FY2012 Annual Report

July 2011 through June 2012

Minnesota Department of Transportation

RESEARCH SERVICES

Office of Policy Analysis, Research & Innovation

LRRB
LOCAL ROAD RESEARCH BOARD

Your Destination...Our Priority

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Minnesota Department of Transportation

RESEARCH SERVICES

FY2012 Annual Report

July 2011 through June 2012

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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 research reports completed in FY2012 and for help on the Technical Summaries and other elements in the *Minnesota Department of Transportation Research Services FY2012 Annual Report*.

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Linda Taylor,
Director, MnDOT Research Services

"Minnesota is committed to being a national leader in transportation innovation, and Research Services is a driving force in that effort."

—Thomas K. Sorel, MnDOT Commissioner

Director's Message

Welcome to the *Minnesota Department of Transportation Research Services FY2012 Annual Report*. This document has been issued to:

- Fulfill federal requirements to account for our research program's finances, progress and results from July 2011 through June 2012.
- Demonstrate our accountability and transparency to Commissioner Thomas K. Sorel, MnDOT's other leaders and district offices, the Local Road Research Board (LRRB), state government, the Legislature and Minnesota taxpayers.
- Disseminate research results to encourage implementation and make the most of Minnesota's research investments.

This report is divided into four main sections:

- An overview of Research Services that includes research and library highlights and statistics for FY2012, a summary of our vision and research management processes, a list of our key partnerships and a staff directory.
- A description of funding sources that support the research we manage, including Minnesota State Planning and Research (SP&R) funds, MnDOT and the LRRB. We have expanded reporting on the SP&R funded projects that MnDOT manages with project descriptions, impact statements and statuses of each project active during FY2012.
- A quick reference table of all active research contracts and multi-state pooled fund projects, providing summary financial information, contract dates and contact names. This table, along with summary financial information and program statistics, is also available as a separate publication—*Research Services FY2012 At-A-Glance*—for easy access.
- Two-page Technical Summaries of completed research projects, organized by research topic area. These comprise the bulk of this report.

New to this year's report are feature articles embedded within a number of sections. These articles highlight a specific aspect of research, illustrating the success of our products and relationships.

FY2012 in Brief

The Minnesota state government shutdown that occurred at the beginning of FY2012 substantially affected our program by stopping work on all contracts, terminating contracting capabilities through master agreements and instituting new auditing requirements. These circumstances led to project delays, additional time required to initiate new contracts and complications in our financial accounting, and their effects were felt well beyond the actual shutdown duration. An additional FY2012 challenge was the adoption of a new accounting system, which required a major report writing, quality assurance and training effort.

More than 400 MnDOT staff retired prior to the shutdown, leaving big holes in technical areas and requiring us to establish new relationships and procedures. In addition, Research Services faced the ongoing challenge of effectively communicating with our customers to ensure that the research we undertake reflects the most critical needs of Minnesota stakeholders.

We were able to successfully meet these challenges with updated systems and workflows that make Research Services run more smoothly and transparently. The library was awarded the American Library Association's 2012 **John Cotton Dana Library Public Relations Award** for its excellent service. MnDOT research resulted in awards such as the Center for Transportation Studies (CTS) Research Partnership Award for **Report 2011-04**, "Advanced LED Warning Signs for Rural Intersections Powered by Renewable Energy." We launched an effort to enhance Research Services' marketing strategy and capabilities that included conducting stakeholder interviews, surveys and focus groups to optimize our products and services to customers. We also increased production of Transportation Research Syntheses, which offer a quick-turnaround, low-paperwork option for fulfilling knowledge needs of MnDOT and local agency staff. This annual report represents the final step in our transition from calendar year reporting to fiscal year reporting, which brings us into better accord with Department record-keeping practices.

Please feel free to contact me or any Research Services staff member for more information about any of the topics described in this report. We are happy to help you identify your research needs, and we can often provide you the information you need through our library services or a Transportation Research Synthesis. Where more extensive research is required, we can guide you through the process of requesting a research or implementation project.

Linda Taylor
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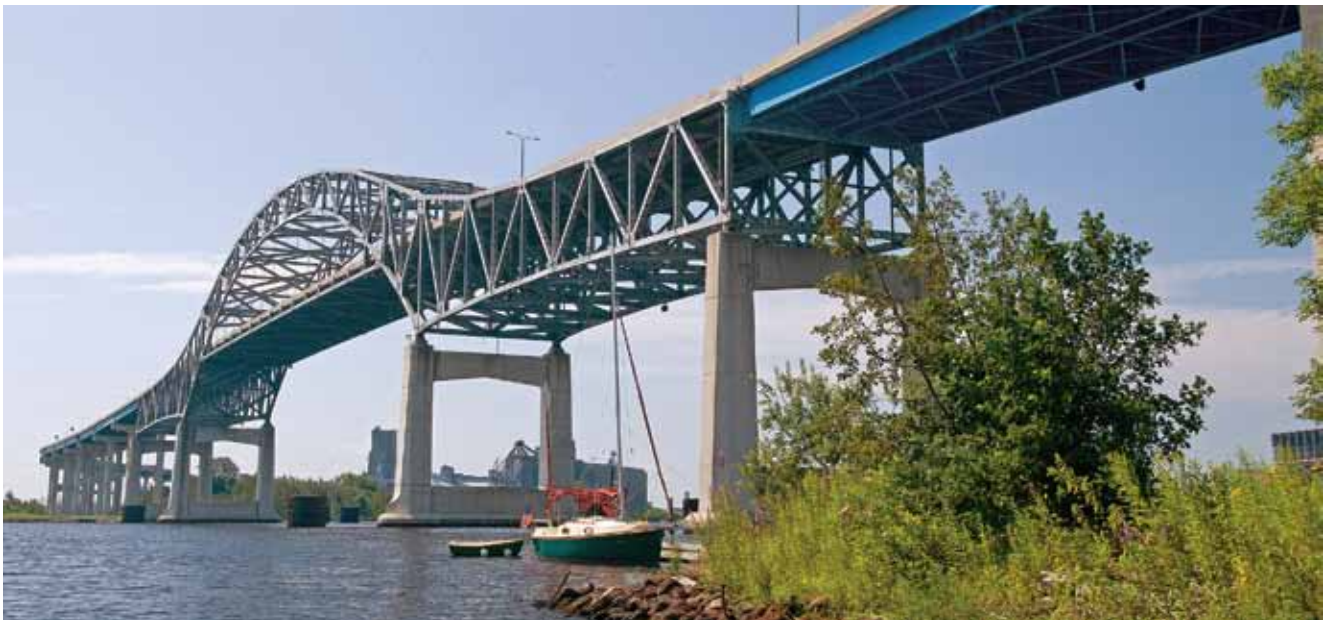


Research Services Overview

Our Mission

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

MnDOT Research Services is tasked with ensuring that optimal use is made of Minnesota taxpayer dollars dedicated to transportation research. Our vision includes fostering a professional and productive environment that leads to innovative research through global and regional collaboration.

Among the highlights of MnDOT's FY2012 research activities was its participation in the High Value Research Projects initiative, sponsored by the American Association of State Highway and Transportation Officials (AASHTO). This program recognizes projects from state transportation departments that provide transportation excellence through research. MnDOT submitted six completed research projects to AASHTO's Research Advisory Committee (RAC):

- Drainable Pavements at MnROAD Pervious Concrete and Porous Concrete Overlay Cells 39, 85, and 89: Pervious Concrete Cells on MnROAD Low-Volume Road
- Concrete Delivery Time Study
- Development of Best Practices for Inspection of Post-Tensioning Bridges in Minnesota
- Snow Plow Calibration Training & Procedure Manual Project
- Review of Workplace Wellness Program Options to Reduce Musculoskeletal Disorders in Laborious Work
- Quality of Life: Assessment and Evaluation to Develop Transportation Performance Measures

Additional research highlights are described throughout this report, including federally funded efforts through the Federal Highway Administration's (FHWA's) State Planning and Research (SP&R) program (page 35), state-funded activities through Minnesota's State Research Program (page 77) and locally funded interests through the Local Road Research Board (LRRB) (page 81).

FY2012 Challenges and Accomplishments

As described in the "Director's Message" (page 6), Research Services' biggest challenge was to get all research projects up and running after the state government shutdown. In addition:

- We needed to clarify the roles and responsibilities of staff members and Research Services as a whole. We initiated a video project for advisory panel members, Project Coordinators and investigators to better communicate information about these various roles and to help orient participants in the process. New naming conventions were established for roles to better express staff responsibilities: **Roadmap Managers are now Project Advisors, and Administrative Liaisons are now Project Coordinators**.
- A consultant worked with Research Services to document our workflows and to assess and streamline our processes to make them more efficient and effective.
- The MnDOT Library received several awards, including the Special Libraries Association Minnesota Chapter 2011 **Innovation in Action Award** for Extreme Makeover: Library Edition project, and the 2012 **John Cotton Dana Library Public Relations Award** from the American Library Association Library Leadership and Management Association Division. The library also completed digitization of ***Minnesota Highways***, the MnDOT employee newsletter from 1951 to 1976, and presented this project during a session at the Transportation Research Board (TRB) annual meeting. For more information, see "MnDOT Library" (page 22).

"Our research program is extremely diverse, touching nearly every activity of the Department—from planning and contracting to design and construction, to safeguarding Minnesota's drivers, workers and environment. MnDOT is dedicated not only to maintaining Minnesota's roads, but to expanding mobility and promoting multimodal strategies."

—Jean Wallace, Director, MnDOT Office of Policy Analysis, Research & Innovation

Research Services also underwent **organizational changes** in FY2012:

- Due to increased recognition of the need to market our research results, the Marketing and Communications group was elevated in organizational status, and staff now reports to the director of Research Services. Nick Busse has been hired as of FY2013 to manage this new unit. We have secured a part-time information officer position, shared with the MnDOT Office of Materials.
- The SP&R program was moved organizationally under Finance and Contract Services to increase efficiency and align with the organizational structure.
- As a result of the governor's initiative to better centralize information technology (IT) across MnDOT, our IT staff member was reclassified and moved into the Research Management area.

FY2013 Goals and Plans

Our goals for the coming year include:

- Developing a marketing and communications plan that better aligns with customer and MnDOT needs.
- Marketing our program, services and research results to raise awareness, build advocates, increase our customer base, and expand the use and application of research results that will facilitate telling our research story.
- Embracing a customer-centric approach that puts our customers first and makes them shine.
- Strengthening our partnerships with the University of Minnesota's Center for Transportation Studies and other MnDOT research programs so that we can work together more seamlessly to share resources, leverage each other's accomplishments and products, and communicate research results.
- Proactively seeking opportunities to engage customers and increasing our presence in national research efforts so that MnDOT will be recognized as a global leader in transportation research.
- Organizing existing network files and documents in the library so that they are categorized properly, findable and in good shape for digitizing. We also plan to develop a digital collection and preservation plan, and make hidden collections and other uncataloged materials findable.

We will continue to bring innovation to MnDOT and to the state of Minnesota with the support and contributions of MnDOT staff, the LRRB, FHWA, and our partners at universities and other public and private organizations. We welcome your comments, questions and suggestions.

"Research Services has been very successful in steering Minnesota's transportation dollars toward projects that reinforce MnDOT's strategic vision."

—Nick Thompson, Director, MnDOT Division of Policy, Safety & Strategic Initiatives

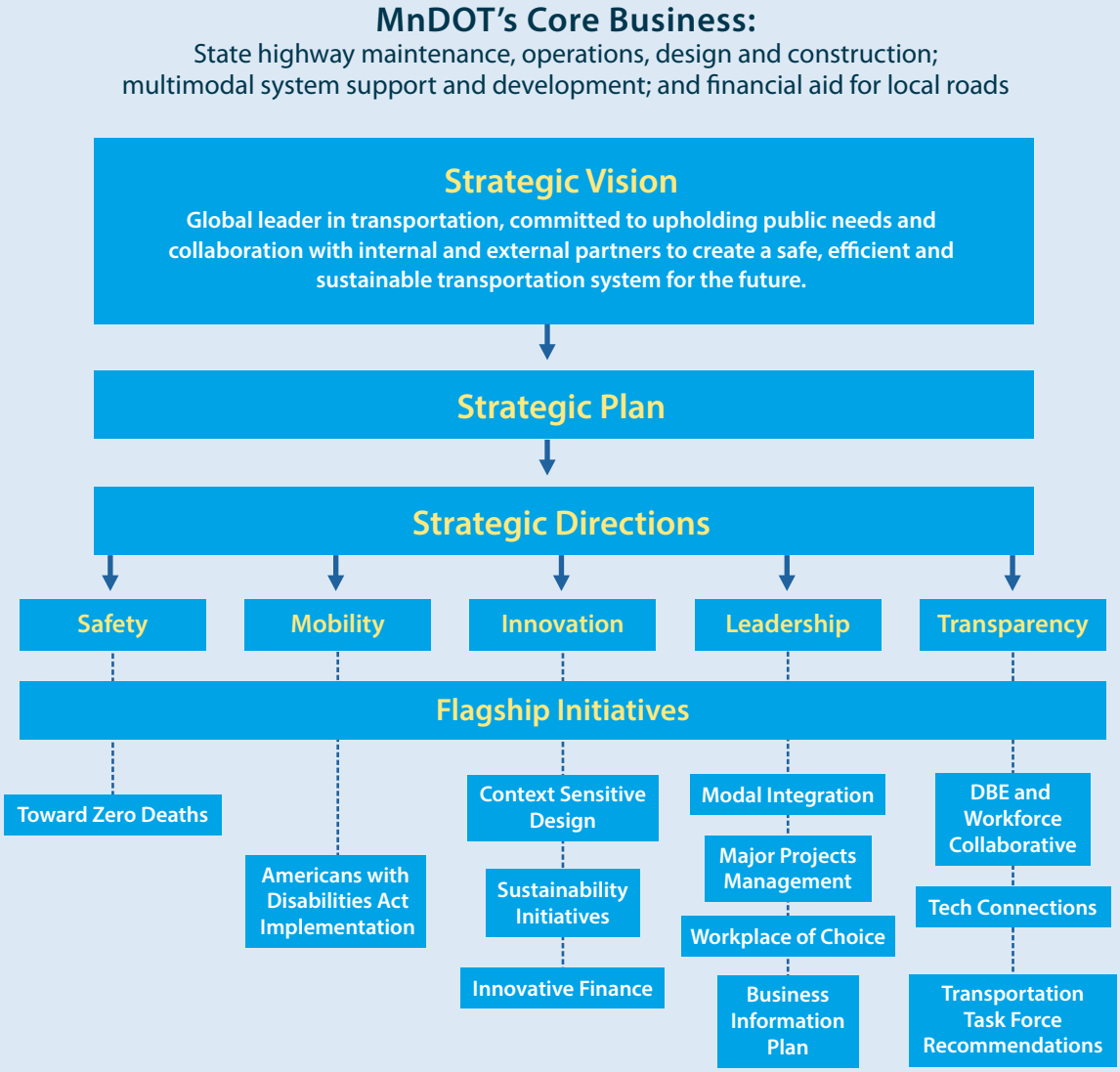
Furthering MnDOT's Strategic Vision through Research

Managing research funded by different sources (federal, state and local) allows Research Services to serve a number of distinct customer groups. This involves adapting efforts to fulfill each group's requirements while coordinating an overall research strategy that avoids duplication and aligns with MnDOT's strategic vision (Figure 1).

In 2010, Research Services management developed an operating plan for FY2011-FY2013 to redefine the key services provided and state the specific values and goals that will define Department activities through the coming years.

Quality of Life: Assessment and Evaluation to Develop Transportation Performance Measures was a two-year consumer research study that revealed citizens' attitudes toward transportation as a central quality of life factor. Researchers identified specific transportation products and services that contribute to quality of life, with satisfaction scores for each. This information is being used to inform MnDOT's service delivery and future investment decisions.

Figure 1. Connecting MnDOT's Strategic Vision to Its Strategic Plan



MnDOT's strategic vision sets the direction for strategic plans such as the Statewide Transportation Policy Plan and modal plans, which establish policies and strategies for focusing investments and services in line with MnDOT's strategic directions. For more information, see www.dot.state.mn.us/strategicplan.

MnDOT's Strategic Directions

MnDOT's leaders have defined the following strategic directions to elaborate on the Department's core values. (More information is available at **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 groundbreaking, multimodal 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 MnDOT.

Transparency—Build public trust in MnDOT.

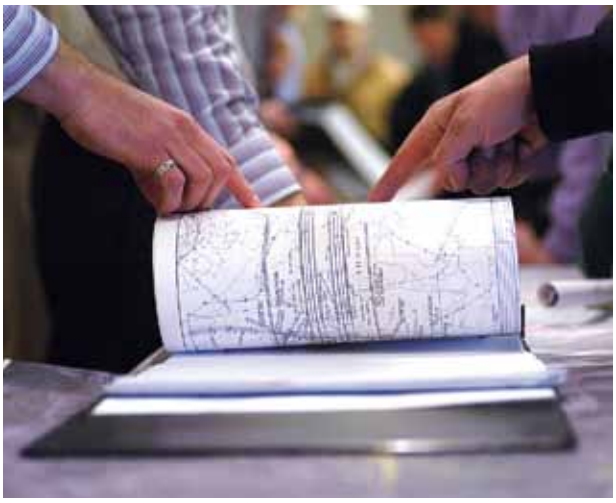
- Develop a simple, yet comprehensive tool for measuring performance across functions that is efficient, accurate, cost-effective and will show accountability to the public.
- Build relationships within local communities and encourage public involvement in developing transportation solutions.
- Effectively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

MnDOT's methodology in managing its projects, funds and staff is designed to align with the Department's 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 MnDOT'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. Through this exercise, managers formulated operations plans to address five strategic goals:

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



Research Services Organization

Research Services has 24 employees, including two part-time positions, in four units. Funding for staff comes from the MnDOT operating budget, the LRRB program and the FHWA SP&R program.

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Research Services Partnerships and Programs

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

Partnerships with Our Districts

Research Services receives research direction and support from the MnDOT districts (Figure 2).

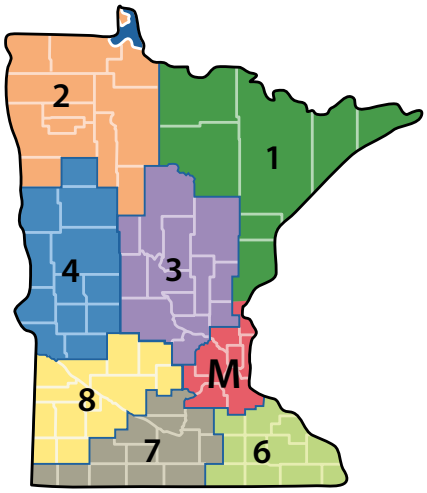


Figure 2. MnDOT Districts

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

Partnerships with MnDOT Offices

Many MnDOT offices request and facilitate our research. MnDOT's organizational chart, which lists current offices and their managers, is available at www.dot.state.mn.us/information/orgchart/mndotorgchart.pdf.

Research Services works with a few MnDOT offices that have research programs of their own:

- **Materials and Road Research**
  Helps to advance the state of the practice of pavement design, construction and maintenance by conducting pavement and materials research projects and implementation of research results.
  www.dot.state.mn.us/materials/research.html

- **MnROAD Cold Weather Research**
  Uses MnDOT materials and pavements in on-site research to enhance road performance and resource allocation. This MnDOT-owned pavement test track is the most sophisticated, independently operated pavement test facility of its type in the world.
  www.dot.state.mn.us/mnroad

- **Minnesota Guidestar—Office of Traffic, Safety and Technology**
  Performs a broad range of intelligent transportation systems (ITS) activities to assist in advancing ITS technology and programs.
  www.dot.state.mn.us/guidestar

- **Maintenance Operations Research—Office of Maintenance**
  Performs primarily "on-the-road" research covering maintenance of all kinds: general, winter, road and bridge, building, roadside, operations management and work zone safety.
  www.dot.state.mn.us/maintenance/research/index.html

MnDOT's Academic Contractors

MnDOT's new FY2012 master contracts include the following out-of-state universities that help to support the research program:

- **The University of Iowa**
- **Montana State University**
- **Texas A&M**

University of Minnesota

- **Twin Cities campus**
  One of the largest research universities in the country.
  www1.umn.edu/twincities/index.php
- **Duluth campus**
  A top-ranking regional university.
  www.d.umn.edu
- **Center for Transportation Studies (CTS)**
  An independent university center that brings MnDOT and the University together to advance transportation knowledge and foster innovations that improve Minnesota's transportation systems and services.
  www.cts.umn.edu

"With the help of our university and consultant partners, Research Services pursues practical innovations supported by collaborative groups and flagship initiatives that will be useful to transportation practitioners throughout Minnesota."

—Bernie Arseneau
MnDOT Deputy Commissioner

- **Humphrey School of Public Affairs**
  A public policy school that works with MnDOT and the LRRB on a variety of policy projects to improve Minnesota's Multimodal infrastructure and transportation planning practices.
  www.hhh.umn.edu
- **Center for Excellence in Rural Safety (CERS)**
  A joint program between CTS and the Humphrey School that works with the LRRB to provide citizen-centered research, training and outreach to enhance rural safety.
  www.ruralsafety.umn.edu
- **Intelligent Transportation Systems (ITS) Institute**
  A federally funded University Transportation Center that advances U.S. technology and expertise in transportation through education, research and technology transfer. The ITS Institute conducts research through several programs and dedicated facilities:
  - HumanFIRST Program
  - Intelligent Vehicles Laboratory
  - Minnesota Traffic Observatory
  - Northland Advanced Transportation Systems Research Laboratories
  - TechPlan: Transportation Planning and Policy Applications of ITS-Related Technologies

  www.its.umn.edu

Minnesota State University

- **Minnesota State University, Mankato**
  Home of the Minnesota Center for Transportation Research and Implementation, which bridges the gap between research and practice in the critical areas of transportation construction and materials.
  www.mnsu.edu
- **Minnesota State Colleges & Universities**
  Additional partners located at 37 public institutions within this system.
  www.mnscu.edu

MnDOT External Partnerships

Federal Highway Administration (FHWA)

In addition to receiving financial support from the FHWA's SP&R program (page 35), MnDOT collaborates with other FHWA offices in its research activities.

- **Turner-Fairbank Highway Research Center (TFHRC)**
  A federally owned and operated research facility in McLean, Va., that is the home of FHWA's Office of Research, Development and Technology.
  www.tfhrc.gov
- **FHWA Minnesota Division Research/Technology Transfer**
  Responsible for overseeing FHWA's SP&R program and the Minnesota Local Technical Assistance Program (LTAP).
  www.fhwa.dot.gov/mndiv/programs/research.htm
- **FHWA Transportation Pooled Fund (TPF) Program**
  A collaborative effort that allows federal, state and local agencies and other organizations to combine resources in support of transportation research studies. Co-sponsored by FHWA, TRB and AASHTO, the TPF Program has been in operation for more than 20 years. Currently almost 200 projects are active, valued at more than $130 million of pooled investment.
  www.pooledfund.org

Transportation Research Board (TRB)

TRB provides leadership in transportation innovation and progress through research and information exchange. Involvement with TRB provides opportunities for MnDOT staff to assume leadership roles in national research, such as Scott Bradley, director of Context Sensitive Solutions, and his involvement in context sensitive solutions (page 18). For more information about MnDOT's involvement in TRB-sponsored programs, see pages 48-50.
www.trb.org

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

Created by AASHTO in 1987, the RAC provides advice about transportation research matters, rates each year's problem statements for the NCHRP and shares state-sponsored research.
research.transportation.org

Transportation Engineering and Road Research Alliance (TERRA)

Funded through SP&R project TPF-5(215), TERRA advances innovations in road engineering and construction. For more information, see the **Technical Summary** on page 152.

Minnesota Local Technical Assistance Program (LTAP)

Administered by CTS, LTAP conducts workshops and seminars, conferences, customized training, demonstrations and distance learning. For more information, see "Implementing MnDOT Research through Strong Partnerships and Local Training" on page 85.
www.mnltap.umn.edu

Operational Research Assistance Program (OPERA)

OPERA promotes innovations in operations and maintenance methods, materials and equipment to provide a safer, more efficient and environmentally sound statewide transportation system for cities and counties. Funding for OPERA is provided in part by LRRB funds.
www.cts.umn.edu/Research/ProjectDetail.html?id=2008034

Feature

Scott Bradley Gives MnDOT a Leading Voice on National Research in Context Sensitive Solutions

Since 2001, Scott Bradley, director of Context Sensitive Solutions in the Office of Environmental Stewardship, has been one of MnDOT's leading representatives when it comes to national research on transportation project planning and design. **Context sensitive solutions** (CSS) is an approach that involves all stakeholders early in the planning for a highway project, thoroughly analyzes the community and environment where the project is to be built, and follows clearly defined decision-making and communication procedures throughout the project. The result is smoother, more cost-effective project implementations that are in sync with their surroundings.

Bradley is the former chair of the TRB's Context Sensitive Design & Solutions Task Force and currently chairs its oldest standing committee, Transportation Landscape and Environmental Design. He co-authored proposals for nine funded NCHRP projects, one of which resulted in ***NCHRP Report 642: Quantifying the Benefits of Context Sensitive Solutions***. Issued in 2009, this report "has had a tangible, singular influence on our operations, becoming a standard part of our advocacy and training," Bradley says. "CSS guides our design procedures and is integral to our emerging **Complete Streets approach**, which aims for an efficient and sustainable statewide transportation system for all users. CSS philosophy, strategies and principles also offer a powerful business case and business model applicable to delivery of all of our programs and services."

The objective of that research effort was to quantify the benefits of CSS, establish performance measures for employing a CSS approach, and generate training materials and other helpful information to enable CSS implementation. The lead investigative team, from the University of Kentucky Transportation Center, has proposed deploying a pilot *NCHRP Report 642* training workshop for MnDOT this fall with an emphasis on the performance measurement components.

"MnDOT's leaders have been very intrigued by the benefits of CSS," Bradley says. "This NCHRP study was the first that got us beyond anecdotal evidence that CSS was an effective approach, producing **a list of 22 demonstrated benefits** such as improved mobility, safety, innovation, stakeholder trust, environmental stewardship and opportunities for economic development. This is exactly in line with some of MnDOT's strategic directions and the reason for elevation of CSS to flagship initiative status."

Bradley's involvement with and leadership in TRB was helpful when Minnesota was selected as one of four national recipients of $250,000 grants from TRB Strategic Highway Research Program 2 (SHRP 2). This grant is being used for a CSS/Complete Streets pilot network planning project in Grand Rapids, Minn. The pilot will evaluate a newly developed SHRP 2 collaborative decision-making tool (Transportation for Communities: Advancing Projects through Partnerships) and recommend enhancements. "We think this pilot effort and tool will provide a model for how we can collaborate more effectively in a multijurisdictional manner to develop cost-effective, practical and sustainable approaches to Complete Streets statewide," Bradley says.

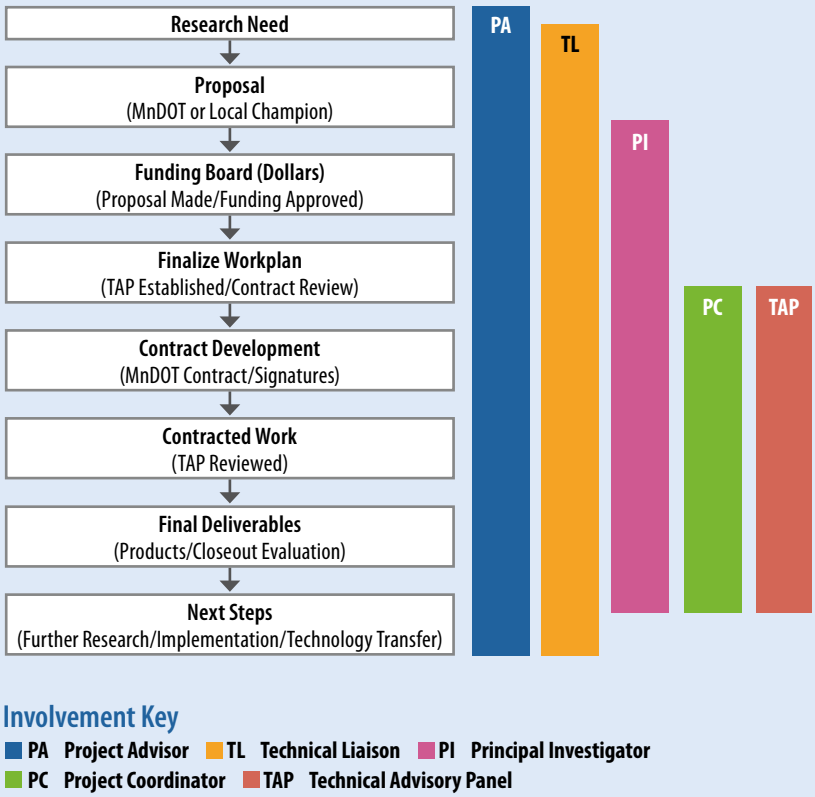
All of this points to the benefits of MnDOT's vigorous leadership in national research programs. "In this case, we were allowed to try something that we wouldn't have been in a position to try this rigorously," he says. "The credibility that we have established in TRB national research efforts puts us in a position to take advantage of opportunities like this."

Bradley was profiled as a leader in the **May-June 2011 *TR News*** based on recommendations from the National Academies and TRB staff.

Research Management

Research Services is responsible for shepherding research through all stages of a project, from the initial idea through final implementation, technology transfer and project evaluation. The Department's research management process, described in the diagram and table, is the product of many years of effort from a number of stakeholders. 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 or implementation effort, indicating which roles are involved in each step. The progress of each contract is documented in MnDOT's computerized Automated Research Tracking System (ARTS), which is also used by Research Services for research project management, finance and contracting.

