements on several 500-foot test sections on MnROAD's northbound I-94 facility. Test sections included concrete pavements with transverse tined, conventional diamond grind and innovative/ultimate diamond grind surface finishes. Researchers also tested a burlap drag surface and another innovative/ultimate grind surface on the regular

continued

"Using the right pavement surface textures can be a cost-effective method for reducing the tire-pavement noise component of highway traffic noise, and could potentially reduce the size of costly noise walls."

—Tim Casey,
Environmental Acoustics Program Manager, HDR Engineering, Inc.

"This project made critical progress in meeting the challenge to develop a pavement finishing method that minimizes road noise without compromising friction."

—Bernard Izevbekhai,
Concrete Research Operations Engineer, Mn/DOT Office of Materials

Produced by CTC & Associates for:
Minnesota Department
of Transportation
Research Services Section
MS 330, First Floor
395 John Ireland Blvd.
St. Paul, MN 55155-1899
(651) 366-3780
www.research.dot.state.mn.us

The innovative/ultimate grind (right) has wider and flatter grooves than the conventional diamond grind (left) and can reduce tire-pavement noise over it by as much as 4 decibels, or 67 percent.

freeway system in the region, where they could evaluate sections that were longer than the 500-foot MnROAD cells. The burlap drag pavement was chosen as a control for the regional innovative/ultimate pavement section and consisted of the same material, age and original finish. For the innovative/ultimate grind freeway section, researchers measured traffic noise at two comparable locations along a stretch of Interstate: one with unground pavement and the other with the innovative/ultimate grind.

For each test section, researchers placed microphones at varying distances from the road to record several hours of sounds made by passing vehicles. They also made video recordings to help correlate collected audio data to distinct pass-by events and prevent contamination by noise from other vehicles and pavements.

Finally, using the Federal Highway Administration's statistical pass-by measurement method, researchers averaged the results for these pass-by events to calculate a mean vehicle sound level for each pavement type, allowing them to rank pavements by relative tire-pavement noise.

What Did We Learn?

Results showed that the innovative/ultimate grind was clearly the quietest pavement for four-wheel passenger cars. For dual-axle and multi-axle heavy vehicles, the innovative/ultimate grind was quieter than all surfaces except the conventional grind, for which there was insufficient data to make a comparison. For all vehicle types, the transverse-tine pavement surface was loudest, and the burlap drag quieter than the conventional grind but louder than the innovative/ultimate grind.

For both passenger and heavy vehicles, there was a notable difference in noise levels for the MnROAD and regional innovative/ultimate grind pavement specimens. This is probably because the grind for the regional test section was conducted more recently than the grind of the MnROAD test cell, and concrete surfaces generally become quieter over time.

What's Next?

The innovative/ultimate diamond grind is a promising method for minimizing road noise without compromising friction. Several projects are under way at MnROAD to further evaluate the relationship between tire noise and pavement texture, including a pooled fund study on HMA surface characteristics and another to establish a portland cement concrete diamond grinding specification.

This Technical Summary pertains to Report 2010-40, "Influence of Pavement on Traffic Noise—Statistical Pass-By Measurements of Traffic on Several Interstate Pavements," published November 2010. The full report can be accessed at http://www.lrrb.org/PDF/201040.pdf.

2010-TPF-5(037)TS
Published January 2011

TRANSPORTATION POOLED FUND PROGRAM

TECHNICAL SUMMARY

Mn/DOT Technical Liaison:
Jerry Geib
Jerry.Geib@state.mn.us

Mn/DOT Administrative Liaison:
Deb Fick
Deb.Fick@state.mn.us

TOTAL STATE CONTRIBUTIONS TO DATE:
$1,822,326

Mn/DOT CONTRIBUTIONS TO DATE:
$21,500

PARTICIPATING STATES:
AL, AZ, CO, FL, GA, KY, LA, MI, MN, MS, NV, NJ, NC, RI, SC, TN, TX, VT, VA, WI

Mn/DOT is using the NCAT-developed close-proximity trailer to study tire-pavement noise. The trailer takes direct measurements of sound pressure using microphones near the road surface.

RESEARCH SERVICES

OFFICE OF POLICY ANALYSIS, RESEARCH & INNOVATION

Pooling Our Research: Southeastern Superpave Center

Why a Pooled Fund Study?

In 1992, the Strategic Highway Research Program introduced the Superpave system, a method for designing asphalt mixtures that produce more durable pavements. To help states implement this system, in 1995 the Federal Highway Administration established five Superpave Regional Centers. These centers involve a partnership between state highway agencies, academia and regional asphalt user-producer groups to conduct training in the use of Superpave testing procedures and equipment as well as to conduct research to refine the Superpave system and facilitate its implementation.

One of these centers, the Southeastern Superpave Center, is housed at the National Center for Asphalt Technology at Auburn University in Auburn, Ala. NCAT's state-of the-art asphalt research facility includes a 1.7-mile test track for accelerated evaluation of pavement sections built from various mixtures. Heavy trucks running on the track around the clock inflict the equivalent of 20 years of normal pavement wear in two years. To benefit from NCAT research, in 2000 Mn/DOT joined SSC pooled fund project TPF-5(037), which continued pooled fund study SPR-3(040).

TPF-5(037) Southeastern Superpave Center. *The Southeastern Superpave Center helps states implement the Superpave system for more durable asphalt pavements. Mn/DOT asked center researchers to compare the tire-pavement loudness of several Minnesota pavement surface textures using the center's close-proximity trailer.*

What is the Pooled Fund Study's Goal?

The goals of the Southeastern Superpave Center pooled fund study are to:

- Assist state agencies with training for implementing Superpave asphalt binder and mixture design specifications and procedures.
- Verify and troubleshoot Superpave binders and mixtures, and perform forensic analysis on roadways with premature failures.
- Conduct other Superpave-related research, including group-sponsored research for the SSC and research on behalf of individual member agencies.

Minnesota joined this pooled fund to ask NCAT researchers to use a new technology—the close-proximity trailer, developed by NCAT in 2002—to compare the loudness of various Minnesota pavement surface textures as they come in contact with vehicle tires.

What Have We Learned?

In 2005, NCAT researchers completed the project on behalf of Mn/DOT and presented their findings in "Evaluation of the Noise Characteristics of Minnesota Pavements." This project measured tire-pavement noise levels using a close-proximity trailer with microphones placed near the interface of the trailer tires and pavement surface. Researchers tested 32 hot mix asphalt and portland cement concrete pavement sections on Mn/DOT highways and nine sections at MnROAD. Concrete surfaces included a number of the different textures that are added during construction by dragging various materials across the wet concrete to create friction and skid resistance. Researchers found that Mn/DOT's current specification for the turf and broom drag surfaces provided the lowest noise levels for concrete, followed by the diamond grind. Asphalt surfaces were uniformly quieter than concrete surfaces, while transversely tined concrete surfaces were considerably noisier than all others tested.

continued

"This pooled fund study provided Mn/DOT with important information concerning tire-pavement noise levels for various pavement surface texture types."

—Deb Fick,
Research SP&R Administrator, Mn/DOT Research Services

"Using the right pavement surface texture can result in a significant reduction of tire-pavement noise, reducing the need for noise barriers to shield populated areas and leading to millions of dollars in cost savings."

—Jerry Geib,
Pavement Design Engineer, Mn/DOT Office of Materials

Produced by CTC & Associates for:
Minnesota Department of Transportation
Research Services Section
MS 330, First Floor
395 John Ireland Blvd.
St. Paul, MN 55155-1899
(651) 366-3780
www.research.dot.state.mn.us

The Southeastern Superpave Center is housed at the National Center for Asphalt Technology in Auburn, Ala. Much of its research involves the 1.7-mile-long NCAT Pavement Test Track, the largest asphalt research testing facility in the Western Hemisphere.

Mn/DOT also benefited from the SSC's various projects to analyze asphalt materials and mixtures, develop new testing equipment and evaluate pavement performance. Results include:

- A finding that the use of AASHTO flexible pavement layer coefficients results in pavements that are 18 percent thicker than necessary, with a recommendation that coefficients be increased for pavements with thicknesses greater than 5 inches.
- An evaluation of fine aggregate angularity testing that may lead to changes in agency specifications.
- A new field permeameter for evaluating the quality and porosity of asphalt pavements.
- Tests that will help refine the mixture designs of open graded friction courses.
- The certification of more than 200 technicians and engineers in Superpave mix design and asphalt binder testing.

What's Going On Now?

While pooled fund study TPF-5(037) is now complete, in April 2010 pooled fund study TPF-5(228) was initiated to continue SSC support, with several research projects beginning in the near future. The SSC continues to offer training courses to state and international participants, providing them with the skills needed to perform Superpave binder and mix design testing.

What's Next?

Under TPF-5(228), the SSC will be conducting projects that include friction testing of several asphalt mixes, noise testing and training courses for stone matrix asphalt mix design. More details concerning these projects will be available in the next quarterly report for TPF-5(228). Researchers recommend new projects to:

- Conduct further noise evaluations of various pavement surface textures under changing traffic conditions.
- Optimize warm mix asphalt designs and evaluate their field performance.
- Evaluate new asphalt industry equipment as it becomes available, conduct specialized training for the inspection of asphalt construction operations and conduct research to validate mechanistic-empirical design.

This Technical Summary pertains to the ongoing Pooled Fund TPF-5(037), Southeastern Superpave Center, continuing the project initiated under SPR-3(040). Details of this effort can be found at http://pooledfund.org/projectdetails.asp?id=30&status=24, http://pooledfund.org/projectdetails.asp?id=191&status=24 *and* http://www.eng.auburn.edu/research/centers/ncat/southeastern.html. *The report for the SSC study commissioned by Mn/DOT, "Evaluation of the Noise Characteristics of Minnesota Pavements," can be accessed at* http://www.dot.state.mn.us/materials/pvmtdesign/noise.html.

For more than 25 years, FHWA's Transportation Pooled Fund Program has been providing state DOTs and other organizations the opportunity to collaborate in solving transportation-related problems. The TPF Program is focused on leveraging limited funds, avoiding duplication of effort, undertaking large-scale projects and achieving broader dissemination of results on issues of regional and national interest.

2010-06TS
Published June 2010

RESEARCH SERVICES

OFFICE OF POLICY ANALYSIS, RESEARCH & INNOVATION

TECHNICAL SUMMARY

Technical Liaison:
Lisa Austin, Mn/DOT
Lisa.Austin@state.mn.us

Administrative Liaison:
Alan Rindels, Mn/DOT
Alan.Rindels@state.mn.us

Principal Investigator:
Nikos Papanikolopoulos,
University of Minnesota

PROJECT COST:
$68,000

One of the most common types of sensors is the pneumatic tube sensor. It is inexpensive and accurate, but not very durable or versatile.

Analysis of Practical Methods for Counting Bicycles and Pedestrians

What Was the Need?

Increasing levels of bicycle and pedestrian traffic create the need to quantify the use of these travel modes and their interaction with vehicles in transportation corridors. Reliable counts are essential to determine whether current corridor designs are working well and for future design of appropriate infrastructure that can accommodate bicycles, pedestrians and vehicles safely. There is little accurate data on pedestrian and bicycle traffic in the state, and current counting methods often rely on volunteers, a method that is neither accurate nor sustainable. Developing an automated counting system that can be used in both urban and trail environments could improve accuracy, reduce long-term labor costs and provide valuable data for planning and design of transportation corridors.

Researchers evaluated current automated methods for counting bicycle and pedestrian traffic in a transportation network and developed a prototype vision-based computer program with the goal of improving accuracy and reducing long-term costs.

What Was Our Goal?

This research was initiated to accomplish two main objectives: evaluate existing methods for counting bicycles and pedestrians, and develop and test a prototype system for automated counting of bicycles and pedestrians through vision-based recognition technology. Tasks included:

- Evaluating currently available counting technologies based on a variety of factors such as ease of use, cost, lighting condition requirements, accuracy, environmental sensitivity, power requirements and wireless capability, portability and applicability for urban and/or rural sites.
- Creating a matrix of current technologies with advantages and disadvantages for use by engineers when choosing a counting methodology.
- Developing a prototype system using pattern recognition software that can be used with field video to identify and accurately count bicycles and pedestrians.
- Testing the vision-based counting prototype in field situations, working with interested groups to acquire immediate user feedback on what works and what can be improved for ultimate use by local road agencies.

What Did We Do?

Researchers began by evaluating current methods of counting bicycle and pedestrian traffic, including buried pressure pads, tube-based and electronic piezo-based counters, infrared sensors and inductive loops. Researchers evaluated each method based on the factors listed above, and then compiled the results of the survey (included as Appendix A of the report).

Researchers then developed a prototype vision-based software program to automatically distinguish between bicycles and pedestrians captured on video recordings. To train the computer to recognize bicycles and pedestrians, researchers used several feature extraction methods, including Scale Invariant Feature Transform, or SIFT, and Scale and Affine Invariant Harris Corners, or Haraff, to create a vocabulary of images corresponding to either bicycles or pedestrians. The program uses the vocabulary to match against objects from a video recording, classifying and counting them automatically.

continued

"There is not a lot of data out there regarding bicycle and pedestrian counts. An accurate system that can be used on trails as well as urban environments would be very helpful, and the system developed here has a lot of potential."

–Lisa Austin,
Mn/DOT Bicycle and Pedestrian Planner

"The biggest advantage of computer vision-based counting is the verifiability of results that is not possible with other methods. When a bicycle or a pedestrian is detected in a video and counted, it can be archived and verified manually in the future."

–Nikos Papanikolopoulos,
University of Minnesota Department of Computer Science and Engineering

Produced by CTC & Associates for:
Minnesota Department
of Transportation
Research Services Section
MS 330, First Floor
395 John Ireland Blvd.
St. Paul, MN 55155-1899
(651) 366-3780
www.research.dot.state.mn.us

A vocabulary of objects was constructed from images of bicycles and pedestrians using both SIFT and Haraff features.

The software was then tested in the field. Researchers used a handheld camcorder mounted on a tripod to capture more than 10 hours of video from five locations. Instead of physically observing a trail or path, manually counting each bicycle or pedestrian who passed, the captured video was transferred to a computer and analyzed by the software program, automatically creating counts of bicycles and pedestrians.

During the course of the project, researchers worked with volunteers from local community groups who were performing manual counts. Researchers conducted a training session for dozens of people from a variety of groups to demonstrate how to use the new vision-based counting system.

What Did We Learn?

Researchers found that each of the 11 counting methods currently in use has limitations. No method evaluated was able to count both bicycles and pedestrians with a high degree of accuracy. For example, commonly used tube counters are very accurate, portable and inexpensive, but these cannot be used to count pedestrians. Infrared and radio beam sensors can theoretically be used to count both pedestrians and bicycles, but accuracy is affected by riders or walkers crossing the sensors parallel to one another. The table comparing available technologies will help engineers choose the best counting method for differing situations.

While testing the prototype video system, researchers discovered that community and business groups were very interested in an accurate, inexpensive and flexible program for counting bicycle and pedestrian use of transportation networks. Researchers established relationships and built good will between Mn/DOT and the communities where the work was done.

The prototype system demonstrated potential, but also some difficulties. The system was able to count bicycles and pedestrians from the video recordings, but accuracy and functionality need to be improved before it can be used commercially. Researchers learned that for this type of counting methodology, the system must be tuned to the requirements of a specific location, and that counting pedestrians, bicycles and vehicles at the same time is still a difficult proposition.

What's Next?

A second phase of this project is being funded by the Intelligent Transportation Systems Institute, a part of the Center for Transportation Studies at the University of Minnesota. This phase will be completed over the next 16 months and aims to improve the accuracy, flexibility and functionality of the prototype developed for this project, and may ultimately lead to a viable product that could be used by Mn/DOT.

This Technical Summary pertains to Report 2010-06, "Analysis of Practical Methods for Analyzing Pedestrian and Bicycle Use of a Transportation Facility," published February 2010. The full report can be accessed at http://www.lrrb.org/PDF/201006.pdf.

2010-34TS
Published November 2010

RESEARCH SERVICES

OFFICE OF POLICY ANALYSIS, RESEARCH & INNOVATION

TECHNICAL SUMMARY

Technical Liaison:
Robert Gale, Mn/DOT
Robert.Gale@state.mn.us

Administrative Liaison:
Shirlee Sherkow, Mn/DOT
Shirlee.Sherkow@state.mn.us

Principal Investigator:
Omar Smadi, Iowa State University

PROJECT COST:
$79,441

Driver fatigue is a factor in 15 percent of crashes involving large trucks, making adequate rest at readily available rest areas critical to roadway safety.

Minnesota Truck Parking Study (Phase 2)

What Was the Need?

Truck parking capacity has been a recognized problem since the mid-1990s, and Minnesota has worked with the private sector to expand truck parking facilities. A previous Mn/DOT study initiated to provide decision support for these efforts involved three major tasks: an inventory of available interstate truck parking in Minnesota, a survey of trucking companies with regard to their practices and attitudes toward truck parking, and an analysis of truck parking demand. The study identified several problem areas: Many facilities had significant capacity issues, and trucking companies did not, in most cases, provide parking location assistance or policy guidance to their drivers. Additional research was needed to identify potential remedies for these problems and improve truck parking over the coming years.

Researchers performed analyses, surveys and literature reviews to better understand Minnesota's truck parking capacity problems and identified specific, low-cost opportunities to expand capacity in the places where it is needed most.

What Was Our Goal?

Phase 2 of this research effort aimed to build on Phase 1 through additional investigation into available truck parking capacity solutions and the needs of Minnesota's freight industry. The objective of this study was to produce a menu of specific opportunities for expanding capacity throughout the state to guide Mn/DOT policy decisions.

What Did We Do?

Researchers focused their investigation on five areas:

- Low-Cost, Marginal Capacity Enhancements. Researchers gathered information about low-cost, easy-to-implement capacity expansion measures including restriping existing facilities to make more efficient use of the existing space, expanding surface pavement at rest areas, allowing overnight parking at weigh stations or creating simple parking along available portions of existing rights of way.
- Development of Urban Parking in Other Areas. Researchers reviewed actions taken in other metropolitan areas across the country in response to truck parking shortages. This information was gathered through telephone interviews with city planners, National Association of Truck Stop Operators officials and other large truck stop operators. Additionally, researchers performed a review of land development literature. They discovered that many other states have also begun conducting truck parking studies.
- Need and Demand for Parking. Researchers conducted a spatial analysis to better understand the relationships between truck traffic generation from the Twin Cities metropolitan area and consequent truck parking demand. The goal was to identify potential locations for strategically placed parking facilities.
- Internal Review. Through several technical advisory panel meetings, research results were reviewed by various Mn/DOT stakeholders, and potential solutions were discussed.
- External Interview. Toward the end of the project, researchers conducted interviews with several external stakeholders to discuss the project's results, including the kinds

continued

"The researchers' survey results were particularly useful and provided us with some very sound data from which to formulate practical, achievable recommendations."

—Robert Gale,
Planner Principal
Transportation, Mn/DOT
Office of Freight and Commercial Vehicle Operations

"The consensus created among many stakeholders was of great value as well as the recognition of the balance needed between the State of Minnesota's role in providing truck parking and the need for partnering with private truck parking operators."

—Omar Smadi,
Research Scientist, Center for Transportation Research and Education, Iowa State University

Produced by CTC & Associates for:
Minnesota Department
of Transportation
Research Services Section
MS 330, First Floor
395 John Ireland Blvd.
St. Paul, MN 55155-1899
(651) 366-3780
www.research.dot.state.mn.us

Rank	Site Name (Direction)	Corridor	Mile Post	Truck Stalls	Auto Stalls	% Days At or Over Capacity
1	Elm Creek (E.B.)	I-94 West	215	10	30	65.2%
2	Marion (W.B.)	I-90 East	222	20	45	64.9%
3	Bergen Lake (W.B.)	I-94 West	105	12	30	59.3%
4	Albert Lea TIC (N.B.)	I-35 South	1	29	75	58.0%
5	St. Croix TIC (W.B.)	I-94 East	265	35	100	50.8%
6	Clear Lake (E.B.)	I-90 West	69	7	30	47.4%
7	Fuller Lake (W.B.)	I-94 West	177	17	80	45.8%
8	Lake Latoka (E.B.)	I-94 West	100	18	45	45.7%
9	Lake Iverson (E.B.)	I-94 West	60	11	50	45.0%
10	New Market (S.B.)	I-35 South	75	15	50	41.1%

Researchers identified 20 rest areas on Minnesota's Interstate highway system as having capacity issues. The first five of these, marked in red in this partial list, are overcapacity more than 50 percent of the time.

of truck parking problems identified by the study and Mn/DOT's proposed solutions. Interviewers solicited input on capacity problems and recommended solutions beyond those proposed by the researchers.

What Did We Learn?

Initially, researchers focused on ways in which truck parking could be expanded closer to the metropolitan area through partnerships with private truck stop operators. One of the barriers encountered when exploring opportunities for establishing new truck stop facilities within this region was the prohibitively high cost of land, especially in light of the recent economic recession. Researchers concluded that focusing on areas outside of the metropolitan area made more sense, and so began identifying areas most in need of parking and making low-cost, short-term and long-term recommendations.

Based on the results of the spatial analysis conducted to gauge truck parking demand, researchers determined that a truck parking facility located adjacent to the Interstate system would provide needed parking for a majority of trucking destinations. Locating additional facilities along either I-35 south of the Twin Cities or I-94 west or east of the Twin Cities would provide more parking relief. Through conversations with planners and traffic generators, researchers determined that the most feasible solution for the short term would be a site along I-35 south.

What's Next?

This project produced a variety of recommendations for low-cost solutions to expand truck parking, including identification of abandoned or available hard-surface facilities that could be inexpensively converted to sleeping-mode facilities. Other options include increasing efficiency in existing facilities through such actions as redesigning parking layouts or restriping.

Longer term solutions include exploring and implementing methods of providing truckers with real-time information regarding current available capacity for an upcoming truck stop by using roadside electronic signs or even mobile phone applications. Several of these suggestions have now been embraced and are being worked into upcoming funding plans.

This Technical Summary pertains to Report 2010-34, "Mn/DOT Truck Parking Study: Phase 2," published November 2010. The full report can be accessed at http://www.lrrb.org/PDF/201034.pdf.

2010-TPF-5(156)TS
Published January 2011

TRANSPORTATION POOLED FUND PROGRAM

TECHNICAL SUMMARY

Mn/DOT Technical Liaisons:
William Gardner
William.Gardner@state.mn.us
John Tompkins
John.Tompkins@state.mn.us

Mn/DOT Administrative Liaison:
Deb Fick
Deb.Fick@state.mn.us

TOTAL STATE CONTRIBUTIONS TO DATE:
$1,050,000

Mn/DOT CONTRIBUTIONS TO DATE:
$100,000

PARTICIPATING STATES:
IL, IN, IA, KS, KY, MI, MN, MO, OH, WI

The Mississippi Valley Freight Corridor, also referred to as the Upper Midwest Freight Corridor, includes 10 states.

RESEARCH SERVICES

OFFICE OF POLICY ANALYSIS, RESEARCH & INNOVATION

Pooling Our Research: The Mississippi Valley Freight Coalition

Why a Pooled Fund Study?

The efficient movement of freight through Minnesota is critical to its economy. Efficient freight operations allow industries to move their products to market at a reasonable cost, which in turn significantly affects the livelihoods of the populations that depend on them. Minnesota is affected not just by the movement of freight within its borders, but by national and international supply chains, most significantly by those in the Mississippi Valley region of which it is a part.

TPF-5(156): Mississippi Valley Freight Coalition. *This pooled fund study supports projects focused on the operation, preservation and improvement of freight transportation infrastructure and networks involving the coalition's 10 member states in the Mississippi Valley region.*

However, growing congestion in this region threatens the efficiency of freight operations. The 2006 Upper Midwest Freight Corridor Study showed that there are major bottlenecks in all modes of the region's freight transportation system that cause long delays resulting in additional expenditures for shippers, carriers and the public. Delays occur at ports of entry, intermodal freight terminals and yards, and locks and dams. There are more than 60 highway-related bottlenecks, with three near Chicago alone, leading to 38.4 million hours of delay per year for vehicles. With current estimates indicating that by the year 2020 freight volume on the nation's highways and rails will increase by 62 percent and 44 percent, respectively, it is clear that steps must be taken to improve the efficiency of the freight network.

To address these problems, in 2006 Minnesota and nine other states formed the Mississippi Valley Freight Coalition. The MVFC and the AASHTO Mid-America Association of State Transportation Officials cooperate in the planning, operation, preservation and improvement of transportation infrastructure in the region.

What is the Pooled Fund Study's Goal?

The MVFC seeks to work closely with the 10 states of the Mississippi Valley region to maximize the operational efficiency of its freight transportation system.

What Have We Learned?

The MVFC is staffed by the National Center for Freight and Infrastructure Research and Education at the University of Wisconsin–Madison and coordinated with the Wisconsin Department of Transportation. Since its inception in 2006, the MVFC has completed eight projects, including:

- Logistics for the Public Sector Training Course, which developed a two-day training session for public agency staff members about logistics concepts important to private sector shippers and carriers.
- Model Freight Planning Approaches, which created a manual of best practices in freight planning.
- Mississippi Valley Freight Coalition Expanded Truck Parking, which provided information necessary for states to evaluate increasing short-term truck parking availability along Interstate highways in the region.
- Assessment of Multimodal Freight Bottlenecks and Alleviation Strategies for Upper Midwest Region, which identified freight bottlenecks on regionally significant routes

continued

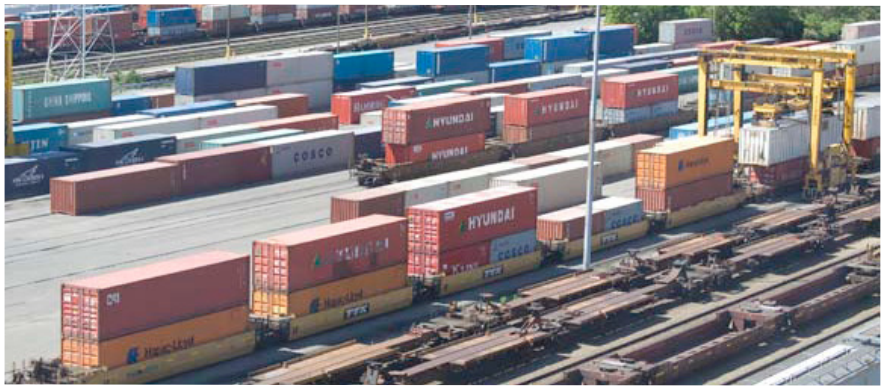
"The coalition provides a forum for improving the region's freight transportation system, bringing together state DOTs to discuss, plan and manage projects benefiting the movement of freight."