Figure 3. Research Project Management Process



RESEARCH SERVICES ROLES	
Project Advisor (PA)	The Project Advisor is a MnDOT Research Services representative who facilitates project startup and provides a link between the Technical Advisory Panel (TAP) and other related efforts occurring within the LRRB, MnDOT and national programs. PAs may or may not be TAP members.
Technical Liaison (TL)	The Technical Liaison is the MnDOT or local agency champion who represents the sponsoring organization's interest, guiding the overall direction and scope of the contract and providing technical guidance. The TL assists in developing the initial need into a contract; helps the PI create deliverables; and approves the deliverables, work plan and amendment requests.
Project Coordinator (PC)	The Project Coordinator (formerly the Administrative Liaison) is assigned to each contract to ensure that contract provisions are followed and that deliverables are submitted and approved on schedule and within budget. The PC works with the TL to help manage projects throughout their life cycles. The PC also coordinates the activities of project TAPs. Each PC reports to a particular PA, and as of FY2012, PCs are typically assigned to particular topic areas to help ensure continuity over potentially related projects.
Principal Investigator (PI)	The Principal Investigator is the contractor/researcher responsible for project development and for the completion of the contract obligations. With TAP guidance and input, the PI designs, develops and performs tasks to carry out contract deliverables.
Technical Advisory Panel (TAP)	The Technical Advisory Panel guides the research, reviewing and approving the deliverables that are developed by the PI. Typically four to six people serve on each TAP. Additionally, other stakeholders may attend TAP meetings to stay informed of project progress, though these "friends of the TAP" don't influence project scope or task approvals.

RESEARCH MANAGEMENT STATISTICS	
Total active contracts for research and implementation managed by MnDOT	206
Completed reports	32
Technical Summaries	31
Transportation Research Syntheses	6
Research Services website hits	172,994

Identifying and Tracking Needs

MnDOT Research Services identifies research and innovation needs throughout the Department and the LRRB using completed research findings and communication with customers. MnDOT Project Advisors use this information to help guide MnDOT's overall research investment throughout the year, ensuring that MnDOT 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 (described on page 35). Research staff members also identify research ideas and trends by participating in state and local research groups and councils and in national organizations.

Customers can also request research support through MnDOT's IdeaScale website (**www.mndot-lrrb.ideascale.com**). This site allows users to submit ideas, review other idea submissions, and vote and comment on their priorities. These methods help promote communication between stakeholders and ensure that the views of MnDOT 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 for implementation projects in the spring of each year. Research proposals are not pursued without a state or local champion, to increase the likelihood that project findings will be incorporated into practice once the research is completed. Participation in national research efforts such as AASHTO's National Cooperative Highway Research Program (NCHRP) and other programs using multiple funding sources allows MnDOT to pool its research efforts with others around the country that have similar research needs. Needs statement and proposal forms, along with more information about MnDOT's research process, are available at **www.dot.state.mn.us/research/process-and-docs.html**.

Developing Projects

MnDOT'S Transportation Research Innovation Group (TRIG) (see page 77) and the Local Road Research Board (LRRB) (see page 81) select proposals for funding in December. Research Services then helps to organize the project TAP, and drafts and executes the contracts needed to carry out approved proposals. Projects are developed with an implementation plan in mind as well as an identified end user product and performance measures to help Research Services evaluate the success of a project.

Project Execution

Project Coordinators organize TAP meetings at regular intervals to check on the progress of a project. A contract amendment can be requested to allow for an evolving scope in light of TAP deliberations or roadblocks in project execution. Research Services provides report publishing guidelines and other assistance to help the Principal Investigator successfully fulfill the terms of the contract.

Implementation

Implementation is a key component of Research Services' contribution to managing a project. Though implementation measures are written into all new research projects, MnDOT also considers funding for specific implementation projects each spring (new research is initiated in the fall) to gain the full benefits of past research investments, not only by MnDOT and LRRB but by other states and national programs.

After a project is complete, Research Services oversees a project evaluation process to help TRIG or LRRB decide whether to keep funding a line of research, whether a particular contractor should be used again, what technology transfer or other actions are needed to fully implement the results, and how the research management process can be improved.

The following feature article highlights a successfully implemented research project.

Feature

MnDOT Research Leads to Smoother Pavement at Lower Cost

In 2010 MnDOT completed a research project to develop a new pavement smoothness specification for contractors. "This was an important innovation on two counts," says Linda Taylor, director of Research Services. "First, it made use of the **International Roughness Index**, a cutting-edge method for measuring pavement smoothness. Second, it combined the previously separate specifications for asphalt and concrete pavements."

According to James Wilde, professor at Minnesota State University, Mankato, the result of this research is a pavement profiling process that is "more consistent and efficient for contractors, leading to smoother pavements at a reduced cost."

The new specification has now been fully implemented, with all paving projects initiated in 2011 employing the new smoothness procedure. According to MnDOT Pavement Management Analyst Tom Nordstrom, "This has been a major change, requiring adjustment from not only contractors, but also MnDOT inspectors and project engineers."

In 2011 MnDOT provided training on the new procedures to project engineers and inspectors. An online training option is now available as well. Nordstrom says that MnDOT is "leading the way for a certification program for this kind of training. We often get calls from outside agencies looking for advice and recommendations."

The new combined pavement specification is based on data from inertial profilers like this one, which use laser sensors to take precise measurements of smoothness.

The **Office of Materials Smoothness Program** website provides more information about this training for MnDOT and local staff, the new specification and the 2012 Inertial Profiler Certification Program for construction vendors. **Research Services Technical Summary 2010-15** includes more information about the MnDOT-funded research projects that made this transition possible.

MnDOT Library

Marketing materials for National Library Week 2012 featured an old-fashioned, sepia-toned photo of MnDOT Library staff in vintage-inspired clothing posing with a Ford Model A. The photo commemorates the digitization of *Minnesota Highways*, the department's employee newsletter from 1951 to 1976. From left are Christie Schultz, Jim Byerly, Sheila Hatchell, Karen Neinstadt, Qin Tang and Pam Gonzalez.

This year the MnDOT Library continued to make use of its recently remodeled space to better serve customers and won several awards for its efforts. Major accomplishments include completing the digitization of the *Minnesota Highways* newsletter, an open house for National Library Week, numerous events and presentations, and various projects to enhance the library's resources and support MnDOT initiatives. These efforts—and the library's continuing tradition of excellent service—are helping the library reach more MnDOT staff than ever to assist them in improving Minnesota's transportation system.

Awards

The MnDOT Library completed a trifecta of honors related to its remodeling and marketing and communications work during 2010-2011.

One of these honors was the 2012 **John Cotton Dana Library Public Relations Award**, one of the most prestigious awards given by the American Library Association. The library received the award for its "moving knowledge" campaign, which informed the public of major improvements to its facilities. The eye-catching marketing campaign succeeded in bringing in new MnDOT users from throughout the state, and a grand reopening event drew 65 percent more attendees than the last open house. Daily visits to the library increased 1000 percent.

"This award typically goes to public and academic libraries," says Sheila Hatchell, MnDOT Library director, "so we are thrilled to be a special library recipient and even more pleased to be a transportation library winner."

The 2012 John Cotton Dana Library Public Relations Award.

The library also recently received:

- Special Libraries Association Minnesota Chapter 2011 **Innovation in Action Award** for its efforts to revitalize the library's space, services and brand
- Minnesota Association of Government Communicators' 2012 Northern Lights Award of Merit for posters and banners created through the library's marketing and communications project during 2010

Minnesota Highways Digitization Project

Among its achievements this year, the library was pleased to announce the release of a new digital collection. ***Minnesota Highways***, the monthly newsletter published by the Minnesota Department of Highways, is now available online. In nearly 300 issues from 1951 to 1976, ***Minnesota Highways*** documents the activities of the Minnesota Department of Highways, the predecessor of MnDOT that was established in 1917 to build and manage state roads and bridges.

Minnesota Highways provides an in-depth perspective on the development of Minnesota's transportation infrastructure during a period when postwar funding authorizations provided for major transportation expansion at the national and state levels. It covers major highway projects that superseded the state's freight rail system, improvements to secondary urban and rural roads, transportation safety campaigns, traffic fatality statistics, changes in transportation finance and policy, bridge and highway construction procedures, and technology developments.

The newsletter also includes the activities and writings of relevant state officials of the time and features many photographs of notable structures, such as the St. Croix, Taylors Falls and Hastings bridges; the Lowry Hill Tunnel; critical and innovatively designed interchanges; scenic photographs of rural Minnesota; and aerial views of urban transportation projects.

This digitization was conducted in partnership with the Minnesota Digital Library's *Minnesota Reflections* project. Current funding for *Minnesota Reflections* comes from the Arts and Cultural Heritage Fund of the Clean Water, Land and Legacy Amendment to the state's constitution.

LIBRARY STATISTICS	
Library materials circulated	14,389
New materials acquired	552
Questions answered	1,510
Literature searches	542
Interlibrary loans	691
Library website hits	130,154

National Library Week Open House

For National Library Week 2012, the library invited guests to step back in time with the theme "Back to Our Routes," which featured the newly digitized ***Minnesota Highways*** collection. The open house included refreshments, door prizes and activities such as a caption guessing contest for newsletter photos. In another game, "Transportation Tunes Tournament," participants were asked to brainstorm song titles that contained words such as road, street, highway, boulevard or interstate. KSTP Channel 5 News was present and conducted interviews with library staff and users.

Marketing and Outreach

The library continues to engage in a variety of efforts to make MnDOT staff aware of library services:

- **New employee orientation.** Library staff presented on library services at 11 new employee orientation events.
- **Letters.** Letters were sent to 143 new employees introducing them to the library and its services, including its periodical routing service and New Library Materials notification service.
- **Local media coverage.** Because of publicity around the library's 2011 **Innovation in Action Award**, KSTP News reporter Nick Winkler spent four hours interviewing guests and customers during the library's National Library Week open house event. The segment was featured on multiple newscasts and can be seen at **http://kstp.com/news/stories/S2606014.shtml**.

Events

Commissioner's Reading Corner

This year the library hosted nine Commissioner's Reading Corner events. In an April teleconference, Stephen M.R. Covey facilitated a live discussion of his book *Smart Trust*. To accommodate the large amount of interest in this event, it was moved to a conference room with available overflow space, and participants were offered the option to attend by teleconference.

Osher Lifelong Learning Institute

Following a well-received visit in 2011, the library again welcomed students from the University of Minnesota's Osher Lifelong Learning Institute (OLLI), a "health club for the mind." Students learned the difference between special, public and academic libraries and became familiar with the MnDOT Library's focus on civil and transportation engineering. This enables the library to support the work of MnDOT as well as cities and counties throughout the state by supplying materials that no other Minnesota library collects.

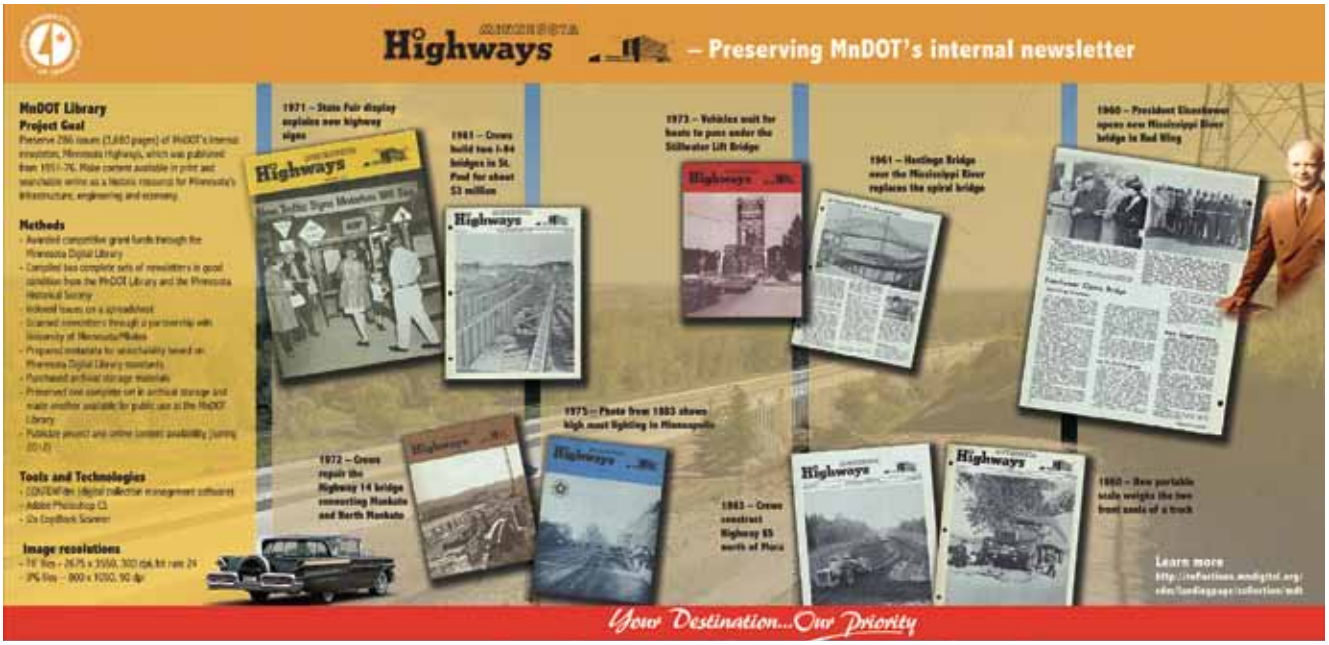
Special Libraries Association Minnesota Chapter: Extreme Makeover

The library was asked to host an event during which Twin Cities librarians could see its remodeled space firsthand as well as learn about marketing and communications efforts. The program featured background information about the project's conception and funding, the look of the library's space before the makeover, and marketing and communications deliverables. Consultants as well as library staff spoke at the event.

Presentations

This year the library gave a number of presentations:

- **LRRB.** A presentation to the Minnesota LRRB featured highlights of library services provided to Minnesota's city and county engineers and practitioners through the Minnesota Transportation Libraries Program. Projects featured from the previous year included a literature search on "smog-eating concrete" (photocatalytic cement) and the popular roundabout video and snowplow kits that were sent to AARP trainers around the state.
- **TRB poster session.** A poster was developed to help tell the story of the importance of the library's project to digitize the department's newsletter, ***Minnesota Highways***, from 1951 to 1976.
- **Bridge Office.** A presentation about library services given at the Bridge Office's annual meeting included handouts, a question-and-answer period and a trivia contest about Minnesota bridges.



This poster was created to publicize the digitization of the *Minnesota Highways* newsletter.

Osher Lifelong Learning Institute (OLLI) members learn about the MnDOT Library. ***Photo by Jim Byerly***

Projects through Pooled Fund TPF-5(237): Library Connectivity and Development

Through its participation in the Library Connectivity and Development TPF-5(237) Pooled Fund Study, the library has been able to implement several projects:

- **Knovel trial.** Through email announcements and webinars, MnDOT engineers were introduced to Knovel, a Web-based application for integrating technical information with analytical and search tools. The trial revealed that there was not enough demand from MnDOT engineers to warrant purchasing a subscription to the tool.
- **American Society of Civil Engineers conference proceedings trial.** The library subscribed to a trial of conference proceedings from the American Society of Civil Engineers (ASCE) that was not included in its current subscription to a suite of ASCE publications. This additional access was enthusiastically received by library customers.
- **Return on Investment/Library Valuation study.** The library is participating in a study to evaluate the return on investment from transportation libraries. The study will include both a full literature review and informal survey. Final results are expected to be published in the fall.

Other Projects

E-books for the iPad

MnDOT managers are actively using iPads in their daily work, and the library is exploring the availability of e-books for use with iPads. Challenges are presented in continuously changing technology, difficulty in deciphering licensing and user agreements, and availability of technical materials in e-format.

Weeding and Collection Shifting

Completing a project that began last year, librarians deleted 986 obsolete records from the library catalog and discarded 1,300 unused items. Weeding through these records and adding 20 shelving units during its 2010 remodeling should allow the library to accommodate new materials for the next five to 10 years. Because of the historical significance of many library materials, few are discarded and most are retained forever.

Leisure Book Exchange

The MnDOT Library is now offering a free book exchange program that allows employees to donate books they no longer want and take books that they would like to read. The library welcomes donations of fiction or nonfiction books that are in good condition. Current, popular and Minnesota-related books are preferred.

Cataloging Hidden Collections

In its 55-year history, the library has collected a number of materials that have not been cataloged. An effort is under way to identify and catalog these collections, making them findable by both library staff and customers. The first documents cataloged under this project are an important part of the department's history, consisting of program pamphlets from the MnDOT-sponsored Transportation Conference held annually from 1969 to 2002.

New Periodical Titles

The library has added several new periodical titles:

- *The American Surveyor*
- *Bench & Bar of Minnesota*
- *Data Digest*
- *Point of Beginning*
- *Professional Surveyor Magazine*
- *Public Performance & Management Review*

New Library Materials

The library's monthly publication, *New Library Materials*, alerts customers to recently received books, reports, periodicals and reference materials. Each issue includes an "Information Extra," which recently covered the following topics as part of the library's initiative to advance the use of technology:

- Word tag clouds
- What's a QR Code?
- Web technology you can use (**www.dot.state.mn.us/library/technologies.html**)
- Transportation Knowledge Networks

New Library Materials can be accessed at **www.dot.state.mn.us/library/recacq-archive.html**.

The library's QR Code.

Supporting MnDOT Initiatives

Library staff assisted MnDOT's Diversity Council by performing literature searches and locating photographs and other supportive information for the production of monthly poster sessions on minorities in transportation and civil engineering. This research encompassed countries and cultures throughout the world.

Library Staff Professional Activities

- Three hold office at the national level in the Special Libraries Association.
- One is a member of the TRB Library and Information Science for Transportation (LIST) Committee.
- One facilitates the local consortium of state government librarians.
- One published two journal articles this year.

Library Services

Now in its 55th year, the MnDOT Library is a vital resource for staff members, saving them time by assisting with finding materials and by performing literature searches critical to their work. Services include:

- **Research assistance**, providing customers with requested facts, data or other information
- **Literature searches**, supplying customers with up-to-date lists of the latest published books, reports, articles and other materials for a specified topic or area of best practices in a given field
- **Document delivery and interlibrary loan services**, accessing resources for customers from libraries worldwide
- **Periodicals routing**, maintaining a list of every magazine or journal received by the library and loaning these periodicals upon request
- **Online catalog access**, providing access via a searchable online database of all titles held by the library
- ***New Library Materials***, informing customers of new titles added to the library collection
- **Ask a Librarian**, allowing customers to request research assistance or materials using a simple online form

Satisfied Customers

"The library brought resources to my attention that I otherwise wouldn't have even known were available, like the Kindles that are available for checkout. The Kindle led me to leadership books by authors like John Maxwell that have changed the way I deal with co-workers and how I see myself within this organization."

—Jamal Love, Engineering Specialist

"Without the help of the MnDOT Library, I would not have had the education or the consistent historical background to research the progress of bikeways in Minnesota. With the documents you provided, I now have a better idea of what has been done, what money was spent on what project, and what is available in the area of biking and walking in Minnesota."

—Volunteer bike/walk advocate
Sierra Club/Active Living Ramsey County

"The information you provided saved MnDOT money by saving our consultant time. The research you provided informs our campaigns to increase carpooling."

—Jessica Wiens, Communications

"I was able to use the information you provided in discussions with legislators who were proposing memorial signing. I continue to use it in discussions with the management staff, District traffic engineers, other department staff who work on signing and others when this issue comes up. Your quick response saved others who may not be as versed in researching a topic a lot of time and allowed me to have this information when I needed it."

—Peter Buchen, Aeronautics

"Until I found the page on the Internet, I didn't know MnDOT had a library. This is gold!"

—Jeff Gretsfeld
St. Louis County Public Works Department

Twin Cities librarians from the Special Libraries Association Minnesota Chapter visited the MnDOT Library's remodeled space and learned about its marketing and communications efforts.

Finance and Contract Services

Research Services' Finance Services staff members provide contractual and financial management, planning, implementation and oversight to the federal, state and local road research programs. The unit is responsible for developing, planning and managing the contractual and financial activities of the statewide research program and 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.

Finance and Contract Services staff oversees and facilitates travel, lodging, food and meeting arrangements. The unit prepares, processes and monitors the University Master Contracts and the Transportation Research Assistance Program (TRAP). It also 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.

In addition, members of the Finance and Contract Services staff serve as experts on available funding sources for research, and help MnDOT and local practitioners and managers to determine the most appropriate contracting method and funding source.

The unit is also charged with administering the LRRB and Research Implementation Committee (RIC) budget and programs. Finance Services tracks partnership contributions; prepares, monitors and tracks contract documents, amendments and invoices; facilitates 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.

FINANCE AND CONTRACT SERVICES STATISTICS	
Contract closeouts	73
New contracts	66
Contract amendments	72
Interoffice agreements	14
Interagency or partnership agreements	11
Purchase orders	38
SP&R funded projects:	
• Active MnDOT-led pooled funds	12
• Other pooled funds with MnDOT contributions	30
• Active single-state SP&R projects	51
• SP&R projects with FY2012 MnDOT contributions	47

The Research Services financial team at work: (from left) Becky Lein, financial services specialist; Ann McLellan, financial services manager; Deb Fick, SP&R Program Coordinator; Carole Wiese, financial services specialist; and Debbie Sinclair, accounting officer principal.

FY2012 Finance and Contract Services Challenges and Accomplishments

The June 2012 shutdown and other changes prompted exceptional effort this year:

- State auditing requirements necessitated that any work done prior to the shutdown be funded with FY2011 dollars, and any after with FY2012 dollars, subject to new fiscal year financial rules.
- The master agreements with the universities that do the bulk of MnDOT's research expired. New contracts were established with the University of Minnesota, the University of Iowa, Montana State University and Texas A&M.
- Also, the Transportation Research Assistance Program (TRAP), which preapproves consultants, expired. The TRAP process streamlines the contracts needed to support Research Services in areas such as research marketing, technical writing, information analysis and event coordination. The new TRAP covers 22 consultants.
- MAPS, the old cost accounting system, was replaced with the new SWIFT system. The migration to SWIFT was coincident with the shutdown and required a major report writing, quality assurance and training effort.
- Research Services instituted new budget monitoring procedures to ensure that SWIFT was properly integrated with the research database (ARTS).
- Research Services completed documentation of its workflow processes for budgets, contract management, partnerships and federal closeout processes with the MnDOT Office of Financial Services and FHWA.
- The SP&R program was moved organizationally under Finance and Contract Services to increase efficiency and align with the organizational structure.
- Federal oversight of the SP&R program was modified because of the program's low-risk status, providing MnDOT with more delegated authority. The use of SP&R funds was consequently expanded to include research along with implementation and administrative activities.
- MnDOT's SP&R coordinator participated on a panel that compiled a financial process guidebook for the Transportation Pooled Fund program. She helped identify problems and direct enhancements, and now serves as a technical support person for the national audience.

An upcoming Research Services video will feature TAP members discussing the MnDOT research process and their roles on the panel.

Marketing and Communications

MnDOT recognizes the need to ensure that research results achieve their maximum effect through technology transfer. To increase focus on this mission, the Marketing and Communications group was elevated within the MnDOT hierarchy in FY2012 to become a formal unit of Research Services.

Marketing and Communications Products

The Marketing and Communications unit uses a variety of tools to promote the program's services and research results, including coordinated communications and publishing through numerous channels. Some of the key products are:

- **Technical Summaries (TSs)**. Research Services produced 33 summaries of FY2012 research projects. Developing a TS to explain and promote the final report is a standard part of most projects; summaries are also produced periodically of ongoing pooled fund studies that MnDOT supports. In FY2012 two ongoing projects were summarized via Innovation Updates, which can be created at the request of a project Technical Liaison in cases where reporting on interim results would be valuable. All of the FY2012 TSs are included in this annual report, organized by research topic area, beginning on page 107.
- **Annual Report, Research Services At-A-Glance and LRRB At-A-Glance**. Our fiscal year-end reporting includes this annual report as well as two At-A-Glance publications that extract and reorganize some of the annual report's information for different audiences and distribution modes. All three of these documents serve as key communication tools, providing a centralized and readable account of Research Services activities and processes. In addition to helping Research Services connect with Minnesota stakeholders, these documents are used at peer exchanges, during visits from other DOT research representatives and at the TRB annual meeting.
- **Articles**. Research Services has stepped up its effort to generate articles for **MnDOT Newsline** and other publications. All of the feature stories in this annual report were produced as part of this project.
- **Videos**. The Marketing and Communications unit has also increased production of informative videos on behalf of both MnDOT and the LRRB. One video project begun in 2012 will feature interviews with Technical Advisory Panel (TAP) members and Research Services managers, explaining their roles for the benefit of new TAP members, Research Services staff, investigators and other stakeholders. Interviewees will provide their insights about the MnDOT research process and describe the responsibilities of the Project Coordinator, Technical Liaison, Project Advisor and Principal Investigator. Another video project under way for FY2013 will feature the city and county "pothole professionals" who maintain safe and smooth roads throughout the state. Additional videos will highlight technical resources developed through specific research projects.
- **Transportation Research Syntheses (TRSs)**. During FY2012 both MnDOT and LRRB increased their requests for TRSs, which are short-turnaround assessments of recent research and best practices in a particular area of transportation. The Marketing and Communications unit has produced a brochure explaining and promoting this service (page 31).

  Investigators produce TRSs through Web and database searches, interviews and surveys. These reports may serve as preliminary research during the early stages of a full project or they may eliminate the need for a more extensive effort. TRSs completed during FY2012 include:

TRS1102	Estimating Non-Automobile Mode Share	September 2011
TRS1103	Small Metropolitan Planning Organization Funding	September 2011
TRS1104	Use of Social Media by Minnesota Cities and Counties	November 2011
TRS1105	Bridge Deck Cracking	November 2011
TRS1201	Impact of Vibratory Equipment to Surrounding Environments During Construction	July 2012
TRS1202	Far-Field Testing of Noise Wall Effectiveness	June 2012
TRS1203	Innovative Bridge Construction for Minnesota Local Roads	July 2012

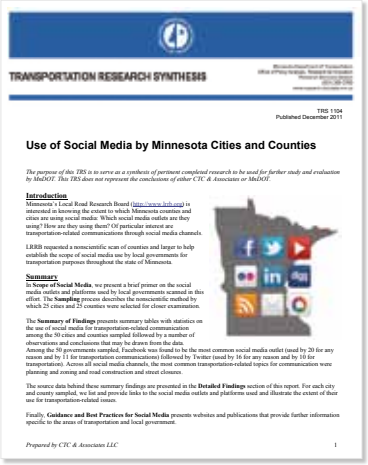
Minnesota Department of Transportation
RESEARCH SERVICES

TRANSPORTATION RESEARCH SYNTHESIS

Quick-turnaround information for MnDOT and LRRB

LOCAL ROAD RESEARCH BOARD

What is a TRS?



TRANSPORTATION RESEARCH SYNTHESIS

TRS 1104
Published December 2011

Use of Social Media by Minnesota Cities and Counties

The purpose of this TRS is to serve as a synthesis of pertinent completed research to be used for further study and evaluation by MnDOT. This TRS does not represent the conclusions of either CTC & Associates or MnDOT.

Introduction
Minnesota's Local Road Research Board (http://www.lrrb.org) is interested in knowing the extent to which Minnesota counties and cities are using social media: Which social media outlets are they using? How are they using them? Of particular interest are transportation-related communications through social media channels.

LRRB requested a nonscientific scan of counties and larger to help establish the scope of social media use by local governments for transportation purposes throughout the state of Minnesota.

Summary
In **Scope of Social Media**, we present a brief primer on the social media outlets and platforms used by local governments scanned in this effort. The **Sampling** process describes the nonscientific method by which 25 cities and 25 counties were selected for closer examination.

The **Summary of Findings** presents summary tables with statistics on the use of social media for transportation-related communication among the 50 cities and counties sampled followed by a number of observations and conclusions that may be drawn from the data. Among the 50 governments sampled, Facebook was found to be the most common social media outlet (used by 20 for any reason and by 11 for transportation communications) followed by Twitter (used by 16 for any reason and by 10 for transportation). Across all social media channels, the most common transportation-related topics for communication were planning and zoning and road construction and street closures.

The source data behind these summary findings are presented in the **Detailed Findings** section of this report. For each city and county sampled, we list and provide links to the social media outlets and platforms used and illustrate the extent of their use for transportation-related issues.

Finally, **Guidance and Best Practices for Social Media** presents websites and publications that provide further information specific to the areas of transportation and local government.

Prepared by CTC & Associates LLC 1

- A synthesis of technical and/or policy information on a specific topic that you have requested.
- Two types: 1) Summary of completed and in-progress research or 2) Report on the state of practice among DOTs nationwide.
- Identifies innovations, recent trends, best practices and federal guidance.
- Based on state, national and international sources, including interviews with experts.
- Clearly written and organized for you to digest and apply.

Recent TRS topics

- Use of social media
- Bridge deck cracking
- Estimating non-auto mode share
- Small MPO funding estimates
- Snowplow blades
- 24-hr headlight use
- Distance-based road user fees
- Unpaving roads
- Survey and right of way data
- Project management software

See the TRS web page.

How can a TRS help *me*?

- Investigate a problem without starting from scratch.
- Find out what other state DOTs are doing: designs, specifications, manuals, procedures.
- Review the latest and greatest on any issue that affects state DOTs.
- Receive a clear, concise report with all of the relevant findings, contact names and web links in one place.
- Save yourself a bunch of time.

To request a TRS

Contact Shirlee Sherkow at 651-366-3783 or shirlee.sherkow@state.mn.us

Call today and get your report in *four to eight weeks*!

TRS Request Form

Education and Outreach

Marketing and Communications staff members help the Department with **idea gathering and market research** using Web collaboration and survey tools like IdeaScale, MnDOT's Online Community and SurveyMonkey.

Research Services has continued to implement **social media** for transparency and communication of research results. The Department anticipates using such media as Facebook (**www.facebook.com/MnDOTResearch**) and YouTube (**www.youtube.com/user/MnDOTResearch**) to share current and past research, important events and awards, and online resources for the benefit of the entire transportation community. These free channels allow Research Services to expand its reach in a manner that aligns with MnDOT's strategic directions of innovation and transparency. By using these applications, Research Services hopes to open new channels of communication to our customers, the public and other government organizations.