—John Tompkins,
Freight Planning Manager, Mn/DOT Office of Freight and Commercial Vehicles Operations

"This project is extremely beneficial to Minnesota, helping us to educate our own leadership about the importance of freight, identify in detail the freight system needs of our region and develop strategies that look beyond our borders."

—William Gardner,
Director, Mn/DOT Office of Freight and Commercial Vehicles Operations

Produced by CTC & Associates for:
Minnesota Department of Transportation
Research Services Section
MS 330, First Floor
395 John Ireland Blvd.
St. Paul, MN 55155-1899
(651) 366-3780
www.research.dot.state.mn.us



The intermodal movement of freight containers—in this case, between rail and truck at the Queensgate Yard in Cincinnati—involves crucial nodes in freight transportation infrastructure whose operation can dramatically affect its efficiency.

and modes including highway, rail and water; developed an inventory of planned projects across the region for addressing these bottlenecks; and recommended additional bottleneck solutions for the region.

What's Going On Now?

On a continuing basis, the MVFC helps agencies share information so that freight can flow more smoothly through the region; works to identify and remove corridor bottlenecks; and supports technologies, traffic regulations and national transportation policies that promote the reliable movement of freight.

The MVFC's ongoing projects include:

- **MVFC Outreach Materials**, which is creating materials to educate the general public and policymakers about the importance of freight to the economy and the fragility of the freight transportation system.
- Transportation Profiles for MVFC Commodities, which is developing information concerning the flow of commodities through the region, including their shipping processes and costs.
- Performance Measures for Evaluating Multi-State Projects, which is developing freight-focused performance measures—such as speed, reliability and safety—for multi-state and interstate corridor projects.
- **Critical Sections and Resiliency of Freight Corridors in the Mississippi Valley Region**, which is identifying critical transportation nodes, segments and intermodal connectors in the region that are vulnerable to disruption and need to be improved to continue serving as corridors for high volumes of freight and passenger travel.

What's Next?

The MVFC was recently authorized to continue through 2012. It will proceed under a new name, the Mid-America Freight Coalition, and focus on research and outreach in commercial vehicle operations training, economic analysis training and regional freight planning.

As it moves forward, the coalition will continue its mission to support the economic well-being of the industries, farms and people of the region by keeping their products flowing to markets reliably, safely and efficiently.

This Technical Summary pertains to the ongoing Pooled Fund TPF-5(156) Mississippi Valley Freight Coalition Pooled Fund Study. Details of this effort can be found at http://www.pooledfund.org/projectdetails.asp?id=382&status=4 *and* http://www.mississippivalleyfreight.org/.

For more than 25 years, FHWA's Transportation Pooled Fund Program has been providing state DOTs and other organizations the opportunity to collaborate in solving transportation-related problems. The TPF Program is focused on leveraging limited funds, avoiding duplication of effort, undertaking large-scale projects and achieving broader dissemination of results on issues of regional and national interest.

2010-01TS
Published May 2010

RESEARCH SERVICES

OFFICE OF POLICY ANALYSIS, RESEARCH & INNOVATION

TECHNICAL SUMMARY

Technical Liaison:
Todd Haglin, Mn/DOT
Todd.Haglin@state.mn.us

Administrative Liaison:
Bruce Holdhusen, Mn/DOT
Bruce.Holdhusen@state.mn.us

Principal Investigator:
Todd Loushine,
University of Minnesota Duluth

PROJECT COST:
$10,546

The study gauged workers' perceptions of risks related to on-the-job injuries.

Evaluating Workforce Perceptions to Identify and Mitigate the Causes of Musculoskeletal Disorders

Researchers interviewed employees about their perceptions of workplace safety to reduce on-the-job injuries. They found that employees' primary concern—contact with public vehicles—needed to be addressed before a successful program to reduce musculoskeletal disorder injuries can be implemented.

What Was the Need?

Workers' compensation data from Mn/DOT District 1 for the years 2004 to 2008 showed that 93 percent of injuries could be attributed to five job classifications: transportation general, transportation general senior, transportation specialist, heavy equipment mechanic and heavy equipment field mechanic. Forty-eight percent of the injuries, representing more than $500,000 in claims, were strains or sprains, and more than $350,000 of those claims were the result of overexertion and/or awkward work postures. These types of injuries are commonly referred to as musculoskeletal disorder injuries.

Implementing a wellness program to maintain and improve employees' physical fitness and well-being could improve worker safety and save Mn/DOT money in reduced workers' compensation payments. To implement a wellness program, it is important to first determine workers' perceptions of safety and risks in the workplace.

What Was Our Goal?

This project was initiated to generate ideas to reduce employee musculoskeletal disorder injuries by identifying workers' perceptions of risk factors related to on-the-job injuries and their perception of management and co-worker commitment. Researchers aimed to learn how receptive employees would be to a wellness and fitness program.

What Did We Do?

Based on the workers' compensation analysis, researchers targeted the five job classifications accounting for the vast majority of injuries and identified three groups of workers representing the northeast, southwest and central areas of District 1. Researchers then conducted telephone interviews of 50 employees randomly chosen from these groups, asking them six questions covering their perceptions of workplace safety, the most dangerous or risky aspects of their jobs, and the commitment of their managers and co-workers to safety. The interviews also solicited ideas on how to increase safety and performance and asked whether respondents would participate in a wellness program aimed at improving their health and fitness.

Researchers recorded and transcribed these interviews, then analyzed all of the answers, discovering and adopting the common language used in response to the questions. The analysis resulted in 15 to 21 response categories for each question. With this data, researchers were able to evaluate interview responses based on the most frequent answers to the interview questions, and then make recommendations to Mn/DOT.

What Did We Learn?

Analysis of interviews revealed that:

- 64 percent of workers interviewed are concerned about getting hit by a vehicle driven by a member of the public through a job site.

continued

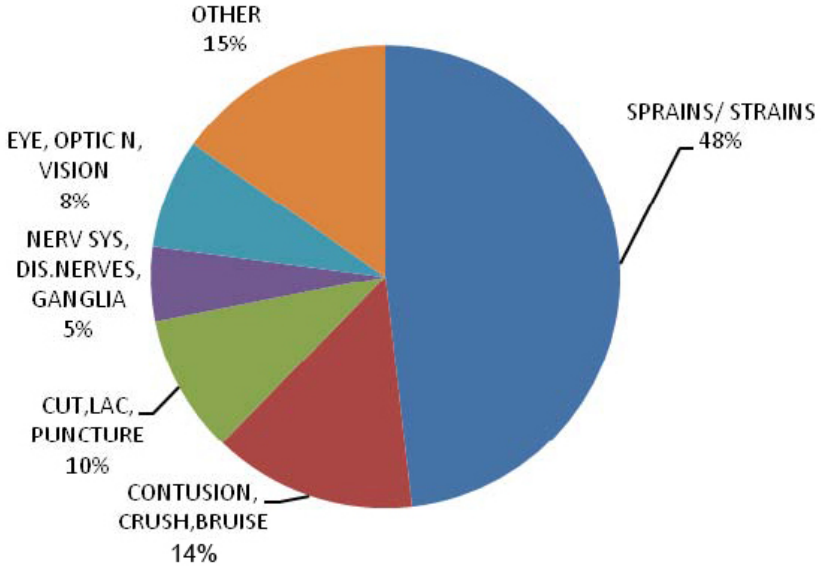
"We have to minimize the perceived need to rush. We do not want employees working in a manner that might compromise their safety."

–Todd Haglin,
Safety Director, Mn/DOT Office of Administration

"A user-centered initiative, such as workplace wellness, requires the workforce's input to understand employees' concerns and perceptions; otherwise the entire effort could fail."

–Todd Loushine,
Assistant Professor, University of Minnesota Duluth Department of Mechanical and Industrial Engineering

Produced by CTC & Associates for:
Minnesota Department
of Transportation
Research Services Section
MS 330, First Floor
395 John Ireland Blvd.
St. Paul, MN 55155-1899
(651) 366-3780
www.research.dot.state.mn.us



Nearly half of all workers' compensation claims were the result of sprains or strains. Those injuries amounted to more than $500,000 in claims over five years.

- 3.2 percent of workers' compensation claims over the past five years were the result of vehicle collisions.
- 14 percent of interviewees indicated a concern regarding heavy, awkward and/or repetitive lifting.
- 20 percent said that having more time to do the job, not to rush through the job, would improve safety.
- 76 percent indicated that management is committed to safety.
- 68 percent indicated co-workers are committed to safety.
- More than 65 percent indicated they would participate in a wellness/fitness program at work and encourage others to participate.

Based on these findings, researchers made several recommendations:

- First, management must address workers' concerns regarding being hit by a public vehicle on the job site. If workers underperceive the risks of musculoskeletal disorder injuries because they are primarily concerned with contact with such a vehicle, then any risk management effort to address musculoskeletal injuries may be ignored or not taken seriously.
- Second, management must address the issue of the perceived need to rush or hurry to get a job done. Workers are at greater risk of injury if they are paying more attention to the speed of the work than their own safety.
- Finally, management should choose one or two sites for a pilot wellness project and use the results to develop and implement a successful model in other locations.

What's Next?

More evaluation is needed to determine an acceptable course of action to Mn/DOT districts, but this study will be the basis for ongoing discussions with risk managers. The current research team will conduct a full-scale literature search and review of current wellness programs being used by other departments of transportation to develop options and recommendations for what would work best in Minnesota. A pilot program to implement the findings of this effort is planned for Mn/DOT District 1.

This Technical Summary pertains to Report 2010-01, "Evaluation of Workforce Perceptions as a Means to Identify and Mitigate the Causes of Musculoskeletal Disorders," published January 2010. The full report can be accessed at http://www.lrrb.org/PDF/201001.pdf.

2010-04TS
Published June 2010

RESEARCH SERVICES

OFFICE OF POLICY ANALYSIS, RESEARCH & INNOVATION

TECHNICAL SUMMARY

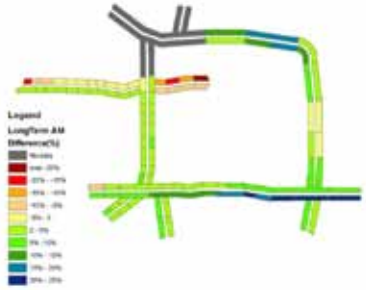
Technical Liaisons:
Christopher Roy, Mn/DOT
Chris.Roy@state.mn.us

Colleen VanWagner, Mn/DOT
Colleen.Vanwagner@state.mn.us

Administrative Liaison:
Bruce Holdhusen, Mn/DOT
Bruce.Holdhusen@state.mn.us

Principal Investigator:
John Hourdos, University of Minnesota

PROJECT COST:
$109,890



This project tracked the percentage volume difference in traffic on alternative routes when TH-36 was closed. The impact was mild but far-reaching.

TH-36 Full Closure Construction: Evaluation of Traffic Operations Alternatives

Researchers evaluated the impact of the first large-scale full closure construction project in Minnesota. They found full closure to be a viable, cost-saving construction alternative under these circumstances and gained valuable knowledge about the tools used to evaluate future project alternatives.

What Was the Need?

Upgrading existing road systems involves construction on roadways that normally serve considerable demand. Planners are consequently interested in mitigating road user costs—or RUCs—associated with this construction, which include time lost due to slowed traffic or finding alternate routes. Typically, some lanes of a highway are kept open during construction, allowing traffic to go through though at slower speeds than normal. This approach introduces safety concerns for construction workers and for the traveling public. An FHWA study in 2003 showed that full closure construction, beyond addressing this safety issue, can dramatically reduce construction duration and ultimate RUCs. The potential downside to full closure is a temporary increase in daily RUCs as compared to partial closure since travelers are forced to find alternate routes.

When Trunk Highway 36 required reconstruction in spring 2007, Mn/DOT decided to employ full closure in the hope of reducing construction staging and costs. This opportunity allowed Mn/DOT to evaluate the actual impact of full closure in real time and collect data to compare RUCs for partial and full closure construction.

What Was Our Goal?

The goals of this project included:

- Comparing the impacts of full and partial closure construction
- Evaluating the impact of full closure using real data before and after construction
- Evaluating available tools and methodologies for selection and planning of full closure projects
- Gathering lessons and experience from stakeholders
- Drafting a lessons-learned guide to help future planners evaluate construction alternatives

What Did We Do?

Researchers collected and analyzed data regarding the impact of the TH-36 full closure on traffic conditions of highways and local roads using Mn/DOT's freeway traffic detection system and through collection equipment set up on major urban streets in the area.

The original goal was to then utilize a microscopic simulator to evaluate the differences between the full closure as it happened and the hypothetical impact of the project under partial closure. Early in the project, researchers realized that the cost in money and time of microscopic simulation far outweighed the potential benefits, so the objective for this portion of the research changed to investigating the pros and cons of available methodologies for evaluating full closure construction costs.

continued

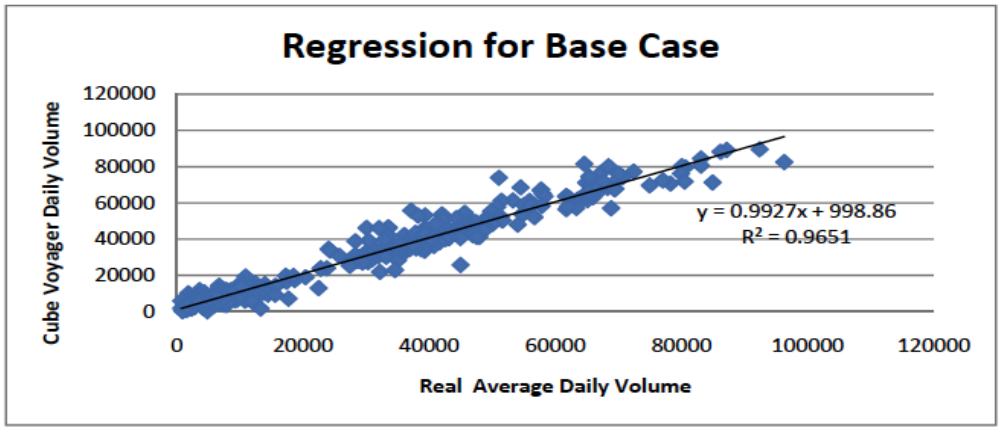
"The research and lessons learned from this project created awareness of and a reference for institutional knowledge that planners will be able to draw on in the future."

–Christopher Roy,
Former Mn/DOT North Metro Area Manager

"As it turned out, full closure was by far the best choice not only in terms of the actual outcome of the project, but also in regard to the small, additional RUCs as compared to the overall savings in labor and time."

–John Hourdos,
Associate Program Director, Minnesota Traffic Observatory, University of Minnesota Department of Civil Engineering

Produced by CTC & Associates for:
Minnesota Department
of Transportation
Research Services Section
MS 330, First Floor
395 John Ireland Blvd.
St. Paul, MN 55155-1899
(651) 366-3780
www.research.dot.state.mn.us



Real data collected during the project was compared with the data projected using different tools. The linear regression above compares real average daily volumes with daily volumes predicted using Cube Voyager, showing very close correlation.

Researchers tested three tools to calculate RUCs. In ascending order of cost, features and complexity, these were QuickZone, Cube Voyager and AIMSUN. Researchers calculated RUCs using each methodology and compared these estimates with the actual costs associated with the full closure of TH-36.

After construction was completed, researchers interviewed key stakeholders to record their viewpoints regarding the planning and execution of the project, public relations and reaction, and overall lessons learned.

What Did We Learn?

Researchers discovered that for this reconstruction, the cost savings and available capacity on roadways serving as detours made full closure clearly the best choice. The construction cost savings far outweighed the increase in daily RUCs.

The tools used to model the impact of full and partial closure construction projects were found to vary greatly in their accuracy and the amount of time, effort and data needed to use them. QuickZone required approximately 1 to 2 weeks of total labor to generate RUC estimates, and Cube Voyager took 1.5 months, while the more accurate microsimulation model took upwards of 12 months. For a project the size of TH-36, microsimulation as an estimation tool was considered overkill and would not be cost-effective to use in the future.

Researchers also discovered that the full closure impacted driver behavior far beyond the immediate construction zone. For example, there was an increase in traffic on Interstate 94 from Wisconsin to St. Paul during the project.

Market research before the project began showed the public split 50/50 on whether to use full or partial closure. After the project, surveys showed a dramatic increase in support of full closure. Agreement to use full closure was "strong" or "somewhat" in 92 percent of residents, 84 percent of businesses and 89 percent of through-commuters.

What's Next?

The lessons learned from this project were distilled into a seminar entitled "TH-36 Full Road Closure: Lessons for the Future." A best practices guide for evaluating full and partial closure still needs to be developed; the Mn/DOT Office of Construction and Innovative Contracting is considering this future effort. This Mn/DOT-funded research effort was aided by simultaneous analyses of the full closure of TH-36 by the Federal Highway Administration and by C2HM HILL; their insights were also used in preparing the report for this project.

This Technical Summary pertains to Report 2010-04, "TH-36 Full Closure Construction: Evaluation of Traffic Operations Alternatives," published January 2010. The full report can be accessed at http://www.lrrb.org/PDF/201004.pdf. *For more information about the TH-36 Full Road Closure seminar, contact* Shawn Haag *at the University of Minnesota.*

2010-09TS
Published July 2010

RESEARCH SERVICES

OFFICE OF POLICY ANALYSIS, RESEARCH & INNOVATION

TECHNICAL SUMMARY

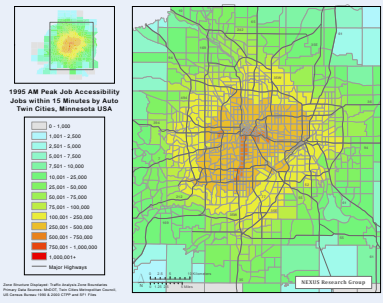
Technical Liaisons:
Brian Gage, Mn/DOT
Brian.Gage@state.mn.us

Paul Czech, Mn/DOT
Paul.Czech@state.mn.us

Administrative Liaison:
Linda Taylor, Mn/DOT
Linda.Taylor@state.mn.us

Principal Investigator:
David Levinson, University of Minnesota

PROJECT COST:
$186,000



Maps like the one above show the number of jobs or workers accessible within a designated time from every location.

Access to Destinations: Measuring Accessibility by Automobile

Researchers analyzed accessibility measures—which indicate proximity to opportunities like jobs, not simply travel times—for the Twin Cities area between 1995 and 2005. Overall, the region is becoming more accessible due to land use changes and network improvements.

What Was the Need?

Traditional congestion measures capture how quickly people can travel from one place to another, whereas accessibility indicates how well travelers are able to reach desired destinations, such as work, shopping, education and recreation. Mn/DOT's Access to Destinations research effort consists of 11 studies aimed at developing measures of accessibility for the Twin Cities region over a 10-year period. The first 10 studies focused on accessibility by walking, bicycle and transit, and on the collection of data ultimately used in this final report on accessibility by automobile. A better understanding of accessibility in the Twin Cities metro area will aid in evaluating and improving land use practices and development alternatives as they affect the transportation system.

What Was Our Goal?

This phase of the Access to Destinations project focused on determining the number of opportunities accessible by automobile from different locations throughout the region. The goals of the study included:

- Using actual measured travel and delay times—as opposed to strictly modeled or assumed figures—as inputs to create accessibility measures.
- Analyzing how accessibility in the region changed from 1995 to 2005.
- Evaluating how land use changes and improvements in the transportation network affected accessibility.
- Creating an interactive Web module that permits users to view accessibility measurements by time, location and desired destinations.

What Did We Do?

Researchers first created a travel time matrix that shows how long it takes to travel by auto from any one place in the region to another. These times were determined using freeway travel time estimates based on freeway loop detector data and ramp delay estimates as well as arterial travel time estimates generated from estimated traffic levels.

Researchers then collected land use data from census records; Longitudinal Employer-Household Dynamics employment records; and Metropolitan Council estimates of the number of jobs, persons and households in the region.

These travel times and land use data were then used to create measures of accessibility, or opportunity for interaction. In this analysis, the cumulative opportunity was calculated as the total number of jobs, residents and workers reachable from each point at a given time. Measurements were made for travel times ranging from five to 60 minutes.

Researchers then used measurements from 1995 and 2005 to analyze the causes of observed changes in accessibility, separating out the network and land use factors to estimate what accessibility measures would be if land use had not changed or if the transportation network had not changed.

Finally, a Web-based interface to the Access to Destinations maps used in the final report was developed. Using the MapServer program, researchers created a custom map

continued

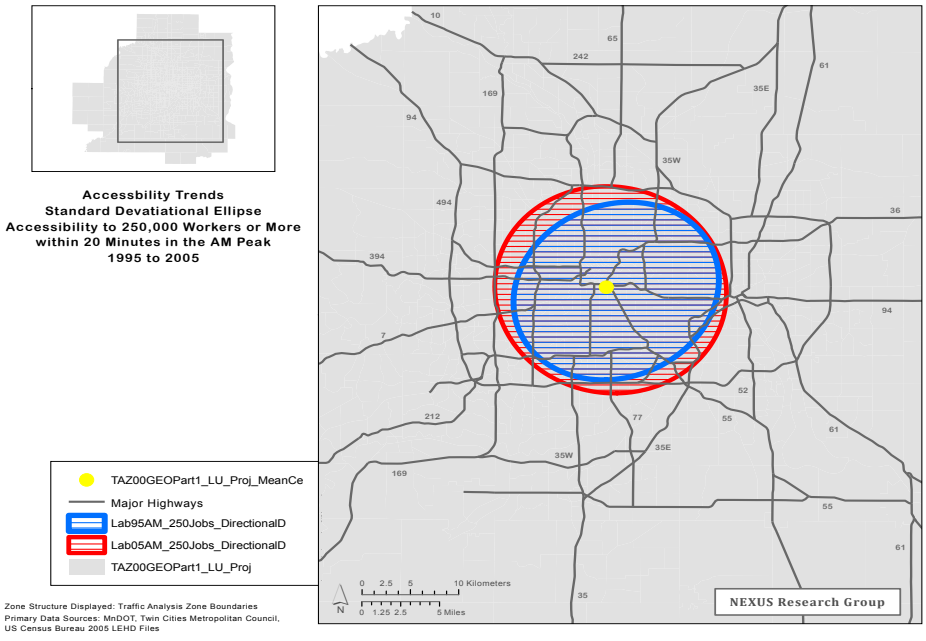
"The concept of accessibility allows us to measure the efficiency of the city in its primary role, enabling people to reach other people and things."

–David Levinson,
Associate Professor, University of Minnesota Department of Civil Engineering

"This study brings together transportation and land use. Instead of looking at how much time it takes to get from point A to point B, it measures the number of opportunities people have within a designated drive time."

–Brian Gage,
Access Management Engineer, Mn/DOT Office of Capital Programs and Performance Measures

Produced by CTC & Associates for:
Minnesota Department
of Transportation
Research Services Section
MS 330, First Floor
395 John Ireland Blvd.
St. Paul, MN 55155-1899
(651) 366-3780
www.research.dot.state.mn.us



Researchers used Standard Deviation Ellipse measurements to show accessibility trends from 1995 to 2005. Above, the red 2005 ellipse is larger and completely encloses the blue 1995 ellipse, demonstrating the increasing and flattening of accessibility throughout the region.

file that allows users to display and query eight of the most pertinent maps: access to jobs and to workers by car in 20 minutes for both a.m. and p.m. peak traffic periods in years 1995 and 2005. (The interface is at http://nexus.umn.edu/mapserver_demos/access; click "Initialize" at the link to display and query the different maps.)

What Did We Learn?

A key finding of this research project is that accessibility measures for nearly every area in the region increased over the time period studied. The greatest growth was observed in faster-growing suburban parts of the region, suggesting that both households and employers were decentralizing. In addition to an overall increase in accessibility, the study showed that these changes led to a "flattening" of accessibility, evidenced by a reduction in the disparity of accessibility among different areas within the region.

Investigators attributed the causes of these changes both to changes in the location of opportunities—land use—and the structure of the transportation network. Increases in population density of existing activity centers generally increased access to jobs in those locations, while specific travel network improvements led to improved job access in the areas where those improvements took place.

What's Next?

The University of Minnesota Center for Transportation Studies has designed a Web interface incorporating study results that will enable users to view accessibility by mode, destination and time period. To display and query the different maps, go to http://nexus.umn.edu/mapserver_demos/access. A more advanced version of this interface is in progress. Mn/DOT now needs to determine how best to use this tool to develop performance measures and guide decision making. Mn/DOT is evaluating a new proposal that would use the interface to analyze the effects of proposed land use or transportation network changes in the region.

This Technical Summary pertains to Report 2010-09, "Access to Destinations Phase 3: Measuring Accessibility by Automobile," published March 2010. The full report can be accessed at http://www.lrrb.org/PDF/201009.pdf.