While the Internet and social media are powerful and useful tools, the Marketing and Communications unit is also active in **grass-roots stakeholder outreach** through a number of organizations, committees and conferences. For example, in May, we held our annual TRB meeting and conducted a TRB Strategic Highway Research Program 2 (SHRP 2) bag lunch presentation to educate and involve MnDOT employees regarding these national programs. Other key outreach efforts include the CTS Education and Outreach Council, the CTS Research Conference Planning Committee, the Toward Zero Deaths Conference Planning Committee, the Minnesota Roadway Maintenance Training and Demo Day (previously Spring Expo), and the Minnesota LTAP and National LTAP annual conferences. We also facilitate meetings focused on particular research topics and functional areas to solicit stakeholder ideas and feedback.

To help MnDOT staff keep abreast of developments in their areas, Research Services created a **new portal on MnDOT's iHUB to support access to TRB's RSS feeds**. This new page contains hyperlinks directing the user to the RSS feeds; TRB e-newsletter subscription and customization functionality; and the multiple ways of receiving a TRB report: downloading it, ordering it from the MnDOT Library or requesting a hard copy from TRB.

Strategizing for the Future

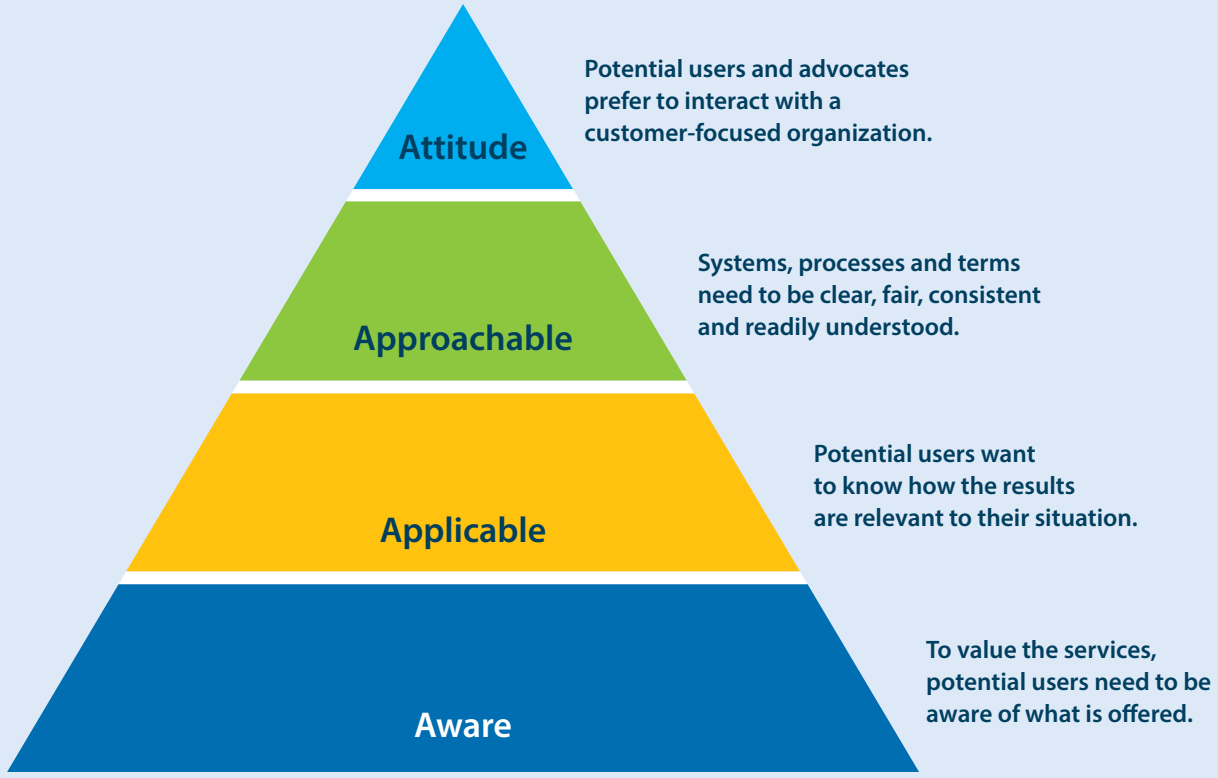
Research Services is moving toward a more customer-centric approach, reaching out to customer groups to determine what kind of research information they need and their preferred channels for receiving it. We are working to collaborate more effectively with other transportation research programs, both within MnDOT and at universities, to develop communications and marketing products that meet customer needs.

In spring 2012 Research Services engaged a consultant to assist with developing a comprehensive marketing and communications plan. First steps included internal workshops aimed at defining the Research Services vision and how to better serve customers. Research Services then conducted baseline interviews to evaluate its current products and determine how to improve them. Interviewees included a small representative sample of key customers and stakeholders. Key results of this initial survey follow:

- Overall, Research Services received high marks for competently fulfilling a valued administrative role in the research process.
- The research conducted through Research Services is respected for its quality and usefulness.
- Leadership and several staff members were individually praised for their contributions.

Next steps include a baseline survey of all customers and stakeholders (city and county engineers, district engineers, LRRB and TRIG members, researchers, consultants and TAP members) to evaluate Research Services programs and services.

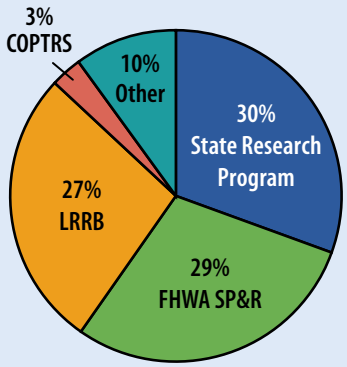
Figure 4. 4 A's of Customer Service



Marketing plan workshops made use of this "four A's" mnemonic to evaluate the current Research Services program and devise strategies for improvement.

Research Funding Programs

Figure 5. FY2012 Research Funds by Funding Source



State Research Program	$3,284,000
FHWA State Planning and Research (Part II)	$3,190,840
Local Road Research Board	$2,902,378
Cooperative Program for Transportation Research and Studies	$363,000
Other*	$1,117,087
Total	**$10,857,305**

*Includes contributions from other MnDOT 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.

In FY2012, Research Services managed $10,857,305 aimed at improving transportation in Minnesota. These funds are generated at state, federal and local levels; the amounts from the various funding sources are shown in Figure 5.

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

FHWA State Planning and Research (SP&R). SP&R funds, representing 29 percent of MnDOT's research budget this year, come from the FHWA. At least 25 percent of the money goes to state-specific research needs. The SP&R program supports funding for federal programs (NCHRP, TRB Core Services and AASHTO Technical Services programs); pool fund projects; and single-state projects (research, implementation and research support contracts). More information about the single-state and cooperative research and implementation efforts supported by SP&R Part II funding is available beginning on page 52 of this report.

MnDOT's State Research Program (SRP). SRP funds comprised 30 percent of MnDOT's FY2012 research budget. The Minnesota state government provides this funding to ensure that agency research needs are addressed and to support MnDOT's strategic directions: safety, mobility, innovation, leadership and transparency. SRP funds are often used to match dollars from other funding sources, including FHWA SP&R, CTS and the Intelligent Transportation Systems (ITS) Institute. These funds are also used to promote, support and complement MnDOT's other research programs. More information about these funds is available starting on page 77 of this report.

Local Road Research Board (LRRB). These funds, which comprised 27 percent of MnDOT's FY2012 research budget, come from the LRRB, which was created to facilitate transportation research and information sharing among Minnesota city and county engineers. Research Services administers the budget and research program for the LRRB. Some of the services that we provide include contract administration; financial management (at both the program level and for individual projects); communications and logistics management (meeting arrangements, record keeping and purchase orders); reporting; and technology transfer. We apply our full research management methodology: from identifying research needs and facilitating proposals to guiding LRRB projects to closeout and implementation. Details about the LRRB are available beginning on page 81 of this report.

Cooperative Program for Transportation Research and Studies (COPTRS). In addition to the three major programs described above, 3 percent of the FY2012 budget was dedicated to the University of Minnesota through COPTRS. This program 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. The level of funding for this program is determined by legislative action.

Other Funding. As Figure 5 indicates, 10 percent of MnDOT's research budget come from funding sources other than those listed above. These funds are contributed by public agencies as well as MnDOT offices and districts, and clearly demonstrate the commitment and support for MnDOT's statewide research programs.

FHWA State Planning and Research

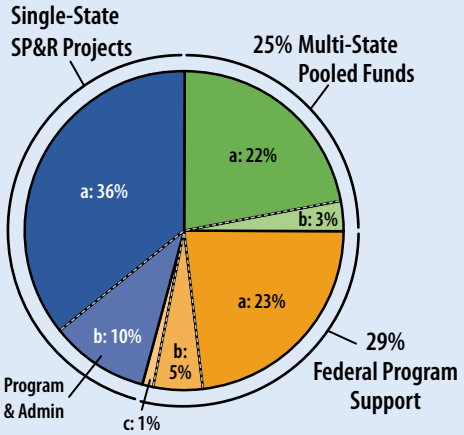
SP&R funds are received from the FHWA for MnDOT planning and research activities. A minimum of 25 percent of these funds are allocated specifically for research (designated SP&R Part II) to address state-specific research needs; the remaining funds are assigned to planning, administration and other needs (SP&R Part I). While this publication only covers Part II funds, it should be noted that unlike most other state DOT research programs, MnDOT Research Services oversees Part I spending as well.

SP&R Part II funds comprised 29 percent ($3,190,840) of MnDOT's FY2012 research budget. (See Figure 5 on page 34.) Figure 6 illustrates the distribution of these funds. Upon determining the funds available for the year, contributions toward national programs are allocated first. A portion of the remaining funds then goes to multi-state pooled funds, research and implementation projects, and the small amount remaining is applied to administrative support.

The FY2012 SP&R work plan included contributions to 47 projects:

- **Pooled funds.** In FY2012 MnDOT contributed to 30 multi-state pooled fund projects, and additional pooled funds that MnDOT contributed to prior to FY2012 are still active and gaining benefits for MnDOT. Among all of these currently active pooled funds, 12 are MnDOT-led (described with current status updates in "MnDOT-Led Multi-State Pooled Fund Projects" on page 38) and 30 are led by other states or agencies (listed in "Other Active Multi-State Pooled Fund Projects" on page 47).
- **Single-state projects.** MnDOT contributed to 15 single-state projects. Numerous additional contracts funded through previous allocations were also active in FY2012, including those listed under "Program and Administrative Support" in Figure 6. MnDOT will contribute funds to these projects in FY2013. The "Single-State SP&R Projects" section on page 52 of this report lists all of these active contracts along with some newly funded projects that do not yet have an associated contract.
- **Federal program support.** SP&R funds are used to support NCHRP, TRB and AASHTO technical programs, described in "Research Services Partnerships and Programs" on page 15. These federal programs sponsor a variety of research and information-sharing efforts and are supported by all of the states.

Figure 6. FY2012 SP&R Part II Funding Distribution



Single-State SP&R Projects	**$ 1,327,327**
a: Research and Implementation	$ 1,036,539
b: Program and Administrative Support*	$ 290,788
Multi-State Pooled Funds	**$ 706,200**
a: Participation in Pooled Funds Led by Other States	$ 613,700
b: MnDOT-Led Pooled Funds	$ 92,500
Federal Program Support	**$ 820,604**
a: NCHRP	$ 658,689
b: TRB	$ 128,915
c: AASHTO	$ 33,000
Total	**$2,854,131**

*Funding during FY2012 for Program and Administrative support came from the 2011 SP&R work plan as a result of MnDOT's transition from calendar to fiscal year SP&R accounting.

SP&R funds enable MnDOT to invest in and pursue long-range strategies and research into innovative new technologies that might not otherwise be feasible. SP&R funds are often used to fund implementation and technology transfer efforts to ensure that developed innovations are understood and used by MnDOT districts and offices.

The oversight of the SP&R program was modified this year based on its program being judged a "lower risk area." This provided MnDOT with more delegated authority, and so the use of SP&R funds was expanded to research along with implementation and administrative activities.

Feature

North/West Passage Pooled Fund Improves Road Condition Information for Interstate Travelers

Travel between the Midwest and the West Coast along I-90 and I-94 began to improve about 10 years ago, thanks to a MnDOT-led effort with seven other states between Wisconsin and Washington. Research for this project—called the North/West Passage Corridor—is aimed at providing travelers with uniform, real-time information about road and weather conditions along this corridor.

"This study's dynamic message sign project is a great example of the importance of sharing solutions across boundaries," says Cory Johnson, traffic research director for MnDOT's Office of Traffic, Safety and Technology. "Making dynamic message signs consistent between states is critical to drivers using them to make better travel decisions."

Another key component of the study was the development of **i90i94travelinfo.com**, a website that provides travel information for the entire corridor, including camera images, truck stop and rest area information, and weather conditions.

The study has also helped Minnesota to better understand federal regulations requiring that state agencies measure, calculate and report transportation system information to travelers. And it has made Minnesota more aware of the value in developing contacts and sharing lessons learned with other states.

"One of the big benefits of North/West Passage Corridor is the ability to communicate with other states," says Johnson. "Collaboration can actually occur face to face, helping us to build relationships with peer states and learn about the latest best practices. This supports the larger objective of making sure we do our homework and establish national baselines before beginning a project."

For its leadership of this pooled fund study, MnDOT Research Services received the CTS 2010 Research Partnership Award and the **2010 Best of ITS Rural Award** in the category Best New Practice at the National Rural ITS Conference.

For more information about this project, see the **Technical Summary** on page 170.

As part of the TERRA Innovations Series, in October 2011 TERRA hosted the MnROAD Research Conference to share findings from several TERRA-initiated studies. More than 160 attendees participated from at least 13 states and Norway.

FY2012 Research Highlights

TPF-5(215): Transportation Engineering and Road Research Alliance (TERRA) is a MnDOT-led pooled fund that brings together government, industry and academia to foster collaborative research and innovation in road engineering and construction, including issues related to cold climates. Its work includes enhancing the capabilities and use by the broader research community of MnROAD, MnDOT's state-of-the-art outdoor pavement research facility. Current projects include a five-year study to test the performance of thinner unbonded concrete overlays subject to interstate traffic and Minnesota's extreme climate; a unique partnership of several state DOTs and four universities to develop asphalt mixture specifications for low-temperature cracking based on laboratory fracture testing and modeling; and a project to evaluate the durability, hydrologic characteristics and environmental effects of porous asphalt pavement when used on a low-volume roadway in a cold climate. A **Technical Summary** about this project can be found on page 152.

TPF-5(198): Urban Mobility Study is developing better tools to monitor and evaluate urban congestion. Researchers are using the latest mobility data sources to develop comprehensive performance measures for tracking congestion improvements, which member agencies then apply to their congestion planning. The study generates products like the well-known **Urban Mobility Report**, which depicts nationwide congestion trends as well as state-focused research efforts such as **Twin Cities Metropolitan and MN Statewide IRC Arterial Travel Time Analysis: Use of Private Sector Traffic Speed Data**. This study showed how speed data already being collected by industry could be used to help MnDOT monitor the statewide network. Current research includes evaluating private sector data from GPS and other mobile devices as well as a variety of studies on land-use and other planning practices, access and traffic management strategies, and transportation data collection devices. For more information about this project, see the **Technical Summary** on page 160.

TPF-5(153): Optimal Timing of Preventive Maintenance is a MnDOT-led study that seeks to better understand the environmental aging of asphalt binder and how aging effects can be reduced through pavement preservation techniques. The work is performed on specially built test sections at MnDOT's MnROAD test facility, which provides a unique opportunity to study pavement aging with detailed weather information and known traffic inputs in a controlled work environment. The findings of this project will help establish recommended guidelines about how and when to apply asphalt surface treatments. Proposed practices will ideally balance maximum life for pavements and minimum costs for preventive maintenance.

The National Cooperative Highway Research Program

The National Cooperative Highway Research Program (NCHRP) addresses the national need for research into highway safety, planning, design, construction, operations and maintenance. NCHRP research includes the development and evaluation of fundamental new technologies and techniques as well as sharing of best practices among states.

MnDOT staff members actively participated on 31 NCHRP technical advisory panels in 2012, giving Minnesota a voice in shaping the scope and direction of these large projects. (See "Active NCHRP Projects with MnDOT Panel Membership" on page 48 for a full list of participants.) MnDOT leaders also work with other TRB cooperative programs including the Transit Cooperative Research Program and the SHRP 2.

One NCHRP report producing significant benefits in Minnesota today is *NCHRP Report 691, Mix Design Practices for Warm Mix Asphalt*, which MnDOT's Tim Clyne helped guide as a panel member for the project. Warm mix asphalt was a promising alternative to hot mix designs, offering improved field performance (with better compaction and a smoother ride), environmental advantages and better conditions for workers as a result of lower exposures to petroleum vapors. But this report helped to standardize the procedures for warm mix application and gave MnDOT greater confidence in the viability of warm mix. Consequently, Minnesota has gone from applying 20,000 to 50,000 tons of warm mix per year to well over a million tons in FY2012.

MnDOT-Led Multi-State Pooled Fund Projects

This section provides basic information about MnDOT-led SP&R projects funded by multiple states that were active in 2012. In some cases, state financial commitments ended prior to 2012, but these funds are still being spent.

TPF-5(093), TPF-5(190): North/West Passage—Phase III

URL: http://www.pooledfund.org/Details/Study/412 | **Number of Participating States:** 9

Funded by: SP&R, SRP | **Total Cost:** $600,000 | **MN 2011 Commitment:** $25,000 | **MN 2012 Commitment:** $25,000

TL: Cory Johnson | **PC:** Deb Fick

Description: Interstates 90 and 94 from Wisconsin to the state of Washington form a major corridor for commercial and recreational travel, and states typically provide motorists with real-time road and weather information using dynamic message signs, 511 phone systems and the Web. These communication tools, together with roadway maintenance and traffic operations systems, are supported by Intelligent Transportation Systems (ITS) technologies. Because states independently maintain their own ITS, it can be difficult to accomplish ITS-related goals that require sharing information among states. This study provides a platform to allow states in the corridor—the North/West Passage—to integrate traveler information systems and coordinate maintenance operations across state lines.

The i90i94travelinfo.com website from pooled fund study TPF-5(190) is a valuable information portal for travelers along the North/West Passage Corridor.

Status: Completed projects in the past year include a custom cost-benefit evaluation tool for rural ITS applications commonly used among the North/West Passage states, a study to help coordinate regional permitting throughout the corridor, and a synthesis of technologies and best practices to help define options for automating road condition reporting. In addition, work continued on a project to promote consistent application of Code of Federal Regulation rules for the Real-Time System Management Information Program. An effort was also started recently to advance open source software throughout the corridor as a way to reduce individual states' software development costs.

Impact: As individual projects continue, work already completed through this pooled fund is making a difference. A notable example is a corridorwide traveler information website, i90i94travelinfo.com, which provides road condition information to the public. This program offers significant value to member states as well, providing a platform for participants to establish contacts, share lessons learned and develop strategies to solve issues of common concern. Member states benefit from efforts toward standards development and work on improved methods for sharing, coordinating and integrating traveler information among neighboring states along the corridor.

MN Commitment End Date: 2011

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

URL: http://www.pooledfund.org/Details/Study/361 | **Number of Participating States:** 6

Funded by: SP&R, SRP | **Total Cost:** $718,120 | **MN 2011 Commitment:** $15,000 | **MN 2012 Commitment:** $0

TL: John Siekmeier | **PC:** Nelson Cruz

Description: Using recycled materials, particularly concrete, as a substitute for aggregate will continue to rise as aggregate supplies around the world diminish in the face of increasing demand. This research aims to quantify the mechanistic and performance value of several common recycled aggregate sources and consider their impact on the environment through effluent runoff.

Status: This work has been completed.

Impact: This study will put the use of recycled aggregate sources on firmer footing for use in mechanistic-empirical design and will situate the use of recycled unbound materials so that their environmental impact can be better understood and considered in design choices.

MN Commitment End Date: 2011

TPF-5(132) Low Temperature Cracking in Asphalt Pavements (Phase II, MnROAD Study)

URL: http://www.pooledfund.org/Details/Study/395 | **Number of Participating States:** 7

Funded by: SP&R, SRP | **Total Cost:** $475,000 | **MN 2011 Commitment:** $20,000 | **MN 2012 Commitment:** $0

TL: Timothy Clyne | **PC:** Bruce Holdhusen

Description: To help prevent low-temperature cracking in asphalt pavements, it is necessary to understand fracture mechanisms and develop low-temperature specifications for conventional and polymer-modified asphalt binders and mixtures. This study, the second phase of a multipart effort, set out to validate the Phase I laboratory test procedures, models and pavement designs by monitoring two new test sections at MnROAD. This study includes three MnROAD test cells, consisting of 500-foot road segments, to study low-temperature cracking in recycled asphalt.

The tools developed from pooled fund study TPF-5(132) will improve asphalt binder selection to help combat cold weather cracking of asphalt pavements.

Status: Most of the work for this pooled fund study was completed by the close of the fiscal year and produced three key final results: First, from among the fracture tests studied in Phase I, the study established the disk-shaped compact tension test as the most reliable and most accurate tool for predicting cold temperature cracking. Next, a mixture specification was developed to give pavement engineers design criteria for asphalt mixes with respect to low-temperature resistance. Finally, investigators developed a thermal cracking computer model, a stand-alone tool that represents an improvement over the methods in the AASHTO Mechanistic-Empirical Pavement Design Guide for predicting cold weather cracking.

Impact: This research helped to determine which binder test was most effective for predicting low-temperature pavement performance, and it validated the new laboratory and pavement design procedures investigated in Phase I. Together the procedures, specifications and software will lead to improved binder selection and more durable, economical roads. MnDOT has initiated an implementation project, scheduled to begin in autumn 2012, that will use these test procedures on three to five asphalt paving projects in the state. Moreover, these methodologies may prove useful for future studies that investigate asphalt fracture resistance to other influences, such as moisture and aging.

MN Commitment End Date: 2011

TPF-5(134) PCC Surface Characteristics—Rehabilitation (MnROAD Study)			
URL: http://www.pooledfund.org/Details/Study/363		**Number of Participating States:** 3	
Funded by: SP&R, SRP	**Total Cost:** $275,000	**MN 2011 Commitment:** $0	**MN 2012 Commitment:** $0
TL: Bernard Izevbekhai		**PC:** Bruce Holdhusen	
Description: The relationship between texture and ride in reducing pavement noise remains poorly understood. This study compares diamond grinding techniques used on concrete pavement surfaces in terms of friction, ride and texture, and correlates these to comfort, noise and safety of riding experiences.			
Status: Participant state agencies are presenting findings to their state transportation communities.			
Impact: This study will provide designers with necessary data for balancing safety, ride comfort and noise generation in approaches to concrete pavement rehabilitation. It will ensure the quietest, most comfortable and safest configuration of pavement surfaces for drivers.			
MN Commitment End Date: 2010			

TPF-5(148) The Effects of Implements of Husbandry "Farm Equipment" on Pavement Performance (MnROAD Study)			
URL: http://www.pooledfund.org/Details/Study/375		**Number of Participating States:** 5	
Funded by: SP&R, SRP	**Total Cost:** $1,000,258	**MN 2011 Commitment:** $0	**MN 2012 Commitment:** $0
TL: Shongtao Dai		**PC:** Bruce Holdhusen	
Description: Heavy agricultural equipment like manure spreaders can overstress rural roadways, causing premature failure and incurring premature repair and replacement costs.			
Status: This work has been completed. A **Technical Summary** covering report 2012-08 issued as part of this study can be found on page 138 of this report.			
Impact: As a result of this study, researchers found that heavy equipment can seriously damage rural roadways. By encouraging use of paved shoulders or driving in the center of the road, rural transportation agencies can limit this damage. Such measures have been implemented in northern Wisconsin as a result of this study and are proving effective.			
MN Commitment End Date: 2008			

TPF-5(149) Design and Construction Guidelines for Thermally Insulated Concrete Pavements (MnROAD Study)			
URL: http://www.pooledfund.org/Details/Study/376		**Number of Participating States:** 4	
Funded by: SP&R, SRP	**Total Cost:** $438,980	**MN 2011 Commitment:** $20,000	**MN 2012 Commitment:** $0
TL: Timothy Clyne		**PC:** Nelson Cruz	
Description: Thermally insulated concrete pavements consist of thin HMA overlays of concrete structures, combining the durability of concrete structures with the ride quality of asphalt. This study evaluates life-cycle analysis; environmental/climatic effects on performance; pavement design; materials properties for the asphalt and concrete materials; and design details such as joint spacing, dowels and joint support.			
Status: This work has been completed.			
Impact: This study will establish strong, research- and performance-based design and planning standards for thermally insulated concrete pavements.			
MN Commitment End Date: 2011			

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

URL: http://www.pooledfund.org/Details/Study/380 | **Number of Participating States:** 6

Funded by: SP&R, SRP | **Total Cost:** $335,000 | **MN 2011 Commitment:** $15,000 | **MN 2012 Commitment:** $0

TL: Thomas Wood | **PC:** Bruce Holdhusen

Description: The purpose of this study is to determine the proper timing of preventive maintenance treatments for asphalt pavements. Environmental aging of asphalt binder is still not well understood, and this study will seek to better understand the aging mechanism and how aging effects can be reduced through pavement preservation techniques. The work is performed on specially built test sections at MnROAD.

An asphalt core is subjected to fracture energy testing conducted in this study. The test helps compare cracking resistance of different asphalt binders and mixes.

Status: This multiyear aging study remains on track, with investigators now in their third year of testing asphalt core samples taken from travel and nontravel lanes of field-test pavements. Investigators are extracting binder from these samples to evaluate binder property changes and to identify the most informative test parameters with respect to aging.

Impact: MnROAD provides a unique opportunity to study pavement aging with detailed weather information and known traffic inputs in a controlled work environment. The research findings will help establish recommended guidelines about how and when to apply asphalt surface treatments. Proposed practices will ideally balance maximum life for pavements and minimum costs for preventive maintenance.

MN Commitment End Date: 2013

TPF-5(165) Development of Design Guide for Thin and Ultra-Thin Concrete Overlays of Existing Asphalt Pavements (MnROAD Study)

URL: http://www.pooledfund.org/Details/Study/389 | **Number of Participating States:** 8

Funded by: SP&R, SRP | **Total Cost:** $330,000 | **MN 2011 Commitment:** $9,200 | **MN 2012 Commitment:** $0

TL: Thomas Burnham | **PC:** Nelson Cruz

Description: Construction of thin and ultra-thin concrete overlays of existing asphalt pavement—also known as whitetopping—is growing in use as a rehabilitation option; in Minnesota, county highway agencies have shown a particular interest in using these overlays. The need for research-based design guidance on thin and ultra-thin overlays prompted this pooled fund project. The aim is to study performance of thin and ultra-thin overlays on highway test sections, assess performance models, and develop design guidance software.

Status: This project is nearly complete, and participant agencies have evaluated an early release of the design software. Based on field testing results, which showed that thin and ultra-thin overlays tend to crack longitudinally rather than transversely as originally assumed, the software is being updated accordingly. In addition, a training module for this software is now under development.

Impact: The final software will represent a unified national design guide for thin and ultra-thin concrete overlays of existing asphalt pavements. It is a significant improvement over current design guidance, and MnDOT plans to use the revised software when it is completed. Though the software design program is a stand-alone tool, it was designed be compatible with the Mechanistic-Empirical Pavement Design Guide if AASHTO chooses to adopt it. This pooled fund study served as a model for TPF-5(269), which will similarly develop guidance for unbonded concrete overlays.

MN Commitment End Date: 2012

TPF-5(269) Development of an Improved Design Procedure for Unbonded Concrete Overlays

URL: http://www.pooledfund.org/Details/Study/498 | **Number of Participating States:** 7

Funded by: SP&R, SRP | **Total Cost:** $420,000 | **MN 2011 Commitment:** $0 | **MN 2012 Commitment:** $20,000

TL: Tom Burnham | **PC:** Deb Fick

Description: Construction of unbonded concrete overlays on existing concrete or composite pavements has been gaining popularity as a pavement rehabilitation option. This pooled fund study was patterned after MnDOT-led pooled fund study TPF-5(165), which developed design guidance software for thin and ultra-thin overlays. This new study looks at unbound overlays of all thicknesses, from the very thin to the very thick, which are not addressed in detail in the AASHTO Mechanistic-Empirical Pavement Design Guide.

Status: This study recently started, with the participant states meeting in summer 2012 to define the request for proposals. Contractor selection is expected by the end of 2012.

Impact: This study will create a unified national design guide for unbonded concrete overlays of existing concrete and composite pavements. The guidance will also help highway agencies determine suitable separator layer (interlayer) materials and properties to ensure long-term performance of this type of overlay system. Like TPF-5(165), the goal is to develop stand-alone software that is also compatible with the AASHTO Mechanistic-Empirical Pavement Design Guide.

MN Commitment End Date: 2014

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

URL: http://www.pooledfund.org/Details/Study/416 | **Number of Participating States:** 15

Funded by: SP&R, SRP | **Total Cost:** $510,000 | **MN 2011 Commitment:** $0 | **MN 2012 Commitment:** $0

TL: Gene Hicks | **PC:** Deb Fick

Description: This pooled fund study focuses on two different areas surrounding length-based vehicle detection systems (compared to traditional systems based on axle count and weight). First, investigators are conducting extensive field and laboratory tests of in-traffic detection hardware systems that can be used to measure vehicle length. This includes inductance loop detectors and nonloop detectors along with the associated controllers and data processors. The second part of the study is an analysis of vehicle length-based data to support recommendations for a length classification and sorting system that can be standardized across states.

Status: A preliminary final report for this study is in draft form, and follow-up testing is ongoing. Initial findings include establishment of margin of error for the different detector configurations and controllers studied. Results to date present preliminary data from participant states on categorization efforts for vehicle length data. Final project deliverables will include a length detection calibration and verification procedure to be validated through multistate testing. This project will also assess conversion of length-based data to the existing vehicle class system used in the national Highway Performance Monitoring System.

Impact: When used for the appropriate application, a vehicle classification system based on length can have advantages over traditional systems. It is less expensive and can be done with portable and nonintrusive equipment for short-term data collection. Length-based vehicle class data can be used to support a variety of highway agency activities: pavement design and management, maintenance and rehabilitation scheduling, freight flow predictions, capacity projections, environmental impact analysis and weight enforcement strategies.