This study concluded work begun in Phase I, Report 2007-35, "Access to Destinations: Travel Time Estimation on Arterials," and Phase II, Report 2010-12, "Access to Destinations: Arterial Data Acquisition and Network-Wide Travel Time Estimation (Phase II)," published August 2007 and March 2010, respectively. These reports are available at http://www.lrrb.org/PDF/200735.pdf *and* http://www.lrrb.org/PDF/201012.pdf, *respectively.*

2010-12TS
Published July 2010

RESEARCH SERVICES

OFFICE OF POLICY ANALYSIS, RESEARCH & INNOVATION

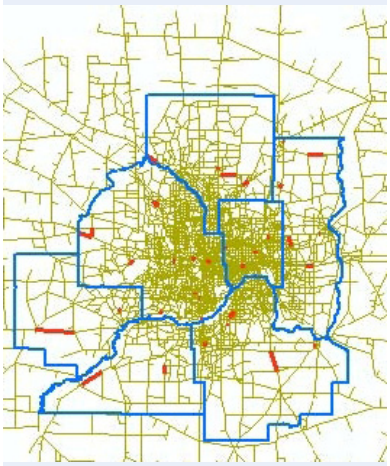
TECHNICAL SUMMARY

Technical Liaison:
Gene Hicks, Mn/DOT
Gene.Hicks@state.mn.us

Administrative Liaison:
Linda Taylor, Mn/DOT
Linda.Taylor@state.mn.us

Principal Investigator:
Gary Davis, University of Minnesota

PROJECT COST:
$150,000



In 2005 there were 72 ATRs on arterial links throughout the Twin Cities region (identified in red).

Access to Destinations: Arterial Data Acquisition and Networkwide Travel Time Estimation (Phase II)

Researchers used updated traffic volume and signal timing data to calculate travel time estimates for arterial links in the Twin Cities region. These estimates can be used to develop accessibility measurements and evaluate changes in the transportation network over time.

What Was the Need?

The Access to Destinations series of projects was initiated to produce accessibility measurements for the Twin Cities metropolitan area. This information can aid in all aspects of urban transportation planning, from road construction decisions to deployment of transit resources and traffic control measures. The specific need addressed by this report (the 10th in the series) is the production of arterial link travel time data.

Extensive use of inductive loop sensors on area freeways makes it possible to obtain travel time estimates for those freeways, but monitoring capabilities on arterial roads are much less developed. Usable travel time estimates on these arterial roads constitute a necessary component for creating accessibility measurements for the region.

The previous phase of this project (described in Mn/DOT Report 2007-35) identified a methodology for producing these estimates that uses the demand traffic flow (a measure of expected traffic used in designing the road and its signals) on an arterial segment and the timing of a signal at the segment's end.

What Was Our Goal?

The objective of the current study was to use the findings of Phase I to produce historic estimates of travel times on Twin Cities arterials for 1995 and 2005, and to develop an initial architecture and database that could, in the future, produce timely estimates of arterial traffic volumes and travel times.

What Did We Do?

The Phase II effort was divided into three main tasks. The first task involved an examination and update of traffic volume estimates from a Twin Cities planning model; the investigation focused on the years 1995 and 2005. Automatic traffic recorder data were extracted from files provided by Mn/DOT for each of these years (1996 ATR data was used because 1995 data was unavailable) and used to update the predicted demand flows from a transportation planning model. Researchers then applied an algorithm obtained from the U.S. Bureau of Public Roads to the updated traffic volume estimates to produce default travel time estimates on arterial roads for a.m. and p.m. peak travel times.

For the second task, researchers collected available signal location and timing data from each jurisdiction in the Twin Cities, creating a geographic database of signalized intersections.

Finally, researchers combined the results of the first two tasks. The new traffic volume estimates and signal timing data were used to produce updated link-by-link, peak-period travel time estimates for Twin Cities arterials for 1995 and 2005.

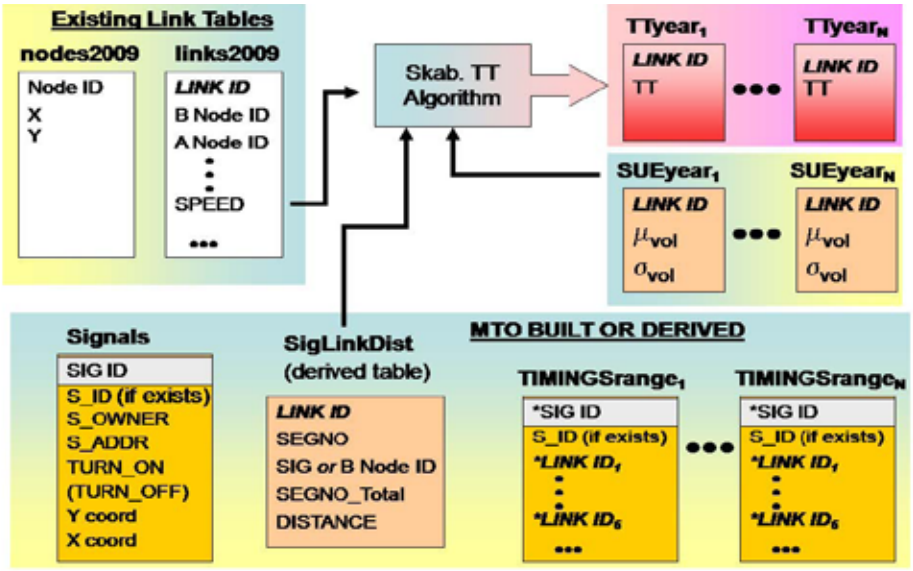
continued

"This type of travel time formulation could help inform a travel demand model that more accurately predicts future travel times, which would be useful information to transportation planners."

–Gene Hicks,
Mn/DOT Principal Engineer

"In this project we put together a geographic database of the arterials in the Twin Cities, with the long run goal of constructing a system for using available data to monitor traffic conditions."

–Gary Davis,
Professor, University of Minnesota Department of Civil Engineering



A travel time algorithm was implemented using the above schema to ultimately determine the travel time calculation using available signal information.

What Did We Learn?

Researchers faced several challenges as they attempted to apply the methodology identified in Phase I of the research. First, updating the traffic volume estimates from the transportation planning model did not produce significantly improved estimates because of the lack of historical ATR data. In 1996, there were 146 working ATRs and in 2005, there were only 72. In a network with thousands of arterial links, the number of ATRs was not sufficient to improve the initial modeled estimates.

In addition, researchers had difficulty collecting and correlating signal location and timing data for the designated years. Historical timing data was often simply unavailable, and the older Twin Cities planning models contained more generalized representations of the road system, complicating the task of establishing correspondence between the 1995 and 2005 networks.

Researchers were able to produce travel time estimates for arterial links to and from each traffic analysis zone and downtown Minneapolis for peak a.m. and p.m. periods in 1995 and 2005. The estimates were usable for the broader Access to Destinations accessibility research program.

Researchers also produced a geographic database of signal locations for the region and began the process of building a signal timing database that when complete, will aid in the monitoring of traffic conditions on arterial links within the network.

What's Next?

The data produced by this research was used in Phase III to produce automobile accessibility measurements for the Twin Cities region. The project report recommends that further work in this area should be focused on producing estimates of future traffic volume and travel times that would be useful in the design and planning of the transportation network.

Produced by CTC & Associates for:
Minnesota Department
of Transportation
Research Services Section
MS 330, First Floor
395 John Ireland Blvd.
St. Paul, MN 55155-1899
(651) 366-3780
www.research.dot.state.mn.us

This Technical Summary pertains to Report 2010-12, "Access to Destinations: Arterial Data Acquisition and Network-Wide Travel Time Estimation (Phase II)," published March 2010. The full report can be accessed at http://www.lrrb.org/PDF/201012.pdf. *The Phase I and III reports referred to can be accessed at* http://www.lrrb.org/PDF/200735.pdf *and* http://www.lrrb.org/PDF/201009.pdf, *respectively.*

2010-21TS
Published June 2010

RESEARCH SERVICES

OFFICE OF POLICY ANALYSIS, RESEARCH & INNOVATION

TECHNICAL SUMMARY

Technical Liaison:
Rabinder Bains, Mn/DOT
Rabinder.Bains@state.mn.us

Administrative Liaison:
Alan Rindels, Mn/DOT
Alan.Rindels@state.mn.us

Principal Investigator:
David Levinson, University of Minnesota

PROJECT COST:
$200,502 with additional support of $30,000 provided by the University of Minnesota Metropolitan Consortium

Travelers tend to avoid sites of network disasters even after the sites have been restored. This finding is confirmed by patterns in the San Francisco Bay network after a disaster similar to the I-35W Bridge collapse.

Responding to the Unexpected: Traveler Behavior and Network Performance in the Wake of the I-35W Bridge Collapse

Researchers evaluated the traveler behavior and the performance of transportation networks in the wake of the I-35W Bridge collapse, advancing understanding of the impacts of full closure compared with staged construction on the safety, quality and cost of construction projects.

What Was the Need?

The collapse of the Minneapolis I-35W Bridge August 1, 2007, was a tragic disaster. However, it also provided a rare opportunity to evaluate the effects of a prolonged, unexpected disruption of a major transportation network as well as a unique window into the behavior and decision-making mechanisms of travelers responding to it.

What Was Our Goal?

The objective of this study was to understand how travelers' behavior and transportation network performance evolve in response to a major, unexpected disruption. Researchers examined:

- Travelers' decisions about travel route, mode of transportation, destination, departure time and telecommuting with the closure and subsequent reopening of the I-35W Bridge.
- The accuracy of the current assumption of user equilibrium in travel demand models for such events, in this case, whether the restoration of capacity to one area of the Twin Cities network led to an even redistribution of traffic within the network as a whole, thus improving commute times on average to their predisruption state.

What Did We Do?

Immediately after the I-35W Bridge collapse, researchers distributed mail-in questionnaires to drivers and transit users near major parking garages in downtown Minneapolis and the University of Minnesota. Following the reopening of the I-35W Bridge, researchers collected data on driver behavior using:

- GPS devices installed in commuters' vehicles to track travel times, routes and speeds for 13 weeks; participants in this study were also required to complete a series of surveys.
- A second round of the initial paper-based surveys, this time distributed both in hard copy and via the Web.

Researchers also obtained Mn/DOT loop-detector data concerning highway network traffic volumes and speeds before and after the bridge collapse. Finally, they combined, geocoded and analyzed all data to evaluate driver behavioral reactions to the bridge reopening, and to compare traffic dynamics and network performance before the bridge collapse, immediately after it and following the bridge reopening.

What Did We Learn?

The bridge collapse did not disastrously disrupt the Twin Cities network. Traffic patterns restabilized in six weeks, and total travel demand did not change significantly. Travelers were very resourceful in dealing with altered traffic patterns—most frequently by changing routes and departure times, and less frequently by forgoing trips or

continued

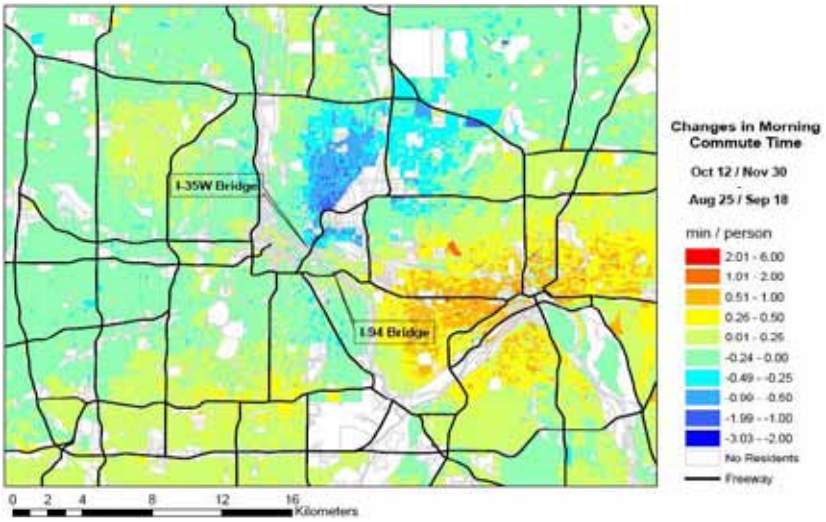
"Closing bridges and other links for construction may not have the dire effect a first analysis could imply. Mn/DOT should consider closing rather than trying to keep open network links during construction. Doing so will make projects faster, less expensive and safer."

–Rabinder Bains,
Economic Policy Analyst,
Mn/DOT Office of
Investment Management

"This project showed that travelers are resilient to adaptive transportation networks; there's a lot of latent capacity that can quickly be deployed to make up for disrupted transportation links."

–David Levinson,
University of
Minnesota
Richard P. Braun/CTS
Chair in Transportation
Engineering

Produced by CTC & Associates for:
Minnesota Department
of Transportation
Research Services Section
MS 330, First Floor
395 John Ireland Blvd.
St. Paul, MN 55155-1899
(651) 366-3780
www.research.dot.state.mn.us



The removal of the fourth lane of I-94 increased average commute times more than the I-35W Bridge reopening decreased them. While residents closer to the I-35W Bridge benefited from its reopening (blue areas), residents to the east of the I-94 Bridge (red and yellow areas) did not.

finding alternative destinations. Adding a fourth lane to I-94 between I-35W and Highway 280 reduced commute times for many travelers.

The reopening of the I-35W Bridge did not restore the same traffic demand patterns as models predicted. Researchers concluded that driver route choice behavior differs between unexpected and preplanned disruptions. Drivers seem initially to avoid the site of an unexpected disruption as a perceived risk, and after its restoration do not re-establish predisruption routes either because of traumatic associations or habituation to new routes.

Consequently, the reopening of the I-35W Bridge's 10 lanes did not benefit all travelers and did not fully compensate for the loss of capacity caused by the subsequent removal of the fourth lane on I-94. While the new I-35W Bridge experienced no congestion, it failed to attract much traffic from the I-94 crossing, even after the latter's lane closure. Commuters living near I-35W were better off after the reopening, but travelers living farther away experienced longer commute times. After the I-94 lane removal, average travel times for the network as a whole significantly worsened.

What's Next?

The study provides a baseline for future research in many traffic-related fields concerning driver behavior and traffic demand models. It will also help transportation officials improve network operational efficiency and safety by distributing resources based on more accurate models of network needs.

Finally, the project is a significant development in understanding the impacts of full closure versus staged construction contracting. Changing planning models would allow Mn/DOT to fully close a network link during construction, significantly speeding it and improving the safety of construction workers. Closure would also dramatically reduce construction costs by altering A & B contracting practices that offer heavy financial incentives for contractors to complete projects quickly.

Mn/DOT has several ongoing projects related to network closure, including the recently completed Report 2010-04, "TH-36 Full Closure Construction: Evaluation of Traffic Operations Alternatives," and a parallel study of the I-35W disruption, "Behavioral Response to the I-35W Disruption: Gauging Equilibration," sponsored by the National Science Foundation and expected to be completed in September 2010.

This Technical Summary pertains to Report 2010-21, "Traffic Flow, Road User Impacts of the Collapse of the I-35W Bridge Over the Mississippi River," published June 2010. The full report can be accessed at http://www.lrrb.org/PDF/201021.pdf.

2010-27TS
Published October 2010

RESEARCH SERVICES

OFFICE OF POLICY ANALYSIS, RESEARCH & INNOVATION

TECHNICAL SUMMARY

Technical Liaison:
Ken Buckeye, Mn/DOT
Kenneth.Buckeye@state.mn.us

Administrative Liaison:
Shirlee Sherkow, Mn/DOT
Shirlee.Sherkow@state.mn.us

Principal Investigator:
Adeel Lari, University of Minnesota

PROJECT COST:
$75,000

MnPASS express lanes currently in use have been well-received by the public.

Public Acceptance of New Highway Capacity Strategies: FAST Miles and FEE Lanes

Researchers conducted six focus groups with Minnesota highway users to determine public understanding of a variety of FAST and FEE lane concepts. Participants were generally open to more efficient use of existing infrastructure but expressed concerns about logistics, fairness and safety.

What Was the Need?

Increasing congestion and limited state budgets are forcing transportation departments across the country to look into better ways to use existing highway infrastructure. In 2005, Minnesota converted the high-occupancy vehicle, or HOV, lane on I-394 to a high-occupancy toll, or HOT, lane. That conversion changed what was a restricted lane—limited to use by buses, motorcycles and vehicles with two or more passengers—to an optional toll lane for single occupant vehicles known as MnPASS.

Mn/DOT is currently evaluating additional strategies to more efficiently use the highway infrastructure. Several different concepts exist, including FAST Miles, which involves creating an optional toll lane combined with a predetermined amount of credits given to motorists each month, and FEE—flexible and efficient express—lanes, which combine active traffic management with a credit-based system, converting general purpose lanes to toll lanes during peak driving times.

For any new value pricing plan to be successful, it is necessary to know how well the public understands the concept and what level of acceptance exists for a plan of this sort.

What Was Our Goal?

The goal of the project was to determine public understanding of the need for increased capacity on the highway system and to gauge public acceptance and understanding of the FAST Miles and FEE lanes concepts.

What Did We Do?

Investigators reviewed relevant literature, looking into the experience of the Federal Highway Administration, California and New York in implementing similar plans. Then they organized and conducted six focus groups containing eight to 10 participants each. Different categories of highway users were targeted, including peak and nonpeak period drivers, transit riders (bus or light rail), MnPASS users and business managers whose employees needed to drive the Twin Cities Metropolitan Area freeways to do their work.

Investigators explained each of the following options for reducing congestion and asked participants for their reactions:

- HOV lanes: This lane is for carpoolers and buses.
- HOT lanes: Vehicles with two or more persons and motorcyclists can use this lane for free, while single occupancy vehicle drivers are charged a fee to use the lane (the MnPASS system).
- FEE lanes (Configuration A): During peak hours, the left general-purpose lane is converted into a toll lane (free for buses) and the right shoulder is converted into a general purpose lane.
- FEE lanes with credits (Configuration B): An additional general-purpose lane would be

continued

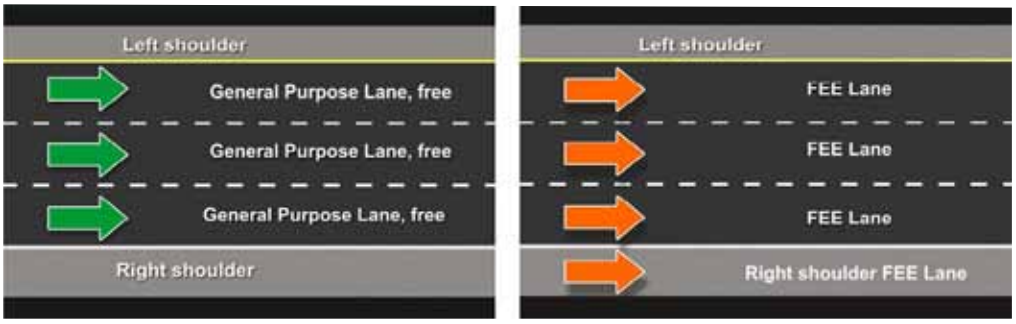
"This study helped identify the concerns of Minnesota highway users regarding the conversion of free general purpose lanes to toll lanes, which has never been done before. This will be valuable as we refine our policies to better utilize existing infrastructure."

—Ken Buckeye,
Program Manager, Mn/DOT Office of Policy Analysis, Research & Innovation

"Once citizens saw how a HOT lane works, they supported it. The same might be said for some of the concepts in this study: Although support may be low at first, over time and through public education, support for value pricing initiatives can grow."

—Adeel Lari,
Director, Innovative Financing in the State and Local Policy Program, University of Minnesota Hubert H. Humphrey Institute of Public Affairs

Produced by CTC & Associates for:
Minnesota Department
of Transportation
Research Services Section
MS 330, First Floor
395 John Ireland Blvd.
St. Paul, MN 55155-1899
(651) 366-3780
www.research.dot.state.mn.us



Configuration C (right) would convert all lanes to FEE lanes during peak periods. Many focus group participants thought this was inevitable but had concerns regarding fairness and equity.

converted to a toll lane, making two FEE lanes, and credits would be provided to all motorists in the metropolitan area for use in the FEE lanes.

- FEE highway with credits (Configuration C): All general-purpose lanes as well as the shoulder travel lane would be converted to FEE lanes during peak periods, and more credits would be offered than under Configuration B.

What Did We Learn?

Responses to each configuration were consistent across focus groups. Users were most familiar with the HOV and HOT systems currently in use and generally held a positive view of both. Responses to each of the three FEE lane configurations were mixed. With FEE Configurations A and B, participants liked the increased choice, the ability to pay to get somewhere on time, the increased capacity provided by using the shoulder during peak times, and the minimal out-of-pocket expenses as a result of the credit system in Configuration B. Key concerns included the potential safety ramifications of having the shoulder used as a travel lane, fairness to carpoolers and the perceived complex nature of the credit system.

Configuration C, which would convert all general purpose lanes to FEE lanes, also elicited a mixed response. Participants thought it was easier to understand than A or B, found it more egalitarian and often expressed the belief that such a configuration is inevitable. Key concerns included the lack of choice, unfairness, logistics and difficulty administering the credit system. Participants worried that people could get priced out of using the highways, but were equally concerned that a credit system would be complicated and costly to implement.

What's Next?

Researchers recommend pursuing HOT lanes and one FEE lane on all major highways, with education and outreach needed to communicate details of the credit system and the need for new configurations to reduce congestion.

A current project under way on I-35W allows people to travel on the shoulder during peak times, much like Configuration A. That project will help determine if the concerns expressed regarding safety, fairness and logistics actually materialize.

This Technical Summary pertains to Report 2010-27, "Study of Public Acceptance of Tolling with New Capacity and Credits: Concepts of FAST Miles and FEE Lanes," published July 2010. The full report can be accessed at http://www.lrrb.org/PDF/201027.pdf.

RESEARCH SERVICES

OFFICE OF POLICY ANALYSIS, RESEARCH & INNOVATION

TECHNICAL SUMMARY

Technical Liaisons:
Scott Bradley, Mn/DOT
Scott.Bradley@state.mn.us

Vanessa Levingston, Mn/DOT
Vanessa.Levingston@state.mn.us

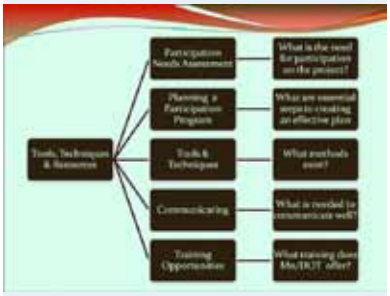
Administrative Liaison:
Becky Lein, Mn/DOT
Rebecca.Lein@state.mn.us

Principal Investigators:
Jim Grothaus, University of Minnesota
Center for Transportation Studies

Patricia Van Gorp, Beacon
& Associates Int'l

PROJECT COST:
$698,000

Mn/DOT CONTRIBUTION:
$111,920



One course presents Mn/DOT managers with a toolbox of public involvement techniques.

Putting Research into Practice: Training to Support "Hear Every Voice"

Investigators developed and administered a training curriculum on the core principles of Mn/DOT's public involvement guidance, designed to assist employees in the planning, implementation and evaluation of public and stakeholder participation.

What Was the Need?

Both the need for sustainable transportation system management and the public's insistence on being involved in transportation-related decisions have continued to increase over the years. In 1999, Mn/DOT produced the highly acclaimed *Hear Every Voice* handbook to guide employees' public involvement efforts. There was, however, still a need to translate the guidance of this handbook into best practices and tools that could be readily incorporated into everyday practices and Mn/DOT operations.

In 2006, Mn/DOT updated *Hear Every Voice* to re-energize the public involvement initiative and confirm compliance with federal regulations. To fully implement the updated guidance, the contents of the handbook needed to be communicated and accessible to Mn/DOT staff and transportation partners.

What Was Our Goal?

The goal of this project was to design, develop, deploy and evaluate a training program to help implement Mn/DOT's public involvement process based on the *Hear Every Voice* handbook.

What Did We Implement?

Investigators used information from the updated *Hear Every Voice* and Mn/DOT Project 2006-069, "Collaborative Research Approach for Managing Conflict & Consensus Building Pilot Project," which in turn leveraged past Mn/DOT research, such as Report 2006-24. Investigators used a curriculum developed by the International Association of Public Participation as the foundation for the core introductory course developed for this project.

How Did We Do It?

Investigators worked with a small initiative team and a public participation advisory group consisting of 38 representatives of Mn/DOT's divisions, districts, and key offices and functional areas to identify and prioritize the needs and interests regarding training and guidance within Mn/DOT. Based on this assessment, investigators created materials for 13 training sessions aimed at different audiences and covering different topics. Pilot training sessions were then conducted by an IAP2 certified master trainer.

The scope of the project evolved to include usability tests of Mn/DOT's public involvement website. Investigators invited staff to test the functionality of the site, providing them with a series of questions, identifying whether users were able to find information quickly and easily and whether the site was useful to Mn/DOT project managers.

Finally, in response to Mn/DOT's increased focus on working effectively with businesses, investigators developed a series of presentation tools and peer discussions to support the emergent priority of minimizing construction impacts on small businesses.

What Was the Impact?

The 13 classes created for this project, each with its own curriculum, agenda and sup-

continued

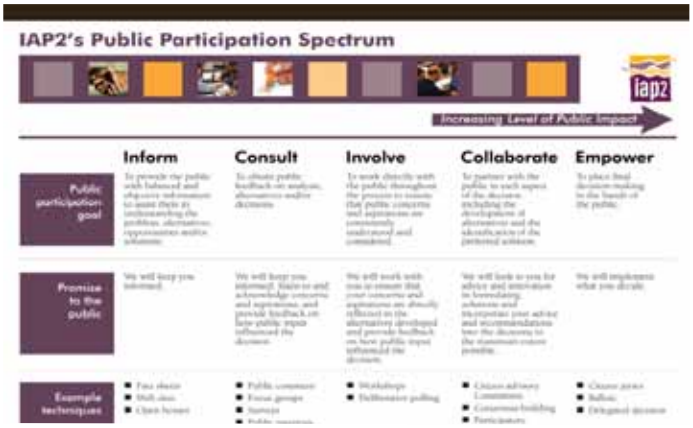
"The update to **Hear Every Voice** *and the increased visibility provided by the training curriculum make a dramatic difference in enabling people to better understand and become better versed in the different tools, techniques and approaches available."*

—Scott Bradley,
Director of Context Sensitive Design/Solutions, Mn/DOT Engineering Services Division

"Developing the 'Minimizing Impacts to Small Businesses' materials met an immediate need, providing Mn/DOT and the general public with a reference tool to answer the question 'How?' when it comes to public engagement."

—Vanessa Levingston,
Public Involvement Consultant, Mn/DOT Office of External Partnering

Produced by CTC & Associates for:
Minnesota Department of Transportation
Research Services Section
MS 330, First Floor
395 John Ireland Blvd.
St. Paul, MN 55155-1899
(651) 366-3780
www.research.dot.state.mn.us



International Association of Public Participation principles were used in the development of the Hear Every Voice training materials.

porting tools, were designed to support employees in the planning, implementation, evaluation and management of public and stakeholder participation. The following courses were delivered during more than 160 hours of face-to-face training sessions:

- *Introduction to Hear Every Voice*. Introduced the new "Hear Every Voice II" program, tools and benefits of the initiative.
- *Stop the Pain and Increase the Gain: Public Participation at Mn/DOT*. Covered the foundational principles of public participation and stakeholder consultation.
- *Effective Public Participation within Mn/DOT: Core Curriculum Overview*. Directed toward upper management and focused on understanding the training and support needs of personnel charged with engaging the public.
- *How to Determine the Need for and Level of Participation*. Designed to answer questions regarding the level of participation required and understanding of the key indicators that define risk within the public participation context.
- *How to Design an Effective Participation Plan within a Project*. Focused on learning the best practices for developing an engagement plan and applying them to case studies.
- *Overview and Selection of Participation Tools and Techniques*. Introduced more than 40 best practices tools and techniques with guidance for selecting the most appropriate technique to meet public participation objectives.

In addition, two peer exchanges were held based on the "Minimizing Impacts to Small Businesses" material. Thirty-five people attended the discussion and 108 people participated through remote online technology. This project also led to the organization and consolidation of tools and resources on Mn/DOT's public involvement website. From this site, transportation employees, stakeholders and community partners can now access Mn/DOT's policies, the *Hear Every Voice II* handbook, outlines and handouts from past trainings, links to webinars and other resources.

What's Next?

With a dedicated resource in place, Vanessa Levingston, Mn/DOT's public involvement consultant and manager of the Hear Every Voice initiative, will continue to offer training for employees and stakeholders with the possibility of offering more courses on demand or through webinars. Investigators have provided a proposed schedule of course offerings for the remainder of 2010 and 2011.

This Technical Summary pertains to Report 2010-33, "Hear Every Voice Public Engagement Initiative," published July 2010. The guide can be accessed at http://www.lrrb.org/PDF/201033.pdf.

Mn/DOT research leveraged for this project includes Mn/DOT Report 2006-24, "Developing a Simple System for Public Involvement Conflict Management," which can be found at http://www.lrrb.org/PDF/200624.pdf. *For information regarding Mn/DOT's public involvement efforts and upcoming trainings, see* http://www.dot.state.mn.us/planning/publicinvolvement.

2010-SPR-3(020)TS
Published January 2011

TRANSPORTATION POOLED FUND PROGRAM

TECHNICAL SUMMARY

Mn/DOT Technical Liaison:
Jon Jackels
Jon.Jackels@state.mn.us

Mn/DOT Administrative Liaison:
Deb Fick
Deb.Fick@state.mn.us

TOTAL STATE CONTRIBUTIONS TO DATE:
$1,295,000

Mn/DOT CONTRIBUTIONS TO DATE:
$120,000

PARTICIPATING STATES:
GA, ID, IL, IA, KS, MI, MN, MS, OK, TX

Road and weather information systems can supply data in real time to dynamic signs and variable speed limit systems.

RESEARCH SERVICES

OFFICE OF POLICY ANALYSIS, RESEARCH & INNOVATION

Pooling Our Research: Accelerating the Development of Intelligent Transportation Systems

SPR-3(020): IVHS Study (ENTERPRISE).
ENTERPRISE facilitates the rapid development of intelligent transportation systems, allowing Minnesota to benefit from the latest technologies for increasing highway safety and efficiency, and reducing congestion and the environmental impacts of travel.

Why a Pooled Fund Study?

As populations expand, traffic congestion is increasingly a problem, reducing the efficiency of transportation infrastructure and increasing travel time, air pollution and fuel consumption. States are increasingly looking to intelligent transportation systems as a solution; ITS involves information and communication technologies for managing transportation infrastructure, and includes everything from car navigation systems and variable message signs to the integration of weather information and other data.

To accelerate the implementation of ITS programs and establish a more efficient, collaborative use of resources, Minnesota joined with several other states in 1991 to form the ENTERPRISE program. As the longest running pooled fund study in the Federal Highway Administration's history, this program has since grown into a multinational consortium dedicated to the advancement of ITS.

What is the Pooled Fund Study's Goal?

The goal of the ENTERPRISE pooled fund study is to provide an international forum for facilitating collaborative research and the rapid development and deployment of ITS.

What Have We Learned?

Mn/DOT has benefited from the ENTERPRISE pooled fund study's nearly 50 completed projects by being able to jointly develop new approaches to ITS that the state would not have been able to develop alone. One of the most significant ENTERPRISE projects for Minnesota was the 511 Traveler Information Implementation, which assisted states in deploying services that allow travelers to access information about road conditions, traffic incidents, commercial vehicle restrictions and weather information simply by dialing "511." Before project implementation began in 2001, there were more than 300 telephone numbers for travel information systems nationwide. Minnesota has also benefited from many other ENTERPRISE initiatives, including these recently completed projects:

- Rural Renewable Power, in which Minnesota researchers explored the use of solar and wind energy to power ITS devices in remote areas where power is not readily available. Researchers developed a prototype renewable power station integrating a small wind turbine and a photovoltaic solar panel. This technology could save significant costs by eliminating the need to extend utility power lines to rural locations.
- ITS Warrants, which established an efficient method for determining whether an ITS technology would provide a cost-effective solution to a given problem.
- Rural Transit Technology, which provided a means of evaluating the costs and benefits of applying ITS to rural transit systems.

What's Going On Now?

Ongoing investigations into a wide range of technologies and their applications include:

- Low-Cost ITS Safety Solution Systems, which is exploring the use of intersection

continued

"By participating in ENTERPRISE, Mn/DOT can leverage a deep pool of ITS experience from other states and international agencies, allowing us to make much more rapid progress than we would working alone."

—Jon Jackels,
ITS Program Manager, Mn/DOT Office of Traffic, Safety and Technology

"The ENTERPRISE pooled fund has been very beneficial for Mn/DOT, giving us a way to secure funding for ITS projects that are critical to Minnesota."

—Deb Fick,
Research SP&R Administrator, Mn/DOT Research Services

Produced by CTC & Associates for:
Minnesota Department of Transportation
Research Services Section
MS 330, First Floor
395 John Ireland Blvd.
St. Paul, MN 55155-1899
(651) 366-3780
www.research.dot.state.mn.us

As part of the Rural Renewable Power project, researchers developed a prototype lighting system that runs on a battery charged by wind and solar power, and installed it at a parking lot in Minnesota District 1, making an expensive extension of power lines unnecessary.

warning systems, intersection collision avoidance systems and dynamic curve warning systems to address run-off-road crashes.

- Impacts of Travel Information on the Overall Network, which is addressing the impacts of travel information dissemination on driver behavior within an urban transportation network so that changes in traffic patterns can be managed accordingly.
- Next Generation Traffic Data and Incident Detection from Video, which is exploring the advantages of 3-D vector-based objection recognition for capturing traffic data and incident detection as well as warning drivers of the presence of wildlife.

What's Next?

Individual agency and ENTERPRISE program projects selected for 2011 include:

- Understanding Utilization of Third-Party Travel Data and Information, which will document the value of and possible uses for data feeds provided to states by various private sector travel information vendors. A separate project will evaluate whether member agencies wish to receive the OnStar data feed for emergency response or for travel information.
- Concept of Operation for Integration of IntelliDrive Data, which will examine opportunities for state DOTs to use IntelliDrive data to improve highway operations such as incident detection and management, traffic management, emergency medical services dispatch and 511 traveler information updating.
- Interpretable Travel Information—Use and Impacts, which will investigate the effect upon travelers of providing interpretable information, including traffic, incident and weather reports; video or still-camera images; and displays of weather monitoring station data.
- Optimization of Renewable Energy for ITS, which will develop a Web-based system to optimize the combined use of solar and wind power energy for ITS devices such as CCTV, vehicle detectors and variable message signs.

As ENTERPRISE continues its work for years to come, Minnesota will benefit from the latest technologies for increasing highway safety and efficiency, reducing congestion and the environmental impacts of travel, and increasing its comfort and convenience.

This Technical Summary pertains to the ongoing Pooled Fund SPR-3(020), IVHS Study (ENTERPRISE), which will continue under TPF-5(231). Details of this effort can be found at http://pooledfund.org/projectdetails.asp?id=159&status=6, http://www.pooledfund.org/projectdetails.asp?id=459&status=4 *and* http://www.enterprise.prog.org/.

For more than 25 years, FHWA's Transportation Pooled Fund Program has been providing state DOTs and other organizations the opportunity to collaborate in solving transportation-related problems. The TPF Program is focused on leveraging limited funds, avoiding duplication of effort, undertaking large-scale projects and achieving broader dissemination of results on issues of regional and national interest.

2010-TPF-5(154)TS
Published December 2010

TRANSPORTATION POOLED FUND PROGRAM

TECHNICAL SUMMARY

Mn/DOT Technical Liaison:
Jonette Kreideweis
Jonette.Kreideweis@state.mn.us

Mn/DOT Administrative Liaison:
Deb Fick
Deb.Fick@state.mn.us

TOTAL AGENCY CONTRIBUTIONS TO DATE:

$1.6 MILLION THROUGH THE POOLED FUND
$5.8 MILLION TOTAL CTPP BUDGET

Mn/DOT CONTRIBUTIONS TO DATE:

$102,546

PARTICIPATING STATES:

CT, GA, ID, IL, IA, MI, MN, NY, PA, WA

The CTPP is an umbrella program of census data products, training, on-demand technical assistance and research designed to support transportation planning.

RESEARCH SERVICES

OFFICE OF POLICY ANALYSIS, RESEARCH & INNOVATION

Pooling Our Research: Providing Transportation Planners with Accurate Census Data

TPF-5(154): Census Transportation Planning Products (CTPP) from the American Community Survey Pooled Fund Study. *This study works in conjunction with AASHTO's Standing Committee on Planning on a project to incorporate annual data from the American Community Survey in a set of special data tabulations used for transportation planning and policy analysis.*

Why a Pooled Fund Study?

For decades, transportation planners have used census data to inform their planning practices, including travel demand modeling, congestion management, emergency preparedness, transit system planning, environmental justice studies, air quality conformity, environmental justice reviews and trends analyses. Since 1970 (with the Urban Transportation Planning Package), a set of special tabulations has summarized nationwide census data by home location, work location and worker flows between home and work.

A unique partnership between states, metropolitan planning organizations, AASHTO, Federal Highway Administration and the Census Bureau, today's Census Transportation Planning Products program generates data that is used to support more than 20 federal planning requirements, especially those that require sound data for small geographic areas. For some smaller planning organizations with limited funding, the CTPP provides the only source of journey-to-work data.

Historically, CTPP data products were developed from the census long form administered once every 10 years. Practitioners considered the large sample size of this census essential to providing reliable and accurate data. In 2006, the new American Community Survey form came into use, and plans were made to eliminate the long form in favor of annual ACS administration starting in 2010. AASHTO's Standing Committee on Planning sponsored a new, multiyear CTPP project to begin incorporating ACS data into transportation planning products and practices. ACS is a continuous form of measurement that requires accumulation of data over multiple years for tabulation. All 50 states and many metropolitan planning organizations are participating in the new CTPP project; each entity contributes funds based on population estimates for 2010 (at $0.0189 per person).

AASHTO's new CTPP project allows agencies to participate by contributing funds directly to AASHTO or through an FHWA pooled fund. Minnesota and nine other states are participating in the CTPP project through this pooled fund.

What is the Pooled Fund Study's Goal?

The goal of this pooled fund study is to determine the usability of the ACS data for transportation planning purposes to develop new three- and five-year CTPP tabulations that are based on the ACS. The project also provides for ongoing technical assistance, user training and related research activities.

What Have We Learned?

CTPP's Oversight Board identifies priorities for census data and how the data should

continued

"The CTPP represents a unique AASHTO, federal, state and local partnership that provides a wealth of data on residential, workplace, journey-to-work and flow characteristics for transportation planning and policy analysis."

—Jonette Kreideweis,
Director, Mn/DOT Office of Transportation Data and Analysis

"CTPP data is a key input for the state's long-range planning for the transportation system across all modes and in the transportation planning done by the state's metropolitan planning organizations."

—Lynne Bly,
Transportation Planning Director, Mn/DOT Office of Statewide Multimodal Planning

Produced by CTC & Associates for:
Minnesota Department
of Transportation
Research Services Section
MS 330, First Floor
395 John Ireland Blvd.
St. Paul, MN 55155-1899
(651) 366-3780
www.research.dot.state.mn.us

CTPP Part 1 Profile 1: Census 2000 and 2005-2007 ACS
Geographic Area: STATE- Minnesota FIPS: 027

R1. Selected Characteristics	Census 2000		2005-2007 ACS		Is Change Significant at 90 Percent Confidence?
	Number	MOE(+/-)	Number	MOE(+/-)	
Total Persons[1]	4,919,479	--	5,155,344	--	--
Persons in Households[2]	4,783,531	--	5,012,749	--	--
Total Households[3]	1,895,209	1,597	2,041,486	5,082	Yes
Average Household Size[4]	2.52	--	2.46	--	--
Average Vehicles per Household[5]	1.80	--	1.89	0.01	--
Persons in Group Quarters[6]	135,948	--	142,595	--	--
Total Workers[7]	2,562,040	4,482	2,710,854	6,487	Yes
Workers at Work[8]	2,541,611	4,485	2,646,371	6,489	Yes

R2. Mode to Work[9]	CTPP2000			2005-2007 ACS			Is Change Significant at 90 Percent Confidence?
	Number	Percent	MOE(+/-)	Number	Percent	MOE (+/-)	
Total Workers	2,541,610	100.0	4,485	2,646,371	100.0	6,489	Yes
Drove alone	1,971,570	77.6	4,398	2,065,607	78.1	7,080	Yes
2-person carpool	215,250	8.5	1,838	197,789	7.5	3,886	Yes
3-person carpool	31,045	1.2	711	29,095	1.1	1,585	Yes
4-person carpool	10,145	0.4	407	10,411	0.4	1,149	No
5- or 6-person carpool	4,825	0.2	281	6,234	0.2	742	Yes
7 or more person carpool	3,425	0.1	237	5,793	0.2	760	Yes
Bus or trolley bus	78,690	3.1	1,126	78,789	2.9	2,675	No
Streetcar or trolley car	315	0.0	72	633	0.0	240	Yes
Subway or elevated	200	0.0	57	1,363	0.1	339	Yes
Railroad	165	0.0	52	1,384	0.1	365	Yes
Ferryboat	110	0.0	47	57	0.0	49	No
Bicycle	10,095	0.4	406	16,476	0.6	1,160	Yes
Walked	84,150	3.3	1,164	81,065	3.1	2,313	Yes
Taxicab	1,790	0.1	171	1,852	0.1	459	No
Motorcycle	1,345	0.1	148	4,950	0.2	480	Yes
Other means	11,730	0.5	438	15,737	0.6	1,103	Yes
Worked at home	118,555	4.6	1,365	131,419	5.0	2,925	Yes

Three-year data from CTPP products using ACS data for the period 2006-2008 will look much like these sample tables that use 2005-2007 ACS data.

be packaged to be most useful to transportation planners. Peer exchanges held in 2006 and 2007 defined CTPP data needs, outlined proposed program tasks and examined the issues surrounding use of census data derived from the new ACS. Three-year data products for 2006 to 2008 will be available soon in 200 tables designed by and for transportation planners. The data profiles and customized tabulations will be limited to states, counties and places with a population of 20,000 or more. They summarize key population, residence, workplace, journey-to-work and flow data characteristics.

What's Going On Now?

The CTPP pooled fund study is one element of a broader effort to provide transportation planners with the best possible census data. The final report for NCHRP Project 08-36, Task 81 describes a project that examined data and potential methods for merging annual data from the ACS and a new quarterly data set from the Census Bureau—Longitudinal Employer Household Dynamics—to obtain better journey-to-work data. NCHRP Project 08-79, expected to conclude in July 2011, is testing techniques to use five-year ACS data that satisfy U.S. Census Bureau disclosure rules and support transportation planning at small-area geography. Another project is developing Web-based data access software for the ACS three-year data products.

The pooled fund is currently identifying priorities for five-year CTPP special tabulations with 2006-2010 data that will provide residence, workplace, journey-to-work and flow data for smaller geographic areas such as tracts, traffic analysis zones and block groups. This data set will be the first CTPP with small-area tabulation using ACS records. Results of NCHRP Project 08-79 are expected to be used to ensure small-area data can be released while preserving individual confidentiality. The five-year data sets are scheduled for release in 2012.

What's Next?

Work continues on developing the five-year CTPP tabulations from ACS data. Planning is under way to host a national census data user conference in fall 2011, and work has begun on a white paper outlining longer-term CTPP data access and archiving opportunities and issues.

This Technical Summary pertains to the ongoing Pooled Fund TPF-5(154), Census Transportation Planning Products (CTPP) from the American Community Survey Pooled Fund. Details of this effort can be found at http://pooledfund.org/projectdetails.asp?id=392&status=4.

For more than 25 years, FHWA's Transportation Pooled Fund Program has been providing state DOTs and other organizations with the opportunity to collaborate in solving transportation-related problems. The TPF Program is focused on leveraging limited funds, avoiding duplication of effort, undertaking large-scale projects and achieving broader dissemination of results on issues of regional and national interest.

2009-36TS
Published May 2010

RESEARCH SERVICES

OFFICE OF POLICY ANALYSIS, RESEARCH & INNOVATION

TECHNICAL SUMMARY

Technical Liaison:
Ernest Lloyd
Ernest.Lloyd@state.mn.us

Administrative Liaison:
Cory Johnson, Mn/DOT
Coryj.Johnson@state.mn.us

Principal Investigator:
Henry Liu
University of Minnesota

PROJECT COST:

$150,000

This screen shot from the evacuation software tool shows how the extent of the user-specified disaster area is highlighted after the user enters the desired radius.

Responding to the Unexpected: Development of a Dynamic Data-Driven Model for Effective Evacuation

Researchers developed an evacuation software tool for small-scale, no-notice evacuations that determines evacuee departure rates, time schedules, shortest paths and critical intersections for police officer deployment. The tool provides substantially improved network clearance times.

What Was the Need?

By their very nature, no-notice emergency events such as chemical spills and unanticipated structural failures are unexpected and unpredictable. Predetermined evacuation scenarios may not apply given a no-notice emergency's unique set of circumstances, when things can change quickly and driver behavior is difficult to predict. To address this dilemma, emergency managers need a tool that manages evacuation traffic efficiently in real time—in just seconds to only a few minutes—and allows for adjustments as facts on the ground change.

What Was Our Goal?

The objective of this research is to develop a decision-support tool for smaller-scale emergency evacuation traffic management, with the primary objective of minimizing the total system travel time. The tool will be used to develop models for evacuee routing calculations and optimal intersection control through the placement of limited numbers of police officers to guide traffic at critical network locations.

What Did We Do?

Researchers developed algorithms and software along with a user's guide to create a framework with three components:

- A prescriptive model that represents the desired response of traffic under evacuation. This model creates only short-term traffic forecasting of a few minutes, with a rolling time horizon.
- A descriptive, real-world model that describes, in a short-term fashion, the real-world traffic flow pattern under evacuation as accurately as possible.
- An adaptive control system that integrates output from the prescriptive model—the desired state of traffic—and the current prevailing traffic conditions described by the descriptive model to generate a traffic control strategy for evacuation.

What Did We Learn?

The adaptive control system developed is a heuristic algorithm for staged traffic evacuation, or HASTE, that determines evacuee departure rates, time schedules and dynamic shortest paths. The basic idea in HASTE is that through departure rate control, travelers will use the same facilities at different times to avoid delay. HASTE keeps the problem size relatively small and results in faster computation than is seen with other traffic assignment models. A preincident calculation component creates efficient transportation subnetworks to simplify shortest-path search operations.

The evacuation software developed to test HASTE includes a geographic information systems-based traffic network for a one-mile radius network of downtown Minneapolis, with signal timing parameters based on different settings for different times of day in-

continued

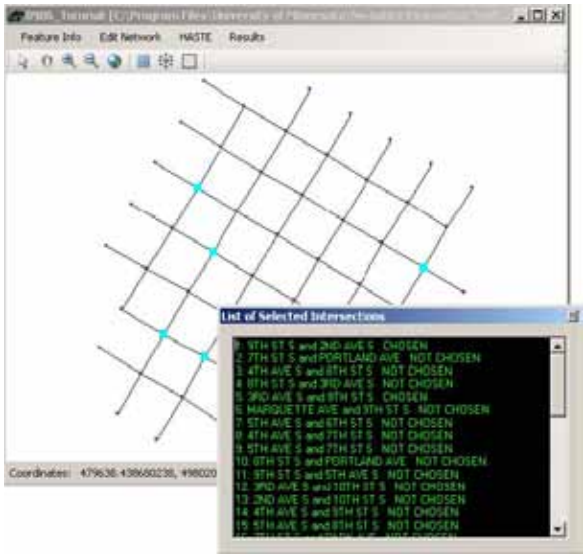
"Our testing demonstrated that HASTE evacuation routing solutions provide substantial improvement in network clearance times when compared to an all-or-nothing assignment. All routing computations were completed within two minutes, illustrating the efficiency of HASTE."

–Henry Liu,
University of Minnesota
Department of Civil
Engineering

"The evacuation software tool is designed to address smaller-scale evacuations. Emergency managers can use the tool to place officers at critical intersections and identify locations for detour signs to implement contraflow traffic."

–Ernest Lloyd,
Director, Financial &
Support Services,
Mn/DOT Office of
Maintenance

Produced by CTC & Associates for:
Minnesota Department
of Transportation
Research Services Section
MS 330, First Floor
395 John Ireland Blvd.
St. Paul, MN 55155-1899
(651) 366-3780
www.research.dot.state.mn.us



In this screen shot from the evacuation software tool, the signalized intersections selected for officer deployment are highlighted on the map. A list of all network signalized intersections identified as "CHOSEN" and "NOT CHOSEN" appears in the "List of Selected Intersections" window.

tegrated into the model. Users enter data or make selections in the software that reflect the emergency scenario by selecting the affected area from the base map; editing the scenario network to represent lane drops and minimize the use of certain roads as part of the evacuation strategy; entering network demands with estimated numbers of vehicles to reflect evacuee concentration points in the network; identifying the network destinations—or boundaries—that constitute safe zones in the evacuation model; and selecting a signal timing period, as different times of the day are associated with different signal timing plans.

The software combines vehicle routing with a determination of critical intersections to which a limited number of police officers can be deployed; signal timing optimization was left for future research. Users may have more intersection candidates than the available number of officers, so HASTE tackles the problem of finding the best combination of intersections and officers.

All routing and officer deployment results of the evacuation software are saved as text files. A departure schedule includes a route index and the number of evacuees assigned to each route. A second text file provides a list of paths, with the total number of evacuees assigned to each path. Some results are displayed graphically.

Using a hypothetical evacuation scenario, researchers found that the software tool is capable of producing results in less than one minute compared to traditional procedures using commercial linear programming solvers that required nearly four hours. When comparing network clearance times of traffic assignment scenarios, clearance times ranged from 248 minutes and 15 seconds for an all-or-nothing traffic assignment where all evacuees use the shortest path to safety, to 102 minutes and 15 seconds using HASTE with no officers, to 68 minutes using HASTE optimized with 20 officers. The results indicate that HASTE provides substantially improved network clearance times.

What's Next?

Mn/DOT will provide the evacuation software tool and its accompanying user's guide to emergency managers in the seven-county Twin Cities metropolitan area for additional testing of evacuation scenarios and future application. Since the system addresses small-scale evacuations, it may be further developed for city and county use with the support of the Local Road Research Board.

This Technical Summary pertains to Report 2009-36, "Responding to the Unexpected: Development of a Dynamic Data-Driven Model for Effective Evacuation," published December 2009. The full report can be accessed at http://www.lrrb.org/PDF/200936.pdf.

2009-39TS
Published June 2010

LRRB
LOCAL ROAD RESEARCH BOARD

TECHNICAL SUMMARY

Technical Liaison:
Glen Ellis, Mn/DOT
Glen.Ellis@state.mn.us

Administrative Liaison:
Shirlee Sherkow, Mn/DOT
Shirlee.Sherkow@state.mn.us

Principal Investigator:
Craig Shankwitz, University of Minnesota

PROJECT COST:
$45,400

Researchers found that adding rumble strips was the most cost-effective strategy for reducing crashes.

MINNESOTA DEPARTMENT OF TRANSPORTATION

RESEARCH SERVICES
OFFICE OF POLICY ANALYSIS, RESEARCH & INNOVATION

In-Vehicle Technologies and Infrastructure Modifications to Prevent Crashes Along Curves and Shoulders

Researchers investigated the most cost-effective roadway designs, treatments and in-vehicle technologies for improving the safety of rural two-lane highways. They found that while static warning signs have a high benefit-to-cost ratio, 80 percent of curves studied had such signs and still had high crash rates.

What Was the Need?

Forty percent of fatal crashes in Minnesota are road departure crashes, and these occur primarily on rural curves and adjacent roadway segments, also referred to as tangential sections. Systems are needed to prevent these crashes but because agencies have limited financial resources, it is important to find strategies that provide the greatest benefit for a given fixed cost.