MN Commitment End Date: 2008

TPF-5(215) TERRA Pooled Fund Support—Transportation Engineering and Road Research Alliance			
URL: http://www.pooledfund.org/Details/Study/443		**Number of Participating States:** 7	
Funded by: SP&R, SRP	**Total Cost:** $200,000	**MN 2011 Commitment:** $7,500	**MN 2012 Commitment:** $7,500
TL: Maureen Jensen		**PC:** Deb Fick	
Description: Established in 2004, The Transportation Engineering and Road Research Alliance (TERRA) brings together representatives from government, industry and academia to foster collaborative research and innovation in road engineering and construction, including issues related to cold climates. TERRA's work includes enhancing the capabilities and use by the broader research community of MnROAD, MnDOT's state-of-the-art outdoor pavement research facility. Current projects include a five-year study to test the performance of thinner unbonded concrete overlays subject to Interstate traffic and Minnesota's extreme climate; a unique partnership of several state DOTs and four universities to develop asphalt mixture specifications for low-temperature cracking based on laboratory fracture testing and modeling; and a project to evaluate the durability, hydrologic characteristics and environmental effects of porous asphalt pavement when used on a low-volume roadway in a cold climate.			
Status: TERRA has grown significantly in the last two years to six member states. Its board meets three times a year. In summer 2012, TERRA members went through a strategic planning process to promote a greater focus on research and implementation. Planning is currently under way for the next phase of MnROAD, to begin in 2016. For more information, see the **Technical Summary** on page 152.			
Impact: TERRA has had a dramatic effect on MnDOT's approach to research, increasing its focus on finding partners and existing solutions before commencing projects. By bringing partners together to collaborate on transportation research problems, TERRA gives MnDOT a broader perspective and keeps it focused on results and implementation.			
MN Commitment End Date: 2014			

TPF-5(218) Clear Roads Winter Highway Operations—Phase 2			
URL: http://www.pooledfund.org/Details/Study/446		**Number of Participating States:** 27	
Funded by: SP&R, SRP	**Total Cost:** $2,105,000	**MN 2011 Commitment:** $25,000	**MN 2012 Commitment:** $25,000
TL: Thomas Peters		**PC:** Deb Fick	
Description: New winter maintenance materials, methods and equipment are constantly being developed, and states need to know the effectiveness of these tools before they can be widely implemented. As state DOTs pursue new technologies and practices for improving winter highway operations, this pooled fund study 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.			
Status: To date, 11 projects have been completed and 11 more are under way or scheduled to begin soon. This pooled fund study recently published a step-by-step instructional video to accompany the previously developed Field Testing Guide for Deicing Chemicals. The video demonstrates the levels of field testing that can be performed to determine the effectiveness of a deicing chemical. Another project now under way is a follow-up effort to enhance a cost-benefit analysis toolkit developed in 2010, which MnDOT recently began incorporating into its training program. Other upcoming projects include efforts for establishing effective salt and anti-icing application rates, understanding how winter chemicals perform on special pavement types, training snowplow operators and supervisors, comparing materials distribution systems and improving snowplow design. For more information, see the **Technical Summary** on page 124.			
Impact: Identification and field testing of innovative winter maintenance solutions improve safety and save money. With participation from more than half the states in the nation, this MnDOT-led study is delivering value to a broad audience of state DOTs by addressing a range of winter maintenance questions. The benefits extend well beyond state agencies to the public at large, as illustrated in nontraditional research activities like a coordinated national winter driver safety campaign, "Ice and Snow…Take It Slow," which continues to reinforce the importance of safe driving in winter conditions.			
MN Commitment End Date: 2012			

TPF-5(262) Evaluation of Guide Sign Fonts

URL: http://www.pooledfund.org/Details/Study/490 | **Number of Participating States:** 5

Funded by: SP&R, SRP | **Total Cost:** $165,000 | **MN 2011 Commitment:** $0 | **MN 2012 Commitment:** $15,000

TL: Cory Johnson | **PC:** Deb Fick

Description: The federal government gives final ruling on which fonts are acceptable for highway signs. The lettering in the current standard font, Series E (Modified), presents readability problems for some motorists, particularly older motorists driving at night. A proposed alternative has not yet met with final federal approval, and as a proprietary font it comes with significant cost issues. This study seeks to develop a new font based on the current standard and to conduct comparison visibility and readability tests using test drivers in a controlled field environment.

Status: Work on this project began recently. Contractor selection has been completed, and work began in autumn 2012.

Pooled fund study TPF-5(262) is seeking to improve upon FHWA's current standard highway font, Series E (Modified).

Impact: The final report from this study will include a recommended alternative font based on testing and analysis. A planned follow-up step beyond this pooled fund study will be to submit the findings and the proposed font to the FHWA for adoption into the federal Manual on Uniform Traffic Control Devices. If this is accomplished, states will be able to produce highway signs that are easier to read and that provide for a safer driving experience for all motorists.

MN Commitment End Date: 2013

Other Active Multi-State Pooled Fund Projects

Study Number	Title	Technical Liaison	Project Coordinator	Lead State or Agency	Number of Participating States or Agencies	Current MN Commitment End Date	Total Cost	Total MN Commit-ment	MN 2012 Commit-ment
SPR-2(207)	Transportation Management Center Pooled Fund Study	Brian Kary	Deb Fick	FHWA	33	2012	$5,632,267	$350,000	$50,000
SPR-3(042)	Aurora Program	Curt Pape	Deb Fick	IA	19	2013	$3,697,500	$425,000	$25,000
SPR-3(074)	Pavement Research and Technology	Roger Olson	Deb Fick	WA	4	2012	$625,000	$310,000	$15,000
TPF-5(029)	High Occupancy Vehicle (HOV)/ Managed Use Lane (MUL)	Brian Kary	Deb Fick	FHWA	12	2013	$1,990,000	$225,000	$25,000
TPF-5(054)	Maintenance Decision Support System (MDSS)	Curt Pape	Deb Fick	SD	20	2013	$4,383,841	$250,000	$25,000
TPF-5(114)	Roadside Safety Research Program	Michael Elle	Deb Fick	WA	9	2013	$1,565,000	$500,000	$50,000
TPF-5(139)	PCC Surface Characteristics: Tire-Pavement Noise Program Part 3—Innovative Solutions/ Current Practices	Bernard Izevbekhai	Deb Fick	IA	9	2008	$720,000	$55,000	$0
TPF-5(156)	Mid America Freight Coalition Pooled Fund	John Tompkins	Deb Fick	WI	10	2013	$1,325,000	$150,000	$25,000
TPF-5(159)	Technology Transfer Concrete Consortium	Maria Masten	Deb Fick	IA	24	2015	$667,000	$51,000	$7,000
TPF-5(174)	Construction of Crack-Free Bridge Decks—Phase II	Paul Kivisto	Deb Fick	KS	14	2011	$995,000	$75,000	$0
TPF-5(179)	Evaluation of Test Methods for Permeability (Transport) and Development of Performance Guidelines for Durability	Bernard Izevbekhai	Deb Fick	IN	11	2011	$843,000	$87,000	$0
TPF-5(193)	Midwest States Pooled Fund Crash Test Program	Michael Elle	Deb Fick	NE	16	2013	$2,667,005	$190,100	$66,700
TPF-5(197)	The Impact of Wide-Base Tires on Pavement Damage: A National Study	Shongtao Dai	Deb Fick	FHWA	7	2012	$725,000	$100,000	$25,000
TPF-5(198)	Urban Mobility Study, 2009 Continuation	Paul Czech	Deb Fick	TX	12	2012	$310,000	$265,000	$30,000
TPF-5(202)	HY-8 Culvert Analysis Program—Phase Three of Development Efforts	Petra DeWall	Deb Fick	FHWA	8	2011	$160,000	$30,000	$0
TPF-5(209)	Transportation Curriculum Coordination Council (TCCC)	Catherine Betts	Deb Fick	FHWA	16	2012	$1,100,000	$75,000	$15,000
TPF-5(224)	Investigation of Jointed Plain Concrete Pavement Deterioration at Joints and the Potential Contribution of Deicing Chemicals	Bernard Izevbekhai	Deb Fick	IA	9	2013	$430,000	$60,000	$15,000
TPF-5(225)	Validation and Implementation of Hot-Poured Crack Sealant	Jim McGraw	Deb Fick	VA	9	2013	$825,000	$100,000	$25,000
TPF-5(231)	ITS Pooled Fund Program (ENTERPRISE)	Jon Jackels	Deb Fick	MI	11	2012	$1,585,000	$60,000	$30,000
TPF-5(237)	Transportation Library Connectivity and Development	Sheila Hatchell	Deb Fick	MO	24	2012	$905,528	$40,000	$20,000
TPF-5(238)	Design and Fabrication Standards to Eliminate Fracture Critical Concerns in Two Girder Bridge Systems	Yihong Gao	Deb Fick	IN	9	2013	$840,000	$60,000	$20,000

cont. ➡

Other Active Multi-State Pooled Fund Projects, Cont.

Study Number	Title	Technical Liaison	Project Coordinator	Lead State or Agency	Number of Participating States or Agencies	Current MN Commitment End Date	Total Cost	Total MN Commitment	MN 2012 Commitment
TPF-5(245)	2012 Multi-State Asset Management Implementation Workshop	Cassandra Isaackson	Deb Fick	FHWA	11	2011	$120,000	$10,000	$0
TPF-5(247)	Field Testing Handheld Thermographic Inspection Technologies Phase II	Paul Rowekamp	Deb Fick	MO	10	2012	$610,000	$60,000	$30,000
TPF-5(253)	Member-Level Redundancy in Built-Up Steel Members	Todd Nieman	Deb Fick	IN	8	2013	$550,000	$75,000	$25,000
TPF-5(254)	Evaluation and Analysis of Decked Bulb T Beam Bridge	Dave Conkel	Deb Fick	MI	5	2014	$380,000	$60,000	$15,000
TPF-5(256)	HY-12 Storm Drain Hydraulic Analysis Program—Phase Two of Development Efforts	Lisa Sayler	Deb Fick	FHWA	6	2013	$80,000	$10,000	$10,000
TPF-5(258)	Traffic Signal Systems Operations and Management	Steve Misgen	Deb Fick	IN	10	2014	$525,000	$75,000	$25,000
TPF-5(265)	Watershed Modeling System License Renewal Agreement	Lisa Sayler	Deb Fick	FHWA	8	2013	$112,000	$5,000	$5,000
TPF-5(266)	Surface-Water Model System License Renewal Agreement	Lisa Sayler	Deb Fick	FHWA	7	2013	$86,000	$10,000	$10,000
TPF-5(270)	Recycled Materials Resource Center—Third Generation	Jerry Geib	Deb Fick	WI	4	2014	$300,000	$75,000	$25,000

Active NCHRP Projects with MnDOT Panel Membership

Project Number	Project Title	MnDOT Panel Member	Division	Role	Start Date	End Date
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	2013
D0836	Research for AASHTO Standing Committee on Planning: Support for Improved Transportation Planning and Project Development	Timothy A. Henkel	Modal Planning & Program Management	Member	1998	Ongoing
D0836113	The Role of Planning in a 21st Century Transportation Agency	Timothy A. Henkel	Modal Planning & Program Management	Member	Pending	Pending
D0876	Strengthening and Integrating Safety in the State and Regional Planning Processes: Best Practices and Recommended Procedures	Brian K. Gage	Modal Planning & Program Management	Member	2009	2012
D0885	The Comprehensive Economic Effects of Highway-Rail At-Grade Crossing Crashes	Susan H. Aylesworth	Modal Planning & Program Management	Member	2011	2012
D0888	Effective Project Scoping Practices to Improve On-Time and On-Budget Delivery of Highway Projects	Michael T. Ginnaty	Engineering Services	Member	Pending	Pending
D0950	Performance-Related Specifications for Asphaltic Binders Used in Preservation Surface Treatments	Shongtao Dai	Policy, Safety & Strategic Initiatives	Member	2011	2014
D0951	Material Properties of Cold In-Place Recycled and Full Depth Reclamation Asphalt Concrete for Pavement Design	John A. Siekmeier	Policy, Safety & Strategic Initiatives	Member	2012	2014
D0952	Short-Term Laboratory Conditioning of Asphalt Mixtures	Timothy R. Clyne	Policy, Safety & Strategic Initiatives	Member	2012	2014
D1084	Modulus-Based Construction Specifications and Issues for Highway Earthwork and Unbound Base Materials	John A. Siekmeier	Policy, Safety & Strategic Initiatives	Chair	2010	Ongoing
D1085	A Guidebook for Construction Manager-At-Risk Contracting for Highway Projects	Jay J. Hietpas	Engineering Services	Member	2011	2013

cont. ➡

Active NCHRP Projects with MnDOT Panel Membership, Cont.

Project Number	Project Title	MnDOT Panel Member	Division	Role	Start Date	End Date
D1089	Determination of Best Practices for Optimal Construction Inspection	Terry Ward	Engineering Services	Member	2012	2014
D1283	Calibration of LRFD Concrete Bridge Design Specifications for Serviceability	David Dahlberg	Engineering Services	Member	2009	2012
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	Ongoing
D1426	Culvert and Storm Drain Inspection Manual	Bonnie Peterson	Engineering Services	Member	Pending	Pending
D1539	Superelevation Criteria for Horizontal Curves on Steep Grades	James Rosenow	Engineering Services	Member	2010	2012
D1546	A Design-Management Guide for Design-Build and Construction Manager/General Contractor Projects	Jon Chiglo	Engineering Services	Member	2012	2013
D1749	Guide for Effective Tribal Crash Reporting	Linda Aitken	Government Affairs	Member	2011	2013
D1751	Input to the Development of a National Highway Safety Strategy	Bernard J. Arseneau	Deputy Commissioner/ Chief Engineer	Member	2011	2012
D1761	Work Zone Crash Characteristics and Countermeasure Guidance	Susan M. Groth	Policy, Safety & Strategic Initiatives	Member	Pending	Pending
D2036	Highway Research and Technology—International Information Sharing	Mukhtar Thakur	Modal Planning & Program Management	Member	1993	2012
D2082	Next Generation of the FHWA Transportation Pooled Fund (TPF) Website	Susan J. Lodahl	Operations	Chair	2009	2012
D208304	Effects of Changing Transportation Energy Supplies and Alternative Fuel Sources on State Departments of Transportation	Jean Wallace	Policy, Safety & Strategic Initiatives	Member	2009	Ongoing
D208307	Sustainable Transportation Systems and Sustainability as an Organizing Principle for Transportation Agencies	Robert Edstrom	Engineering Services	Member	2010	2013
D2085	Wind, Solar and Ground-Source Energy for Maintenance Area Facilities	Robert Miller	Operations	Member	2010	2013
D2433	Development of Design Methods for In-Stream Flow Control Structures	Petronella L. DeWall	Engineering Services	Member	2008	2012
D2436	Scour at the Base of Retaining Walls and Other Longitudinal Structures	Petronella L. DeWall	Engineering Services	Member	Pending	Pending
D2437	Combining Individual Scour Components to Determine Total Scour	Nicole A. Danielson-Bartelt	Engineering Services	Member	Pending	Pending
D2539	Developing Environmental Performance Measures and a Methodology for Incorporation into Performance Management Programs	Jennie Ross	Engineering Services	Member	Pending	Pending
D2540	Long-Term Performance and Life-Cycle Costs of Stormwater Best Management Practices	Nicklas Tiedeken	Engineering Services	Chair	2012	2014
D1749	Guide for Effective Tribal Crash Reporting	Linda Aitken	Government Affairs	Member	2011	2013

Active ACRP Projects with MnDOT Panel Membership

Project Number	Project Title	MnDOT Panel Member	Division	Role	Start Date	End Date
DA0327	Evaluating Methods for Counting Aircraft Operations at Non-Towered Airports	Peter Buchen	Modal Planning & Program Management	Member	2011	2013

Active NCFRP Projects with MnDOT Panel Membership

Project Number	Project Title	MnDOT 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 Management	Member	2011	2012
DF035	The Great Lakes Region Impacts on the Intermodal Freight Systems	William D. Gardner	Modal Planning & Program Management	Chair	2010	2012

Active SHRP 2 Technical Expert Task Groups with MnDOT Membership

Project Number	Project Title	MnDOT Technical Expert Task Group Member	Division	Role	Start Date	End Date
FB034	Using Infrared and High Speed GPR for Uniformity Measurements on New HMA Layers and Nondestructive Testing to Identify Delaminations between HMA Layers	Shongtao Dai	Policy, Safety & Strategic Initiatives	Member	2009	2013
FB052	Communicating Railroad-DOT Mitigation Strategies and Tools for Communicating Railroad-DOT Mitigation Strategies	Susan H. Aylesworth	Modal Planning & Program Management	Member	2011	2013
FC020	Incorporating Reliability Performance Measures into the Transportation Planning and Programming Processes	Peggy A. Reichert	Modal Planning & Program Management	Member	2010	2012
FC029	Regional Operations Academy for Operations Management	Bernard J. Arseneau	Deputy Commissioner/ Chief Engineer	Member	Pending	Pending
FC030	Urban Freeway Models Validation	James M. Kranig	Engineering Services	Member	Pending	Pending

Feature

Bill Gardner Brings National Freight Research to MnDOT

Dozens of MnDOT staff members take key roles in guiding research efforts through several national programs such as the Federal Highway Administration's (FHWA's) **Transportation Pooled Fund Program** and the Transportation Research Board's (TRB) **Cooperative Research Programs**. MnDOT staff also serves on technical committees of the state DOTs' nonprofit group, the **American Association of State Highway and Transportation Officials (AASHTO)**. These efforts multiply Minnesota taxpayer dollars by giving MnDOT a voice in directing national research to the needs of the state and exposure to the innovative practices of other agencies. This helps MnDOT solve problems rapidly, often without costly, duplicative research.

Bill Gardner, MnDOT director of the Office of Freight & Commercial Vehicle Operations, actively supports a variety of freight research activities, conducting freight research projects in cooperation with MnDOT Research Services. On the national level he participates in the **National Cooperative Freight Research Program (NCFRP)**, serving on several project advisory panels and as a member of the NCFRP program oversight committee. He is also one of two U.S. representatives to the **World Road Association's Freight Transport Committee**, which conducts international research, and represents MnDOT in the AASHTO **Mid-America Freight Coalition**, which conducts pooled fund research specific to the Midwest. Gardner's active involvement in freight research helps Minnesota achieve its goal of being a global leader in transportation, with direct access to the latest data, technologies, practices and plans.

Gardner cites shifting supply chains and changes in infrastructure as trends MnDOT needs to better understand. One example is the widening of the Panama Canal for larger ships, scheduled for completion in 2014. This effort will shift some freight away from West Coast ports to Gulf and East Coast ports, which, together with the return of some manufacturing to the United States is changing how goods flow into and out of Minnesota.

"We need to make certain Minnesota remains connected and competitive as the national and international freight transportation systems evolve," Gardner says. His involvement in research helps keep Minnesota properly positioned for these developments.

Gardner also cites NCFRP Project #24, **"Preserving and Protecting Freight Infrastructure and Routes,"** as particularly relevant for helping Minnesota achieve a unified vision for freight corridors and facilities. "Part of this effort," Gardner says, "has been to educate decision-makers about the value of freight to the local and regional economy. Communities often don't want to accommodate freight services, but we rely upon those services to keep our shelves stocked and enable our shippers to move their goods to market cost-effectively."

Using numerous case studies, including European experience, this national research project developed tools related to planning, land use, design and private-public collaboration to help mitigate conflicts. A toolbox developed through this project is available at **www.envisionfreight.com/index.html**.

Some Minnesota communities are struggling with freight conflicts along highways, rail lines and ports. "MnDOT needs to do a better job of proactively bringing communities and the freight industry together to mitigate existing conflicts and avoid future ones," Gardner says. "These tools and strategies will help with that effort."

Single-State SP&R Projects

This section provides basic information about single-state SP&R projects with active contracts in FY2012 or, in some cases, funds that were committed in 2012 but have not yet resulted in a contract.

Studies with FY2012 Commitments

MPR-0(002): Culvert Repair Best Practices, Specifications and Special Provisions			
Funded by: SP&R, SRP	**Total Cost:** $80,000	**Paid to Date:** $21,171	**MN 2012 Commitment:** $0
Performed by: CNA Consulting Engineers, Inc.			
PI: Bruce Wagener	**TL:** Lisa Sayler	**PC:** Bruce Holdhusen	
Description: The objective of this project is to develop best practices for the replacement and rehabilitation of culverts during typical highway maintenance and improvement projects. Guidelines cover installation practices, advantages and disadvantages of various methods of repair, cost comparisons, environmental safeguards, and supporting specifications and detail drawings.			
Status: Researchers have performed a literature review and a survey of MnDOT and other state personnel. An upcoming TAP meeting will review the results to date and recommend specific repair methods that include specifications and guidelines. A final report is expected in July 2013.			
Impact: The results of this project will provide guidance to MnDOT and city and county engineers in making better decisions on culvert repairs. New materials specifications and special provisions will ensure adherence to standardized practices and increase the effectiveness and longevity of repairs.			
Start Date: 11/1/11	**Projected End Date:** 7/31/13		

MPR-0(003): Reporting Capabilities for Continuous Vehicle Class and WIM Data			
Funded by: SRP, SP&R	**Total Cost:** $35,268	**Paid to Date:** $8,298	**MN 2012 Commitment:** $0
Performed by: University of Minnesota – Duluth			
PI: Taek Kwon	**TL:** Benjamin Timerson	**PC:** Nelson Cruz	
Description: The goal of this project is to modify software for analyzing data from MnDOT's automated traffic recorders at weigh-in-motion (WIM) sites, which record the number, speed, classification and weight of passing trucks. Software modifications enhance MnDOT's ability to ensure the quality of this data by increasing error tracking and also enhance reporting functions for analyzing data.			
Status: After modifying error decoding and existing reporting functions, researchers added new reporting functions and are currently testing, verifying and debugging all functionality. The project will be completed in December 2012.			
Impact: This project will enhance MnDOT's ability to evaluate and verify the quality of data from WIM and vehicle classification sites. It will also allow MnDOT to more quickly produce reports using higher quality data.			
Start Date: 11/18/10	**Projected End Date:** 12/31/12		

MPR-0(004): Scour Monitoring Technology Implementation			
Funded by: SP&R, SRP	**Total Cost:** $38,233	**Paid to Date:** $19,180	**MN 2012 Commitment:** $0
Performed by: University of Minnesota			
PI: Jeff Marr	**TL:** Andrea Hendrickson	**PC:** Shirlee Sherkow	
Description: This project monitors two bridges for bridge scour—the removal of sediment from abutments and piers that can lead to bridge failure—over a three-year period. Researchers install and evaluate fixed monitoring equipment at two bridge sites and also work on streamlining data retrieval. MnDOT will use the findings to create guidelines for equipment maintenance and installation at other locations.			
Status: In 2012, researchers summarized lessons learned from the installation of scour monitoring equipment, addressing significant issues that arose during and immediately after installation. They also detailed post-installation administration and maintenance, reviewing significant incidents. Moving forward, researchers will complete the technical documentation for these systems, test them by simulating a scour event, continue to monitor sensor readings and equipment operations, and perform data collection and analysis.			
Impact: Data collected from the installed equipment will be used to implement the FHWA-mandated Plans of Action required for all scour-critical bridges. Because bridge scour can result in bridge foundation failure, timely data collection is critical so that countermeasures can be deployed if necessary. The equipment will help preserve bridge infrastructure and protect the safety of the traveling public.			
Start Date: 4/18/11	**Projected End Date:** 5/31/14		

MPR-0(005): Analysis of Bridge Deck Cracking Data			
Funded by: SP&R, SRP	**Total Cost:** $44,993	**Paid to Date:** $0	**MN 2012 Commitment:** $0
Performed by: American Engineering Testing, Inc.			
PI: Dave Rettner	**TL:** Ronald Mulvaney	**PC:** Shirlee Sherkow	
Description: This implementation project conducts a statistical analysis of data collected from more than 60 recent bridge deck construction projects to identify which construction controls, material properties or environmental characteristics most affect the cracking susceptibility of typical MnDOT concrete bridge decks. Investigators will recommend specification revisions based on their findings.			
Status: Because of problems with the data set, the project scope is slated to be modified to include fieldwork that will provide additional data for analysis. Investigators plan to conduct under-deck crack surveys to provide this data. The crack surveys will include a focus on inverted-T bridges, where significant cracking has been observed. An amendment to extend the contract end date to March 31, 2013, is pending.			
Impact: Based on the results of the data analysis, investigators will recommend revisions to MnDOT's bridge construction specifications to minimize cracking in new concrete bridge decks. Producing longer-lasting bridge decks will preserve critical infrastructure, reduce maintenance requirements and lower life-cycle costs, ultimately leading to improved system performance.			
Start Date: 5/25/11	**Projected End Date:** 7/31/12		

MPR-0(005): Bridge Deck Cracking TRS			
Funded by: SP&R, SRP	**Total Cost:** $4,930	**Paid to Date:** $4,930	**MN 2012 Commitment:** $0
Performed by: American Engineering Testing, Inc.			
PI: Dave Rettner	**TL:** Ronald Mulvaney	**PC:** Shirlee Sherkow	
Description: This Transportation Research Synthesis provides information for the research project "Analysis of Bridge Deck Cracking Data," which is using statistical analysis to determine the most significant causes of bridge deck cracking. The TRS prepares for this larger research project by examining the causative factors for bridge deck cracking identified by previous research studies and by reviewing the statistical methods used in similar research.			
Status: This work has been completed. The TRS is available online at **www.dot.state.mn.us/research/TRS/2011/TRS1105.pdf**.			
Impact: The analysis provided in this TRS will help researchers identify the design, construction and environmental factors that cause cracking in concrete bridge decks. Ultimately this effort is expected to lead to revised construction specifications that will yield longer-lasting bridge decks.			
Start Date: 3/22/11	**Projected End Date:** 11/30/11		

MPR-1(002): Development of a Spatial-Time-Domain Acoustic Device for Rapid Concrete Evaluation			
Funded by: SP&R, SRP	**Total Cost:** $98,000	**Paid to Date:** $18,000	**MN 2012 Commitment:** $0
Performed by: MnDOT Materials Lab			
PI: Bernard Izevbekhai	**TL:** Maureen Jensen	**PC:** Daniel Warzala	
Description: To develop a method for the early detection of deterioration in concrete pavements and bridge decks, this project uses a system that measures acoustic impulses reflected from concrete pavements driving speed. The system consists of an acoustic intensity and frequency analyzer that replaces the more subjective use of the human ear with chain drags. Researchers develop a device that transmits impulses to which concrete at various degrees of degradation or poor mixing respond differently.			
Status: Researchers have conducted a synthesis of the application of acoustic emissions to tire pavement acoustics and the use of ultrasonic pulse waves and time-domain concepts for rapid concrete evaluation, establishing the natural frequency bands for various pavement conditions. They are currently procuring equipment for data collection and anticipate field trials in the summer of 2013.			
Impact: Conducting comprehensive concrete evaluation at driving speed will improve MnDOT's ability to detect concrete deterioration, reducing the costs and duration of lane closures and detours. It will also enhance public safety by providing a tool to detect early forms of deterioration in bridge decks.			
Start Date: 4/8/11	**Projected End Date:** 3/31/14		

MPR-1(003): Implementation of Pavement Evaluation Tools

Funded by: SP&R, SRP	**Total Cost:** $78,000	**Paid to Date:** $0	**MN 2012 Commitment:** $0
Performed by: University of Minnesota			
PI: Joseph Labuz	**TL:** Shongtao Dai	**PC:** Deb Fick, Nelson Cruz	

Description: This project develops a user-friendly graphical interface to help county and state engineers perform state-of-the-art pavement diagnoses using integrated ground-penetrating radar and falling weight deflectometer measurements. Despite their effectiveness as tools for noninvasively determining pavement thickness and resilient modulus, these devices currently are not widely used because of the difficulty of interpreting their data. The software integrates a more consistent and reliable algorithm for back-calculation developed by the University of Minnesota, called GopherCalc.

Status: Researchers have developed initial software for interpreting GPR and FWD data. Future tasks include the development and calibration of back-calculation capabilities and their integration with a user-friendly graphical interface.

Impact: The graphical user interface being developed in this project eliminates the usual complexities of back-calculation involved in interpreting GPR and FWD data, and increases its accuracy by integrating data (for example, by allowing the use of GPR measurements of pavement thickness in back-calculations of resilient modulus). The software will be useful to pavement designers from state and local agencies.

Start Date: 11/1/11	**Projected End Date:** 6/30/13	

MPR-1(004): Partially Grouted Riprap Implementation Matrix Riprap Implementation

Funded by: SP&R, SRP	**Total Cost:** $16,635	**Paid to Date:** $9,663	**MN 2012 Commitment:** $0
Performed by: Ayres Associates			
PI: Paul Clopper	**TL:** Nicole Danielson-Bartelt	**PC:** Shirlee Sherkow	

Description: Bridge scour causes material loss around bridge abutments, which can result in the loss of the approach panel and bridge failure. Matrix riprap (also known as partially grouted riprap) is a relatively new scour countermeasure in the United States. Although MnDOT has developed construction specifications for this technique, implementation has been challenging because of the lack of experience with this method. In this implementation project, the consultant trains MnDOT personnel on the basic design and installation of matrix riprap on bridge abutments, and supervises its installation on a bridge in District 3. The consultant also provides technical guidance documentation and recommendations for revising the matrix riprap special provision and design details.

Investigators train MnDOT staff on proper techniques for installing matrix riprap on a bridge abutment.

Status: The training and field demonstration was completed in May 2012. Since current matrix riprap grout test procedures use European testing equipment and standards, a contract amendment is pending that would use the remaining project budget to define grout testing standards using typical U.S. equipment.

Impact: The training and guidance given through this project will allow MnDOT to effectively implement this promising scour countermeasure, providing the department with a new abutment slope protection technique. Using this technique appropriately is expected to help decrease abutment repairs and replacement, which will reduce costs and delays and improve motorist safety.

Start Date: 12/14/11	**Projected End Date:** 2/28/13	

MPR-1(007): Commercial Freight Weight Enforcement Innovation

Funded by: SP&R, SRP	**Total Cost:** $96,613	**Paid to Date:** $23,109	**MN 2012 Commitment:** $0
Performed by: SRF Consulting Group, Inc.			
PI: Brian Scott	**TL:** Benjamin Timerson	**PC:** Deb Fick, Alan Rindels	

Description: This project evaluates the use of a license plate reading (LPR) system to improve overweight vehicle enforcement at a weigh-in-motion (WIM) site. The system monitors traffic crossing a Mississippi River bridge in Winona, capturing license plate data that can be linked to WIM data for enforcement efforts. This project documents the system's accuracy, performance and life-cycle costs; makes recommendations for data management; and assists stakeholders with integrating the technology into current systems. Investigators also evaluate and refine the vehicle classification algorithm used in the state's WIM systems.

Investigators use a bucket truck to adjust the position of a new license plate reader camera at the WIM site on US 43 in Winona.

Status: The LPR camera was installed in June 2012. The camera was initially able to read standard Minnesota and Wisconsin license plates, but not most commercial vehicle plates. The camera manufacturer is developing an algorithm that will improve the camera's ability to read these plates. An amendment is pending to extend the contract end date to November 30, 2013.

Impact: This project demonstrates how technology enhancements can improve overweight vehicle enforcement at WIM sites. The LPR system provides evidence that will enable the State Patrol to issue many more citations than current technology allows; this increased enforcement is expected to be more effective at deterring violators. In addition, by refining the state's existing vehicle classification algorithm, this project will improve the accuracy of WIM data, thereby better measuring the tonnage of freight being shipped in Minnesota.

Start Date: 9/22/11	**Projected End Date:** 11/30/12	

MPR-1(008): Developing Performance Measures Using GPS Arterial Travel Time Data

Funded by: SP&R, SRP	**Total Cost:** $125,000	**Paid to Date:** $0	**MN 2012 Commitment:** $0
Performed by: Texas Transportation Institute			
PI: Shawn Turner	**TL:** Paul Czech	**PC:** Deb Fick, Alan Rindels	

Description: The goals of this project are to develop and implement mobility-related performance measures for arterial roadways using private-sector GPS speed data, similar to practices currently used on the instrumented freeway system.

Status: This year investigators began reviewing arterial mobility performance measures used by MnDOT and other agencies, and reviewing relevant MnDOT plans and policies. The panel and investigators evaluated options for licensing speed data from a private company, and a request for proposals was drafted in June 2012.

Impact: The performance measures developed through this project will help MnDOT better understand arterial street performance in the Metro District and make decisions based on this information, enhancing mobility in the Twin Cities. Similar private-sector GPS data is available for the Greater Minnesota Interregional Corridor System, giving the project results statewide significance.

Start Date: 4/9/12	**Projected End Date:** 5/13/13	

MPR-1(010): Vehicle-Mounted Robotic Roadway Message and Symbol Painter			
Funded by: SRP, SP&R	**Total Cost:** $95,000	**Paid to Date:** $0	**MN 2012 Commitment:** $0
Performed by: University of Minnesota – Duluth			
PI: Ryan Rosandich	**TL:** Randy Reznicek	**PC:** Alan Rindels	
Description: In this project, researchers develop a computer-controlled, truck-mounted robotic message painter system that automates painting of pavement markings, which currently requires a stencil. The project enhances productivity and safety by replacing a two-person painting crew with a one-person operation, completing pavement markings more quickly and allowing the operator to remain inside the truck when markings are painted.			
Status: This project is in its initial stages of development. Despite a slight delay in receiving parts, researcher will test the robotic arm in the field by the summer of 2013.			
Impact: If effective, the robotic message painter system will save money in sign painting. Typical pavement painting projects will require only one operator and will eliminate stencils, cleanup time and some preparation time. The system will also create shorter drying times, reducing inconvenience to drivers.			
Start Date: 12/8/11	**Projected End Date:** 5/31/13		

MPR-1(012): Statewide Cycloplan: Bicycle Planning Tool and Participatory GIS			
Funded by: SP&R, SRP	**Total Cost:** $130,000	**Paid to Date:** $0	**MN 2012 Commitment:** $0
Performed by: University of Minnesota			
PI: Loren Terveen	**TL:** Greta Alquist	**PC:** Shirlee Sherkow	
Description: This project promotes the statewide implementation of Cycloplan, an innovative way to assist planners in creating a regional bikeways system map through coordination and input from various agencies and the public. Cycloplan lets planners keep a regional bikeways system map current and determine where additions and improvements to the system are most needed. Key features of Cycloplan include maintenance of a bikeways registry; communication of route closures, additions and upcoming projects that require input; and feedback from personalized geographic regions.			
Status: This project is in the early stages of work on user interface features.			
Impact: This project will expand existing Cycloplan Web services to the entire state. Cycloplan allows users to find point-to-point bike routes and integrates an algorithm that refines route development based on user reviews and input. This tool offers bike users a detailed, sensitive route-development option based on traffic volume, path access, safety preferences and other parameters.			
Start Date: 2/6/12	**Projected End Date:** 4/30/14		

MPR-1(013): Use of Non-Woven Fabric Interlayer for Unbonded Concrete Overlays			
Funded by: SP&R, SRP	**Total Cost:** $74,998	**Paid to Date:** $34,694	**MN 2012 Commitment:** $0
Performed by: University of Minnesota			
PI: Lev Khazanovich	**TL:** Thomas Burnham	**PC:** Daniel Warzala	
Description: The goal of this project is to determine the performance and design parameters of non-woven fabric as an interlayer for unbonded concrete overlays. Researchers conduct laboratory tests to evaluate the ability of non-woven fabric to prevent bonding and provide drainage and stress relief.			
Status: Researchers constructed several 6 feet wide by 15 feet long test sections at the Minne-ALF pavement research facility, which simulates vehicle loads using hydraulic actuators. Sections were evaluated for strain, deflection, pavement distress, modulus of elasticity, compressive strength and drainability. Currently researchers are performing a forensic study of the final test section to determine the patterns of pavement failure and cycles to failure, and to evaluate the crack arresting performance of the fabric interlayer. Results thus far show that the fabric provides stress relief, and researchers have developed a better understanding of its drainage capabilities.			
Impact: Once long-term performance best design practices are established, non-woven fabrics have the potential to reduce unbonded concrete overlay project costs. The end product for this project will include guidance to pavement designers and construction specifications. Based on the results of this project, researchers plan to construct a similar test section at MnROAD in 2013.			
Start Date: 11/1/11	**Projected End Date:** 12/31/12		

MPR-1(015): Implementation of LED Roadway Lighting			
Funded by: SP&R, SRP	**Total Cost:** $40,000	**Paid to Date:** $0	**MN 2012 Commitment:** $20,000
Performed by: Short Elliott Hendrickson, Inc.			
PI: TBD	**TL:** Susan Zarling	**PC:** Deb Fick	
Description: This project evaluates the use of LED luminaires in MnDOT roadway lighting. Researchers replace existing high-pressure sodium (HPS) luminaires with LED luminaires along a segment of highway, and compare the electrical power usage and light levels of the LED luminaires with adjacent newly installed HPS luminaires. Researchers create a cost comparison of the LED and HPS luminaires and document maintenance issues.			
Status: This project is in its initial stages of development.			
Impact: LED luminaires are designed to be longer-lasting and more energy-efficient than conventional roadway luminaires. This project examines whether this emerging alternative can provide required lighting levels more cost-effectively than HPS luminaires, potentially reducing energy and maintenance costs associated with roadway lighting in the state.			
Start Date: TBD	**Projected End Date:** TBD		

MPR-1(016): Field Implementation, Testing and Refinement of Density-Based Coordinated Ramp Control Strategy

Funded by: SP&R, SRP	**Total Cost:** $103,735	**Paid to Date:** $0	**MN 2012 Commitment:** $82,989
Performed by: University of Minnesota			
PI: John Hourdos	**TL:** Brian Kary	**PC:** Deb Fick, Alan Rindels	

Description: A recently completed research project developed a new density-based ramp metering algorithm that showed promise at improving traffic flow in simulation tests. This follow-up project deploys and field-tests the new algorithm at a heavily congested site on Highway169.

Status: This project is in its initial stages of development. In May, the project panel agreed to amend the contract to allow for the additional programming necessary to implement the new ramp metering algorithm, and also agreed that the literature review portion of the project would be funded separately.

The new ramp metering algorithm shows promise in using freeway capacity more efficiently and reducing long ramp queues.

Impact: If the performance of the new ramp metering algorithm is validated in this field test, it will provide an improved tool for decreasing congestion along the Highway 169 corridor. The data collected through this project will allow the algorithm to be refined as needed and will help facilitate large-scale deployment on Twin Cities freeways. Ultimately this next-generation ramp metering algorithm is expected to alleviate congestion, reduce system travel time and provide associated environmental benefits.

Start Date: 5/3/12	**Projected End Date:** 4/30/14	

MPR-2(001): Lighting Levels for Isolated Intersections Leading to Safety Improvements

Funded by: SP&R, LRRB, SRP	**Total Cost:** $94,170	**Paid to Date:** $0	**MN 2012 Commitment:** $42,185
Performed by: University of Minnesota			
PI: Christopher Edwards	**TL:** Susan Zarling	**PC:** Daniel Warzala	

Description: Installing roadway lighting at isolated rural intersections is a cost-effective way of increasing visibility and reducing collisions. This project's goal is to identify a minimum lighting level that provides drivers with adequate information about an upcoming intersection. Investigators are measuring actual lighting levels at isolated rural intersections and examining crash rates at these intersections.

Status: This project is in its initial stages of development.

Impact: Roadway lighting installations at isolated intersections vary throughout the state and vary in their conformance to national lighting standards. By providing recommendations based on actual measured lighting levels and crash rates at intersections in Minnesota, this project will directly benefit local agencies throughout the state.

Start Date: 7/31/12	**Projected End Date:** 7/31/14	

MPR-2(002): Time-Dependent Considerations of I-35W St. Anthony Falls Bridge Including Long-Term Monitoring Applications			
Funded by: SP&R, SRP	**Total Cost:** $100,000	**Paid to Date:** $0	**MN 2012 Commitment:** $80,000
Performed by: University of Minnesota			
PI: Cathy French	**TL:** Benjamin Jilk	**PC:** Shirlee Sherkow	
Description: The objective of this project is to conduct structural monitoring of the I-35W St. Anthony Falls Bridge to investigate how post-tensioned concrete structures change over time and to develop long-term maintenance strategies for these systems. Researchers also evaluate the use of finite element models to account for concrete creep and shrinkage, comparing them to static data collected by instruments on the bridge, in order to develop long-term predictions of bridge behavior.			
Status: This project is in its initial stages of development. Researchers will soon begin Task 1, the development of creep and shrinkage finite element models.			
Impact: This project will allow MnDOT to gain a better understanding of the long-term behavior of the I-35W St. Anthony Falls Bridge and other post-tensioned concrete box girder structures. Developing creep and shrinkage models will help to determine long-term bridge maintenance strategies, including the timing of restorative measures designed to counteract excessive deflections, balance large prestress losses and prevent tension from developing in the concrete. It will also help in the future design of similar structures.			
Start Date: 6/29/12	**Projected End Date:** 12/31/14		

MPR-2(003): MnPASS Modeling and Pricing Algorithm Enhancement			
Funded by: SP&R, SRP	**Total Cost:** $103,735	**Paid to Date:** $0	**MN 2012 Commitment:** $82,989
Performed by: University of Minnesota			
PI: John Hourdos	**TL:** Brian Kary	**PC:** Farideh Amiri	
Description: Setting toll prices in high-occupancy toll lanes involves weighing maximized traffic throughput against the travel time reliability that can be guaranteed to users. This project produces a comprehensive platform for evaluating and optimizing the pricing algorithm used in the MnPASS HOT lanes. **Status:** This project is in its initial stages of development. **Impact:** This project provides MnDOT planners and policymakers with a tool to help make informed decisions for balancing the service and revenue levels of the MnPASS facility. The platform will allow MnDOT operations engineers to develop and test algorithm refinements in a simulated environment before deploying them in the field.		 **This project provides tools to enhance decision-making regarding toll prices in MnPASS HOT lanes.**	
Start Date: 6/29/12	**Projected End Date:** 7/31/14		

MPR-2(004): Evaluate and Develop Innovative Pavement Repair and Patching: Taconite-Based Repair Options			
Funded by: SP&R, SRP	**Total Cost:** $32,000	**Paid to Date:** $0	**MN 2012 Commitment:** $25,600
Performed by: University of Minnesota – Duluth			
PI: Lawrence Zanko	**TL:** Sue Lodahl, Duane Hill	**PC:** Nelson Cruz	
Description: This project refines and optimizes two promising alternatives to conventional pavement and pothole repair materials and methods, and evaluates their performance compared with current methods. The two innovations are a fast-setting, taconite-based pavement repair compound and a vehicle-based microwave system for in-place pavement repairs and recycling. Guidance on selecting and using pavement and pothole repair methods is developed.			
Status: This project is in its initial stages of development.			
Impact: These emerging repair strategies are anticipated to lead to longer-lasting and more efficient pavement and pothole repairs. Longer-lasting repair methods reduce the maintenance costs and traffic disruption associated with repeated repair of failing patches, ultimately increasing driver and worker safety.			
Start Date: 8/9/12	**Projected End Date:** 4/30/14		

MPR-2(005): Value Increase and Value Capture Study—TH 610 Case Study			
Funded by: SP&R, SRP	**Total Cost:** $81,000	**Paid to Date:** $0	**MN 2012 Commitment:** $64,800
Performed by: University of Minnesota			
PI: Zhirong Jerry Zhao	**TL:** Matthew Shands	**PC:** Nicole Peterson	
Description: With funding assistance through the American Recovery and Reinvestment Act (ARRA), construction was completed in 2011 on a new segment of Highway 610 from Brooklyn Park to Maple Grove. MnDOT and its partners are working to identify supplemental funding sources to accelerate the development of the highway's final phase, which would extend from County Road 81 to Interstate 94. Building on a previous value capture study, this research project examines the property value increases that this highway segment is expected to provide, identifies feasible value capture strategies and estimates the strategies' revenue-raising potential.	**This project explores how value capture strategies could help provide funding for the extension of Highway 610 to Interstate 94 (shown in red). A new segment of the highway (shown in orange) was completed in 2011 with ARRA assistance.**		
Status: This project is in its initial stages of development.			
Impact: This research uses the Highway 610 project as a case study to examine how value capture techniques could be used to help fund and advance highway projects. The results will provide information and options for decision-makers as they explore methods for funding and advancing the Highway 610 project, and will identify strategies that can be applied to other projects as well.			
Start Date: 6/29/12	**Projected End Date:** 3/31/14		

MPR-2(006): Monitoring of Fracture-Critical Steel Bridges, Phase 3			
Funded by: SP&R, SRP	**Total Cost:** $166,000	**Paid to Date:** $0	**MN 2012 Commitment:** $92,800
Performed by: University of Minnesota			
PI: Arturo Schultz	**TL:** Moises Dimaculangan	**PC:** Shirlee Sherkow	
Description: This project builds on previous research that developed an acoustic emission monitoring system on a problem-free bridge. Researchers apply the monitoring system to a bridge with higher potential for future cracking problems and continue monitoring the previously instrumented bridge.			
Status: The contract has just gotten under way.			
Impact: Many steel bridges in Minnesota are designated as fracture-critical. This research develops a monitoring system for such bridges to help MnDOT prioritize bridge maintenance needs and prevent catastrophic bridge failure such as the fracture-critical I-35W bridge in 2007.			
Start Date: 6/29/12	**Projected End Date:** 1/31/15		

MPR-2(007): Using Truck GPS Data for Freight Performance Analysis			
Funded by: SP&R, SRP	**Total Cost:** $96,500	**Paid to Date:** $0	**MN 2012 Commitment:** $77,200
Performed by: University of Minnesota			
PI: Chen-Fu Liao	**TL:** John Tompkins	**PC:** Bruce Holdhusen	
Description: Researchers integrate private-sector GPS data from commercial trucks with MnDOT's existing freight data and use the integrated data to conduct a freight performance analysis in the Twin Cities metropolitan area. The analysis generates freight mobility and reliability measures, and identifies significant freight nodes and corridors.			
Status: This project is in its initial stages of development.			
Impact: This freight performance analysis will help MnDOT better identify system impediments such as traffic congestion and truck bottlenecks, and examine how truck volume contributes to traffic congestion. MnDOT can use the measures generated through this project to inform freight planning and forecasting and to help guide decisions about infrastructure investments.			
Start Date: TBD	**Projected End Date:** TBD		

MPR-2(008): Measuring Minnesota's Traffic Safety Culture			
Funded by: SP&R, SRP	**Total Cost:** $235,217	**Paid to Date:** $0	**MN 2012 Commitment:** $188,174
Performed by: Montana State University – Western Transportation Institute			
PI: Nicholas Ward	**TL:** Katie Fleming	**PC:** Shirlee Sherkow	
Description: This project provides a survey tool to MnDOT's ongoing effort to analyze traffic safety. The tool examines the psychosocial determinants and risk behaviors of Minnesota's driving culture to guide traffic safety planning.			
Status: Task 1, a literature review, is scheduled to be complete by late October 2012. Task 2, identifying driver demographics for a classification taxonomy, will begin after Task 1 is completed.			
Impact: This survey tool will augment current work on traffic safety in Minnesota to assist MnDOT and other Minnesota groups in their pursuit of zero traffic deaths.			
Start Date: 6/22/12	**Projected End Date:** 8/31/14		

MPR-2(009): Simplified Design Table for Minnesota Concrete Pavements			
Funded by: SP&R, SRP	**Total Cost:** $89,989	**Paid to Date:** $0	**MN 2012 Commitment:** $71,991
Performed by: University of Minnesota			
PI: Lev Khazanovich	**TL:** Luke Johanneck	**PC:** Daniel Warzala	
Description: The advent of mechanistic-empirical design principles requires local adaptation. Given the complexity of the Mechanistic-Empirical Pavement Design Guide (MEPDG), this research produces a simplified table of examined mechanistic inputs for use in concrete pavement design. The project identifies critical inputs, submits them to sensitivity analysis and develops a spreadsheet for engineers to use when applying mechanistic-empirical principles to their work.			
Status: Researchers are identifying an initial round of critical design inputs to submit to sensitivity analysis.			
Impact: This project will extract key elements from sophisticated mechanistic-empirical concrete pavement design methods. It will analyze and test these elements, and then present them in a user-friendly way to local-level pavement engineers not otherwise well-equipped to employ the MEPDG.			
Start Date: 6/29/12	**Projected End Date:** 8/31/14		

MPR-2(010), MPR-2(011): AASHTO Technical Services Program			
Funded by: SP&R	**Total Cost:** $93,000	**Paid to Date:** $33,000	**MN 2012 Commitment:** $33,000
Performed by: N/A			
PI: N/A	**TL:** N/A	**PC:** N/A	
Description: These funding contributions support AASHTO's Technical Services Programs. MnDOT is contributing $20,000 per year for four years to the Transportation System Preservation program, which provides resources related to preserving highway infrastructure. The total funding amount also reflects one-time contributions to support three other programs: the Technology Implementation Group ($6,000); the Snow and Ice Cooperative Program ($4,000); and the Equipment Management Technical Services Program ($3,000).			
Status: AASHTO's work is ongoing.			
Impact: These contributions will help support national programs that provide significant benefits to all states. The Transportation System Preservation program serves as a comprehensive clearinghouse of information about efficient, effective preservation measures for pavements and bridges, and facilitates technical exchange and discussion among state DOTs in these areas. The Technology Implementation Group accelerates the adoption of innovative technologies, while the Snow and Ice Cooperative Program and the Equipment Management Technical Services Program focus on winter maintenance and fleet management issues, respectively.			
Start Date: N/A	**Projected End Date:** Ongoing		

MPR-2(017): Investigation of the Impact the I-94 ATM System has on the Safety of the I-94 Commons High Crash Area			
Funded by: SP&R, SRP	**Total Cost:** $140,000	**Paid to Date:** $0	**MN 2012 Commitment:** $99,200
Performed by: University of Minnesota			
PI: John Hourdos	**TL:** Brian Kary	**PC:** Daniel Warzala	
Description: This project conducts a before-and-after study to evaluate the safety impact of a new active traffic management (ATM) system on a crash-prone segment of Interstate 94. This roadway section has atypical traffic patterns and has historically logged more than 100 crashes each year. The study provides a detailed analysis of traffic patterns and driver behavior under the ATM system.			
Status: This project is in its initial stages of development.			
Impact: Because of the high number of crashes, this portion of I-94 presents an ideal location to implement, evaluate and refine an ATM system. The study will help detect undesired traffic patterns early, and the data collected will help traffic operations staff and planners understand and improve operations across the entire system.			
Start Date: 8/9/12	**Projected End Date:** 5/31/14		

MPR-6(003): Business Assessment of RSS Processes and Tools			
Funded by: SRP, SP&R, Other State Funds	**Total Cost:** $172,080	**Paid to Date:** $132,480	**MN 2012 Commitment:** $0
Performed by: Trissential			
PI: Steve Beise	**TL:** Nicole Peterson	**PC:** Ann McLellan	
Description: Research Services is redesigning the way it provides services. The primary goal of this project is to analyze and document the remaining business processes and detail all business flows.			
Status: This project is on schedule. A new process manual will be completed by the end of 2012.			
Impact: This project has helped to refine and streamline Research Services' approach to identifying, managing, scoping and implementing research. It also has documented the process so both new and current employees are familiar with the section's work processes.			
Start Date: 11/4/09	**Projected End Date:** 1/31/13		

MPR-6(003): Strategic Program Development			
Funded by: SRP, SP&R, Other State Funds	**Total Cost:** $49,977	**Paid to Date:** $49,977	**MN 2012 Commitment:** $0
Performed by: David Johnson			
PI: Dave Johnson	**TL:** Nicole Peterson	**PC:** Nelson Cruz	
Description: In this project, Research Services is determining and documenting the workflows and handoff points for managing research contracts to optimize its new Automated Research Tracking System database .			
Status: This work has been completed.			
Impact: Research Services has a streamlined process that should favor innovation, be more fluid in handling data and special projects, and improve the section's ability to work more closely with the state library.			
Start Date: 12/22/09	**Projected End Date:** 3/31/12		

MPR-6(005): Next Generation of ARTS Tech Support and Maintenance Services			
Funded by: SP&R, SRP, Other State Funds	**Total Cost:** $179,400	**Paid to Date:** $124,850	**MN 2012 Commitment:** $0
Performed by: ArchWing Innovations, LLC			
PI: Ryan Anderson	**TL:** Nelson Cruz	**PC:** Ann McLellan	
Description: The primary goals of this project are to provide technical support and maintenance services for three Web-based applications of the current generation of the Automated Research Tracking System. Project activities include training and knowledge transfer to MnDOT staff.			
Status: This is a continuing service contract.			
Impact: This contract provides MnDOT with maintenance and technical support for key databases by maintaining and producing data for reports.			
Start Date: 5/13/09	**Projected End Date:** 2/28/13		

MPR-6(011): Intelligent Compaction			
Funded by: SP&R, Other State Funds, SRP	**Total Cost:** $225,000	**Paid to Date:** $194,453	**MN 2012 Commitment:** $0
Performed by: Transtec Group, Inc.			
PI: George Chang	**TL:** None	**PC:** Benjamin Worel	
Description: The purpose of this project is to implement intelligent compaction performance-based specifications in the field.			
Status: This work has been completed.			
Impact: This enhanced software will allow efficient data management from intelligent compaction operations in the field and will improve quality control as well as quality assurance.			
Start Date: 9/13/10	**Projected End Date:** 6/30/12		

MPR-6(016): Construction Report for MnROAD Thin Unbonded Concrete Overlay Test Cell 5 (Sub-Cells 105-405)			
Funded by: SP&R, Other State Funds, Partnership Funds	**Total Cost:** $126,100	**Paid to Date:** $0	**MN 2012 Commitment:** $0
Performed by: MnDOT Materials Lab			
PI: Thomas Burnham	**TL:** Bernard Izevbekhai	**PC:** Bruce Holdhusen	
Description: In this project, researchers are investigating the performance of thinner unbonded concrete overlays placed over older concrete pavements by developing better distress and life prediction models. Secondary objectives include understanding the behavior of these overlays with regard to maturity, slab warp, curl thermal expansion and repair techniques. In 2008, Mainline Test Cell 5 at MnROAD was resurfaced with a 1-inch drainable stress relief layer and sub-cells with concrete overlays of 4 and 5 inches thick. In subsequent years researchers have been monitoring these sub-cells for load response and field performance.			
Status: In the last year researchers have continued monitoring the performance of sub-cells. Two 5-inch sub-cells are in service but have many cracks and are slowly deteriorating; some of these cracks were retrofitted in 2011 with plate dowels to extend their life. Two 4-inch sub-cells were replaced in 2011 because of significant cracking distress caused by panel sizes that were too large for the thickness of the slabs. These sub-cells were replaced with 5-inch sub-cells with smaller panel sizes and a fabric interlayer. This project has produced several reports, including a construction report (**www.mrr.dot.state.mn.us/research/pdf/201030.pdf**), a Technical Summary (**www.mrr.dot.state.mn.us/research/pdf/2010MRRDOC015.pdf**), a report about a related test section near Duluth (**www.mrr.dot.state.mn.us/research/pdf/201023.pdf**) and several unpublished task reports. An interim task report is expected in the winter of 2013, and a final report is due in 2014.			
Impact: Reduced thickness in unbonded concrete overlays will decrease their initial cost substantially, providing additional design alternatives for cost-effectively rehabilitating older concrete pavements in Minnesota and helping to conserve the scarce virgin aggregates needed to construct pavements. The findings of this study will also provide guidance to counties and cities that are interested in using these overlays.			
Start Date: 12/29/08	**Projected End Date:** 2/28/14		

MPR-6(019): Technology Transfer Material Development			
Funded by: SP&R, SRP	**Total Cost:** $100,789	**Paid to Date:** $99,791	**MN 2012 Commitment:** $0
Performed by: CTC & Associates LLC			
PI: Patrick Casey	**TL:** Linda Taylor	**PC:** Sandra McCully	
Description: This project funds the creation of the two-page Technical Summaries (TSs) found in this report as well as Transportation Research Syntheses (TRSs), which are quick-turnaround research reports that can serve as an initial step in a research project or as a substitute for a project. This contract also covers other technical transfer materials as needed.			
Status: This contract has been completed, with TSs and TRSs generated to populate the FY2011 and FY2012 annual reports.			
Impact: Reseach Services' technology transfer efforts have helped make the most out of Minnesota's research investments, with TSs used to spark interest among practitioners, legislators and others about MnDOT's research reports. TRSs have saved time and funds by providing needed information quickly, without the need to contract for a full research project.			
Start Date: 9/17/10	**Projected End Date:** 9/30/11		

MPR-6(019): Technology Transfer Material Development			
Funded by: SP&R, SRP	**Total Cost:** $99,973	**Paid to Date:** $91,331	**MN 2012 Commitment:** $0
Performed by: CTC & Associates LLC			
PI: Patrick Casey	**TL:** Linda Taylor	**PC:** Sandra McCully	
Description: This new contract continues the work of the Technology Transfer Material Development project (97585).			
Status: Technical Summary and Transportation Research Synthesis production is ongoing, with new work in FY2012 to include videos documenting Research Services' roles and processes as well as drafting articles for the MnDOT publication *Newsline* (some of which have been reproduced in this report). Funding on this contract was largely expended during FY2012; the effort is continuing for FY2013 via a new contract.			
Impact: These efforts continued to raise awareness of MnDOT's research products.			
Start Date: 4/29/11	**Projected End Date:** 1/31/13		

MPR-6(019): Technology Transfer Material Development—2011 Annual Reporting			
Funded by: SP&R, SRP	**Total Cost:** $35,102	**Paid to Date:** $35,083	**MN 2012 Commitment:** $0
Performed by: CTC & Associates LLC			
PI: Patrick Casey	**TL:** Linda Taylor	**PC:** Sandra McCully	
Description: This contract funded creation of the FY2011 Half-Year Annual Report and the FY2011 Research Services At-A-Glance and LRRB At-A-Glance documents.			
Status: This contract has been completed.			
Impact: These products fulfill federal reporting requirements and serve as vital tools for communicating the value of MnDOT's products and services.			
Start Date: 4/28/11	**Projected End Date:** 9/30/12		

MPR-6(019): Technology Transfer Material Development FY2012 and FY2013 Annual Reporting			
Funded by: SP&R, SRP	**Total Cost:** $88,358	**Paid to Date:** $1,123	**MN 2012 Commitment:** $0
Performed by: CTC & Associates LLC			
PI: Patrick Casey	**TL:** Linda Taylor	**PC:** Sandra McCully	
Description: This new contract creates comparable products to those developed for project 98727.			
Status: Work on this report and the accompanying At-A-Glance documents is in its initial stages of development, with the bulk of the work coming in subsequent months.			
Impact: These efforts continued to raise awareness of MnDOT's research products and services.			
Start Date: 6/13/12	**Projected End Date:** 1/31/14		

MPR-6(019): Technology Transfer Material Development Marketing Plan			
Funded by: SP&R, SRP	**Total Cost:** $149,575	**Paid to Date:** $10,000	**MN 2012 Commitment:** $0
Performed by: Strategic Toolbox, LLC			
PI: Janese Evans	**TL:** Ann McLellan	**PC:** Sandra McCully	
Description: This project develops a strategic marketing plan to guide Research Services' efforts to align its services with the needs of its customer groups. Investigators capture the needs and perceptions of Research Services customers and stakeholders, and use this content to develop a marketing plan. The plan will guide the creation of collateral marketing materials to help Research Services reach its target audiences.			
Status: Two half-day Visioning Alignment workshops were held in May 2012. Research Services staff and partners worked to define the program's vision, identify and prioritize key targets and stakeholders, develop common language and priorities, and discuss how to align internal resources with the program's goals. This year investigators also began planning stakeholder interviews.			
Impact: The strategic marketing plan will help shape Research Services' marketing, communications and customer service efforts to ensure that the program is meeting customers' needs. The marketing materials produced through this project will raise awareness and value of the program's products and services.			
Start Date: 3/27/12	**Projected End Date:** 7/31/13		