What Was Our Goal?

The goal of this study was to establish the most cost-effective roadway designs, treatments and in-vehicle technologies for improving the safety of rural two-lane highways.

What Did We Do?

Researchers completed this study in two phases. In the first phase, they began by collecting data for 204 curves and 137 tangential sections from Mn/DOT districts and county highway departments. They analyzed this data to correlate crash and fatality rates to curve radius (a measure of the severity of curves) and to shoulder width and paving material (which affect the ability of drivers to recover from lane departures). Researchers then identified curves and tangential sections that had received safety treatments, including:

- Rumble strips and stripes, grooved patterns on roadsides and/or centerlines that alert drivers by causing their vehicles to vibrate and make noise; stripes also have highly reflective paint for nighttime visibility.
- Curve flattening, a process in which curves are realigned or completely reconstructed to alter their radius and so decrease their severity.
- Traffic control devices, such as chevrons alerting drivers to the shapes of curves, static warning signs alerting drivers to sharp curves, and static speed warning signs informing drivers of a lower speed limit during the curve.
- Paving and widening of tangential section shoulders.

Researchers compared crash and fatality rates for road sections before and after the implementation of these treatments and used this comparison to establish cost-benefit ratios for each.

In the second phase of this study, researchers compared the costs and benefits of these traditional road safety treatments to newer, technology-based treatments, including dynamic curve warning signs, which detect the speed of oncoming vehicles and use flashing beacons to warn drivers if they are coming into a curve too quickly, and lane departure warning systems, which alert drivers of unintentional lane changes using either a Global Positioning System or cameras that track lane markings.

continued

"Results suggested that agencies with limited budgets should improve road safety by adding rumble strips or stripes before they consider more expensive measures such as widening shoulders."

–Craig Shankwitz,
Program Director,
University of Minnesota
ITS Institute Intelligent
Vehicles Program

"This project optimizes the ability of Mn/DOT to improve highway safety on a fixed annual budget, moving Minnesota closer to its goal of eliminating fatal crashes."

–Glen Ellis,
Mn/DOT Metro District
Design Engineer

Produced by CTC & Associates for:
Minnesota Department
of Transportation
Research Services Section
MS 330, First Floor
395 John Ireland Blvd.
St. Paul, MN 55155-1899
(651) 366-3780
www.research.dot.state.mn.us

A vision-based lane departure warning system uses a camera and software to track and display a vehicle's position relative to lane markings, alerting the driver when a vehicle crosses markings at speeds greater than 25 mph or without a turn signal.

What Did We Learn?

Results show that while static warning signs have a high benefit-to-cost ratio, 80 percent of curves studied had such signs and still had high crash and fatality rates. Researchers recommend complementing signs with additional cost-effective countermeasures for curves with radii between 500 and 1,500 feet, which account for 90 percent of fatal crashes and 75 percent of injuries in curve-related accidents. When possible, curves should be designed with radii of more than 2,000 feet.

Of such countermeasures, while curve flattening was the most effective infrastructure-based treatment, it is also the least cost-effective. For a given fixed safety budget, adding rumble strips or stripes to tangential sections is the most cost-effective treatment and produced the highest reduction in fatalities. Researchers recommend paving shoulders and adding rumble strips or stripes on all projects since the latter are much more cost-effective than paving alone.

Treatments in order of cost-effectiveness from highest to lowest (with absolute crash-rate reduction percentages in parentheses) were: addition of rumble strips on curves of any width or on tangential sections up to four feet in width (15 percent crash-rate reduction), paving and addition of rumble strips to tangential section aggregate shoulders (37 percent), static curve warning signs (18 percent), chevrons (20 percent), static curve speed warning signs (22 percent), dynamic curve speed warning signs (30 percent) and curve flattening (66 percent). Because paving tangential section aggregate shoulders without adding rumble strips or widening tangential section paved shoulders showed inconclusive safety benefits, cost-benefit analyses were not undertaken for these conditions.

For in-vehicle technologies, camera-based lane departure warning systems were about as cost-effective on a 10-year analysis as adding rumble strips or stripes to tangential section shoulders, and are about as effective as paving shoulders (a 7 percent crash-rate reduction). Although differential GPS-based lane departure warning systems have proven to be very effective, today's low deployment numbers and a conservative 20-year price/volume model make these systems currently about as cost-effective as paving shoulders.

What's Next?

With limited financial resources, achieving Minnesota's Toward Zero Deaths initiative of eliminating fatal traffic crashes requires finding the most cost-effective road safety strategies. To that end, the results of this study will be incorporated into Mn/DOT's highway safety manual to help local agencies make critical decisions about how they spend their highway safety funding.

This Technical Summary pertains to the LRRB-produced Report 2009-39, "Benefit:Cost Analysis of In-Vehicle Technologies and Infrastructure Modifications as a Means to Prevent Crashes along Curves and Shoulders," published December 2009. The full report can be accessed at http://www.lrrb.org/PDF/200939.pdf.

2010-02TS
Published January 2010

RESEARCH
SERVICES SECTION

TECHNICAL SUMMARY

Technical Liaison:
Cassandra Isackson, Mn/DOT
cassandra.isackson@state.mn.us

Administrative Liaison:
Dan Warzala, Mn/DOT
dan.warzala@state.mn.us

Principal Investigator:
Kathleen Harder, University of Minnesota

PROJECT COST:
$99,500

The driving simulator console had three 17-inch CRTs, a steering wheel and pedals, and an automobile seat. Speakers behind the CRTs simulated engine noise.

Using Dual-Phase Message Signs to Display Airline Information

What Was the Need?

Changeable Message Signs are electronic traffic signs that can be programmed to display important messages that vary according to current roadway conditions, including the presence of traffic congestion and accidents. CMSs can also be used to display messages that are too long to fit on a single static sign. A "dual-phase" CMS divides a long message into shorter messages displayed sequentially in phases lasting a certain number of seconds.

Conveying a large amount of information is often achieved by displaying static signs at short distances from each other, but the limited length of a highway segment may make this unfeasible. The approach to the Minneapolis-St. Paul International Airport includes a large number of road signs in a relatively short distance. Unfortunately, while these signs inform travelers of where to exit to reach one of two terminals, the signs do not show which airlines are present at these terminals. Travelers who know only the name of their airline may arrive at the wrong terminal and—because the two terminals do not share a roadway within the airport—have to return to the highway to reach the correct terminal.

The Metropolitan Airport Commission and the Minnesota Department of Transportation plan to remedy this problem by displaying airline names on signs, but would like to do so without increasing the already large number of static signs along the highway approaches. Dual-phase CMSs appear to be a promising solution for displaying the nine airline names serviced by the airport's Lindbergh Terminal (Terminal 1) without the use of multiple signs, but research was needed to demonstrate the effectiveness of these signs in conveying information to drivers and leading them to the right terminal.

What Was Our Goal?

The objective of this study was to conduct a driving simulation experiment to determine whether messages displayed on dual-phase CMSs are as effective in influencing driving behavior as messages displayed on static CMSs.

What Did We Do?

Researchers tested driver responses using a driving simulator consisting of an automobile-styled seat facing a bank of three 17-inch CRT monitors that displayed a virtual six-lane divided highway with a speed limit of 60 mph.

In the experiment, 120 participants were divided into two groups of 60 each; one group was assigned to a scenario using a dual-phase CMS and the other group, a scenario in which two static CMSs were located 500 feet apart. Researchers asked participants to drive as they normally would along the highway to find the airport and the correct terminal for an assigned airline. They then recorded whether drivers had taken the correct exits to their terminals as well as whether CMSs caused them to reduce their driving speeds.

The 60 participants assigned to each scenario included 10 males and 10 females from each of three age groups: 18 to 24 years, 32 to 47 years and 55 to 65 years. Each participant performed the test twice, using the same scenario each time.

What Did We Learn?

Results showed that the performance of drivers did not vary significantly between dual-phase CMS and static CMS scenarios. In both cases, 89.6 percent of participants took the

continued

"This project provided strong evidence that dual-phase Changeable Message Signs will be just as effective in conveying airline information to travelers approaching the Minneapolis-St. Paul International Airport as successive static signs."

–Kathleen Harder,
Director, University of Minnesota's Center for Design in Health

"We found that dual-phase messages are far more effective at conveying information than DOTs previously thought. This study could have wide applicability to other areas, such as urban highway segments that are congested with signs."

–Cassandra Isackson,
Assistant State Traffic Engineer, Mn/DOT Traffic Engineering Section

Produced by CTC & Associates for:
Minnesota Department
of Transportation
Research Services Section
MS 330, First Floor
395 John Ireland Blvd.
St. Paul, MN 55155-1899
(651) 366-3780
www.research.dot.state.mn.us

The first of two signs displaying airlines serviced by Terminal 1 were presented to participants in the static scenario 800 feet after a sign informing them that they were approaching the airport.

correct exit. There was also no statistically significant difference in the average speed of the participants in the dual-phase and static CMS scenarios, or in the magnitude of drivers' speed reduction as they approached signs. About the same number of participants in each group reduced their speed by at least 2 mph in response to the signs.

Researchers concluded that displaying airline information on a dual-phase CMS is as effective at influencing driving behavior as displaying the same information on two successive static CMSs. There was no evidence to suggest that a dual-phase CMS should not be used instead of two static CMSs.

What's Next?

Because many interstates are running out of room for static signs on segments that run through urban areas, this study can be applied more broadly to these cases. Currently, some static signs on these segments may be placed closer to each other than would be optimally effective in conveying information to travelers, especially older drivers, who are a rapidly increasing percentage of the driving population. More research is needed into the effect that the spacing and quantity of signage has on its effectiveness, and to determine the role of dual-phase CMSs as a remedy for this problem. Mn/DOT currently is engaged in a number of related projects, including the development of a manual of practice for CMSs.

This Technical Summary pertains to the Report 2010-02, "Comparison of Dual-Phase and Static Changeable Message Signs to Convey Airline Information on Interstate Freeways," published January 2010. The full report can be accessed at http://www.lrrb.org/PDF/201002.pdf.

2010-05TS
Published June 2010

LRRB
LOCAL ROAD RESEARCH BOARD

TECHNICAL SUMMARY

Technical Liaisons:
Lee Amundson, Lincoln County Engineer
lamundson@co.lincoln.mn.us

Thomas Behm, Mn/DOT
Thomas.Behm@state.mn.us

Administrative Liaison:
Alan Rindels, Mn/DOT
Alan.Rindels@state.mn.us

Principal Investigators:
Omar Smadi, Iowa State University
Neal Hawkins, Iowa State University

PROJECT COST:
$18,720

Surveying pavement markings can help local agencies identify and prioritize the need for restriping, saving money and resources.

MINNESOTA DEPARTMENT OF TRANSPORTATION

RESEARCH SERVICES
OFFICE OF POLICY ANALYSIS, RESEARCH & INNOVATION

State of Practice for Minnesota Local Agency Pavement Marking Management

Investigators surveyed Minnesota local transportation agencies regarding their practices for managing pavement markings and produced recommendations for best practices in this area.

What Was the Need?

In 2007 the FHWA held two workshops to get input from city, county and state transportation agencies about future changes to the Manual on Uniform Traffic Control Devices standards related to pavement marking retroreflectivity. In April 2010, the FHWA published text for the proposed pavement marking retroreflectivity standard. The new rule will apply to all local agencies with jurisdiction over public roads and sets minimum standards for the design and maintenance of pavement markings.

Currently, each local agency in Minnesota has its own policy and procedures for measuring the quality of markings (for example, how much of the marking remains on the road and how well the marking reflects light at night); determining when to replace them; selecting the appropriate material; and deciding how to perform the replacement. Once the rule-making process is complete, agencies across the state will be responsible for assuring that pavement markings meet or exceed the new minimum criteria. By identifying and sharing best practices for pavement markings, each agency will be able to improve roadway safety, reduce costs, and identify and implement standards to comply with new MUTCD rules.

What Was Our Goal?

This project's objective was to review and document existing pavement marking practices by local agencies in Minnesota, including material selection, installation, specifications and contracting procedures. This inventory and analysis would then be used to develop recommendations for pavement marking management best practices, and all findings would be shared with Minnesota's cities and counties.

What Did We Do?

Researchers first sent a short survey electronically to all of Minnesota's local transportation agencies to determine how each agency places pavement markings, what marking materials are used on new pavement and seal coat surfaces, and what marking materials are used for striping maintenance. From the 48 agency responses, nine counties and six cities representing a mix of different practices were selected for follow-up phone surveys. Agencies were interviewed to provide more detailed information about marking material selection, application processes, contracting procedures, specifications and quality control procedures.

Researchers then compiled and analyzed the results of the phone survey, working with experts on the project Technical Advisory Panel and Local Road Research Board members to identify best practices and develop recommendations for cost-effectively improving the quality and life expectancy of pavement markings.

What Did We Learn?

The initial survey of all local agencies in Minnesota found that:

- A majority of cities and counties use private contractors to install pavement markings.
- A majority of respondents use either latex or epoxy to stripe new or overlaid pavement segments.

continued

"This report serves as a method of sharing valuable information between local agencies throughout the state. It is part of a learning process where cities and counties can look to the report and gain ideas that will enhance safety."

–Lee Amundson,
Lincoln County Engineer

"Pavement markings are a low-cost safety solution. Preliminary results from a nationwide study have shown that 6-inch pavement markings reduce all crashes by 3 percent."

–Mark Vizecky,
Mn/DOT State Aid Program Support Engineer

Produced by CTC & Associates for:
Minnesota Department
of Transportation
Research Services Section
MS 330, First Floor
395 John Ireland Blvd.
St. Paul, MN 55155-1899
(651) 366-3780
www.research.dot.state.mn.us

Using GIS technology to create pavement marking plans (shown here for St. Louis County) was among the best practices identified in this project.

- Nearly all respondents use latex for new seal coat surfaces.

The phone surveys provided more detailed information, finding that:

- Only approximately half of the agencies surveyed perform assessments to determine their annual paint program.
- The vast majority of counties employ private contractors to apply pavement markings; for cities, this was still the most common response, but less dramatically so.
- Most agencies use Mn/DOT standard specifications for materials and application.

Researchers found that the best method of assessing pavement markings is to conduct an annual nighttime and daytime survey to evaluate the quality of markings; this can save money on actual replacement cost. For example, in 2009 Washington County began using a nighttime survey method and as a result, it striped 23 percent less than in 2008.

Researchers recommend storing information from pavement surveys in a geographic information systems database to allow for easier review and decision making and to serve as a tool to communicate future striping needs. Researchers also noted that the use of in-house crews instead of contract crews has the benefit of flexible scheduling and minimized concerns over quality control.

The report emphasized that local agencies face a variety of challenges when it comes to managing pavement markings. Smaller localities often do not have the resources or the need to stripe as much as larger cities and counties. Each agency has developed different solutions for its needs within the limits of the agency's resources. The information obtained from this research and shared with local agencies can serve as a tool for each agency to make the most effective decisions with regard to cost and quality.

What's Next?

This project highlighted the need for continued information sharing between Minnesota's cities and counties and Mn/DOT regarding best pavement marking practices. Researchers recommend development of a training course to communicate pavement marking options readily available in the state. Future projects could document the best practices for each material type, exploring costs and identifying an approach for choosing one over another.

This Technical Summary pertains to the LRRB-produced Report 2010-05, "Minnesota Local Agency Pavement Marking Practices—Phase 1," published February 2010. The full report can be accessed at http://www.lrrb.org/PDF/201005.pdf.

2010-25TS
Published October 2010

RESEARCH SERVICES

OFFICE OF POLICY ANALYSIS, RESEARCH & INNOVATION

TECHNICAL SUMMARY

Technical Liaison:
Glen Ellis, Mn/DOT
Glen.Ellis@state.mn.us

Administrative Liaison:
Shirlee Sherkow, Mn/DOT
Shirlee.Sherkow@state.mn.us

Principal Investigator:
Howard Preston,
CH2M HILL, Inc.

PROJECT COST:
$37,512

Variables such as uphill grades of more than 3 percent can shorten deceleration distances by 10 percent to 20 percent.

Putting Research into Practice: Guidelines for Designing Turn Lanes

Investigators assembled a guide that identifies and analyzes the primary factors influencing turn lane design. The guide includes a step-by-step process to calculate safe and effective turn lane lengths based on the specific characteristics of each intersection.

What Was the Need?

Turn lanes need to be designed so that vehicles will have adequate time to decelerate and sufficient storage room while waiting to make a turn. Minnesota's "Road Design Manual" suggests that a typical full-width turn lane be 300 feet long, with an additional 180-foot taper section leading into the lane.

Higher traffic speeds and volumes along with an increase in the percentage of commercial vehicles throughout the system led to safety concerns and complaints from motorists that turn lanes were not providing adequate distance for deceleration. Some district design engineers in recent years consequently began using longer turn lane lengths, resulting in inconsistency across the Mn/DOT system. Recent Mn/DOT research has identified a variety of factors—speed, volume, intersection control and percentage of heavy commercial vehicles—to evaluate in determining appropriate turn lane design. These and other recently established best practices needed to be codified into new design documentation for Mn/DOT use.

What Was Our Goal?

The primary goals of this project were to document best practices in determining appropriate turn lane lengths, prepare guidelines detailing a recommended design process and develop new turn lane length guidelines for Mn/DOT.

What Did We Implement?

Investigators leveraged information from the Mn/DOT Research Report 2008-14, "Turn Lane Lengths for Various Speed Roads and Evaluation of Determining Criteria," the "AASHTO 2004 Green Book: A Policy on Geometric Design of Highways and Streets" and "NCHRP Report 650: Median Intersection Design for Rural High-Speed Divided Highways" to create a new design process for determining turn lane lengths.

How Did We Do It?

Investigators reviewed existing research to identify how variables such as turn lane location, vehicle speeds, volume, type of intersection control, fraction of heavy commercial vehicles and roadway geometry affect turn lane storage capacity and room for deceleration. Working with a technical advisory committee composed of staff from Mn/DOT's Office of Traffic Safety and Technology, Metro District Design and the Office of Technical Support, investigators developed a process to determine optimal turn lane lengths that considered all of these factors.

Investigators then created a turn lane design checklist and provided example calculations for each of eight Mn/DOT facility types and locations: conventional or expressway, signalized and unsignalized in both rural and urban settings.

What Was the Impact?

The resulting guide provides design engineers with step-by-step guideline worksheets for determining safe and functional turn lane lengths based on the specific characteris-

continued

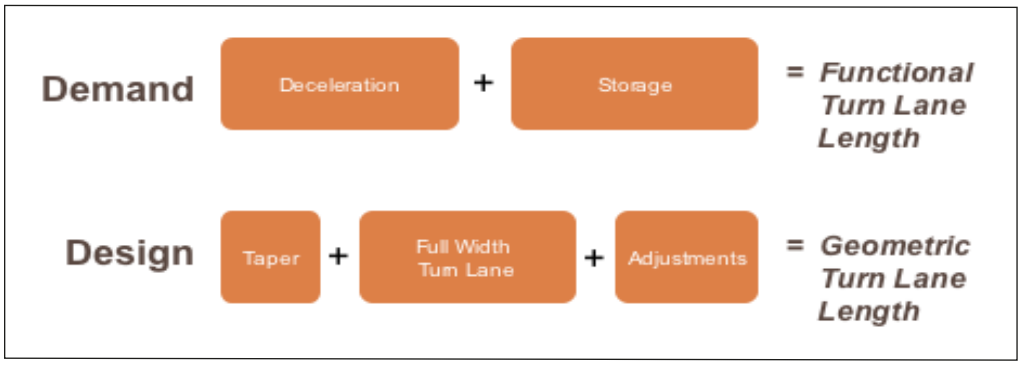
"Longer turn lanes, based on the new design process, will allow motorists to get out of thru lanes earlier, have greater opportunity for deceleration and have more storage room, which will lead to safer intersections with fewer crashes."

–Glen Ellis,
Senior Project Engineer, Mn/DOT Metro District Design

"These guidelines provide a resource for designers that will allow greater consistency between the length of turn lanes and traffic and roadway characteristics."

–Howard Preston,
Senior Transportation Engineer, CH2M HILL, Inc.

Produced by CTC & Associates for:
Minnesota Department
of Transportation
Research Services Section
MS 330, First Floor
395 John Ireland Blvd.
St. Paul, MN 55155-1899
(651) 366-3780
www.research.dot.state.mn.us



Turn lane length is ultimately calculated by combining the functional turn lane length with the geometric length.

tics of each intersection. The guide includes detailed descriptions and illustrations of the five-step process, including:

- Collect data: Identify design speed, forecasted traffic volumes, percentage of heavy commercial vehicles, grade, seasonal variations in traffic volume, roadway geometry and corridor characteristics.
- Determine facility type and intersection control: Categorize each roadway as rural or urban and as conventional or expressway. Intersection control is either signalized or unsignalized.
- Calculate turn lane demand: Combine deceleration distance (determined by speed and facility type) with storage distance (based on intersection control) to equal the basic turn lane demand length.
- Calculate turn lane design: Determine taper length based on facility type and subtract from turn lane demand to identify length of the full-width turn lane.
- Make adjustments and create final turn lane design: Adjust taper length if the intersection is located on a horizontal curve. Calculate adjustments for grade, commercial vehicle volume, use of dual turn lanes, local constraints and corridor consistency.

Sample calculations using the new design process demonstrate that there is no standard turn lane length applicable to all facility types and locations. Many intersections now require much more than the previously recommended 300 feet of turn lane length to be safe and effective. Analyzing individual characteristics of each intersection will result in turn lanes that provide appropriate distances for safe deceleration and storage, which are tailored for each intersection.

What's Next?

The guide produced by this project has been distributed to Mn/DOT design engineers and will be presented by Glen Ellis, Senior Project Engineer for Mn/DOT Metro District Design, at the Statewide Design Engineers Meeting in November 2010. The next step is for Mn/DOT's Design Advisory Committee to review the guide and determine how to incorporate it into Minnesota's "Road Design Manual."

This Technical Summary pertains to Report 2010-25 "Design of Turn Lane Guidelines," published July 2010. The guide can be accessed at http://www.lrrb.org/PDF/201025.pdf.

The research cited as source material for this guide includes "Turn Lane Lengths for Various Speed Roads and Evaluation of Determining Criteria," "NCHRP Report 650 Median Intersection Design for Rural High-Speed Divided Highways" and "AASHTO 2004 Green Book: A Policy on Geometric Design of Highways and Streets."

2010-36TS
Published October 2010

TRANSPORTATION POOLED FUND PROGRAM

TECHNICAL SUMMARY

Mn/DOT Technical Liaison:
Jerry Kotzenmacher
Jerry.Kotzenmacher@state.mn.us

Mn/DOT Administrative Liaison:
Deb Fick, Mn/DOT
Deb.Fick@state.mn.us

Principal Investigator:
Erik Minge, SRF Consulting Group

PROJECT COST:
$210,000

Mn/DOT CONTRIBUTION:
$15,000

PARTICIPATING STATES:
CT, FL, GA, HI, IA, ID, IL, MN, MS, MT, NY, OH, TX, WI

Members of the pooled fund study's Technical Advisory Committee toured the shelter at Mn/DOT's permanent test site.

RESEARCH SERVICES

OFFICE OF POLICY ANALYSIS, RESEARCH & INNOVATION

Pooling Our Research: Evaluating Non-Intrusive Traffic Detection Technologies

Continuing with research that began in 1994, pooled fund TPF-5(171) evaluated the accuracy of the newest generation of non-intrusive traffic detection technologies that collect speed and volume data, and have the added capability of gathering classification data.

What Was the Need?

Transportation agencies collect traffic data to spot areas of congestion and forecast future infrastructure investments. Today, the most commonly used technology for traffic monitoring is the inductive loop detector. While accurate, loop detectors require road closures for installation and maintenance. Non-intrusive sensors provide an alternative that meets the accuracy of loop detectors and offers other benefits. Rather than requiring installation in the pavement, these sensors are placed above, beneath or to the side of the roadway. This means safer installation and maintenance, no disruption in traffic flow, and the added bonus of gathering more than vehicle-presence data.

Mn/DOT's interest in non-intrusive traffic detection dates back to 1994, when it collaborated with the Federal Highway Administration to launch the first of two projects that evaluated emerging technologies; a second study concluded in 2002. The two projects evaluated 26 sensors representing eight technologies and compared them to roadway-embedded technologies.

FHWA's national Transportation Pooled Fund Program provided an optimal method for Mn/DOT to lead a coalition of states to further pursue this line of research.

What Was Our Goal?

The objective of this pooled fund study was to conduct field tests of the latest generation of non-intrusive traffic sensors to assess their accuracy in detecting volume, speed and vehicle classification by length and axle configuration under a variety of conditions.

What Did We Do?