MPR-6(021): Evaluation of Skid Resistance of Turf Drag Textured Concrete Pavements			
Funded by: SP&R, Other State Funds	**Total Cost:** $100,882	**Paid to Date:** $0	**MN 2012 Commitment:** $0
Performed by: MnDOT Materials Lab			
PI: Bernard Izevbekhai	**TL:** Benjamin Worel	**PC:** Bruce Holdhusen	
Description: This study focuses on fundamental pavement surface characteristics, including ride quality, friction, hydroplaning potential, splash and spray, texture and noise. Various texturing configurations in the MnROAD low-volume road and the mainline are used, but comparative analysis may introduce data from cells or test sections outside of MnROAD. The study observes the progression of these variables with time and the function of their interdependency within a five-year period.			
Status: An interim report issued in April 2011 is available at **www.dot.state.mn.us/research/TS/2011/201112.pdf**.			
Impact: This study will help designers understand how friction values change as concrete pavement ages and undergoes more loading. It will also help to plan maintenance activities to address reduced friction properties.			
Start Date: 12/19/08	**Projected End Date:** 1/1/13		

MPR-6(022), INV 864: Recycled Asphalt Pavements			
Funded by: SP&R, LRRB, Other State Funds	**Total Cost:** $275,000	**Paid to Date:** $165,500	**MN 2012 Commitment:** $0
Performed by: MnDOT Materials Lab			
PI: Eddie Johnson	**TL:** Gregory Johnson	**PC:** Bruce Holdhusen	
Description: In this project, researchers study the performance of recycled asphalt pavement (RAP) under controlled testing conditions. The asphalt concrete test sections 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: This study is on schedule. Researchers are drafting the final report.			
Impact: This project will help to improve the quality and durability of new Minnesota asphalt pavements by focusing on the quality of RAP mixtures. The work specifically explored the way in which RAP mixes with virgin binder and aggregate, and examined fractionation practices and design specifications.			
Start Date: 1/4/08	**Projected End Date:** 12/31/12		

MPR-6(024), INV 878: Porous Asphalt Pavement Performance in Cold Regions			
Funded by: LRRB, SP&R, Other State Funds	**Total Cost:** $82,400	**Paid to Date:** $59,400	**MN 2012 Commitment:** $0
Performed by: MnDOT Materials Lab			
PI: Matthew Lebens	**TL:** Larry Matsumoto	**PC:** 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 low-volume roads in a cold climate. Additional activities include documenting appropriate construction and maintenance procedures.			
Status: This work has been completed.			
Impact: Porous asphalt pavement has been added to the MnDOT toolbox for low-volume roads. In certain situations, it may be a viable alternative to regular asphalt with stormwater structures. Such pavements will result in less damage to ground- and surface water, and provide good traction for drivers.			
Start Date: 7/26/07	**Projected End Date:** 4/30/12		

MPR-6(027), INV 879: Pervious Concrete Cells on MnROAD Low-Volume Road			
Funded by: LRRB, SP&R, Other State Funds	**Total Cost:** $48,000	**Paid to Date:** $48,000	**MN 2012 Commitment:** $0
Performed by: MnDOT Materials Lab			
PI: Bernard Izevbekhai	**TL:** Mark Maloney	**PC:** Bruce Holdhusen	
Description: In this project, researchers evaluate the performance of pervious concrete pavements in Minnesota's cold weather climate. They construct three test cells on MnROAD's low-volume road—a porous concrete overlay, a section of pervious concrete over a granular subgrade and a section of pervious concrete over a cohesive subgrade—and evaluate these cells for permeability, sound absorption, texture, friction and ride quality, temperature and moisture, freeze-thaw degradation and pavement distress.			
Status: This project has been completed. Researchers have produced two final reports: Drainable Pavements at MnROAD Pervious Concrete and Porous Concrete Overlay Cells 39, 85 and 89 (2010-16, published in April 2010) and Pervious Concrete Test Cells on MnROAD Low-Volume Road (2011-23, published in December 2011). Results showed improved sound absorption compared to typical pavements, highly variable permeability, reduced temperature gradient (possibly reducing freeze-thaw damage) and higher falling weight deflectometer deflections.			
Impact: If pervious concretes can be shown to perform adequately in Minnesota's climate, their use would help MnDOT both to reduce stormwater runoff and to lessen tire-pavement noise pollution. Pervious concretes have the potential to lead to large savings in costs associated with building stormwater facilities to manage runoff from regular impervious concretes.			
Start Date: 7/30/07	**Projected End Date:** 9/30/11		

MPR-6(029), INV 868: HMA Surface Characteristics			
Funded by: SP&R, LRRB, Other State Funds	**Total Cost:** $250,000	**Paid to Date:** $122,625	**MN 2012 Commitment:** $0
Performed by: MnDOT Materials Lab			
PI: Timothy Clyne	**TL:** Gregory Johnson	**PC:** Bruce Holdhusen	
Description: This project is evaluating the noise, texture, friction and ride characteristics of more porous hot-mix asphalt pavement designs that are used for noise reduction, and comparing them to more dense-graded HMA pavements. Researchers have constructed test cells at MnROAD using various kinds of porous HMA, and are monitoring them over time for noise and other characteristics.			
Status: Researchers are continuing the annual and seasonal monitoring of surface characteristics for MnROAD test cells, collecting data on how these change over time. Testing includes noise (OBSI and sound absorption), texture (circular texture meter), friction (skid truck and dynamic friction tester), permeability, ride quality (LISA and Pathways) and durability (distress surveys and ALPS rutting). Preliminary results show trends in how the pavement surface characteristics change over time and help to identify good and poor performers in terms of surface characteristics (especially skid resistance and noise). In the next few months, researchers will send data to Purdue University for analysis, and project reports will be completed by the summer of 2013.			
Impact: The results of this study will enable MnDOT to optimize pavement friction, ride and texture for quieter HMA mixtures, reducing the incidence of uncomfortable ride and hydroplaning.			
Start Date: 9/18/07	**Projected End Date:** 6/30/13		

MPR-6(029), INV 868: HMA Surface Characteristics Related to Ride, Texture, Friction, Noise and Durability			
Funded by: SP&R, LRRB, Other State Funds	**Total Cost:** $50,000	**Paid to Date:** $14,635	**MN 2012 Commitment:** $0
Performed by: Purdue University			
PI: Rebecca McDaniel	**TL:** Timothy Clyne	**PC:** Bruce Holdhusen	
Description: As part of the larger HMA Surface Characteristics project (LAB868), Purdue University has been subcontracted to develop a model to predict on-board sound intensity on hot-mix asphalt pavements using on-site and laboratory data. Data measured on MnROAD test sections is used to develop a nonlinear statistical model that predicts one-third octave band and overall sound intensity on HMA pavements and identifies the pavement parameters that most affect tire-pavement noise generation.			
Status: Researchers have conducted a literature review to determine which pavement characteristics are important in predicting noise on HMA pavements and to identify frequency ranges or mechanisms that are dominant for a broad collection of HMA types. They have also examined MnROAD data to establish relationships between seasonal variations in environmental conditions and HMA surface characteristics. Currently researchers are identifying pavement characteristics shown to correlate with overall noise levels and developing a model for determining the expected noise between a tire and pavement from measured pavement characteristics. Final results are expected in the next several months, and project reports will be completed by the summer of 2013.			
Impact: This project will help improve MnDOT's current traffic noise model so that it can be applied to open-graded sound-absorbing pavements. The project will help to further the larger goal of using pavements that produce less noise while maintaining friction and ride quality—a less expensive solution to the problem of road noise pollution than sound walls.			
Start Date: 8/11/11	**Projected End Date:** 7/3/13		

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	**MN 2012 Commitment:** $0
Performed by: MnDOT Materials Lab			
PI: Thomas Burnham	**TL:** Bernard Izevbekhai	**PC:** Bruce Holdhusen	
Description: In this project, researchers are investigating how to construct thin jointed concrete pavements that provide predictable long-term performance. In 2008, five thin concrete test sections were constructed at MnROAD, with thicknesses from 5 to 6.5 inches. Researchers are monitoring the performance of these sections in response to live, high-volume Interstate traffic, including visual distress, joint faulting and load transfer efficiency, panel deflections and ride quality. Researchers are comparing observed performance to performance predicted by the current MnDOT pavement design procedure.			
Status: Surprisingly, the thinnest test sections carried more than 1.5 million CESALs before showing fatigue cracking. However, once cracks occurred, they multiplied and sections deteriorated rapidly. Successful repairs have been very challenging in such thin slabs, and it appears that for Interstate traffic loads, slab thicknesses should be 6 inches or greater to ensure long-term performance. This year researchers are presenting major findings from this project at a conference; next year forensic investigations and a final report will be completed, and test sections reconstructed.			
Impact: The data and observations gathered from test sections will help in designing more cost-effective thin concrete pavements, including the development of mechanistic-empirical design procedures.			
Start Date: 1/3/08	**Projected End Date:** 7/31/14		

MPR-6(033): Construction Project Management Software Evaluations			
Funded by: SP&R, SRP, Other State Funds	**Total Cost:** $190,932	**Paid to Date:** $180,307	**MN 2012 Commitment:** $0
Performed by: Mankato State University			
PI: Brian Wasserman	**TL:** Thomas Wiener	**PC:** Farideh Amiri	
Description: The objectives of this project are to evaluate and improve the Transportation Automated Control System (TRACS), which streamlines field inspectors' documentation and payment processes on large, complex transportation construction projects. Training on proper use of TRACS is also included.			
Status: The work has been completed.			
Impact: This study will help MnDOT manage business processes more efficiently. The project also establishes a standard for management technology against which other products can be evaluated.			
Start Date: 9/24/08	**Projected End Date:** 6/30/12		

MPR-8(004): Development of a Concrete Maturity Test Protocol			
Funded by: SP&R, SRP	**Total Cost:** $113,952	**Paid to Date:** $73,695	**MN 2012 Commitment:** $0
Performed by: Mankato State University			
PI: W. James Wilde	**TL:** Alexandra Akkari	**PC:** Sandra McCully	
Description: The objective of this project is to develop strength-maturity relationships in concrete that allow contractors, field personnel and materials engineers to estimate with reduced sampling and testing the strength of concrete pavement mixes that have high ratios of pozzolan-to-supplementary cementious materials and low ratios of water to cement. 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. While strength-maturity relationships are commonly available for standard concrete mixtures, few are available for the mixtures in question, leading to their limited use in late- or early-season paving, when ambient temperatures have a strong and unpredictable effect on the mixtures' development of strength during paving and curing.			
Status: In fiscal year 2012, researchers completed laboratory and field validation of a test method specification developed in an earlier task; incorporated data into the maturity protocol database; and submitted final reports for these tasks. Researchers visited eight projects during the 2011 construction season, which brought the total projects visited to 18 in three years, with 16 having complete maturity data. Results so far show reasonably consistent maturity curves between most of the different mixes. The maturity database developed in this project is being used to establish the soundness of the maturity method for predicting concrete strength in the field, includes mix characteristics and all test results from laboratory and field projects, and allows users to develop maturity curves using additional information from new mixes and maturity testing. Researchers developed detailed analyses of three models used to develop maturity curves through statistical regression, recommended one of these models for use by MnDOT and made other recommendations for implementing the maturity method to obtain the most accurate and reliable results. The chosen model fits early age strength data well compared to others, demonstrating low error and many other advantages. In fiscal year 2013, researchers will conduct laboratory testing to determine how various mix design variables affect strength-maturity relationships, and will submit a final report.			
Impact: The results of this project will allow MnDOT to estimate concrete strength as a function of age for nonstandard mixtures, helping the agency to determine when to saw joints and open a pavement to traffic. Mistakes in the timing of these steps can be costly, leading to spalling and cracking. This project also will allow MnDOT to optimize mix selection based on performance requirements and anticipated ambient temperature conditions.			
Start Date: 4/2/09	**Projected End Date:** 9/30/12		

MPR-8(008): Essentials Web ADF Tool Customizations			
Funded by: SP&R, SRP	**Total Cost:** $0	**Paid to Date:** $0	**MN 2012 Commitment:** $0
Performed by: Latitude Geographics Group, Ltd.			
PI: Jed Harrison	**TL:** Paul Weinberger	**PC:** Alan Rindels	
Description: This project customizes an IT development framework used in various MnDOT applications such as transportation planning, transportation business processes and geographic information system applications.			
Status: The client customized the Application Developer Framework before work on the contract began. This work has been completed.			
Impact: This project will provide a criticial development platform for various MnDOT transportation applications, transportation business processes and GIS applications.			
Start Date: 11/22/10	**Projected End Date:** 7/31/11		

MPR-8(008): Right of Way Mapping Process Improvement, Phase 3 (Prioritize Mapping Backlog, Develop Highest Priority Data and Assist in Training and Support—Task 2)			
Funded by: SP&R, SRP	**Total Cost:** $429,798	**Paid to Date:** $334,177	**MN 2012 Commitment:** $0
Performed by: Widseth, Smith, Nolting and Associates, Inc.			
PI: Bryan Balcome	**TL:** Jay Krafthefer	**PC:** Clark Moe	
Description: Right of way maps need frequent updating. This project assists MnDOT in assembling, processing and completing right of way maps for publication.			
Status: The work has been completed.			
Impact: This project updated 338 right of way maps for publication, making a large portion of Minnesota's right of way maps current.			
Start Date: 1/28/10	**Projected End Date:** 7/31/11		

MPR-9(002): Concrete Bridge Deck Crack Sealant Evaluation and Implementation			
Funded by: SP&R, SRP	**Total Cost:** $80,918	**Paid to Date:** $33,567	**MN 2012 Commitment:** $0
Performed by: Braun Intertec Corporation			
PI: Matthew Oman	**TL:** Edward Lutgen	**PC:** Daniel Warzala	
Description: This project is evaluating the performance of crack repair materials for MnDOT bridges. Researchers are field-testing various crack sealant products, including a product MnDOT field crews have been using for several years, to evaluate their effectiveness and depth of penetration. The results of the field testing will be used to determine best practices and develop a guidance document or handbook of materials and methods for MnDOT practitioners.			
Status: In 2011 researchers applied 11 crack sealant products to bridge deck test sections, and currently they are monitoring these sections for permeability and pavement distress. Preliminary data is already producing recommendations for crack sealant use on current projects. A final report is expected in March 2013.			
Impact: The guidelines produced by this project will be used by bridge maintenance crews and their supervisors to select the best treatment options and products to prevent premature failure of concrete bridge decks and avoid reactive repairs, helping MnDOT make the most cost-effective decisions to preserve its current bridge deck infrastructure. Choosing the right crack sealant products will help extend the service lives of bridge decks in Minnesota.			
Start Date: 9/30/09	**Projected End Date:** 3/31/13		

MPR-9(004): Load and Resistance Factor Design (LRFD) Pile Driving Static Load Test Data Collection (LRFD Implementation)			
Funded by: SP&R, SRP	**Total Cost:** $99,752	**Paid to Date:** $99,752	**MN 2012 Commitment:** $0
Performed by: American Engineering Testing, Inc.			
PI: Gregory Reuter	**TL:** Derrick Dasenbrock	**PC:** Bruce Holdhusen	
Description: Several states, including Minnesota, have recently completed research to develop new pile design formulas using the Load and Resistance Factor Design (LRFD) mandated by AASHTO. The objective of this project is to provide a reusable static load test reaction frame for a new testing program that will be applied statewide to develop an improved LRFD model. Elements of the project includes instrumentation, monitoring, testing and reporting associated with conducting a static load test on the MnDOT Trunk Highway 5 bridge construction project in Victoria.			
Status: The work has been completed.			
Impact: Conducting a static load test allows the geotechnical designer to verify the required piling depth based upon actual site conditions rather than assuming a generalized safety factor, which will result in substantial cost savings on large projects. By building a database of static load test results, MnDOT will be able optimize pile design methods.			
Start Date: 1/21/11	**Projected End Date:** 7/31/12		

MPR-9(005): Changeable Message Signs (CMS)/Digital Message Signs (DMS) Manual of Practice Development, Implementation and Training			
Funded by: SP&R, SRP	**Total Cost:** $96,302	**Paid to Date:** $74,271	**MN 2012 Commitment:** $0
Performed by: Iteris, Inc.			
PI: Lisa Raduenz	**TL:** Jesse Larson	**PC:** Alan Rindels	
Description: This project focuses on developing documentation similar to other states (such as Texas and California) that contains experience and guidance for Regional Transportation Management Center (RTMC) Design, Construction and Maintenance staff about proper messaging for changeable message signs (permanent and temporary). The goal of this messaging is to provide traveler information without negatively impacting freeway traffic or work zone and driver safety (causing drivers to slow down to read the message).			
Status: This project is near completion. MnDOT has requested final changes to changeable message sign materials developed by researchers.			
Impact: This project will allow MnDOT to gather the available information about changeable message sign technologies and their effects on road users and compile it into the CMS/DMS Manual of Practice that will serve as a source for RTMC Design, Construction and Maintenance personnel. The document created from this project will be incorporated into the MnDOT Traffic Engineering Manual and updated as new and different applications are developed.			
Start Date: 11/3/10	**Projected End Date:** 11/30/12		

MPR-9(006): Research Implementation of the SMART Signal System on TH 13			
Funded by: SP&R, SRP	**Total Cost:** $239,000	**Paid to Date:** $222,000	**MN 2012 Commitment:** $0
Performed by: University of Minnesota			
PI: Henry Liu	**TL:** Steven Misgen	**PC:** Alan Rindels	
Description: The SMART-Signal (Systematic Monitoring of Arterial Road Traffic and Signals) system generates both intersection and arterial performance measures in real time. At the single intersection level, the SMART-Signal system monitors the maximum queue length, intersection delay and level of service. At the arterial level, it reports travel time, speed and average number of stops. The objectives of this project are to 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, and to test the redesigned system hardware and software on Trunk Highway 13 at 14 intersections between Yankee Doodle Road and TH 101.			
Status: The work on this project is on schedule.			
Impact: This project will provide MnDOT with real-time, proactive monitoring and management capability of arterial traffic signals. This innovative system displays travel data on site for road users, gathers valuable data for planning purposes and can be used by traffic managers to reduce congestion in the monitored area.			
Start Date: 12/17/09	**Projected End Date:** 2/28/13		

MPR-2(018): Using a Smartphone App to Help the Visually Impaired Navigate Work Zones Safely			
Funded by: SP&R, SRP	**Total Cost:** $89,500	**Paid to Date:** $0	**MN 2012 Commitment:** $71,600
Performed by: University of Minnesota			
PI: Chen-Fu Liao	**TL:** Kenneth Johnson	**PC:** Nelson Cruz	
Description: This project develops a smartphone-based navigation system to assist visually impaired pedestrians in navigating work zones safely. Researchers develop standardized message formats for conveying work zone bypass or routing instructions, provide guidance on message content and develop a smartphone app to provide this information to pedestrians approaching a work zone in advance of decision points.			
Status: This project is in its initial stages of development.			
Impact: This research will improve the consistency and quality of the accessible work zone information provided to visually impaired pedestrians, helping eliminate physical and information barriers for the visually impaired. If successful, the smartphone app could be implemented at all urban and suburban work zones involving pedestrian movements, ultimately improving work zone safety and mobility statewide.			
Start Date: 8/9/12	**Projected End Date:** 3/31/14		

MnDOT's State Research Program

Funds dedicated to MnDOT's State Research Program (SRP) comprised 30 percent ($3,284,000) of MnDOT's FY2012 research budget. (See Figure 5 on page 34.) These funds are available through Minnesota Statute 161.53, which states:

> *The commissioner may set aside in each fiscal year up to two percent of the total amount of all funds appropriated to the commissioner other than county state-aid and municipal state-aid highway funds for transportation research including public and private research partnerships.*
>
> *The commissioner shall spend this money for (1) research to improve the design, construction, maintenance, management, and environmental compatibility of transportation systems; (2) research on transportation policies that enhance energy efficiency and economic development; (3) programs for implementing and monitoring research results; and (4) development of transportation education and outreach activities.*

In many cases, SRP projects are funded using matching dollars from other funding sources, including FHWA State Planning and Research (SP&R) and the University of Minnesota's Center for Transportation Studies (CTS) and Intelligent Transportation Systems (ITS) Institute.

MnDOT'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.

Figure 7. Transportation Research Innovation Group (TRIG) Division Representatives

MnDOT's TRIG is the governing board for the State Research Program. TRIG is composed of representatives from each MnDOT office and district, and meets quarterly to recommend research investments.

Name	Represents
Specialty Offices	
Lynn Clarkowski	Environmental Stewardship
Nancy Daubenberger	Bridges
Michael Ginnaty	Project Management and Technical Support
Susan Groth	Traffic, Safety & Technology
Steven Lund	Maintenance
Mark Nelson	Statewide Multimodal Planning
Keith Shannon	Materials & Road Research
Linda Taylor	Research Services
Jean Wallace	Policy, Analysis, Research & Innovation
Districts	
Daniel Anderson	District 3
Greg Coughlin	Metro District
Nelrae Succio	District 6
Greg Ous	District 7
Nonvoting Members	
James Close	Information & Technology Services
Bill Lohr	FHWA

Research Services Support Staff

- Nicole Peterson—Research Engineer
- Ann McLellan—Finance & Contract Services
- Bruce Holdhusen, Alan Rindels, Farideh Amiri—Project Advisors

A segment of road with a living snow fence (bottom) offers better driver visibility and road surface conditions than a segment of road without this natural windbreak (top). MnDOT traffic safety data suggest that living snow fences can reduce snow- and ice-related accidents by 40 percent on roadways with super-elevated curves.

FY2012 SRP Research Highlights

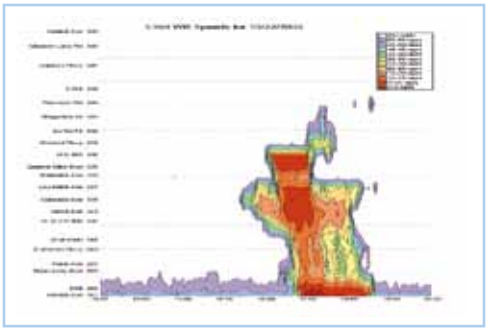
Report 2012-03, "Economic and Environmental Costs and Benefits of Living Snow Fences: Safety, Mobility, and Transportation Authority Benefits, Farmer Costs, and Carbon Impacts," was written to help MnDOT optimize its program for compensating landowners who plant living snow fences. Designed to reduce the volume of snow that drifts onto adjacent roadways, living snow fences—trees, shrubs or standing corn rows—can reduce road maintenance and safety costs as well as carbon emissions. Researchers used input from landowner focus groups and financial analyses to develop a calculator that determines the appropriate compensation for a given landowner according to a per-acre cost-benefit analysis. The study's recommendations included offering shorter and more flexible landowner contracts, increasing compensation at key locations, adjusting payments for inflation, tying payments to corn and land prices, increasing payments in the first three years to offset maintenance, reducing risk and landowner liability, compensating for replanting and increasing awareness of the payment program. More information about this study is available in the **Technical Summary** on page 120.

Report 2012-01, "Best Value Granular Material for Road Foundations," described an effort to validate the use of local aggregate sources in pavement base and subbase layers. Using local materials instead of those brought in from gravel pits and rock quarries will promote sustainability and cost-effective construction. Investigators studied local aggregates to determine how an aggregate's properties affect performance, and consequently how these properties affect the design thickness of unbound pavement layers. The project also determined where locally available materials with defined performance characteristics should be placed, what traffic levels are appropriate for these aggregates, and how to combine high quality and marginal quality aggregates for optimal performance. More information about this study is available in the **Technical Summary** on page 134.

FY11 MnDOT Hear Every Voice Training and Assistance is a project in which MnDOT worked with CTS to modify and deliver training developed in 2010 under the **Hear Every Voice public engagement initiative**. This program consists of 13 training modules based on the **Hear Every Voice** employee handbook on public involvement efforts. The current project modified five of these modules and delivered each training module twice over six months in 2011. It also provided technical support for 10 two-hour public participation webinars and developed public participation **case studies** describing tools and mechanisms used to engage the public during transportation projects. These efforts will help MnDOT continue to involve the public in developing and implementing state plans and programs, improving the agency's efficiency and relationships with customers.

Full-Depth Precast Concrete Bridge Deck System—Phase II monitored the field performance of precast composite slab span bridge systems. These systems consist of a series of 6-foot-wide, inverted precast T-sections positioned between supports, with cast-in-place concrete applied over the precast sections to form a monolithic slab span system. Effective for short- to medium-span bridges (20 to 60 feet long), these systems use reinforcement to mitigate longitudinal cracking. Several of these systems, using three different design iterations, have been in service for up to three years. Researchers mapped their surface cracking and evaluated core samples for the development of reflective cracks, with results showing that recent designs have less cracking than older designs. Researchers also continued to collect strain and temperature data from an early implementation of this system, the Center City Bridge. They evaluated MnDOT's latest design methods for these systems, providing recommendations for improvements to future designs. The final report is expected to be published in the next few months, and researchers recently presented results at the Transportation Research Conference.

Report 2012-04, "Development of Freeway Operational Strategies with IRIS-in-Loop Simulation," described the development of new software tools for operating Minnesota freeway corridors and evaluating traffic management strategies. These tools include new performance measures, a computer traffic simulation environment and strategies for improving ramp metering and variable message sign operations in the Twin Cities area. These enhancements could lead to significant improvements in both congestion and traveler safety. More information about this study is available in the **Technical Summary** on page 166.



A main product of 2012-04 was TICAS, the Traffic Information and Condition Analysis System, which allows traffic system operators to visualize and evaluate a highway system's performance. This display provides a contour plot of average vehicle speeds over time for various freeway corridors.

Feature

Innovative Stormwater Treatment Device Could Transform the Industry

A project funded through MnDOT's SRP has led to the development of an innovative stormwater treatment device that is far more cost-effective than existing proprietary systems.

Named after the University of Minnesota St. Anthony Falls Laboratory at which it was developed, the SAFL Baffle is a porous barrier made for use in sumps—cylindrical tanks that are a common feature of urban stormwater infrastructure.

"The SAFL Baffle has the potential to dramatically transform the industry," says Omid Mohseni, professor at the University of Minnesota Department of Civil Engineering and co-developer of the device. "Its use in sumps could allow them to be turned into much more effective stormwater treatment devices, significantly lowering the cost of complying with federal and state environmental regulations."

Sumps are typically a feature of manholes that provide maintenance access to sewers and help to reduce harmful pollutants in runoff water before the toxins reach lakes and streams. As water from rainfall and melting snow flows into these tanks, its velocity is reduced. This allows some of the sediments in the water to settle at the bottom of the sump as the water exits through an outgoing pipe. These sediments can carry heavy metals and other pollutants picked up from surfaces such as paved streets and parking lots.

However, after a heavy rainfall the velocity of the water entering a sump can wash out the sediment it has already collected. The SAFL Baffle is designed to prevent washout by slowing down water as it enters the sump, and it is porous to avoid creating a pattern of water circulation that would decrease its effectiveness.

"The SAFL Baffle virtually eliminates washout from sumps," says Mohseni, whose research also showed that the SAFL Baffle improved sediment capture by 10 percent to 15 percent, and can usually perform well even when clogged with trash and debris.

Typical baffles are impermeable, leading to a circulation of water that washes collected sediment out of sumps. The SAFL Baffle developed by the University of Minnesota St. Anthony Falls Laboratory is porous, distributing the water jet flowing from the inlet pipe more evenly across the sump, reducing its velocity and virtually eliminating sediment washout.

Other proprietary devices used for similar purposes can be much more expensive.

"On average, a sump equipped with a SAFL Baffle is one-fourth the cost of proprietary devices," says Barbara Loida, MS4 coordinator engineer for the MnDOT Metro District. "Cities and counties have been purchasing these expensive proprietary devices for more than 10 years."

In 2011 MnDOT along with Minnesota cities, counties and private entities installed the SAFL Baffle in more than 50 sumps. Many more are on order in 2012.

"As part of their commitment to the environment, MnDOT and local agencies implement programs to minimize the effects of stormwater runoff on regional surface waters and groundwater," says Loida. "This project has significantly advanced that objective."

More information about this study is available in the **Technical Summary** on page 114.

Local Road Research Board

For more than 50 years, the Local Road Research Board (LRRB) has facilitated both new transportation research and the sharing of the latest knowledge among Minnesota city and county engineers. LRRB innovations range from new ways to determine pavement strength to innovative methods for engaging the public. In the last 15 years, the LRRB has sponsored more than 200 projects and offered local communities tools to improve pavement management and rural safety; upgrade crash analysis software; evaluate the performance of stormwater treatment technology; explore the environmental benefits of porous pavements; and better calibrate snowplow sanders.

In FY2012, LRRB funds accounted for 27% ($2,902,378) of MnDOT's research budget. (See Figure 5 on page 34.)

The legislative origin and purpose of LRRB are described this way in the **2012 LRRB Strategic Plan**:

> *In 1959, the Minnesota Legislature established funding from the state aid allocation for the purposes of supporting research on problems of specific interest to local road engineers. The legislation, Chapter 162.06 subd. 4 and Chapter 162.12 subd. 4, also established the LRRB to manage activities. The original legislation stated that LRRB allocate those funds "...solely for the purpose of conducting research in the methods of and materials for the construction and maintenance of county state-aid highways and municipal state-aid streets." The 1959 legislation set the funding level at ¼ of 1 percent of the state aid allocation and mandated that the Commissioner of Transportation oversee the administration of these funds. In 1974, the Minnesota Legislature modified the original legislation by adding a research focus to improve the design and environmental compatibility of state-aid highways, streets, and appurtenances. It also allowed for constructing research elements and reconstructing or replacing research elements that fail. In addition, the legislation broadened the LRRB's scope to include conducting programs for implementing and monitoring research results.*
>
> *The latest change in the LRRB legislation occurred in 1994, when the funding level was increased from ¼ of one percent to its current level of ½ of one percent of the state aid allocation, effectively doubling LRRB's funding capabilities.*

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**

Making a Difference

The LRRB's current research includes projects to explore better methods to inspect and maintain timber bridges, determine best practices in applying Complete Streets principles to design work, and evaluate the impacts of implements of husbandry on our roads and bridges.

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

Grass-Roots Involvement

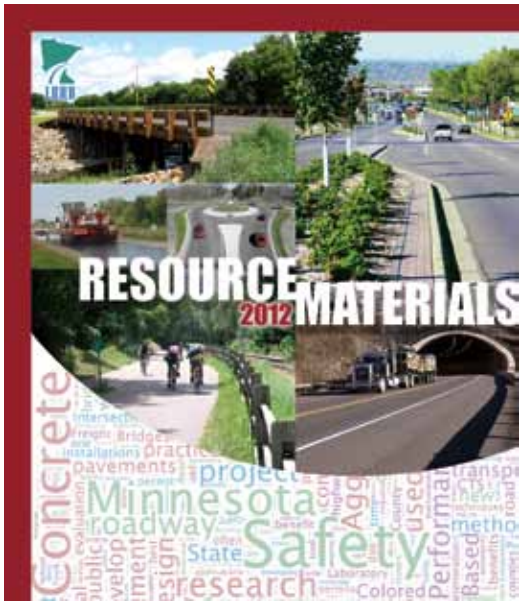
The transportation practitioners who are responsible for county highways and city streets best understand the problems and challenges in providing safe, efficient roadways. The LRRB makes it easy for them to participate in setting the research agenda.

Each year, the **LRRB Board**, including city and county engineers and key MnDOT decision-makers, approves and funds the most innovative research projects addressing the needs of local transportation practitioners.

Once research has been completed, the **Research and Implementation Committee (RIC)** (www.lrrb.org/ric.aspx) communicates the results and facilitates their practical application. This multiplies the impact of LRRB-sponsored research, as more and more engineers see its potential applications. 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.

Submitting Ideas

The LRRB is continually on the lookout for research that addresses transportation issues facing Minnesota's cities and counties, and that ultimately helps improve the quality of Minnesota's transportation systems. Please submit your research ideas to the LRRB at www.lrrb.org/submit-ideas.



In FY2012 the LRRB developed a new set of Resource Materials, including updates of the Strategic Plan and Operating Procedures guide, which provides LRRB members with a one-stop resource for LRRB procedures, goals and background information. These can be accessed at www.lrrb.org.

Figure 8. LRRB Board Members

2012

Rick West (Chair), Otter Tail County

Julie Skallman, State Aid Division

Tom Ravn, MnDOT Office of Construction & Innovative Contracting

Linda Taylor, MnDOT Research Services

Bruce Hasbargen, Beltrami County

Lyndon Robjent, Carver County

Tim Stahl, Jackson County

Steve Koehler, City of New Ulm

John Powell, City of Savage

Laurie McGinnis, University of Minnesota CTS

2011

Rick West (Chair), Otter Tail County

Julie Skallman, State Aid Division

Tom Ravn, MnDOT Office of Construction & Innovative Contracting

Linda Taylor, MnDOT Research Services

Mitch Anderson, Stearns County

Bruce Hasbargen, Beltrami County

Sue Miller, Freeborn County

Deb Bloom, City of Roseville

Steve Koehler, City of New Ulm

Laurie McGinnis, University of Minnesota CTS

LRRB Board members: (front row, from left) Lyndon Robjent, Carver County; Julie Skallman, MnDOT State Aid; Rick West (Chair), Otter Tail County; Bruce Hasbargen, Beltrami County; (back row) Laurie McGinnis, CTS director; Steve Koehler, City of New Ulm; John Powell, City of Savage; Linda Taylor, MnDOT Research Services director; Tom Ravn, MnDOT Office of Construction & Innovative Contracting; Tim Stahl, Jackson County (RIC Liaison).

Figure 9. Research Implementation Committee (RIC) Members

2012

Rich Sanders (Chair), Polk County

Jeff Hulsether, City of Brainerd

Mitch Rasmussen, Scott County

Dave Robley, Douglas County

Tim Stahl, Jackson County

Klayton Eckles, City of Woodbury

Walter Leu, MnDOT

Rick Kjonaas, MnDOT

Maureen Jensen, MnDOT

Nicole Peterson, MnDOT

Farideh Amiri, MnDOT

Jim Grothaus, University of Minnesota

2011

Rich Sanders (Chair), Polk County

Tom Colbert, City of Eagan

Jeff Hulsether, City of Brainerd

Mitch Rasmussen, Scott County

Tim Stahl, Jackson County

Sue Miller, Freeborn County

Walter Leu, MnDOT

Rick Kjonaas, MnDOT

Maureen Jensen, MnDOT

Ben Worel, MnDOT

Farideh Amiri, MnDOT

Jim Grothaus, University of Minnesota

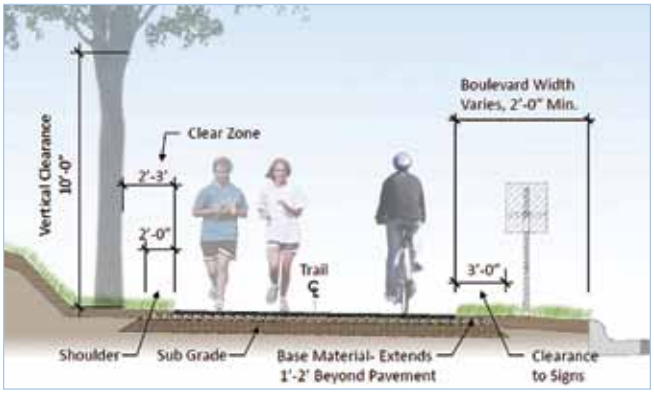
RIC members: (front row, from left) Farideh Amiri, MnDOT Research Services; Tim Stahl, Jackson County; Rick Kjonaas, MnDOT State Aid; Maureen Jensen, MnDOT; Jeff Hulsether, City of Brainerd; (back row) Dave Robley, Douglas County; Mitch Rasmussen, Scott County; Jim Grothaus, CTS; Walter Leu, MnDOT District 1; Rich Sanders (Chair), Polk County. Not pictured: Nicole Peterson, MnDOT Research Services, and Klayton Eckles, City of Woodbury.

The LRRB's New Website

Please visit LRRB's redesigned website, **www.lrrb.org**, for more information about LRRB research and activities. This site lists our members, provides news and events information, explains more about LRRB's mission and plans, provides links to all of our published reports, connects readers to local and national resources, and sports a variety of Web-based tools, including:

- Handbooks, manuals, and presentation documents to help local agencies with a variety of issues, including snowplow calibration, traffic sign management and pavement rehabilitation and management
- Software tools that analyze crash patterns, track Minnesota's research test sections, provide best practices in managing interactions between local authorities and major traffic generators, help write project memos to attain federal funds, assist in designing hot-mix asphalt pavements and more
- Videos demonstrating technologies and procedures
- Synthesis documents summarizing recent research on various topics including bridge construction, highway construction impact mitigation, social media practice in Minnesota cities and counties, and noise wall effectiveness testing

The redesigned site is easier to use, with improved navigation and search functionality, an updated idea submission process, and an LRRB members-only section that offers access to even more resources.



The Maintenance of Recreational Trails workshop provided guidance for maintaining trail pavement as well as designing and maintaining vegetation, signage and other elements.

FY2012 LRRB Research Highlights

Report 2011RIC05, "Maintenance of Recreational Trails," leveraged past LRRB-funded research into best practices for preserving trails to design and administer a workshop for city and county maintenance managers. This guidance covered the pavement life cycle, identifying and prioritizing maintenance needs, building a maintenance schedule and more. It was presented through the Minnesota Local Technical Assistance Program at various Minnesota locations as well as through national forums like the American Public Works Association conference. Maintaining trails is much more cost-effective than rehabilitation, and this project will help ensure the safety and enjoyment of trail users throughout Minnesota. For more information, see the **Technical Summary** for this project on page 154.

Report 2012-17, "Material Testing Rates for Low-Volume Roads," will save local governments money by reducing the amount of testing required for the materials going into local roads. The previous testing specifications were designed for statewide use, but since lower-traffic roads don't undergo the stresses of state highways, the testing was excessive. In fact, some required lab test results would take longer to generate than the duration of many local construction projects. By surveying Minnesota inspectors, project engineers and contractors, and reviewing information about current material control practices and the risks associated with changing various requirements, investigators were able to confirm that a less stringent testing regimen could be implemented safely, and they developed a new **State Aid for Local Transportation Schedule of Materials for Low Volume Roads** tailored specifically for city and county needs. For more information, see the **Technical Summary** for this project on page 144.

INV 923, "**Minnesota Concrete Flatwork Specifications for Local Government Agencies**," is a recently completed effort to develop up-to-date local concrete infrastructure guidelines and to determine how these can be used to update the 2006 **State Aid Concrete Pavement Rehabilitation Best Practices Manual**. Investigators also developed training materials to present the new specifications to local design and inspection personnel. These materials will provide guidance for product selection and for testing concrete flatwork construction to ensure that concrete flatwork construction projects in Minnesota's cities and counties will be consistent, resulting in higher quality and more durable concrete.

Feature

Implementing MnDOT Research through Strong Partnerships and Local Training

Jim Grothaus, Director, Minnesota Local Technical Assistance Program

MnDOT Research Services and the Local Road Research Board work with many partners to bring innovation to the Department and the state of Minnesota. A key partner is the University of Minnesota Center for Transportation Studies, which houses, among other joint initiatives, the **Minnesota Local Technical Assistance Program**. According to MnDOT Director of Research Services Linda Taylor, "Leveraging our partnerships with the University and the Local Road Research Board to fund LTAP helps us to implement our research by educating and training stakeholders."

The LTAP's mission is to improve the skills and knowledge of local transportation agencies through training, technical assistance and technology transfer. Using LTAP and its mobile arm, the **Circuit Training and Assistance Program**, MnDOT facilitates adoption of successful research innovations in areas such as **winter maintenance**, **pavement rehabilitation**, **work zones**, **traffic sign programs** and **vegetation management**.

"Our outreach through LTAP helps city, county and state agencies effectively manage changes in policies, practices and technology by providing them with current information and training," says Taylor. In addition to formal courses and workshops, LTAP tools "can be used as refreshers for MnDOT and local staff, such as at safety meetings. If an office is experiencing issues regarding cargo securement, for instance, it can just call up the training resources it needs on that topic right from the LTAP site." Taylor also cites the recent **Minnesota Roadway Maintenance Training and Demo Day**, where state and local maintenance personnel were able to learn about and test the latest innovations through classroom sessions and outdoor demonstrations.

Program Director **Jim Grothaus** describes the LTAP initiative as providing a national model: "Minnesota's LTAP is unique in the country due to its participating organizations," he says. "It is supported through both federal funds, allocated through MnDOT Research Services, and local tax dollars. Working out of the Center for Transportation Studies, we have the power of the University combined with the power of MnDOT and LRRB."

An emerging outreach strategy enabled by LTAP is online training. The first module, covering maintenance and design of gravel roads, recently became available. (See the poster on page 86 for details.) "We realize that as budgets get tighter and people's time gets tighter, there's a need to develop and deliver different methods of training," says Grothaus. Interested local road engineers can view the gravel roads training in six to eight hours, but shorter modules are in development, including training on work zone traffic control, snowplow operations, culvert installation and asphalt pavement-related topics.

Grothaus is currently president-elect of the National Local Technical Assistance Program Association, the professional association representing all LTAP programs nationwide. He will begin his term as president in August 2013. According to Grothaus, his service to the association will "create visibility for our state, city and county engineers, and share with other states what MnDOT and Minnesota's LTAP are doing so well."

A schedule of upcoming training opportunities through LTAP is available at **www.mnltap.umn.edu/training**.

Online Distance-Learning Course

This online distance-learning course, the first offered by Minnesota LTAP, was created in an effort to help local agencies provide training for their staff in a more cost effective manner. The online curriculum is similar to our traditional classroom training but perfect for students who are unable to travel or prefer a "work at your own pace" environment. Students are free to access the course anytime and anywhere within a three-month time frame.

This course helps supervisory personnel and operators better understand the materials, techniques, and equipment needed for maintaining gravel roads. It will also review new techniques and ideas in gravel road maintenance.

The course consists of 10 lessons, each containing a narrated presentation, video clips, reading assignments, a quiz, time to reflect on what has been learned, and time to develop an action plan. The course was designed to help students succeed. One way we accomplish this goal is by allowing students to take the quizzes and final test as many times as necessary until they understand the curriculum.

Students may repeat the lesson or parts of the lesson and then test themselves again. Test questions change with each attempt. Students who have already taken the classroom version of this workshop can test and refresh their knowledge, become familiar and comfortable with computer-based training, and earn an additional credit by taking the online training.

Course Lessons

- The properly shaped gravel road
- Distresses in gravel roads
- Drainage
- Adding gravel
- What is good gravel
- Turning a poor gravel road into a good one
- Shaping the roadway
- Dust control
- Equipment innovations
- Summary and conclusion

All reading assignments are available online within the course, so no additional books or materials need to be purchased.

Course Instruction

The curriculum is a collaboration of work from **John Okeson**, our current face-to-face workshop instructor; former instructor **Rick West**; and **Ken Skorseth**, our ***Gravel Road Maintenance: Meeting the Challenge*** DVD instructor. Online materials include curriculum from our face-to-face workshop, the DVD, and the FHWA Gravel Road Maintenance and Design Manual.

Cost and Credit

Students will earn 1.0 required Roads Scholar credit and may also register for 1 Continuing Education Credit (CEU).

Cost: $45, or $55 to register for the CEU.

To the best of our knowledge, this course meets the continuing education requirements for 12.5 PDHs.

Students who have previously taken the classroom version of the LTAP Gravel Road Maintenance and Design workshop may earn an additional credit by taking the online version.

LRRB

MINNESOTA LTAP
UNIVERSITY OF MINNESOTA

www.mnltap.umn.edu

This poster, representing an innovative service that LTAP can offer local officials thanks to LRRB funding, won first prize at the 2012 Local/Tribal Technical Assistance Program Annual Conference.

FY2012 LRRB Technical Summaries

Summaries of many completed LRRB reports can be found in this document, organized by topic area. These include:

INV 645: 2011RIC01: Decision Tree for Stormwater BMPs 116

INV 645: 2011RIC05: Best Practices for Recreation Trails 154

INV 768: 2011-20: Monitoring Geosynthetics in Local Roadways (LRRB 768) 10-Year Performance Summary 128

INV 854: 2012-08: TPF-5(148): Effects of Implements of Husbandry (Farm Equipment) on Pavement Performance 138

INV 878: 2012-12: MPR-6(024): Porous Asphalt Pavement Performance in Cold Regions . . 140

INV 890: 2012-06: Vehicle Speed Impacts of Occasional Hazard (Playground) Warning Signs. 168

INV 891: 2011-19: Performance Assessment of Oversized Culverts to Accommodate Fish Passage 108

INV 892: 2011TREE01: The Road to a Thoughtful Street Tree Master Plan. 118

INV 901: 2011-26: Concrete Delivery Time Study. 132

INV 902: 2012-17: Material Control Testing Rates for Low-Volume Roads 144

INV 908: 2011-21: Minnesota's Best Practices and Policies for Safety Strategies on Highway and Local Roads 162

Additionally, we have completed a summary of an ongoing project:

INV 767, INV 825 and INV 899: Research in Progress: Increasing the Gradation of Limestone Aggregate Bases to Increase Road Performance 148

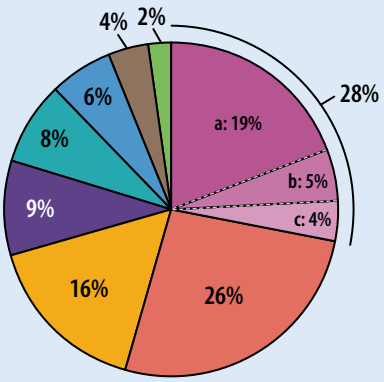
FY2012 Research Projects Summary

This section provides general information about research contracts active during any part of FY2012, both projects managed by Research Services and multi-state pooled fund projects to which MnDOT has contributed. For your convenience, the table of projects is also available, along with statistics and pie charts from this report, as a separate publication, *Research Services FY2012 At-A-Glance*. Please contact Research Services to request this document.

Research Topic Areas

The projects in this section are organized by research topic area. Research Services managers have created these categories to align with Department offices and functions, help managers oversee project tracking and communication efforts, and support strategic funding decisions to ensure that all elements of MnDOT's strategic vision are addressed appropriately through its research. Funds were distributed as follows over these topic areas:

Figure 10. FY2012 Research Funds Allocated by Topic Area*



Administrative	$ 1,492,746
a: Dedicated Programs (CTS & LTAP)	$ 1,032,458
b: Research Administration	$ 268,909
c: LRRB/RIC Administration	$ 191,379
Materials & Construction	$ 1,361,781
Traffic & Safety	$ 865,945
Policy & Planning	$ 501,029
Bridges & Structures	$ 412,027
Multimodal	$ 234,085
Maintenance Operations & Security	$ 335,551
Environmental	$ 117,915
Total	**$ 5,321,080**

*Includes only projects with contracts maintained by MnDOT Research Services.

To help readers understand this system of categorization, we have listed sub-areas for each topic area:

Figure 11. Research Topic Areas and Sub-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
- Multimodal & 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

Within a given topic area, completed reports in the table on page 91 are listed first, in order of report number, followed by the report title and, when appropriate, the LRRB and/or SP&R identifier. Next, the ongoing contracts that reached their end dates during FY2012 are listed, followed by those that are still continuing.

- The Investigator column lists the Principal Investigator employed by the contractor. In many cases, additional investigators or authors contributed to the report.
- For information about the roles of Principal Investigator, Technical Liaison and Project Coordinator, see "Research Management" on page 19.
- See "Research Funding Programs" beginning on page 34 for more information about the items in the Funding Source column.
- The Amount Paid and % Paid columns reflect accounting as of July 1, 2012, in most cases. Some projects are completed without the full contracted amount (Total Cost) being paid; % Paid does not necessarily reflect the percentage of scoped tasks completed on the project.

The pooled fund studies (many of which involve multiple contracts not managed by MnDOT) are listed after the contracts within a given topic area, with MnDOT-led studies listed first.

- The Technical Liaison is the MnDOT representative to the pooled fund study; for those studies not led by MnDOT, the lead state representative as well as other information about a particular project can be found at **www.pooledfund.org**.
- The Current MN Commitment End Date reflects commitments already recorded. This does not preclude Minnesota from making a commitment beyond this date or reflect the end of the pooled fund study.
- Some pooled fund studies are listed even though Minnesota no longer contributes to them because they are still active and producing value for the state.
- Since SP&R Part II work plans have been drafted historically by calendar year and not fiscal year, Research Services has provided both Minnesota's 2011 and 2012 commitments as well as the combined Minnesota commitment for all years so far. In some cases, when a pooled fund study has continued over multiple study numbers, the total reflects Minnesota payments to all of the studies in the series.

The TS column indicates research contracts or pooled fund studies for which a Technical Summary has been created in FY2012; see "MnDOT Research: FY2012 Technical Summaries" beginning on page 107.

For more information about any of these projects, please contact the listed Technical Liaison or Research Services.

FY2012 Research Projects Summary

RESEARCH PROJECTS:

- Completed research reports and Transportation Research Syntheses that were released in fiscal year 2012: July 2011 to June 2012
- Research contracts with end dates during FY2012 that did not result in a final report
- Other research contracts active during FY2012, including some tasks or contracts that are part of larger programs that MnDOT tracks individually

POOLED FUND TABLES*:

- Multi-state transportation pooled fund studies led by MnDOT
- Other multi-state transportation pooled fund studies in which MnDOT participates, either through a calendar year 2011 or 2012 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	MnDOT State Research Program
SP&R	State Planning and Research (FHWA)

A mark in the "TS" column indicates that a Technical Summary for this project can be found in the 2012 Annual Report or at www.dot.state.mn.us/research.

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

Bridges & Structures

Report Number	Contract Number	Title	Contractor	Investigator	Technical Liaison	Project Coordinator	Start Date	End Date	Funding Source	Total Cost	Amount Paid	% Paid	TS
2011-19	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	LRRB, SRP, COPTRS	$83,428	$83,428	100%	X
2012-09	89261 W0192	Development of Best Practices for Inspection of PT Bridges in Minnesota	University of Minnesota – Duluth	Andrea Schokker	Paul Kivisto	Shirlee Sherkow	7/8/10	5/31/12	COPTRS, SRP	$123,195	$123,195	100%	X
2012-16	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	COPTRS	$100,000	$100,000	100%	X
TRS1105	98511	MPR-0(005): Bridge Deck Cracking	American Engineering Testing, Inc.	Dave Rettner	Ronald Mulvaney	Shirlee Sherkow	3/22/11	11/30/11	SP&R, SRP	$4,930	$4,930	100%	
TRS1203	99586	INV 926: Innovative Bridge Construction for Minnesota Local Roads	HDR Engineering	Daniel Dorgan	Steve Misgen	Shirlee Sherkow	12/9/11	7/31/12	LRRB	$24,996	$24,976	100%	
N/A	97835	Bridge Deck Delam Inspection Technology Evaluation and Development of Best Practices	EVS	Paul Keranen	Duane Green	Bruce Holdhusen	11/4/10	3/31/12	SRP	$52,026	$52,026	100%	
N/A	97918	National Bridge Inspection Standards	HDR Engineering	Farhad Reza	Thomas Styrbicki	Bruce Holdhusen	12/10/10	7/31/12	SRP	$19,534	$14,694	75%	
2012-24	89261 W0131	Instrumentation, Monitoring and Modeling of the I-35W Bridge	University of Minnesota	Cathy French	Benjamin Jilk	Shirlee Sherkow	2/2/09	8/30/12	Partnership Funds	$235,431	$164,801	70%	
N/A	89261 W0142	Full-Depth Precast Concrete Bridge Deck System—Phase II	University of Minnesota	Cathy French	Keith Molnau, Paul Rowekamp	Daniel Warzala	7/30/09	10/31/12	SRP	$165,000	$135,004	82%	
N/A	89261 W0145	Wakota Bridge Monitoring Program	University of Minnesota	Arturo Schultz	Arielle Ehrlich	Shirlee Sherkow	6/19/09	3/31/13	SRP	$193,990	$154,893	80%	
N/A	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	7/31/13	SRP	$71,950	$44,661	62%	
N/A	89261 W0244	A Research Plan and Factors Affecting Service Life for Culvert Pipe Materials in Minnesota	University of Minnesota	Jeff Marr	Andrea Hendrickson	Shirlee Sherkow	4/18/11	9/30/12	SRP	$29,999	$28,499	95%	
N/A	89261 W0261	MPR-0(004): Scour Monitoring Technology Implementation	University of Minnesota	Jeff Marr	Andrea Hendrickson	Shirlee Sherkow	4/18/11	5/31/14	SP&R, SRP	$38,233	$19,180	50%	

Bridges & Structures [cont.]

Report Number	Contract Number	Title	Contractor	Investigator	Technical Liaison	Project Coordinator	Start Date	End Date	Funding Source	Total Cost	Amount Paid	% Paid	TS
N/A	95439	MPR-9(002): Concrete Bridge Deck Crack Sealant Evaluation and Implementation	Braun Intertec Corporation	Matthew Oman	Edward Lutgen	Daniel Warzala	9/30/09	3/31/13	SP&R, SRP	$80,918	$33,567	41%	
N/A	96271	Synthesis of Bridge Approach Panel Best Practices	Minnesota State University, Mankato	Farhad Reza	Paul Rowekamp	Shirlee Sherkow	7/15/10	5/31/13	SRP	$25,000	$15,304	61%	
N/A	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	$60,000	50%	
N/A	98166	MPR-9(004): Load and Resistance Factor Design (LRFD) Pile Driving Static Load Test Data Collection (LRFD Implementation)	American Engineering Testing, Inc.	Gregory Reuter	Derrick Dasenbrock	Bruce Holdhusen	1/21/11	7/31/12	SP&R, SRP	$99,752	$99,752	100%	
N/A	98640	MPR-0(005): Analysis of Bridge Deck Cracking Data	American Engineering Testing, Inc.	Dave Rettner	Ronald Mulvaney	Shirlee Sherkow	5/25/11	3/31/13	SP&R, SRP	$44,993	$0	0%	
N/A	99008 W01	Investigation of Shear Distribution Factors in Prestressed Concrete Girder Bridges	University of Minnesota	Cathy French	Yihong Gao	Shirlee Sherkow	9/27/11	3/31/15	SRP	$320,000	$7,300	2%	
N/A	99008 W041	Anchorage of Shear Reinforcement in Prestressed Concrete Bridge Girders	University of Minnesota	Cathy French	Benjamin Jilk	Shirlee Sherkow	6/29/12	11/30/14	SRP	$175,000	$0	0%	
N/A	99008 W042	MPR-2(002): Time-Dependent Considerations of I-35W St. Anthony Falls Bridge Including Long-Term Monitoring Applications	University of Minnesota	Cathy French	Benjamin Jilk	Shirlee Sherkow	6/29/12	12/31/14	SP&R, SRP	$100,000	$0	0%	
N/A	99008 W049	MPR-2(006): Monitoring of Fracture-Critical Steel Bridges—Phase III	University of Minnesota	Arturo Schultz	Moises Dimaculangan	Shirlee Sherkow	6/29/12	1/31/15	SP&R, SRP	$166,000	$0	0%	
N/A	99136	MPR-1(004): Partially Grouted Riprap Implementation Matrix Riprap Implementation	Ayres Associates	Paul Clopper	Nicole Danielson-Bartelt	Shirlee Sherkow	12/14/11	2/28/13	SP&R, SRP	$16,635	$9,663	58%	
N/A	99620	MPR-0(002): Culvert Repair Best Practices, Specifications and Special Provisions	CNA Consulting Engineers, Inc.	Bruce Wagener	Lisa Sayler	Bruce Holdhusen	11/1/11	7/31/13	SP&R, SRP	$80,000	$21,171	26%	

Bridges & Structures Pooled Fund Studies

Study #	Title	Technical Liaison	Project Coordinator	Lead State or Agency	Number of Participating States	Current MN Commitment End Date	Total Cost	MN 2011 Commitment	MN 2012 Commitment	Total MN Commitment	TS
TPF-5(174)	Construction of Crack-Free Bridge Decks—Phase II	Paul Kivisto	Deb Fick	KS	14	2011	$995,000	$15,000	$0	$75,000	
TPF-5(179)	Evaluation of Test Methods for Permeability (Transport) and Development of Performance Guidelines for Durability	Bernard Izevbekhai	Deb Fick	IN	11	2011	$843,000	$12,000	$0	$87,000	
TPF-5(202)	HY-8 Culvert Analysis Program—Phase III of Development Efforts	Petra DeWall	Deb Fick	FHWA	8	2011	$160,000	$10,000	$0	$30,000	
TPF-5(238)	Design and Fabrication Standards to Eliminate Fracture Critical Concerns in Two Girder Bridge Systems	Yihong Gao	Deb Fick	IN	9	2013	$840,000	$20,000	$20,000	$60,000	
TPF-5(247)	Field Testing Handheld Thermographic Inspection Technologies—Phase II	Paul Rowekamp	Deb Fick	MO	10	2012	$610,000	$30,000	$30,000	$60,000	
TPF-5(253)	Member-Level Redundancy in Built-Up Steel Members	Todd Nieman	Deb Fick	IN	8	2013	$550,000	$25,000	$25,000	$75,000	
TPF-5(254)	Evaluation and Analysis of Decked Bulb T Beam Bridge	Dave Conkel	Deb Fick	MI	5	2014	$380,000	$15,000	$15,000	$60,000	
TPF-5(256)	HY-12 Storm Drain Hydraulic Analysis Program—Phase II of Development Efforts	Lisa Sayler	Deb Fick	FHWA	6	2013	$80,000	$0	$10,000	$10,000	
TPF-5(265)	Watershed Modeling System License Renewal Agreement	Lisa Sayler	Deb Fick	FHWA	8	2013	$112,000	$0	$5,000	$5,000	
TPF-5(266)	Surface-Water Model System License Renewal Agreement	Lisa Sayler	Deb Fick	FHWA	7	2013	$86,000	$0	$10,000	$10,000	

Environmental

Report Number	Contract Number	Title	Contractor	Investigator	Technical Liaison	Project Coordinator	Start Date	End Date	Funding Source	Total Cost	Amount Paid	% Paid	TS
2011-08, 2012-13	89261 W0100	Assessment and Recommendations for the Operation of Standard Sumps as Best Management Practices for Stormwater Treatment (Vol. 2)	University of Minnesota	Omid Mohseni	Barbara Loida	Shirlee Sherkow	7/8/08	5/31/12	SRP	$257,000	$257,000	100%	X
2011RIC01	93463 Task 1	Decision Tree for Stormwater BMPs	SRF Consulting Group, Inc.	Mike Marti	Michael Sheehan	Bruce Holdhusen	2/19/09	12/31/12	LRRB	$51,748	$51,748	100%	X
2011TREE01	89261 W0187	INV 892: The Road to a Thoughtful Street Tree Master Plan	University of Minnesota	Gary Johnson	Daniel Gullickson	Sandra McCully	4/8/10	9/30/11	LRRB	$20,000	$20,000	100%	X
2012-03	89261 W0157	Research and Assess the Farmer and MnDOT 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	2/28/12	SRP, COPTRS, Other State Funds	$99,000	$99,000	100%	X
TRS1202	N/A	Far-Field Testing of Noise Wall Effectiveness: Survey of State Practice and Literature Scan	CTC & Associates LLC	Patrick Casey, Mark Linsenmayer	John Welle	Farideh Amiri, Shirlee Sherkow	N/A	N/A	LRRB	N/A	N/A	100%	
N/A	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	$75,887	95%	
N/A	00734	Flocculation Treatment BMPs for Construction Water Discharges	Minnesota State University, Mankato	Stephen Druschel	Dwayne Stenlund	Bruce Holdhusen	6/22/12	12/31/13	SRP	$79,464	$0	0%	
N/A	89258 W02	Wetblade to Control Canada Thistle and Phragmites Along Roadways	Michigan Technological University	Catherine Tarasoff	Kenneth Graeve	Nelson Cruz	6/25/09	5/31/14	SRP	$139,966	$71,062	51%	
N/A	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, SRP	$314,000	$46,000	15%	
N/A	89261 W0211	INV 897: Developing Salt-Tolerant Sod Mixtures for Use as Roadside Turf in Minnesota	University of Minnesota	Eric Watkins	Dwayne Stenlund	Daniel Warzala	6/8/10	8/31/14	LRRB	$176,516	$61,779	35%	
N/A	89261 W0250	Development of Stormwater Effluent Turbidity Monitoring Methods for Linear Construction	University of Minnesota	Bruce Wilson	Dwayne Stenlund	Bruce Holdhusen	6/27/11	7/31/13	SRP	$193,500	$0	0%	
N/A	89261 W0252	Wetland Mitigation in Abandoned Borrow Areas	University of Minnesota – Duluth	Kurt Johnson	Sarma Straumanis	Shirlee Sherkow	3/28/11	8/31/14	SRP	$142,023	$49,671	35%	
N/A	96273	Concrete Slurry, Wash and Loss Water Mitigation	Minnesota State University, Mankato	Stephen Druschel	Dwayne Stenlund	Bruce Holdhusen	5/11/10	8/31/12	SRP	$104,945	$97,945	93%	
N/A	99008 W054	INV 932: Determination of Effective Impervious Area in Urban Watersheds	University of Minnesota	John Gulliver	Scott Anderson	Shirlee Sherkow	6/29/12	7/31/15	LRRB	$150,000	$0	0%	
N/A	LAB914	INV 914: Research Using Waste Shingles for Stabilization or Dust Control for Gravel Roads and Shoulders	MnDOT Materials Lab	Thomas Wood	Tim Stahl	Daniel Warzala	5/11/11	1/31/14	LRRB, SRP	$77,000	$0	0%	

Maintenance Operations & Security

Report Number	Contract Number	Title	Contractor	Investigator	Technical Liaison	Project Coordinator	Start Date	End Date	Funding Source	Total Cost	Amount Paid	% Paid	TS
2012-20	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	7/31/12	SRP	$69,600	$69,600	100%	X
N/A	89261 W0230	INV 906: LTAP Gravel Road Maintenance Independent Online Distance Training (ODL)	University of Minnesota	Jim Grothaus	Richard West	Daniel Warzala	11/3/10	5/31/12	LRRB	$45,000	$45,000	100%	

Maintenance Operations & Security [cont.]