Researchers conducted a literature search to identify sensors to include in the study. Among the five products tested were:

- Two optical sensors that are installed on the side of the roadway: Peek Traffic Corporation's AxleLight and the Transportable Infra-Red Traffic Logger, or TIRTL, side-fire laser sensor from Control Specialists Company. Both of these systems are axle-based sensors that detect vehicle presence when wheels break the laser's beam, and can also collect speed and classification data.
- Miovision Technologies Inc.'s Video Collection Unit, a video sensor that includes a telescoping mast that can be attached to an existing pole or mounted as part of a stand-alone tripod system and a sensor that performs similarly to loop detectors.
- Canoga Microloop sensors from Global Traffic Technologies. These magnetic sensors are installed under the roadway in conduit bored from the roadway shoulder and gather data on volume, speed and vehicle length.
- SmartSensor HD (Model 125) from Wavetronix LLC, a radar sensor with a detection range of 250 feet that measures volume, speed, classification and other traffic parameters.

continued

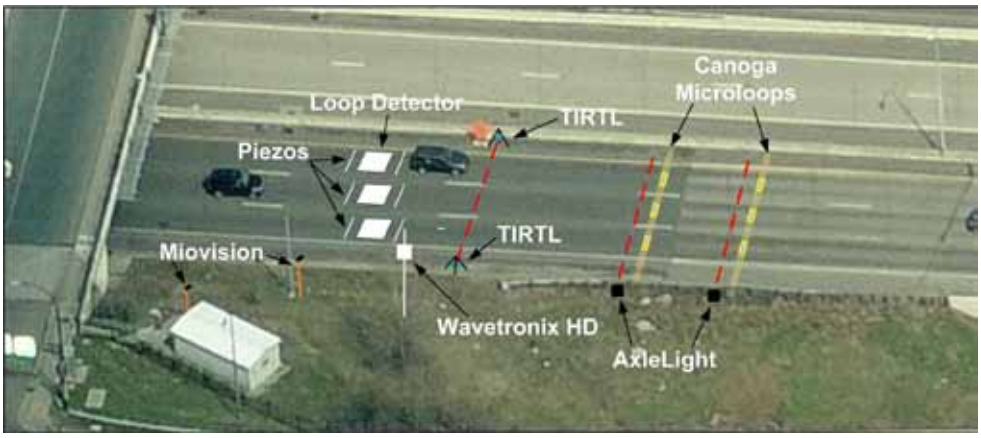
"There are some things one product can do better than others. Agencies should think about the type of data that's most important to them, and then look at each product's accuracy and cost to make the best choice for their needs."

—Jerry Kotzenmacher,
Senior Engineering Specialist, MnDOT Office of Safety, Traffic and Operations

"Newer non-intrusive traffic detectors have more capabilities than ever, and required us to conduct a detailed per-vehicle analysis to better understand the subtleties of observed errors in the products we tested."

—Erik Minge,
Senior Associate, SRF Consulting Group

Produced by CTC & Associates for:
Minnesota Department of Transportation
Research Services Section
MS 330, First Floor
395 John Ireland Blvd.
St. Paul, MN 55155-1899
(651) 366-3780
www.research.dot.state.mn.us



This shows the layout of Mn/DOT's permanent test site located at Penn Avenue and I-394 near downtown Minneapolis. Researchers gathered baseline data and most of the test data for the five products examined in the study at this site.

Researchers evaluated four types of data: volume, axle-based classification, length-based classification and speed. Much of the testing occurred at Mn/DOT's permanent test site located near downtown Minneapolis.

An additional test evaluated the Miovision sensor's ability to perform for intersection turning movement counts. Researchers conducted hourly and 24-hour testing during periods of heavy congestion and varying weather and lighting conditions. Baseline data collected at the Mn/DOT test site using loop detectors, video cameras and manual counts were compared with results from the sensors tested.

What Did We Learn?

While the sensors tested in the current project performed better than sensors tested in Phase I and Phase II with regard to accuracy of speed and volume data, the additional classification capabilities generated mixed results. The length-based sensors were generally able to report accurate vehicle lengths. However, the lack of a presence detector caused axle-based sensors to erroneously classify tailgating passenger vehicles as four-axle trucks. A presence sensor can be used in conjunction with axle-based laser sensors to overcome classification irregularities, or an agency can modify its classification algorithm to properly reflect traffic flow.

What's Next?

Mn/DOT and many other agencies are already using some of the technologies tested in this study. Mn/DOT offices and programs with an interest in traffic detection—including traffic engineering, traffic forecasting and analysis, Minnesota Guidestar, Mn/DOT's Intelligent Transportation Systems program and the Regional Transportation Management Center—can use these research results to validate current use of the tested technologies, make adjustments to data analysis recommended by the research or make the case for deployment of a new technology.

This Technical Summary pertains to Report 2010-36, "Evaluation of Non-Intrusive Technologies for Traffic Detection," published September 2010, produced to conclude Pooled Fund TPF-5(171). The final report can be found at http://www.lrrb.org/PDF/201036.pdf, *and details of the pooled fund effort can be found at* http://pooledfund.org/projectdetails.asp?id=398&status=4 *and* http://portal.srfconsulting.com/NITPhase3.

2010RIC02TS
Published September 2010

LRRB
LOCAL ROAD RESEARCH BOARD

TECHNICAL SUMMARY

Technical Liaison:
Michael Sheehan, Olmstead County
Sheehan.Michael@co.olmsted.mn.us

Administrative Liaison:
Clark Moe, Mn/DOT
Clark.Moe@state.mn.us

Principal Investigators:
Mike Marti, SRF Consulting Group
Renae Kuehl, SRF Consulting Group

IMPLEMENTATION PROJECT COST:
$25,992

Handheld contact reflectometers can accurately measure retroreflectivity and are usually used with other inspection methods.

MINNESOTA DEPARTMENT OF TRANSPORTATION

RESEARCH SERVICES
OFFICE OF POLICY ANALYSIS, RESEARCH & INNOVATION

Putting Research into Practice: Establishing a Sign Retroreflectivity Maintenance Program

Investigators created a toolkit consisting of sample letters and a summary of FHWA guides to help assist Minnesota local agencies in complying with the FHWA's requirements regarding a sign retroreflectivity maintenance program.

What Was the Need?

While only about a quarter of road travel happens at night, half of all traffic fatalities occur during this time. These fatalities often involve departures from the roadway caused by decreased nighttime visibility. Critical to preventing such crashes is the retroreflectivity of road signs, which is their ability to bounce light from vehicle headlights back to a driver's eyes, making signs appear brighter and easier to see and read.

Retroreflectivity of traffic signs deteriorates with time, so highway agencies need to actively maintain signs to ensure that they remain clearly visible at night. To that end, the Federal Highway Administration recently revised the Manual on Uniform Traffic Control Devices to establish minimum requirements for the retroreflectivity of traffic signs and set deadlines for implementing them.

By January 2012, agencies must establish a sign maintenance program to identify signs that lack the minimum required level of retroreflectivity. By January 2015, agencies must replace deficient regulatory, warning and ground-mounted guide signs, excluding street name signs, and by January 2018, street name and overhead guide signs that fail to meet these standards must be replaced. These requirements apply to all agencies, regardless of size, including townships and cities with a population of less than 5,000.

There are a number of different options for establishing a sign maintenance program, and not all local agencies in Minnesota had begun a program to comply with FHWA requirements. The Local Road Research Board needed a toolkit to inform agencies of these deadlines and help each agency create a sign maintenance plan appropriate to its budget, resources and sign inventory.

What Was Our Goal?

The goal of this project was to develop a sign retroreflectivity toolkit designed to provide Minnesota local governments, especially small cities and townships, with guidance on FHWA's sign retroreflectivity requirements and deadlines as well as resources they can use to meet these deadlines.

What Did We Implement?

This project supplements FHWA's Sign Retroreflectivity Toolkit, an interactive online resource that assists local agencies in establishing a sign maintenance program that best meets their needs. The technical advisory committee for the current project reviewed this toolkit and provided feedback to FHWA regarding its usability, eliciting several updates before the toolkit was released to the public.

How Did We Do It?

Investigators synthesized the new FHWA retroreflectivity standards and consulted with a technical advisory panel and county engineers to determine the needs of local agencies and the information that would best help them meet the FHWA requirements. Then they used this feedback to create a toolkit with a variety of resources, including:

continued

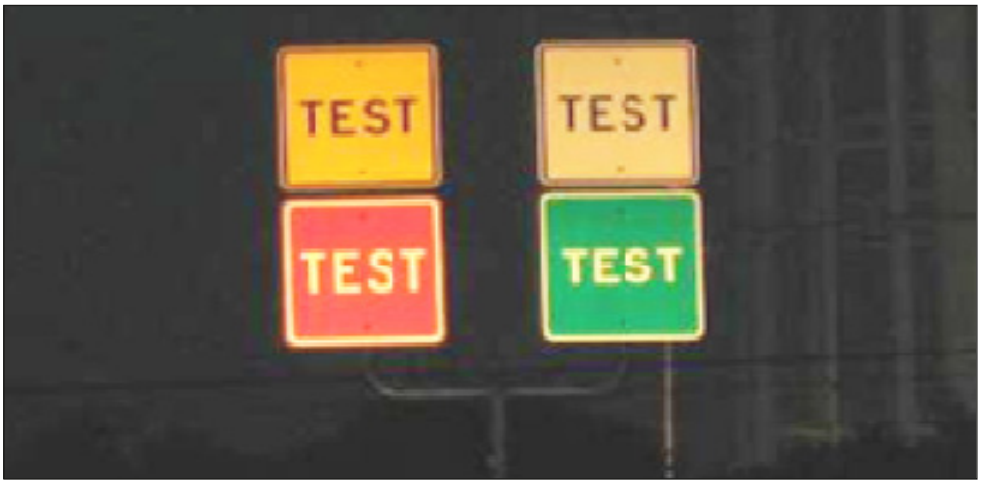
"This toolkit will make the process of complying with FHWA's retroreflectivity requirements simpler and easier to understand for local agencies."

–Renae Kuehl,
Associate, SRF Consulting Group

"Because local agencies have limited budgets and varying circumstances, it's important that they be given all the available options for customizing a sign maintenance program to meet their specific needs."

–Michael Sheehan,
Olmsted County Engineer

Produced by CTC & Associates for:
Minnesota Department
of Transportation
Research Services Section
MS 330, First Floor
395 John Ireland Blvd.
St. Paul, MN 55155-1899
(651) 366-3780
www.research.dot.state.mn.us



Control signs involve monitoring the performance of a sample set of signs that are representative of a part of an agency's inventory. When the retroreflectivity levels of these signs approaches minimum levels, agencies replace all signs in the field associated with these control signs.

- Communication materials to be sent by county engineers to small local agencies within their county to notify them of retroreflectivity requirements and resources and then to follow up to stress the importance of addressing these requirements.
- A MN MUTCD Requirements document summarizing official minimum retroreflectivity requirements in Minnesota.
- A summary of relevant FHWA guides, including Methods for Maintaining Traffic Sign Retroreflectivity and appendices in Know Your Retro 2007 detailing methods for assessing and managing sign retroreflectivity.

What Was the Impact?

This project produced a promising toolkit for helping Minnesota local agencies to meet these retroreflectivity standards cost-effectively and within FHWA's deadlines. Options for sign management described in the toolkit include:

- Visual nighttime inspection by a trained sign inspector.
- Measurement using a retroreflectometer.
- Expected sign life, based on past experience, of sign retroreflectivity degradation in a given geographic area.
- Blanket replacement, in which all signs within a given area are replaced at specified intervals.
- Control signs, in which signs are replaced based on the performance of a sample of control signs.

The Minnesota toolkit includes a one-page summary of procedures for each of these methods, and also includes examples of sign inventory and management plans.

What's Next?

City and county engineers have been informed of the online availability of this toolkit by email; they can now use the provided letter templates to inform other agencies within their communities. Investigators have presented this information at several conferences and plan to conduct further presentations in the future. By adequately maintaining the retroreflectivity of signs, agencies can help improve highway safety and prevent roadway crashes.

This Technical Summary pertains to the LRRB-produced Report 2010RIC02, "Sign Retroreflectivity: A Minnesota Toolkit," published March 2010. The full report can be accessed at http://www.lrrb.org/PDF/2010RIC02.pdf.

The information being implemented via this project can be found in the FHWA's "Sign Retroreflectivity Toolkit" at http://safety.fhwa.dot.gov/roadway_dept/night_visib/retrotoolkit.

2010RIC10TS
Published September 2010

LRRB
LOCAL ROAD RESEARCH BOARD

TECHNICAL SUMMARY

Technical Liaison:
Mark Vizecky, Mn/DOT
Mark.Vizecky@state.mn.us

Administrative Liaison:
Clark Moe, Mn/DOT
Clark.Moe@state.mn.us

Principal Investigator:
Howard Preston, CH2M HILL, Inc.

IMPLEMENTATION PROJECT COST:
$74,985

One way to measure sign retroreflectivity is by using a retroreflectometer like the one shown above.

MINNESOTA DEPARTMENT OF TRANSPORTATION

RESEARCH SERVICES
OFFICE OF POLICY ANALYSIS, RESEARCH & INNOVATION

Putting Research into Practice: Best Practices Guide for Removing Traffic Signs

Investigators assembled a guide that provides key information regarding the effectiveness of traffic signs. The guide also details steps to reduce sign management costs by designing and implementing a policy to remove unnecessary signs.

What Was the Need?

Recently published Federal Highway Administration regulations require all traffic signs to meet new minimum retroreflectivity standards. As a result, localities are investing time and effort studying their systems of traffic signs and considering alternative maintenance techniques. A series of township workshops and road safety audits conducted over the past several years identified two key challenges: First, local road agencies do not have the funds to maintain their existing sign inventory, and second, in many cases local agencies have far more signs than are needed.

One alternative maintenance technique not previously explored in detail is the removal of signs that engineering studies have determined to be unnecessary. Local engineers expressed concerns regarding liability of removing signs and the lack of research available documenting actual effectiveness of signs. A document was needed that addressed these concerns and provided information regarding the development of a sign maintenance and removal policy.

What Was Our Goal?

The goal of this project was to identify perceived roadblocks to removing unnecessary signs and to develop a best practices guide based on that information. The guide would address technical issues and provide guidelines for developing policies for removing unnecessary signs.

What Did We Implement?

Investigators used information gathered from more than 20 road safety audits, evaluations of an individual township's entire road system, a pilot sign replacement program that funded sign replacement in six Minnesota counties, and a variety of research reports. Research included the Mn/DOT Transportation Research Synthesis "Effectiveness of Traffic Signs on Local Roads" and a Wisconsin DOT document, "Effectiveness of 'Children at Play' Warning Signs." Investigators also relied on the Minnesota Manual on Uniform Traffic Control Devices, or MN MUTCD.

How Did We Do It?

Investigators first identified relevant literature dealing with the effectiveness of specific types of traffic signs, legal issues related to sign installation and risk management, and sign management techniques. Investigators met with city and county engineers to identify their concerns regarding the removal of traffic signs and also met with attorneys representing city, county and township insurance trusts to understand the possible linkage between traffic sign removal and tort liability.

What Was the Impact?

The project resulted in the Best Practices for Traffic Sign Maintenance and Management guide that local road agencies can use to develop and implement appropriate sign management policies. The first portion of the guide:

continued

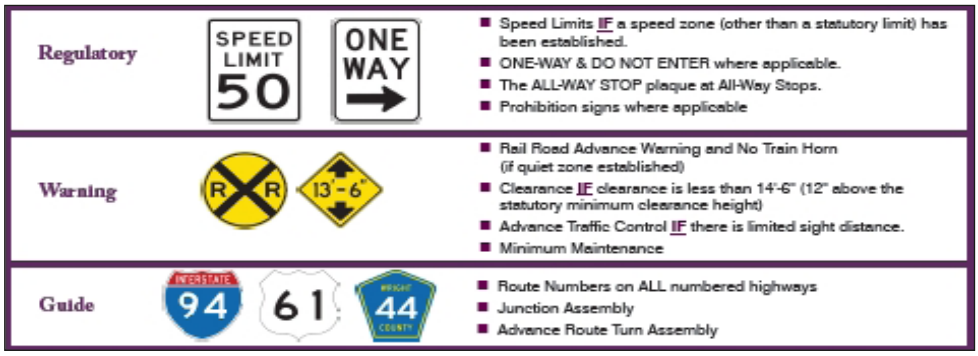
"This guide provides local engineers with information and reinforcement to talk to the public at large and explain why, in some circumstances, sign removal makes sense and can be a good thing."

–Mark Vizecky,
Traffic Safety Support Engineer, Mn/DOT State Aid Division

"If you look at the research, there is little proof that signs affect driver behavior or reduce crashes. Before localities put up a sign, they need to determine whether it is actually effective."

–Howard Preston,
Senior Project Engineer, CH2M HILL, Inc.

Produced by CTC & Associates for:
Minnesota Department
of Transportation
Research Services Section
MS 330, First Floor
395 John Ireland Blvd.
St. Paul, MN 55155-1899
(651) 366-3780
www.research.dot.state.mn.us



Out of the hundreds of signs contained in the MN MUTCD, only 13 types of signs are actually required. This means that the majority of signs are installed based on engineering judgment and not MN MUTCD requirements.

- Provides specific information regarding the new retroreflectivity requirements and compliance dates.
- Reviews different assessment methods, including visual and measured assessment. This section also discusses different management methods, from the blanket replacement of all signs to replacement based on the performance of a small sample of control signs.
- Details the cost of compliance for townships, cities and counties based on the size of sign inventory and the replacement schedule and method.

The guide then focuses on reducing costs associated with sign maintenance and management by reducing the agency's sign inventory. Research is presented regarding the level of effectiveness of regulatory, warning and guide signs. For example, research shows that "Children at Play" signs neither change driver behavior nor improve safety; other potential candidates for removal in certain situations are Deer Crossing, Intersection Ahead and Pedestrian Crosswalk signs.

Finally, the guide details a process to manage risks associated with sign removal. Immunity from potential liability is generated by localities taking actions consistent with adopted policies and ordinances and by exercising and documenting engineering judgment as part of an engineering study. The guide recommends that before any signs are removed, localities have the highest decision-making body pass a resolution specifying types of signs that will be installed and those that will not (which would then be candidates for removal), conduct an engineering study, document applicable MN MUTCD guidance and conditions in the field, and document actions taken (installing or replacing signs versus removing signs).

Three six-hour training sessions covering the entire guide were held with more than 150 city, county and township officials.

What's Next?

Feedback was provided from the original training sessions and minor changes are being made to the final guide. An additional 2,600 copies will be printed and distributed to all Minnesota cities and counties and to the association of townships. The Minnesota Local Technical Assistance Program has four additional trainings planned in fall 2010 and will continue outreach associated with this guide.

This Technical Summary pertains to the LRRB-produced implementation product 2010RIC10, "Minnesota's Best Practices for Traffic Sign Maintenance and Management," published September 2010. The guide can be accessed at http://www.lrrb.org/pdf/2010RIC10.pdf.

2010RIC13TS
Published September 2010

LRRB
LOCAL ROAD RESEARCH BOARD

TECHNICAL SUMMARY

Technical Liaison:
Gary Danielson, Kandiyohi County
Gary_D@co.kandiyohi.mn.us

Administrative Liaison:
Clark Moe, Mn/DOT
Clark.Moe@state.mn.us

Principal Investigators:
Mark Marti, SRF Consulting Group
Renae Kuehl, SRF Consulting Group

IMPLEMENTATION PROJECT COST:
$54,495

Bullnose guardrails have a distinctive U-shaped design to prevent vehicles from crashing into bridge supports on medians or falling into openings between side-by-side bridges.

MINNESOTA DEPARTMENT OF TRANSPORTATION

RESEARCH SERVICES
OFFICE OF POLICY ANALYSIS, RESEARCH & INNOVATION

Putting Research into Practice: Maintaining Guardrails for Roadside Safety

Investigators created a guide summarizing proper inspection and maintenance practices for guardrails and end treatments currently used in Minnesota, updating an obsolete manual and helping Minnesota local agencies reduce costs while increasing roadway safety.

What Was the Need?

In Minnesota, about 18 percent of the 79,095 vehicle crashes in 2008 involved run-off-road crashes, and 36 percent of these resulted in a fatality or personal injury. Key to protecting against the disproportionate dangers of run-off-road crashes are guardrails—longitudinal roadside barriers designed to prevent an errant vehicle from colliding with fixed objects or taking a dangerous, off-roadway course.

Also important are guardrail end treatments, designed to protect vehicles that hit the ends of guardrails rather than the sides. For many years, the ends of guardrails were twisted down toward the ground to prevent the spearing of vehicles during head-on collisions. Because this design has a ramp effect that can lead to vehicle rollovers, these guardrails are gradually being replaced with plate-beam terminals that shield vehicles from guardrail ends.

Consequently, guardrail maintenance is a key component of roadside safety. Guardrails must be quickly repaired or replaced when damaged by crashes or deterioration. However, many Minnesota local and county agencies were uncertain how to maintain the various guardrails and end treatments currently in use, and there were no standard guidelines to ensure that maintenance practices were consistent throughout the state.

What Was Our Goal?

The goal of this project was to summarize the proper inspection and maintenance practices for guardrails and end treatments currently used in Minnesota.

What Did We Implement?

These guidelines were developed to replace *Mn/DOT Research and Implementation Series Number 14*, "Guardrails, End Treatments and Transitions," which includes some obsolete hardware and does not include all of the latest guardrail and end treatment types currently used in Minnesota.

How Did We Do It?

To create these guidelines, investigators adapted the comprehensive reference manual from National Highway Institute Course No. 380034A, "Design Construction and Maintenance of Highway Safety Features and Appurtenances."

What Was the Impact?

Investigators created a resource for local agencies to decide when to fix or replace damaged guardrails. This guide details inspection and maintenance procedures for the four types of guardrails used in Minnesota on both low- and high-volume roads:

- W-beam and thrie-beam barriers: The W-beam—named because of the shape created by the corrugations in its plates—is the most commonly used plate beam guardrail in Minnesota and the nation. It consists of a semirigid beam mounted on wood or steel

continued

"This guide will contribute to saving lives by helping agencies keep guardrails in repair and will save costs by encouraging maintenance practices that allow guardrails to be replaced less frequently."

–Renae Kuehl,
SRF Consulting Group

"This guide will be an excellent quick reference for county engineers, among whom there are significant differences in knowledge and expertise concerning guardrail replacement and maintenance."

–Gary Danielson,
Kandiyohi County Engineer

Produced by CTC & Associates for:
Minnesota Department
of Transportation
Research Services Section
MS 330, First Floor
395 John Ireland Blvd.
St. Paul, MN 55155-1899
(651) 366-3780
www.research.dot.state.mn.us

The SRT-350 slotted rail terminal is one of seven end treatments currently used in Minnesota and is designed to prevent spearing during a head-on collision by deflecting the vehicle behind the guardrail. This system provides an easy upgrade on obsolete installations.

posts, and bends to resist the impact of vehicles while limiting lateral deflection. The thrie-beam is a stronger and wider version of the W-beam, with one additional corrugation in its plates.

- Cable barriers: This system is composed of cables held by weak wood or steel posts, and designed as an inexpensive way to capture or redirect errant vehicles before they cross medians into oncoming traffic.
- Bullnose rail systems: Bullnose rail systems consist of a thrie-beam guardrail modified for use at bridge overpasses and underpasses, using curved sections to protect vehicles from either crashing into bridge supports or falling into the opening between side-by-side bridges.
- Concrete barriers: These barriers are used on high-speed roadways in locations where little or no deflection can be tolerated, such as medians, bridge rails and bridge supports.

For each of these barriers, the report details procedures for:

- Basic inspection, conducted periodically to ensure that barriers are not significantly damaged.
- In-depth inspection, carried out when roadways are reconstructed or extensively repaired to determine whether guardrails are compatible with the new road design, existing traffic conditions and the latest guardrail standards, or should be upgraded to improve safety.
- Routine maintenance, including occasionally replacing or adjusting parts.
- Crash-related maintenance, performed to repair crash damage. In the case of severe damage, barriers should be upgraded to the latest standards.

The guide also describes maintenance procedures for the seven guardrail end treatments currently used in Minnesota and includes links to resources and standards for decision support and installation of roadside protection devices as well as a one-page quick-reference guide to each guardrail and end treatment type.

What's Next?

This guide will be available to county agencies via the Web and includes access to the extensive manual for the National Highway Institute course on which it is based. By eliminating uncertainty among county and local agencies about the maintenance of a critical roadside safety feature, the guide is a key component of Minnesota's Toward Zero Deaths campaign, which seeks to create a culture that helps eliminate traffic fatalities and serious injuries.

This Technical Summary pertains to the LRRB-produced implementation product 2010RIC13, "Guardrail Replacement and Maintenance Guidelines," published March 2010. This guide can be accessed at http://www.lrrb.org/PDF/2010RIC13.pdf.

The research being implemented via this project can be found mainly in Mn/DOT Research and Implementation Series Number 14, "Guardrails, End Treatments and Transitions," published August 1993, and available at http://www.ctre.iastate.edu/mndot_ors/detail.cfm?productID=110.

2010-SPR-2(207)TS
Published September 2010

TRANSPORTATION POOLED FUND PROGRAM

TECHNICAL SUMMARY

Mn/DOT Technical Liaison:
Brian Kary
Brian.Kary@state.mn.us

Mn/DOT Administrative Liaison:
Deb Fick, Mn/DOT
Deb.Fick@state.mn.us

TOTAL AGENCY CONTRIBUTIONS TO DATE:

$4,862,267

Mn/DOT CONTRIBUTIONS THROUGH 2011:

$350,000

PARTICIPATING STATES:

AZ, CA, CT, DE, FL, GA, ID, IL, IN, KS, KY, MI, MN, MO, NE, NV, NJ, NY, NC, PA, RI, TN, TX, UT, VA, WA, WI, I-95 CORRIDOR COALITION, RTC OF SOUTHERN NEVADA (FAST) AND FHWA

This I-35W changeable message sign, controlled by Mn/DOT's Regional Transportation Management Center, updates drivers about current driving conditions.

RESEARCH SERVICES

OFFICE OF POLICY ANALYSIS, RESEARCH & INNOVATION

Pooling Our Research: Improving Transportation Management Center Performance

SPR-2(207): Transportation Management Center Pooled Fund Study. *This ongoing study provides technical guidance, best practices, training, innovative techniques and technologies, and fact-based tools to help transportation management centers improve services and performance.*

Why a Pooled Fund Study?

Transportation management centers are used by public agencies to monitor and report on roadway and travel conditions, coordinate with local agencies to respond to changing conditions, and proactively manage and control traffic to mitigate the impacts of congestion and improve the reliability of travel.

Led by the Federal Highway Administration, the Transportation Management Center pooled fund study was established in 2000 to deal with agencies' limited resources and the increasing complexity involved in managing and operating TMCs. The study serves as a forum for regional, state and local agencies to coordinate investments that will improve the safety, mobility and productivity of travel.

The 30 members of the TMC pooled fund study include 27 state DOTs, two regional agencies and FHWA. The level of commitment may vary based on agency size and type, with the desired annual contribution for each agency set at $50,000; the minimum commitment is $25,000.

What is the Pooled Fund Study's Goal?

This study identified six critical initiatives to direct the selection of projects that will develop the resources and tools needed to address challenges faced by TMCs:

- Improving day-to-day operations
- Enhancing business management
- Developing TMCs and managing their evolution
- Developing and delivering roadway and travel condition information
- Developing, training, hiring and contracting TMC staff and services
- Sharing knowledge and information

What Have We Learned?

Every year, TMC study members propose projects for funding consideration and select projects to fund. To date, 18 projects have been completed, and 12 projects are under way or scheduled to begin soon. Mn/DOT's Regional Transportation Management Center, which serves as the TMC for the Twin Cities Metropolitan Area freeways, uses TMC study research to help meet Mn/DOT's goal of providing motorists with faster, safer trips on metro area freeways.

Highlighted below are a few TMC pooled fund projects that are contributing to the development of current Mn/DOT initiatives:

- A TMC pooled fund study that reviewed state DOT best practices for operating changeable message signs on freeways is proving to be a valuable resource as Mn/DOT

continued

"Mn/DOT gets not only the benefits of specific research projects from the TMC pooled fund study, but also invaluable benefits from participating in a forum that helps us connect with peers operating similar centers across the country."

–Brian Kary,
Freeway Operations Engineer, Mn/DOT Regional Transportation Management Center

"The TMC pooled fund has led to valuable collaborations. Caltrans' use of Mn/DOT's open-source Intelligent Roadway Information System software is just one example where Mn/DOT and Caltrans are benefiting from collaborating with study partners."

–Jim Kranig,
Director, Mn/DOT Regional Transportation Management Center

Produced by CTC & Associates for:
Minnesota Department of Transportation
Research Services Section
MS 330, First Floor
395 John Ireland Blvd.
St. Paul, MN 55155-1899
(651) 366-3780
www.research.dot.state.mn.us

Mn/DOT's original Traffic Management Center, built in 1972, served as the first central control facility to manage the Twin Cities Metropolitan Area freeway system. Today, Mn/DOT's Regional Transportation Management Center is one of the most successful and comprehensive facilities of its kind in the country.

updates its current CMS guidelines. The national level TMC study documents the empirical evidence that relates CMS messaging to driver behavior, traffic, travel flow and safety. Mn/DOT can use this information to validate provisions in its own CMS manual.

Related studies that address driver use of real-time travel information and the impacts of dynamic CMS messaging will also prove helpful in updating Mn/DOT's CMS manual.

- In 2006, the U.S. DOT launched the Integrated Corridor Management Initiative to help curb congestion. This concept involves integrating freeways, arterial streets and transit systems to optimize performance of each system. Mn/DOT is deploying an integrated corridor on the west side of Minneapolis centered on I-394, a commuter path for travelers coming in and out of the Twin Cities. A handbook produced by a TMC study project that examined ways to integrate freeway and arterial traffic management systems provided input as Mn/DOT developed the corridor.

What's Going On Now?

The TMC study produces more than traditional research. Collaboration among study partners is another key benefit, with the California Department of Transportation's (Caltrans') experimental use of Mn/DOT's open-source advanced traffic management system software providing just one example. Operating costs are low with this free, full-featured software and its ancillary General Public License. More important, the open-source license provides Mn/DOT, Caltrans and any other state DOT access to all software enhancements made by users. Benefits will expand as more users implement this open-source software.

What's Next?

One of the projects approved at the TMC study's May 2010 annual meeting examines the design and operation of dynamic shoulder lanes in the United States and worldwide. This study is of particular interest to Mn/DOT, with its recent deployment of a priced dynamic shoulder lane on I-35W near downtown Minneapolis. The first of its kind in the United States, this project involves using the shoulder as a high-occupancy toll lane during peak periods, allowing transit, carpoolers and motorcycles to use the lane for free; single-occupancy vehicles can use the lane for a fee. The upcoming research project will help Mn/DOT assess the design of this lane configuration and assist in deploying similar lanes throughout the Twin Cities Metropolitan Area.

This Technical Summary pertains to the ongoing Pooled Fund SPR-2(207), Transportation Management Center Pooled Fund Study. Details of this effort can be found at http://www.pooledfund.org/projectdetails.asp?id=106&status=6 *and* http://tmcpfs.ops.fhwa.dot.gov/index.cfm.

For more than 25 years, FHWA's Transportation Pooled Fund Program has been providing state DOTs and other organizations the opportunity to collaborate in solving transportation-related problems. The TPF Program is focused on leveraging limited funds, avoiding duplication of effort, undertaking large-scale projects and achieving broader dissemination of results on issues of regional and national interest.

2010-TPF-5(029)TS
Published January 2011

TRANSPORTATION POOLED FUND PROGRAM

TECHNICAL SUMMARY

Mn/DOT Technical Liaison:
Brian Kary
Brian.Kary@state.mn.us

Mn/DOT Administrative Liaison:
Deb Fick
Deb.Fick@state.mn.us

TOTAL STATE CONTRIBUTIONS TO DATE:

$1,940,000

Mn/DOT CONTRIBUTIONS TO DATE:

$225,000

PARTICIPATING STATES:

CA, GA, MD, MA, MN, NJ, NY, TN, VA, WA

Typical dynamic message toll signs, for use with HOT lanes, inform drivers as to whether lanes are open and of applicable tolls for single occupant vehicles.

RESEARCH SERVICES

OFFICE OF POLICY ANALYSIS, RESEARCH & INNOVATION

Pooling Our Research: Reducing Congestion with HOV Toll Lanes

Why a Pooled Fund Study?

As populations grow and traffic in urban areas increases, current highway infrastructure capacity is being outstripped by demand, and congestion is increasingly a problem. One critical method for combating congestion is the use of high-occupancy vehicle lanes. HOV lanes have minimum vehicle occupancy requirements set to provide an incentive for carpooling.

HOV lanes have been used to manage congestion in the United States for more than 30 years, and currently there are more than 130 HOV facilities operating on more than 1,000 miles of freeway within 27 metropolitan areas. The Minneapolis-St. Paul metro area HOV facilities are among the few to have implemented high-occupancy tolling. HOT lanes allow vehicles with only one occupant to use an HOV lane for a toll that varies dynamically based on peak travel times in the HOT lanes. This toll is collected automatically via electronic transponder and is also enforced with the help of advanced electronic systems.

HOV facilities present state highway agencies with significant operational challenges, including enforcement, safety, pricing and general policies. Because these challenges are similar among states, in 2002 the High Occupancy Vehicle/Managed Use Lane pooled fund study was established to help states cooperate in addressing them.

TPF-5(029): High Occupancy Vehicle/ Managed Use Lane Pooled Fund Study. *Since 2002, this study has allowed states to address key challenges common to public agencies responsible for managing and operating HOV facilities by providing an avenue to collectively develop more efficient HOV operations methods.*

What is the Pooled Fund Study's Goal?

The objective of this pooled fund study is to identify and address the key issues and challenges common to public agencies responsible for managing and operating HOV facilities, including issues related to planning, design, implementation and management.

What Have We Learned?

HOV/MUL projects focus on critical program, policy, technical and other issues that arise throughout the life cycle of an HOV facility. They involve such activities as conducting research and operational tests, preparing technical guidance and recommending practices, and developing training and pursuing technology transfer initiatives. Recently completed projects include:

- HOV Facility Performance Monitoring, Evaluation and Reporting Handbook, which developed guidance on evaluating the need for HOV facilities, initiating and sustaining them, and managing the information generated by monitoring and evaluating their performance. Minnesota HOV lanes served as a useful model for other states.
- Automated Vehicle Occupancy Technologies Study, which identified, compiled and systematically evaluated the latest concepts, methods and technologies available worldwide for automated vehicle occupancy detection.
- Implications of Pricing on Existing HOV Lanes, which developed a technical document that identifies the technical, institutional and organizational implications of converting HOV to HOT lanes, and provides guidance on planning and implementing pricing techniques.

continued

"This project is extremely important to Mn/DOT, informing our efforts as we continue to develop our HOV system and expand it into other corridors."

—Jim Kranig,
Director, Mn/DOT
Regional Transportation
Management Center

"This pooled fund study allows Mn/DOT to benefit from information gained both from networking with DOTs facing similar challenges and from the many handbooks developed by its projects."

—Brian Kary,
Freeway Operations
Engineer, Mn/DOT
Regional Transportation
Management Center

Produced by CTC & Associates for:
Minnesota Department
of Transportation
Research Services Section
MS 330, First Floor
395 John Ireland Blvd.
St. Paul, MN 55155-1899
(651) 366-3780
www.research.dot.state.mn.us

Mn/DOT's enforcement methods for HOV sections of I-394 include double white stripe pavement markings, police patrols and various electronic methods for determining whether vehicles with a single occupant have a MnPass transponder to pay tolls.

What's Going On Now?

On an ongoing basis, this study provides member states with an opportunity to share information and best practices to improve the current state of the practice related to the management, operation and performance of HOV facilities. Current projects include:

- HOV Lane Hours of Operations and Eligibility Requirements, which is developing a handbook of best practices for assessing specific policy-level choices and trade-offs related to setting and changing HOV lane eligibility, operating periods and access restrictions.
- HOV Lane Safety Considerations Handbook, which is developing a technical document addressing issues and best practices for safety enhancements of HOV facilities.
- HOV Lane Enforcement Handbook, which is developing a handbook that provides an update of the state of the practice on HOV enforcement, expanding previous reference material and focusing on the use of advanced technologies for enforcement.

What's Next?

This pooled fund study is expected to continue to at least 2015, with members meeting annually to prioritize, develop and select new projects. Projects to begin soon include:

- Identification and Analysis of Current Dynamic Pricing Schemes, to identify, review, compare and synthesize the current dynamic pricing schemes for HOT lane operations.
- Benefit/Cost Analysis of Value Pricing Projects, to provide transportation agencies and legislators with a summary of the societal benefits and costs associated with value pricing projects around the nation.
- Dynamic Speed Design Elements, to investigate the design and applications of dynamic speed control devices.

With one of the first metropolitan HOV systems in the country to be converted to HOT systems, Minnesota is a role model and stands to benefit from this pooled fund's continuing development of more efficient methods for HOV operations management.

This Technical Summary pertains to the ongoing Pooled Fund TPF-5(029), High Occupancy Vehicle/Managed Use Lane. Details of this effort can be found at http://pooledfund.org/projectdetails.asp?id=17&status=6 *and* http://hovpfs.ops.fhwa.dot.gov.

For more than 25 years, FHWA's Transportation Pooled Fund Program has been providing state DOTs and other organizations the opportunity to collaborate in solving transportation-related problems. The TPF Program is focused on leveraging limited funds, avoiding duplication of effort, undertaking large-scale projects and achieving broader dissemination of results on issues of regional and national interest.

2010-TPF-5(099)TS
Published August 2010

TRANSPORTATION POOLED FUND PROGRAM

TECHNICAL SUMMARY

Mn/DOT Technical Liaison:
David Engstrom
David.Engstrom@state.mn.us

Mn/DOT Administrative Liaison:
Deb Fick, Mn/DOT
Deb.Fick@state.mn.us

TOTAL STATE CONTRIBUTIONS TO DATE:

$3,135,000

Mn/DOT CONTRIBUTIONS TO DATE:

$195,000

PARTICIPATING STATES:

AZ, CA, CT, FL, GA, IL, IN, IA, KS, KY, MD, MA, MN, MS, MO, MT, NY, NC, ND, OK, PA, SC, SD, TN, TX, UT, VA, WI

One method that has been used to reduce crashes that occur on two-lane roadway segments is to provide a center two-way left-turn lane.

RESEARCH SERVICES

OFFICE OF POLICY ANALYSIS, RESEARCH & INNOVATION

Pooling Our Research: Cost-Effective Strategies for Making Roads Safer

Why a Pooled Fund Study?

To reduce fatalities and the severity of roadway crashes, Mn/DOT and other state agencies frequently use low-cost safety strategies such as signage enhancements, left-turn lane treatments, run-off-road crash countermeasures and curve visibility improvements.

However, a 2004 National Cooperative Highway Research Program study, Report 500, Volume 4: A Guide for Addressing Head-On Collisions, concluded that these strategies will remain unproven until rigorous before-and-after studies confirm their effectiveness.

To remedy this knowledge gap, states came together to evaluate these strategies nationwide, by implementing them at sites in various states and comparing crash data before and after installation. With participation from 28 states, the program is studying more than 20 of these strategies over 10 years.

TPF-5(099): Evaluation of Low Cost Safety Improvements. *With participation from 28 states, this program is conducting a 10-year evaluation of more than 20 low-cost strategies for making roads safer by reducing crashes and crash severity.*

What is the Pooled Fund Study's Goal?

The goal of this program is to rigorously evaluate the effectiveness of low-cost strategies recommended by *NCHRP Report 500* for improving the safety of highways.

What Have We Learned?

The program is proceeding in six phases. Phases I, II and IV are complete; Phases III and V are in progress; and a sixth phase will be added in the near future.

In Phase I of the program, completed in 2008, researchers evaluated existing low-cost safety improvement strategies. These included:

- Safety Evaluation of Center Two-Way Left-Turn Lanes on Two-Lane Roads: Two-way left-turn lanes are used to reduce rear-end, head-on and turning-related crashes occurring on two-lane roads by removing vehicles from the primary travel lane while waiting to turn. They also reduce head-on collisions by providing a buffer between opposing directions of travel. Results showed these treatments to be effective at reducing crashes, were most effective at rural intersections and were most cost-effective at two-lane rural locations. The full report can be accessed at http://www.tfhrc.gov/safety/pubs/08042/index.htm.
- Safety Evaluation of Increasing Retroreflectivity of STOP Signs: Used to make drivers more aware of STOP signs at unsignalized intersections, increasing retroreflectivity showed promise for reducing crashes, particularly at lower volume intersections, and is a very low-cost treatment. The full report can be accessed at http://www.fhwa.dot.gov/publications/research/safety/08041/index.cfm.
- Safety Evaluation of STOP AHEAD Pavement Markings: Results showed that STOP Ahead pavement markings show promise as a cost-effective method of making drivers aware of unsignalized intersections. Crash data sources included 158 sites in Minnesota. The full report can be accessed at http://www.fhwa.dot.gov/publications/research/safety/08043/.

continued

"Some of the low-cost strategies we're interested in include adjustment of pavement lane and shoulder widths and delineation of curves for approaching drivers. As this project produces more data, Mn/DOT can choose the most cost-effective means for making its roads safer."

–David Engstrom,
State Traffic Engineer,
Mn/DOT Office of Traffic,
Safety and Technology

"This project supports Mn/DOT's Toward Zero Deaths program, aimed at reducing deaths and severe crashes on our roads. Finding low-cost improvements that can be deployed systemwide is key to the program's success."

–Sue Groth,
State Traffic Engineer,
Mn/DOT Office of Traffic,
Safety and Technology

Produced by CTC & Associates for:
Minnesota Department
of Transportation
Research Services Section
MS 330, First Floor
395 John Ireland Blvd.
St. Paul, MN 55155-1899
(651) 366-3780
www.research.dot.state.mn.us

Many unsignalized intersections may be unexpected or not visible to approaching drivers. Consequently, enhancing their visibility by providing pavement markings with supplementary messages such as "STOP AHEAD" may help alert drivers and reduce crashes.

- Safety Evaluation of Flashing Beacons at STOP-Controlled Intersections: Results showed that beacons are effective at reducing crashes by alerting drivers to intersections. The full report can be accessed at http://www.tfhrc.gov/safety/pubs/08044/index.htm.

In Phase II of the study, completed in 2009, researchers studied offset left-turn lanes, advance street name signing, curve treatments and lane-width/shoulder-width combinations. In Phase IV, completed in 2009, researchers conducted simulations of:

- Low-cost safety improvements for curves, including chevrons, post-mounted delineators and light-emitting-diode-mounted delineators, all designed to enhance the visibility of curves at night.
- Low-cost safety improvements for small towns, including bulb-outs, chicanes and medians, all designed to slow traffic while driving through small towns.

Publication of results for Phases II and IV is pending.

What's Going On Now?

In Phase III, to be completed in October 2010, researchers are evaluating strategies that keep vehicles from encroaching on the roadside, minimize their likelihood of crashing into an object or overturning if they travel beyond the shoulder of the road, and reduce the severity of crashes when they do occur. Several pooled fund member states volunteered to implement these strategies at 20 to 30 sites in 2009 and 2010, including surface friction treatments on curves on two- or four-lane roads and ramps, in-lane pavement markings for curve warnings, optical speed bars at curves, larger chevrons and edgeline rumble strips on curves.

What's Next?

While the project originally consisted of four phases, a fifth phase was added to this study in March 2009 to study more low-cost strategies, and a sixth phase will be added in the near future. As it moves forward, this pooled fund study will help achieve the Mn/DOT and national goals to reduce fatality rates and save lives. The cost-benefit analyses produced by this study will help Mn/DOT and other state departments of transportation prioritize their safety improvements depending on both circumstances and budget.

This Technical Summary pertains to the ongoing Pooled Fund TPF-5(099), Evaluation of Low Cost Safety Improvements. Details of this effort can be found at http://www.pooledfund.org/projectdetails.asp?id=332&status=4 *and* http://www.tfhrc.gov/safety/evaluations/.

For more than 25 years, FHWA's Transportation Pooled Fund Program has been providing state DOTs and other organizations with the opportunity to collaborate in solving transportation-related problems. The TPF Program is focused on leveraging limited funds, avoiding duplication of effort, undertaking large-scale projects and achieving broader dissemination of results on issues of regional and national interest.

2010-TPF-5(114)TS
Published September 2010

TRANSPORTATION POOLED FUND PROGRAM

TECHNICAL SUMMARY

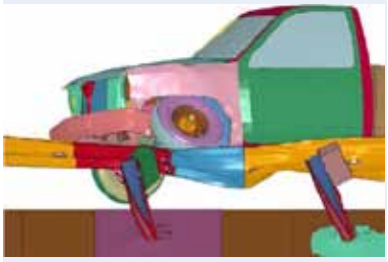
Mn/DOT Technical Liaison:
Mike Elle
Michael.Elle@state.mn.us

Mn/DOT Administrative Liaison:
Deb Fick, Mn/DOT
Deb.Fick@state.mn.us

TOTAL STATE CONTRIBUTIONS TO DATE:
$1,240,000

Mn/DOT CONTRIBUTIONS TO DATE:
$250,000

PARTICIPATING STATES:
AK, CA, LA, MN, PA, TN, TX, WA



The program's evaluation of roadside structures often includes both field crash testing of existing structures and computer simulations of possible design improvements before they are tested again in the field.

RESEARCH SERVICES

OFFICE OF POLICY ANALYSIS, RESEARCH & INNOVATION

Pooling Our Research: Making Roadsides Safer

Why a Pooled Fund Study?

Critical to reducing the dangers of vehicle crashes in Minnesota—including the severity of injuries and the chance of fatalities—is the design of safety structures into which vehicles collide after leaving the road, such as guardrails, median barriers and breakaway supports.

To help make these roadside structures as safe as possible, in 1993 the Federal Highway Administration adopted uniform standards for crash-testing them, defined in *National Cooperative Highway Research Program Report 350*. Because all states were mandated to use these standards, the most efficient approach to crash-testing roadside structures was to pool resources rather than duplicate efforts. To this end, in 2005 Mn/DOT and seven other states led by Washington created the Roadside Safety Research Program pooled fund study.

TPF-5(114): Roadside Safety Research Program. *This study was established in 2005 to crash-test and evaluate the design of roadside structures. More than 25 projects have been completed that support Minnesota's goal to reduce fatalities and serious injuries on its roads.*

What is the Pooled Fund Study's Goal?

The purpose of this effort is to crash-test and evaluate the design of roadside structures, including bridge rails; guardrails; transitions; median barriers; portable concrete barriers; end treatments; crash cushions; culverts; work zone traffic control devices; and breakaway support structures such as sign supports, light posts and mailboxes. Research also addresses the influence on single vehicle collisions of highway features such as driveways, slopes, ditches, shoulders, medians and curbs.

What Have We Learned?

The program has committed more than $1 million in research funding to more than 25 projects in various stages of completion, all of which have been performed by the Texas Transportation Institute. Member states also develop and fund their own projects, taking advantage of reduced overhead under the pooled fund agreement to make these projects more efficient and cost-effective.

Research has included in-service performance evaluation studies; computer simulations; clinical analyses; analysis of real-world crash data; cost-benefit analyses; and the development of guidelines for the use, selection and placement of roadside structures. By participating in this consortium, Mn/DOT has benefited from the research of other states and reduced the costs of its own roadside safety research.

Completed projects investigated new technologies to cost-effectively meet NCHRP Report 350 criteria:

- Minnesota Swing-Away Mailbox, which tested an Mn/DOT swing-away mailbox support to determine if it complied with NCHRP-recommended criteria for breakaway supports.
- Long-Span Guardrail—Phases I-III, which developed a long-span guardrail design that is less expensive to construct than existing designs.
- High-Tension Cable, which evaluated the crash performance of high-tension cable median barriers under excessive impacts. The results may be used to develop cable barrier placement guidelines.

continued

"By participating in this study, Mn/DOT is leveraging the contributions of other states to create safer roadways in Minnesota."

–Mike Elle,
Mn/DOT Design Standards Engineer

"This pooled fund study is integral to Minnesota's Toward Zero Deaths initiative, which seeks to create a culture in which fatalities and serious injuries are no longer acceptable."

–Deb Fick,
Research SP&R Administrator, Mn/DOT Research and Library Services

Produced by CTC & Associates for:
Minnesota Department of Transportation
Research Services Section
MS 330, First Floor
395 John Ireland Blvd.
St. Paul, MN 55155-1899
(651) 366-3780
www.research.dot.state.mn.us

According to *NCHRP Report 350*, during crash testing, structures must be evaluated based on structural adequacy, occupant risk and vehicle trajectory after collision. To evaluate the vehicle trajectory in the crash test of a guardrail, a high-speed video camera captures a vehicle's collision in fractions of a second.

- W-Beam Guardrail Post Installation in Rock, which developed cost-effective guidelines for placement of W-beam guardrail posts in rock.
- Steel Posts Over Underground Structures, which developed a steel post design using a concrete slab that can be used to support guardrails where there are shallow underground obstructions.

What's Going On Now?

Current projects include:

- Development of a T-Intersection/Curved Guardrail System, which involves crash-testing short radius guardrail systems that can be used at intersections. A second phase will include the design, simulation and crash testing of a new system.
- Development of Field Applied Fittings for Cable Barrier and Conversion to High Tension, which is identifying and testing a new field application method for wire rope terminations on cable barrier systems, evaluating the benefits of converting the low-tension wire rope systems to higher tension systems, and performing related performance evaluations via crash testing.
- Crash Wall Design for Mechanically Stabilized Earth Retaining Wall, which involves designing and testing a crash wall to protect a mechanically stabilized earth structure from vehicular impact.
- U.S. 11 Lake Pontchartrain Bridge Rail Replacement, which involves developing a more cost-effective retrofit bridge rail design for use on the US 11 Lake Pontchartrain Bridge.
- F-Shape Concrete Barrier with Slotted Drain Holes, which is evaluating the geometry and placement of the drainage slots on a concrete F-shape barrier. Drainage is critical to vehicle safety on bridges during heavy rainfall.

What's Next?

On an annual basis, representatives from participating states gather to identify common research needs, select projects for funding and oversee the implementation of results. This group approved five additional research projects for the coming year, and a new solicitation was issued inviting more states to participate in the program. Funding for this pooled fund project runs through 2011.

This Technical Summary pertains to the ongoing Pooled Fund TPF-5(114), Roadside Safety Research Program. Details of this effort can be found at http://www.pooledfund.org/projectdetails.asp?id=345&status=4 *and* http://www.roadsidepooledfund.org.

For more than 25 years, FHWA's Transportation Pooled Fund Program has been providing state DOTs and other organizations the opportunity to collaborate in solving transportation-related problems. The TPF Program is focused on leveraging limited funds, avoiding duplication of effort, undertaking large-scale projects and achieving broader dissemination of results on issues of regional and national interest.

2010-TPF-5(144)TS
Published May 2010

TRANSPORTATION POOLED FUND PROGRAM

TECHNICAL SUMMARY

Mn/DOT Technical Liaison:
Ray Starr, Mn/DOT
Ray.Starr@state.mn.us

Mn/DOT Administrative Liaison:
Deb Fick, Mn/DOT
Deb.Fick@state.mn.us

Principal Investigator:
Daniel McGehee, University of Iowa

PROJECT COST:
$160,000

Mn/DOT CONTRIBUTION:
$80,000

PARTICIPATING STATES:
IA, MN

The DriveCam event-triggered video recording system was mounted on the windshield behind the rearview mirror of each participant's vehicle.

RESEARCH SERVICES

OFFICE OF POLICY ANALYSIS, RESEARCH & INNOVATION

Pooling Our Research: Enhancing Teen Driver Safety with Video Feedback Systems

TPF-5(144): Use of Video Feedback in Urban Teen Drivers. *Researchers evaluated whether using an event-triggered video system in vehicles could reduce safety-relevant driving errors made by newly licensed teens. Researchers found that video feedback was immediately effective, reducing safety-relevant events by 61 percent.*

What Was the Need?

Motor vehicle crashes have long been the leading cause of death for 16- to 19-year-olds, and fatal crashes are higher for teenagers than for any other segment of the population. These crashes are most frequent in the first six to 12 months of independent driving for newly licensed teens.

Addressing these issues requires obtaining a window into the everyday driving behaviors of these teens, and recent research has focused on doing so by placing event-triggered video systems and other monitoring technologies within their vehicles. These technologies can provide teens with feedback and facilitate parent mentoring of driving beyond the supervised learning phase. Research was needed to evaluate whether using these technologies during the first six months of independent driving would improve the safety of teen drivers by curtailing risk-taking behaviors and improving their awareness of hazards.

The national Transportation Pooled Fund Program, sponsored by the Federal Highway Administration and funded by interested state departments of transportation on a project-by-project basis, offered an opportunity for Mn/DOT to work with the Iowa Department of Transportation to study this issue, saving both agencies money.

What Was Our Goal?

The objective of this pooled fund study (TPF-5(144)) was to determine whether feedback from an event-triggered video system can reduce the number of safety-relevant driving errors made by newly licensed urban teens.

What Did We Do?

Study participants included 36 16-year-old Minnesota high school students who had received their driver's licenses within the previous six months and had been driving without supervision from one week to five months.

Researchers equipped participants' vehicles with a DriveCam event-triggered video recording system. This palm-sized device consists of accelerometers linked to two video cameras, one facing the windshield of the car and the other facing its interior. The device records video continuously, temporarily holding 20 seconds of data at a time in a memory buffer. When its accelerometers detect hard cornering, swerving or abrupt changes in speed, the system displays a blinking LED and writes this data permanently to an internal hard drive, including video covering 10 seconds before and after the event.

For the first six weeks of the study, researchers turned off the LED feedback mechanism to collect baseline data concerning driver behavior. During the subsequent 16 weeks, drivers' parents were provided with LED feedback as well as a weekly report card detailing these events and a CD containing the week's video recordings.

continued

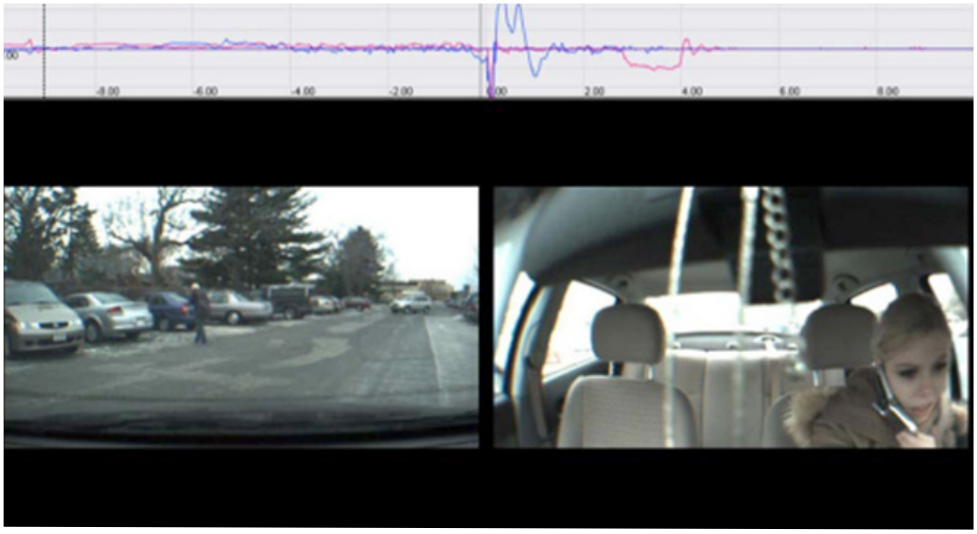
"Minnesota is very interested in these results, which will help Mn/DOT with its ongoing development of feedback solutions for reducing teen driving fatalities."

–Ray Starr,
Assistant State Traffic Engineer, Mn/DOT ITS

"This technology has the potential to save lives by reducing crashes involving loss of control during high-speed turns, which are a leading cause of injury and death for teens."

–Daniel McGehee,
Director, University of Iowa Human Factors and Vehicle Safety Research Program, Public Policy Center

Produced by CTC & Associates for:
Minnesota Department
of Transportation
Research Services Section
MS 330, First Floor
395 John Ireland Blvd.
St. Paul, MN 55155-1899
(651) 366-3780
www.research.dot.state.mn.us



The DriveCam system uses accelerometers to measure changes in vehicle velocity and lateral forces acting on the vehicle when cornering. If acceleration or deceleration exceeds a threshold value, an event is triggered and a video recording of it is saved.

After 16 weeks, 16 of the original 36 participants remained in the study. Eight of these participated in the feedback phase for a supplementary 24-week period. All 16 teen drivers participated in a final six-week phase without feedback to assess whether feedback-induced changes in behavior persisted.

Finally, researchers analyzed this data by classifying events into several categories describing their characteristics, causes and context.

What Did We Learn?

Results showed that the video feedback was immediately and extremely effective, reducing the number of safety-relevant events by 61 percent overall, from an average of 21 to eight per 1,000 miles. These reductions continued after the feedback phase ended and were most dramatic in the category of improper turns and curves (the most represented scenarios in fatal car crashes), with a 78 percent decrease in the events between baseline phases. Feedback from the system was shown to increase communication between parents and teens regarding safety. User acceptance of the devices was extremely high, with 100 percent of subjects recommending this program to other teens.

What's Next?

This study has been published in the American Journal of Public Health, and some states are continuing to fund this line of research through TPF-5(207) Novice Teen Drivers: Million Mile Study by examining other driver populations (drivers younger than those allowed under Minnesota law) and the psychology of driver decisions; Eagan High School in Minnesota has provided support for this project. Researchers are also conducting a follow-up study, "Age Versus Experience in Video Feedback," to incorporate wireless transmission of data from its video feedback system and to improve on the current study and its predecessor by employing a control group of drivers that did not receive feedback; this will provide a baseline regarding how new drivers improve over their first six months of driving.

Some insurance companies are currently offering video feedback systems free to their customers. The results of this study have benefited Minnesota's teen driving efforts and its larger Toward Zero Deaths goal to reduce the number of fatalities to fewer than 400 in 2010. Teen driving is one of seven critical emphasis areas identified in Mn/DOT's Strategic Highway Safety Plan.

This Technical Summary pertains to the completed Pooled Fund TPF-5(144), "Use of Video Feedback in Urban Teen Drivers." Details of this effort, including a link to the final report, can be found at http://pooledfund.org/projectdetails.asp?id=372&status=23.

2010-TPF-5(193)TS
Published June 2010

TRANSPORTATION POOLED FUND PROGRAM

TECHNICAL SUMMARY

Mn/DOT Technical Liaison:
Mike Elle
Michael.Elle@state.mn.us

Mn/DOT Administrative Liaison:
Deb Fick
Deb.Fick@state.mn.us

TOTAL STATE CONTRIBUTIONS TO DATE:

Nearly $12,000,000

Mn/DOT CONTRIBUTIONS TO DATE:

$1,320,863

PARTICIPATING STATES:

CA, CT, FL, IA, IL, KS, MN, MO, MT, NE, NJ, NY, OH, SD, TX, WI

Computer simulations representing real-life impacts of vehicles with roadside structures reduce development costs by detecting design weaknesses before physical testing.

RESEARCH SERVICES

OFFICE OF POLICY ANALYSIS, RESEARCH & INNOVATION

Pooling Our Research: Innovative Technologies to Improve Motorist Safety During Roadside Crashes

TPF-5(193): Midwest States Pooled Fund Crash Test Program. *Now in its 19th year, this multistate pooled fund study is dedicated to making roadsides less hazardous to motorists by evaluating roadside safety hardware such as guardrails and median barriers.*

Why a Pooled Fund Study?

In 1974, a small research program was created to evaluate standard roadside safety hardware used by state highway agencies. Today, this program is an international leader in the development of innovative technologies for making run-off-road crashes less dangerous; these technologies include guardrails, bridge rails, transitions, median barriers and breakaway support structures.

Hosted at the University of Nebraska's Midwest Roadside Safety Facility, the dramatic growth of the program was made possible by the cooperation of a number of other states. In 1991 it was established as the Midwest States Pooled Fund Crash Test Program, and since then the number of participating states has grown from three to 16.

Mn/DOT leverages this cooperative effort by taking advantage of the MwRSF's on-demand crash-testing services. "The MwRSF is a great resource for us," said Mike Elle, Mn/DOT design standards engineer and pooled fund study technical liaison. "We can make specific requests to have our hardware tested for a reduced cost at a state-of-the-art facility. We also benefit from the MwRSF's development of original solutions and crash testing of hardware for other states."

What is the Pooled Fund Study's Goal?

The program is dedicated to making the roadside less hazardous to motorists by:

- Conducting performance evaluations of existing roadside safety features.
- Designing, developing and crash-testing new roadside hardware.
- Performing computer simulation modeling of vehicle impacts with roadside hardware.

What Have We Learned?

The MwRSF has developed numerous safety features that have been adopted nationwide and several that have been adopted internationally. These features have saved the lives of countless motorists across the nation over the last decade, and include:

- The Minnesota thrie-beam bullnose median terminal, developed using finite crash analysis computer modeling. The MwRSF is recognized as a leader in computer simulation modeling of roadside safety features.
- The Midwest Guardrail System, developed to better accommodate high-center-of-gravity light trucks by raising the standard rail height and making several other design changes. This system earned a Roadside Safety Award from the Roadside Safety Foundation and the Federal Highway Administration.
- Numerous other guardrail terminals, crash cushions, guardrail systems, approach guardrail transition systems, bridge rails and work zone devices.

Of the many projects involved in the development of these features, 10 were performed specifically at the request of Mn/DOT. The MwRSF also provides ongoing advice to Mn/DOT engineers concerning the safety of possible design changes.

continued

"The service provided by the MwRSF is excellent. When we wanted to develop a new bridge railing standard, we received prompt and detailed advice from the MwRSF based on its crash-test data."

–Paul Rowekamp,
Mn/DOT Bridge Standards & Research Engineer

"The safety products and crash-testing services produced by this effort will continue to benefit Minnesota, saving lives and money."

–Mike Elle,
Mn/DOT Design Standards Engineer

Produced by CTC & Associates for:
Minnesota Department
of Transportation
Research Services Section
MS 330, First Floor
395 John Ireland Blvd.
St. Paul, MN 55155-1899
(651) 366-3780
www.research.dot.state.mn.us

At Mn/DOT's request, the MwRSF currently is developing a guardrail with a breakaway steel post. The purpose of such posts is to make the impact of a vehicle less severe than it would be with a completely rigid object. While the guardrail failed in the test pictured above, the system passed a more recent test.

What's Going On Now?

The MwRSF is currently working on 20 pooled fund projects that may lead to changes in Mn/DOT standards:

- One project was requested by Mn/DOT to test breakaway steel posts for guardrails. Two others involve the development of breakaway supports for luminary and pedestrian signal poles, and may help Mn/DOT evaluate manufacturer safety standards.
- Six projects involve the development of the Midwest Guardrail System. This could help to resolve some roadside safety problems associated with the low-height system currently used.
- One project tested numerous roadside system hardware components that are used by Mn/DOT for its roadside safety projects.
- Two projects tested and evaluated the safety performance of vertical, F-shaped and temporary concrete barriers widely used in Mn/DOT work zones to separate the flow of traffic within a construction area.
- Three projects involve the development of a nonproprietary high-tension cable system for crashes involving vehicles crossing medians into oncoming traffic. Cable systems are one of the most cost-effective measures for reducing highway fatalities. Mn/DOT will use the results of this study to develop its own cable system design standards.
- Two projects evaluated roadside safety measures using a cost-effectiveness methodology that Mn/DOT may consider when selecting a roadside system evaluation method.
- Two projects evaluated precast concrete bridge railing systems and may affect Mn/DOT bridge design standards.
- One project tested nonproprietary box beam guardrail terminals, which may significantly reduce the cost and enhance the use of box beam guardrails in Minnesota.

What's Next?

Since its inception, the MwRSF has received more than $14 million in research funding, including support from the National Cooperative Highway Research Program. Under the NCHRP, the MwRSF is currently developing guidelines for the safety performance evaluation of roadside features; establishing warrants for the use of roadside safety structures; and conducting a long-term accident investigation study to better understand the causes of injuries and fatalities in run-off-road crashes.

This Technical Summary pertains to the ongoing Pooled Fund TPF-5(193), Midwest States Pooled Fund Crash Test Program, continuing the project initiated under SPR-3(017). Details of this effort can be found at http://pooledfund.org/projectdetails.asp?id=418&status=4 and http://engineering.unl.edu/specialty-units/mwrsf.

For more than 25 years, FHWA's Transportation Pooled Fund Program has been providing state DOTs and other organizations the opportunity to collaborate in solving transportation-related problems. The TPF Program is focused on leveraging limited funds, avoiding duplication of effort, undertaking large-scale projects and achieving broader dissemination of results on issues of regional and national interest.

2010-TPF-5(105)TS
Published January 2011

TRANSPORTATION POOLED FUND PROGRAM

TECHNICAL SUMMARY

Mn/DOT Technical Liaison:
Sheila Hatchell
Sheila.Hatchell@state.mn.us

Mn/DOT Administrative Liaison:
Deb Fick
Deb.Fick@state.mn.us

TOTAL STATE CONTRIBUTIONS TO DATE:
$1,290,000

Mn/DOT CONTRIBUTIONS TO DATE:
$100,000

PARTICIPATING STATES:
AZ, CA, CT, ID, IA, KS, LA, LACMTA, MI, MN, MS, MO, MT, NM, NY, OH, OR, PA, TN, WA, WI

TRB Special Report 284 called for establishing transportation knowledge networks in every region of the United States and at the federal level.

RESEARCH SERVICES

OFFICE OF POLICY ANALYSIS, RESEARCH & INNOVATION

Pooling Our Research: Increasing the Accessibility of Transportation Research

Why a Pooled Fund Study?

Mn/DOT and transportation agencies across the nation produce a vast amount of valuable research. Their performance depends in turn on the reliable and timely access to this research provided by transportation libraries, which collect and organize it for future use.

However, a large amount of the information needed by transportation practitioners often cannot be identified and retrieved when needed. Unlike many other disciplines the transportation industry has been hampered by a lack of investment in library and knowledge management infrastructure. It also has lacked a systematic approach to managing information and coordinating the efforts of regional libraries at a national level.

*TPF-5(105): **Transportation Library Connectivity.** This pooled fund study advances the collaboration of transportation libraries to make research more accessible, increasing the sharing of resources and the awareness of the importance of libraries to the performance of transportation agencies.*

To address the challenges of sharing transportation information resources, in 2000 staff at Mn/DOT's Office of Research Services began to discuss the establishment of a consortium of libraries within AASHTO Region III. This consortium was established in 2001 as the Midwest Transportation Knowledge Network through the cooperation of Mn/DOT, the Wisconsin Department of Transportation and the Midwest Regional University Transportation Center at the University of Wisconsin–Madison.

The objective of the MTKN was not only to improve access to transportation information resources in the Midwest, but to support the continued existence of a strong National Transportation Library created within U.S. DOT in 1998. It was hoped that NTL would eventually be able to coordinate regional TKNs and support the development of well-staffed, well-funded transportation libraries at the state and local levels throughout the United States. In the interim, to help advance and fund this vision, the Transportation Library Connectivity Pooled Fund Study was created in 2005.

What is the Pooled Fund Study's Goal?

The goal of this pooled fund study is to advance the accessibility and sharing of transportation library resources through better communication and coordination among state, federal, academic and private sector libraries.

What Have We Learned?

Since 2005, the Transportation Library Connectivity Pooled Fund Study has helped significantly change the transportation library landscape, expanding from the MTKN to a network of TKNs nationwide. The development of this national infrastructure has led to:

- Increased awareness of the value of library and information services and the importance of TKNs among transportation executives and practitioners. As a result, struggling libraries are now participating at a regional and national level, and two DOT libraries that had been eliminated were reinstated by their agencies. Critical to establishing this awareness was the "Transportation Librarian's Toolkit," developed to serve as a roadmap for establishing and developing library services and as an outreach tool.
- Increased library connectivity and access to information resources, resulting in more sharing of best practices within the transportation library community and cooperation

continued

"This pooled fund study provides travel funding for our librarians to attend its annual meetings, giving us continuing education and professional development opportunities and practical tools we can use to enhance our customer service."

—Sheila Hatchell,
Library Director, Mn/DOT Research Services

"Mn/DOT has been a leader in this pooled fund study, helping other members tremendously by sharing its expertise and forward-thinking approach to transportation library services."

—Maggie Sacco,
Consulting Librarian, Transportation Library Connectivity Pooled Fund Study

Produced by CTC & Associates for:
Minnesota Department
of Transportation
Research Services Section
MS 330, First Floor
395 John Ireland Blvd.
St. Paul, MN 55155-1899
(651) 366-3780
www.research.dot.state.mn.us

Mn/DOT's Library is the most comprehensive transportation resource in Minnesota, serving both Mn/DOT employees and other state transportation officials and practitioners. Its affiliation with the MTKN and national TKNs gives it access to the resources of more than 50,000 libraries.

in the collection, cataloging and sharing of resources. The Library Connectivity Pooled Fund Study has widened participation by state DOT libraries in the Online Computer Library Center—the world's largest library catalog—and the Transportation Libraries Catalog, which makes accessible the holdings of 36 transportation libraries in a single database. The National TKN Resource Sharing Pilot funded OCLC Resource Sharing subscriptions for TKN libraries, forming a national resource sharing network of nearly 50 transportation libraries and information centers.

What's Going On Now?

On an ongoing basis, the Transportation Library Connectivity pooled fund continues to promote the value of transportation libraries and facilitate their interconnectivity. It also:

- Provides individual technical assistance via site visits by the technical library services consultant to help establish higher quality bibliographic records, improve local workflows, place qualified librarians and select suitable integrated library systems.
- Advances the professional development and networking of member librarians by supporting their participation in conferences, workshops and webinars.
- Implements focused research and technology projects proposed by members on topics such as the Historical ASTM Standards Transfer Project, which rescued from destruction a complete set of historical ASTM standards at Washington State DOT Library.

What's Next?

The Transportation Library Connectivity study will continue to address the challenges facing transportation libraries outlined in 2006 in "TRB Special Report 284," focusing in particular on meeting the need for a sustained funding mechanism for TKNs. It will also adapt to the changing landscape of transportation library and information services so that it can continue to increase collaboration among the region's transportation libraries and so that managers, engineers and planners are better able to find and apply the most recent, credible and validated technical information to their current projects.

This Technical Summary pertains to the ongoing Pooled Fund TPF-5(105), Transportation Library Connectivity Pooled Fund, which will be continuing as TPF-5(237). Details of this effort can be found at http://www.pooledfund.org/projectdetails.asp?id=337&status=4, http://www.pooledfund.org/projectdetails.asp?id=466&status=4 *and* http://www.libraryconnectivity.org.

For more than 25 years, FHWA's Transportation Pooled Fund Program has been providing state DOTs and other organizations the opportunity to collaborate in solving transportation-related problems. The TPF Program is focused on leveraging limited funds, avoiding duplication of effort, undertaking large-scale projects and achieving broader dissemination of results on issues of regional and national interest.

2010-TPF-5(209)TS
Published January 2011

TRANSPORTATION POOLED FUND PROGRAM

TECHNICAL SUMMARY

Mn/DOT Technical Liaison:
Mike Leegard
Mike.Leegard@state.mn.us

Mn/DOT Administrative Liaison:
Deb Fick
Deb.Fick@state.mn.us

TOTAL STATE CONTRIBUTIONS TO DATE:
$1,197,404

Mn/DOT CONTRIBUTIONS TO DATE:
$75,000

PARTICIPATING STATES:
CA, ID, IA, MI, MN, MO, NY, OK, SC, TX

Through its National Transportation Training Resource website, the TCCC provides a continually expanding, searchable database of training products available nationwide.

RESEARCH SERVICES

OFFICE OF POLICY ANALYSIS, RESEARCH & INNOVATION

Pooling Our Research: The Transportation Curriculum Coordination Council

Why a Pooled Fund Study?

Building and maintaining the nation's highways require that agency and industry employees be well-trained and qualified. However, because of attrition and an aging workforce, there is a serious shortage of trained and experienced personnel. Further, since 2000 the law has required that all states receiving federal highway funding ensure the quality of their construction projects by training and certifying their highway construction inspectors, technicians and engineers.

To help agencies meet these workforce requirements without duplicating each other's efforts, the Transportation Curriculum Coordination Council was established in 2000 to create a training curriculum that draws from and consolidates resources from across the nation. The TCCC is a partnership between the FHWA and its National Highway Institute, AASHTO, five regional training and certification groups representing 46 state transportation agencies, and private industry. The five-year pooled fund study TPF-5(046) was established in 2002 to support the TCCC, and in 2009 TPF-5(209) was funded to continue the TCCC's efforts.

TPF-5(209): Transportation Curriculum Coordination Council. *This effort helps states train and certify personnel through national core curriculum and training materials for various transportation disciplines, providing the most comprehensive Web-based training resource available to the transportation community today.*

What is the Pooled Fund Study's Goal?

The objective of the TCCC is to support states' training and certification of transportation agency personnel by developing a national core curriculum and training materials for various transportation disciplines.

What Have We Learned?

The TCCC has developed a Core Curriculum Matrix composed of five program areas—Construction, Materials, Maintenance, Safety and Employee Development—and core competencies for a wide variety of disciplines within each subject area. The Matrix was developed with input from field practitioners, managers and industry representatives in several states, and includes training courses that agencies can use at no cost. Minnesota joined this pooled fund effort at its inception in 2002 to provide input on curriculum development using its own pre-existing training program so that the TCCC's activities would closely reflect Mn/DOT needs.

The Matrix is designed to be the most inclusive and comprehensive Web-based training resource available to the transportation community today. By using the Matrix, states can draw on a body of knowledge and training materials that are flexible enough to be adapted to their particular needs rather than developing individual training modules on the same subject. Agencies benefit from cost savings and the opportunity to share knowledge and training courses among states, and personnel benefits from broader opportunities for training and advancement.

Among the TCCC's training resources available through its partnership with the National Highway Institute are these recently developed courses:

- Construction Inspection, Workmanship and Quality, which is designed to help trans-

continued

"Through the TCCC, Mn/DOT was able to network with other agencies experiencing training issues as well as influence the development of TCCC courses to better suit Minnesota's needs."

—Cathy Betts,
Technical Certification Specialist, Mn/DOT Office of Construction and Contract Administration

"The TCCC offers a suite of trainings to supplement our courses, allowing us to meet federal regulations on training and certification in the most efficient and cost-effective way possible."

—Deb Fick,
Research SP&R Administrator, Mn/DOT Research Services

Through its partnership with the National Highway Institute, the TCCC helps states offer courses in flexible, blended-learning formats that include self-study portions along with instructor-led and group activities. It also sponsors conferences on training issues such as the recent Future of Training and New Technology conference in Austin, Texas.

portation professionals involved in the inspection of highway construction projects improve their understanding of the factors that contribute to high-quality products.

- Bridge Construction Inspection, which is designed to give bridge construction inspectors a basic knowledge of bridge construction procedures, an awareness of the problems that can arise during construction and how these factors will impact the safety and service life of the structure, and an understanding of the inspections that should be performed to confirm fulfillment of the construction contract.
- Pavement Preservation Online Guide and Training, which will provide participants with an introduction to the Pavement Preservation online guide created by Caltrans and the National Center for Pavement Preservation. The guide covers basic pavement preservation concepts as well as information about specific treatments to extend the life of asphalt pavements.

What's Going On Now?

TCCC courses currently under development include:

- Inspection of Bridge Rehabilitation, which will present innovative and state-of-the-art bridge rehabilitation technologies and procedures for a broad array of structural elements, including bridge decks, girders, piers and abutments.
- Maintenance Leadership Academy, which will provide intensive training for individuals rising to supervisory maintenance positions. Topics are expected to include pavement preservation, weather-related maintenance, maintenance management, equipment and personnel management, and project planning and selection.
- Environmental Factors in Highway Construction, which will familiarize construction teams with environmental concerns to be addressed as part of construction operations.

What's Next?

Upcoming training courses include Highway Maintenance Quality Assurance for State and Local Agencies, Understanding Benchmarking and Performance Measures, QA Specifications Development and Validation, and Structural Bolting. Other recently identified training needs include embankment inspection, basic earthwork for inspectors, placement and testing of self-consolidating concrete, and inspection of pipe installation. The Matrix is designed to be a living document that will grow as the program evolves; it will be updated periodically as new disciplines, course materials and technologies emerge.

This Technical Summary pertains to the ongoing Pooled Fund TPF-5(209), Transportation Curriculum Coordination Council, continuing the project initiated under TPF-5(046). Details of this effort can be found at http://www.pooledfund.org/projectdetails.asp?id=435&status=4, http://www.pooledfund.org/projectdetails.asp?id=299&status=6 *and* https://fhwaapps.fhwa.dot.gov/tccc/.

For more than 25 years, FHWA's Transportation Pooled Fund Program has been providing state DOTs and other organizations the opportunity to collaborate in solving transportation-related problems. The TPF Program is focused on leveraging limited funds, avoiding duplication of effort, undertaking large-scale projects and achieving broader dissemination of results on issues of regional and national interest.

Produced by CTC & Associates for:
Minnesota Department of Transportation
Research Services Section
MS 330, First Floor
395 John Ireland Blvd.
St. Paul, MN 55155-1899
(651) 366-3780
www.research.dot.state.mn.us

Produced by CTC & Associates for:

Minnesota Department of Transportation
Office of Policy Analysis, Research & Innovation
Research Services Section
MS 330, First Floor
395 John Ireland Blvd.
St. Paul, MN 55155-1800

(651) 366-3780
www.research.dot.state.mn.us

MINNESOTA DEPARTMENT OF TRANSPORTATION

LRRB
LOCAL ROAD RESEARCH BOARD

U.S. Department of Transportation
Federal Highway Administration

For more information, please visit:
Minnesota Department of Transportation: **www.dot.state.mn.us**
Mn/DOT Library: **www.dot.state.mn.us/library**
Minnesota Local Road Research Board: **www.lrrb.org**

Connect with us on Facebook, Twitter and LinkedIn:

www.facebook.com/MnDOTResearch

www.twitter.com/MnDOTResearch

www.linkedin.com
(Search "Groups" for "MnDOT Research – Minnesota Department of Transportation")