Report Number	Contract Number	Title	Contractor	Investigator	Technical Liaison	Project Coordinator	Start Date	End Date	Funding Source	Total Cost	Amount Paid	% Paid	TS
N/A	93463 Task 4	INV 645: RIC Task 4: Pavement DVD/Video	SRF Consulting Group, Inc./ Greer & Associates/Minnesota State University, Mankato	Mike Marti, Richard Kronick, W. James Wilde	Gary Danielson	Farideh Amiri	2/19/09	12/31/12	LRRB	$80,752	$80,752	100%	
N/A	98203	TPF-5(218): Clear Roads Winter Highway Operations—Phase II	CTC & Associates LLC	Patrick Casey	Thomas Peters	Deb Fick	1/19/11	9/30/11	SP&R, Partnership Funds	$69,526	$61,836	89%	X
N/A	01387	TPF-5(218): AASHTO SCOM Meeting and Support for the Clear Roads September 2012 TAC Meeting	CTC & Associates LLC	Kim Linsenmayer	Thomas Peters	Deb Fick	6/12/12	1/31/13	SP&R, Partnership Funds	$13,520	$1,030	8%	
N/A	89261 W0191	Comparative Performance Study of Chip Seal and Bonded Wear Course Systems Applied to Bridge Decks and Approaches	University of Minnesota – Duluth	Eshan Dave	Thomas Peters	Nelson Cruz	7/8/10	8/31/14	COPTRS	$90,872	$0	0%	
N/A	89261 W0199	Estimation of Winter Snow Operation Performance Measures with Traffic Flow Data	University of Minnesota – Duluth	Eil Kwon	Thomas Peters	Daniel Warzala	8/20/10	12/31/12	COPTRS	$58,000	$45,000	78%	
N/A	93463 Task 6.7	INV 645: INV Task 6.7: Dust Control	SRF Consulting Group, Inc.	Mike Marti	Rich Sanders	Farideh Amiri	1/22/11	12/31/12	LRRB	$31,350	$25,000	80%	
N/A	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	9/30/13	LRRB, SRP	$109,984	$26,704	24%	
N/A	95099	TPF-5(153), INV 863: 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	LRRB, SP&R, Other Federal Funds	$286,185	$81,913	29%	
N/A	98247	TPF-5(218): Clear Roads Winter Highway Operations—Understanding the True Costs of Snow and Ice Control	PB America, Inc.	Patrick Hughes	Thomas Peters	Deb Fick	8/25/11	7/31/13	SP&R, Partnership Funds	$192,720	$23,462	12%	
N/A	98248	TPF-5(218): Clear Roads Winter Highway Operations—Mapping Weather Severity Zones	Meridian Environmental Technology, Inc.	John Mewes	Thomas Peters	Deb Fick	8/17/11	7/31/12	SP&R, Partnership Funds	$49,725	$39,484	79%	
N/A	99008 W019	INV 998: Operational Research Program for Local Transportation Groups (OPERA), FY2012	University of Minnesota	Jim Grothaus	Julie Skallman	Farideh Amiri	9/23/11	11/30/12	LRRB	$90,000	$0	0%	
N/A	99008 W056	INV 934: Field Evaluation of Friction Measurement and Applicator Control Systems for Winter Road Maintenance	University of Minnesota	Rajesh Rajamani	Rich Sanders	Daniel Warzala	6/29/12	11/30/13	LRRB	$40,000	$0	0%	
N/A	99083	TPF-5(218): Determining the Toxicity of Deicing Materials—RFP	Barr Engineering Company	Keith Pilgrim	Thomas Peters	Deb Fick	2/1/12	1/31/13	SP&R, Partnership Funds	$76,610	$8,245	11%	
N/A	99085	TPF-5(218): Snow Removal at Extreme Temperatures	Montana State University Western Transportation Institute	Xianming Shi	Thomas Peters	Deb Fick	3/20/12	1/31/13	SP&R, Partnership Funds	$50,000	$0	0%	
N/A	99392	TPF-5(218): Developing a Totally Automated Spreading System for Clear Roads	Thompson Engineering Company	Gregory Thompson	Thomas Peters	Deb Fick	2/1/12	1/31/13	SP&R, Partnership Funds	$69,550	$7,900	11%	
N/A	99556	I-35 Emergency Alternate Route Signage—District 6 Pilot Project	SRF Consulting Group, Inc.	Andy Mielke	Michael Schweyen	Nelson Cruz	1/25/12	1/31/14	SRP	$98,101	$30,009	31%	
N/A	99716	TPF-5(218): Clear Roads Administration, Research Support and Information Services for FY2012	CTC & Associates LLC	Kim Linsenmayer	Thomas Peters	Deb Fick	10/13/11	9/30/12	SP&R, Partnership Funds	$97,306	$77,594	80%	

Maintenance Operations & Security [cont.]

Report Number	Contract Number	Title	Contractor	Investigator	Technical Liaison	Project Coordinator	Start Date	End Date	Funding Source	Total Cost	Amount Paid	% Paid	TS
N/A	LAB886	INV 886: Cost-Effective Pavement Preservation Solutions for the Real World	MnDOT Materials Lab	Thomas Wood	Gregory Coughlin	Nelson Cruz	9/10/09	9/30/13	LRRB, SRP	$15,000	$2,000	13%	
N/A	LAB904	INV 904: Stripping of Hot Mixed Asphalt Pavements Under Chip Seals	MnDOT Materials Lab	Thomas Wood	Thomas Tesch	Daniel Warzala	7/19/10	12/31/12	LRRB	$40,000	$22,000	55%	

Maintenance Operations & Security Pooled Fund Studies

Study #	Title	Technical Liaison	Project Coordinator	Lead State or Agency	Number of Participating States	Current MN Commitment End Date	Total Cost	MN 2011 Commitment	MN 2012 Commitment	Total MN Commitment	TS
TPF-5(153)	Optimal Timing of Preventive Maintenance for Addressing Environmental Aging in HMA Pavements	Thomas Wood	Bruce Holdhusen	MN	6	2013	$335,000	$15,000	$0	$131,205	
TPF-5(218)	Clear Roads Winter Highway Operations—Phase II	Thomas Peters	Deb Fick	MN	27	2012	$2,105,000	$25,000	$25,000	$100,000	
SPR-3(042)	Aurora Program	Curt Pape	Deb Fick	IA	19	2013	$3,697,500	$25,000	$25,000	$425,000	
TPF-5(054)	Maintenance Decision Support System (MDSS)	Curt Pape	Deb Fick	SD	20	2013	$4,383,841	$25,000	$25,000	$250,000	
TPF-5(225)	Validation and Implementation of Hot-Poured Crack Sealant	Jim McGraw	Deb Fick	VA	9	2013	$825,000	$25,000	$25,000	$100,000	

Materials & Construction

Report Number	Contract Number	Title	Contractor	Investigator	Technical Liaison	Project Coordinator	Start Date	End Date	Funding Source	Total Cost	Amount Paid	% Paid	TS
2010-16, 2011-23	LAB879	INV 879, MPR-6(027): Pervious Concrete Cells on MnROAD Low-Volume Roads	MnDOT Materials Lab	Bernard Izevbekhai	Mark Maloney	Bruce Holdhusen	7/30/07	9/30/11	LRRB, SP&R, Other State Funds	$48,000	$48,000	100%	
2011-18	89261 W0173	INV 893: Optimal Contract Mechanism Design for Performance-Based Contracts	University of Minnesota	Diwakar Gupta	Richard Kjonaas	Daniel Warzala	11/10/09	10/31/11	SRP	$30,000	$30,000	100%	X
2011-20	INV768	INV 768: Monitoring Geosynthetics in Local Roadways (LRRB 768) 10-Year Performance Summary	MnDOT Materials Lab	Timothy Clyne	Luane Tasa	Daniel Warzala	10/1/00	9/1/11	LRRB	$30,000	$30,000	100%	X
2011-22	89261 W0269	Synthesis of Performance Testing of Asphalt Concrete	University of Minnesota – Duluth	Eshan Dave	Timothy Clyne	Alan Rindels	5/19/11	9/30/11	SRP	$19,924	$19,924	100%	X
2011-26	96033	INV 901: Concrete Delivery Time Study	American Engineering Testing, Inc.	Dan Vruno	Maria Masten	Shirlee Sherkow	3/29/10	1/31/12	LRRB, SRP, Other State Funds	$99,998	$99,411	99%	X
2012-01	89260 W01	Best Value Granular Material for Road Foundations	University of Illinois	Erol Tutumluer	John Siekmeier	Nelson Cruz	9/15/08	12/31/11	SRP	$192,000	$192,000	100%	X
2012-02	89261 W0140	Mechanistic Modeling of Unbonded Concrete Overlay Pavements	University of Minnesota	Roberto Ballarini	Shongtao Dai	Daniel Warzala	6/29/09	3/31/12	SRP	$110,000	$110,000	100%	X
2012-08	89261 W079	TPF-5(148), INV 854: Effects of Implements of Husbandry (Farm Equipment) on Pavement Performance	University of Minnesota	Lev Khazanovich	Shongtao Dai	Bruce Holdhusen	10/12/07	5/31/12	LRRB, SP&R, SRP, Partnership Funds, Other State Funds	$275,239	$275,239	100%	X

Materials & Construction [cont.]

Report Number	Contract Number	Title	Contractor	Investigator	Technical Liaison	Project Coordinator	Start Date	End Date	Funding Source	Total Cost	Amount Paid	% Paid	TS
2012-10	00068	INV 919: Use of StreetPave for Design of Concrete Pavements for Cities and Counties in Minnesota	Braun Intertec Corporation	Matthew Oman	Malaki Ruranika	Farideh Amiri	10/19/11	3/31/12	LRRB	$18,315	$18,314	100%	
2012-12	LAB878	INV 878, MPR-6(024): Porous Asphalt Pavement Performance in Cold Regions	MnDOT Materials Lab	Matthew Lebens	Larry Matsumoto	Bruce Holdhusen	7/26/07	4/30/12	LRRB, SP&R, Other State Funds	$82,400	$59,400	72%	X
2012-15	97281	Lump Sum Estimating: Discovery and Simulation	Minnesota State University, Mankato	Brian Wasserman	Thomas Wiener, Christopher Anderson	Alan Rindels	7/30/10	7/31/12	SRP	$17,000	$17,000	100%	X
2012-17	96885	INV 902: Material Control Testing Rates for Low-Volume Roads	Minnesota State University, Mankato	Brian Wasserman	Joseph MacPherson	Farideh Amiri	6/1/10	7/31/12	LRRB	$25,000	$25,000	100%	X
2012-18	94080	Subgrade Stabilization ME Properties Evaluation and Implementation	Minnesota State University, Mankato	Aaron Budge	Shongtao Dai	Daniel Warzala	5/4/10	6/30/12	SRP	$44,369	$44,369	100%	X
TRS1201	98488	Impact of Vibratory Equipment to Surrounding Environments During Construction	CNA Consulting Engineers, Inc.	Bruce Wagener	Charles Howe	Shirlee Sherkow	5/4/11	7/31/12	SRP	$9,918	$9,219	93%	
N/A	89258 W03	Transportation Enterprise Warm Mix Asphalt Synthesis Technology Transfer	Michigan Technological University	George Dewey	Timothy Clyne	None	1/21/11	9/30/11	SRP	$5,000	$5,000	100%	
N/A	89261 W0101	TPF-5(148): Vibrating Wire and Horizontal Clip Data Analysis	University of Minnesota	Ahmed Tewfik	Thomas Burnham	Bruce Holdhusen	6/10/08	12/31/11	LRRB, SP&R, SRP, Partnership Funds, Other State Funds	$66,500	$66,500	100%	
N/A	89261 W0189	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	LRRB, SP&R, SRP	$45,000	$45,000	100%	
N/A	89261 W0220	INV 869: TERRA Board Support (FY2011)	University of Minnesota	Laurie McGinnis	Julie Skallman, Mark Maloney	Benjamin Worel	7/20/10	11/30/11	LRRB	$35,000	$35,000	100%	
N/A	89261 W0254	INV 889: Performance of Recycled Asphalt and High RAP Asphalt Mix	University of Minnesota	Mihai Marasteanu	Gregory Coughlin	Daniel Warzala	2/8/11	3/31/12	LRRB	$30,000	$30,000	100%	
N/A	93103 W016	INV 645: Best Value Procurement Development	HNTB Corporation	Steve Howe	Kevin Kosobud	Farideh Amiri	8/5/09	7/31/12	LRRB, Partnership Funds	$140,547	$90,626	64%	
N/A	93263	MPR-6(033): Construction Project Management Software Evaluations	Minnesota State University, Mankato	Brian Wasserman	Thomas Wiener	Farideh Amiri	9/24/08	6/30/12	SP&R, SRP, Other State Funds	$190,932	$180,307	94%	
N/A	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	$17,472	58%	X
N/A	98638	ELMOD 6—Dynatest Deflection Analysis Software Training	Dynatest Consulting Inc.	Gabriel Bazi	Maureen Jensen	Benjamin Worel	4/22/11	7/31/11	SRP	$13,631	$13,631	100%	
N/A	98686	Seismic Research Data Analysis Support	Carr Geophysical Consulting LLC	Bradley Carr	Jason Richter	Bruce Holdhusen	4/29/11	7/31/11	SRP	$5,000	$5,000	100%	
N/A	98782	Future Tools to Aid in Asphalt Paving Construction Compaction	Braun Intertec Corporation	Matthew Oman	Gregory Johnson	Alan Rindels	5/11/11	7/31/11	SRP	$10,348	$10,348	100%	
N/A	98783	Assessment of Weather Effects on Construction Activities	Professional Engineering Services, Ltd.	Ann Johnson	Thomas Wiener	Alan Rindels	4/29/11	7/31/11	SRP	$15,001	$13,627	91%	
N/A	99008 W07	INV 923: Guidelines for Local Concrete Infratructure and Updating the State Aid Concrete Pavement Rehabilitation Best Practice Manual (2006)	University of Minnesota	Jim Grothaus	Ronald Dahlquist	Shirlee Sherkow	9/23/11	5/31/12	LRRB	$37,000	$37,000	100%	

Materials & Construction [cont.]

Report Number	Contract Number	Title	Contractor	Investigator	Technical Liaison	Project Coordinator	Start Date	End Date	Funding Source	Total Cost	Amount Paid	% Paid	TS
N/A	LAB840	INV 840-1: Performance of PG 52-34 Oil on Local Roads	MnDOT Materials Lab	Shongtao Dai	Brian Noetzelman	Daniel Warzala	6/22/06	12/31/11	LRRB	$56,200	$56,200	100%	
2011-05, 2012-07	93028	TPF-5(134): Rolling Resistance Measurements at the MnROAD Facility	Minnesota State University, Mankato	W. James Wilde	Bernard Izevbekhai	Bruce Holdhusen	7/23/08	11/30/12	SP&R	$118,760	$71,000	60%	
2011-12	MPR-6(021)	MPR-6(021): Evaluation of Skid Resistance of Turf Drag Textured Concrete Pavements	MnDOT Materials Lab	Bernard Izevbekhai	Benjamin Worel	Bruce Holdhusen	12/19/08	1/1/13	SP&R, Other State Funds	$100,882	$0	0%	
2011-25	92965	TPF-5(165): Development of Design Guide for Thin and Ultra-Thin Concrete Overlays of Existing Asphalt Pavements, Task 2 Report: Review and Selection of Structural Response Models	University of Pittsburgh	Julie Vandenbossche	Thomas Burnham	Nelson Cruz	9/12/08	1/31/13	SP&R, Partnership Funds	$405,000	$133,000	33%	
2012RIC11	95937	INV 895: Traffic Generating Developments and Roadway Life Consumption	Minnesota State University, Mankato	W. James Wilde	Tim Stahl	Farideh Amiri	1/22/10	12/31/12	LRRB	$37,038	$22,772	61%	
N/A	00669	Alaska AUTC Funds, Alaska AKDOT Funds, INV 921: Frost Video Update and Enhancement	SRF Consulting Group, Inc.	Michael Marti	Benjamin Worel	Shirlee Sherkow	6/14/12	8/31/13	LRRB, Partnership Funds	$63,271	$0	0%	
N/A	89256 W011	Construction Manager/General Contractor Issue Identification	Iowa State University	Jennifer Shane	Jay Hietpas	Nelson Cruz	5/31/11	7/31/12	SRP	$59,092	$55,092	93%	
N/A	89260 W02	Cost-Effective Base Type and Thickness for Long Life Concrete Pavements	University of Illinois	Erol Tutumluer	Terrence Beaudry	Shirlee Sherkow	6/20/11	1/31/14	SRP	$136,000	$30,925	23%	
N/A	89261 W090	TPF-5(149), INV 867: Composite Pavements Design and Construction Guidelines for Thermally Insulated Concrete Pavements	University of Minnesota	Lev Khazanovich	Timothy Clyne	Nelson Cruz	1/30/08	1/30/13	SP&R, LRRB	$438,980	$366,987	84%	
2012-23	89261 W0103	TPF-5(132), INV 865: Low Temperature Cracking in Asphalt—Phase II	University of Minnesota	Mihai Marasteanu	Timothy Clyne	Bruce Holdhusen	6/17/08	8/31/12	LRRB, SP&R, SRP	$475,000	$305,660	64%	
N/A	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	$32,260	84%	
N/A	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, COPTRS, SRP	$109,900	$28,574	26%	
N/A	89264 W02	TPF-5(129): Recycled Unbound Materials	University of Wisconsin – Madison	Tuncer Edil	John Siekmeier	Nelson Cruz	6/4/08	11/30/12	SP&R	$349,910	$200,000	57%	
N/A	89264 W05	Cost-Effective Means of Managing Pavements in Poor Condition	University of Wisconsin – Madison	Teresa Adams	Mark Watson	Nelson Cruz	6/7/11	7/31/13	LRRB, SRP	$139,953	$0	0%	
N/A	94262	MPR-8(004): Development of a Concrete Maturity Test Protocol	Minnesota State University, Mankato	W. James Wilde	Alexandra Akkari	Sandra McCully	4/2/09	9/30/12	SP&R, SRP	$113,952	$73,695	65%	
N/A	94288	INV 645: Integrated Tools for Pavement Design and Management	Minnesota State University, Mankato	W. James Wilde	Rich Sanders	Farideh Amiri	4/21/09	5/31/13	SRP	$65,531	$48,169	74%	
N/A	97334	MPR-6(011): Intelligent Compaction	Transtec Group, Inc.	George Chang	None	Benjamin Worel	9/13/10	6/30/12	SP&R, Other State Funds, SRP	$225,000	$194,453	86%	
N/A	98108	INV 907: Impact of Garbage Haulers on Pavement Performance	Minnesota State University, Mankato	W. James Wilde	Deb Bloom	Daniel Warzala	2/22/11	8/31/13	LRRB	$54,000	$2,000	4%	
N/A	98109	Use of Recycled Brick in Aggregates	Minnesota State University, Mankato	Farhad Reza	Terrence Beaudry	Nelson Cruz	5/26/11	8/31/13	SRP	$77,811	$36,649	47%	

Materials & Construction [cont.]

Report Number	Contract Number	Title	Contractor	Investigator	Technical Liaison	Project Coordinator	Start Date	End Date	Funding Source	Total Cost	Amount Paid	% Paid	TS
N/A	98110	Cost-Effective Base Type and Thickness for Long Life Concrete Pavements	Minnesota State University, Mankato	W. James Wilde	Terrence Beaudry	Nelson Cruz	6/24/11	1/31/14	SRP	$199,000	$0	0%	
N/A	98283	INV 868, MPR-6(029): HMA Surface Characteristics Related to Ride, Texture, Friction, Noise and Durability	Purdue University	Rebecca McDaniel	Timothy Clyne	Bruce Holdhusen	8/11/11	7/3/13	SP&R, LRRB, Other State Funds	$50,000	$14,635	29%	
N/A	98319	INV 918: Implementation of TONN 2010	Minnesota State University, Mankato	W. James Wilde	Rich Sanders	Farideh Amiri	5/4/11	12/31/12	LRRB, SRP	$35,000	$0	0%	
N/A	99008 W06	INV 869: TERRA Board Support, FY2012-FY2013	University of Minnesota	Laurie McGinnis	Mark Maloney	Julie Skallman	10/18/11	11/30/13	LRRB, SP&R, SRP	$60,000	$22,500	38%	
N/A	99008 W09	New Optimum Moisture Method for Soil Compaction	University of Minnesota	John Nieber	John Siekmeier	Nelson Cruz	10/4/11	5/31/13	SRP	$65,289	$6,244	10%	
N/A	99008 W012	MPR-1(013): Use of Non-Woven Fabric Interlayer for Unbonded Concrete Overlays	University of Minnesota	Lev Khazanovich	Thomas Burnham	Daniel Warzala	11/1/11	12/31/12	SP&R, SRP	$74,998	$34,694	46%	
N/A	99008 W026	MPR-1(003): Implementation of Pavement Evaluation Tools	University of Minnesota	Joseph Labuz	Shongtao Dai	Deb Fick, Nelson Cruz	11/1/11	6/30/13	SP&R, SRP	$78,000	$0	0%	
N/A	99008 W034	TPF-5(215): TERRA Membership Pooled Funds, FY2012-FY2014	University of Minnesota	Laurie McGinnis	Maureen Jensen	Linda Taylor	1/12/12	9/30/14	LRRB, SP&R, SRP	$55,000	$0	0%	
N/A	99008 W044	MPR-2(009): Simplified Design Table for Minnesota Concrete Pavements	University of Minnesota	Lev Khazanovich	Luke Johanneck	Daniel Warzala	6/29/12	8/31/14	SP&R, SRP	$89,989	$0	0%	
N/A	INV 885	INV 885: Research Test Section Tracking—Phase II	MnDOT Materials Lab	Melissa Cole	Luane Tasa	Farideh Amiri	12/21/09	12/21/14	LRRB	$55,000	$5,000	9%	
N/A	LAB864	MPR-6(022), INV 864: Recycled Asphalt Pavements	MnDOT Materials Lab	Eddie Johnson	Gregory Johnson	Bruce Holdhusen	1/4/08	12/31/12	SP&R, LRRB, Other State Funds	$275,000	$165,500	60%	
N/A	LAB868	MPR-6(029), INV 868: HMA Surface Characteristics	MnDOT Materials Lab	Timothy Clyne	Gregory Johnson	Bruce Holdhusen	9/18/07	6/30/13	SP&R, LRRB, Other State Funds	$250,000	$122,625	49%	
N/A	LAB887	INV 887: Structural Evaluation of Asphalt Pavements with Full-Depth Reclaimed Base	MnDOT Materials Lab	Shongtao Dai	Merle Earley	Daniel Warzala	10/5/09	3/31/13	LRRB, Other State Funds	$41,548	$8,960	22%	
N/A	LAB889	INV 889: Performance of Recycled Asphalt and High RAP Asphalt Mix	MnDOT Materials Lab	Eddie Johnson	Gregory Coughlin	Daniel Warzala	2/22/10	2/28/13	LRRB	$30,000	$14,000	47%	
N/A	LAB899	INV 899, INV 825: Performance Monitoring of Olmsted CR 117/104 and Aggregate Base Material Update	MnDOT Materials Lab	Matthew Lebens	Michael Sheehan	Alan Rindels	6/8/10	2/28/15	LRRB	$36,000	$0	0%	X
N/A	LAB929	INV929: Investigation and Assessment of Colored Concrete Pavement	MnDOT Materials Lab	Alexandra Akkari	Dallas Larson	Bruce Holdhusen	4/24/12	4/28/14	LRRB	$45,000	$0	0%	
N/A	MPR-1(002)	MPR-1(002): Development of a Spatial-Time-Domain Acoustic Device for Rapid Concrete Evaluation	MnDOT Materials Lab	Bernard Izevbekhai	Maureen Jensen	Daniel Warzala	4/8/11	3/31/14	SP&R, SRP	$98,000	$18,000	18%	
N/A	MPR-6(031)	MPR-6(031): Concrete Pavement Optimization, Determining the Lower Threshold of Slab Thickness for High-Volume Roadways	MnDOT Materials Lab	Thomas Burnham	Bernard Izevbekhai	Bruce Holdhusen	1/3/08	7/31/14	SP&R, Other State Funds	$126,100	$0	0%	

Materials & Construction Pooled Fund Studies

Study #	Title	Technical Liaison	Project Coordinator	Lead State or Agency	Number of Participating States	Current MN Commitment End Date	Total Cost	MN 2011 Commitment	MN 2012 Commitment	Total MN Commitment	TS
TPF-5(129)	Recycled Unbound Pavement Materials (MnROAD Study)	John Siekmeier	Nelson Cruz	MN	6	2011	$718,120	$15,000	$0	$532,243	
TPF-5(132)	Low Temperature Cracking in Asphalt Pavements (Phase II, MnROAD Study)	Timothy Clyne	Bruce Holdhusen	MN	7	2011	$475,000	$20,000	$0	$75,000	
TPF-5(134)	PCC Surface Characteristics—Rehabilitation (MnROAD Study)	Bernard Izevbekhai	Bruce Holdhusen	MN	3	2010	$275,000	$0	$0	$75,000	
TPF-5(148)	The Effects of Implements of Husbandry "Farm Equipment" on Pavement Performance (MnROAD Study)	Shongtao Dai	Bruce Holdhusen	MN	5	2008	$1,000,258	$0	$0	$667,258	X
TPF-5(149)	Design and Construction Guidelines for Thermally Insulated Concrete Pavements (MnROAD Study)	Timothy Clyne	Nelson Cruz	MN	4	2011	$438,980	$20,000	$0	$100,000	
TPF-5(165)	Development of Design Guide for Thin and Ultrathin Concrete Overlays of Existing Asphalt Pavements (MnROAD Study)	Thomas Burnham	Nelson Cruz	MN	8	2012	$330,000	$9,200	$0	$69,200	
TPF-5(215)	TERRA Pooled Fund Support—Transportation Engineering and Road Research Alliance	Maureen Jensen	Deb Fick		7	2014	$200,000	$7,500	$7,500	$37,500	X
TPF-5(269)	Development of an Improved Design Procedure for Unbonded Concrete Overlays	Thomas Burnham	Deb Fick	MN	7	2014	$420,000	$0	$20,000	$60,000	
SPR-3(074)	Pavement Research and Technology	Roger Olson	Deb Fick	WA	4	2012	$625,000	$15,000	$15,000	$310,000	
TPF-5(159)	Technology Transfer Concrete Consortium	Maria Masten	Deb Fick	IA	24	2015	$667,000	$5,000	$7,000	$51,000	
TPF-5(197)	The Impact of Wide-Base Tires on Pavement Damage: A National Study	Shongtao Dai	Deb Fick	FHWA	7	2012	$725,000	$25,000	$25,000	$100,000	
TPF-5(224)	Investigation of Jointed Plain Concrete Pavement Deterioration at Joints and the Potential Contribution of Deicing Chemicals	Bernard Izevbekhai	Deb Fick	IA	9	2013	$430,000	$15,000	$15,000	$60,000	
TPF-5(270)	Recycled Materials Resource Center—Third Generation	Jerry Geib	Deb Fick	WI	4	2014	$300,000	$0	$25,000	$75,000	

Multimodal

Report Number	Contract Number	Title	Contractor	Investigator	Technical Liaison	Project Coordinator	Start Date	End Date	Funding Source	Total Cost	Amount Paid	% Paid	TS
2011-17	89261 W0215	TH50501: Rationale for Funding a Feasibility Study for an Automated Rapid Transit Application in the Twin Cities	University of Minnesota	Lee Munnich	Mukhtar Thakur	Alan Rindels	6/8/10	11/30/11	Multimodal PRT, Modal Planning & Program Management	$33,000	$33,000	100%	
2011RIC05	93463 Task 5	INV 645: RIC Task 5: Best Practices for Recreation Trails	SRF Consulting Group, Inc.	Mike Marti	Tom Behn	Bruce Holdhusen	2/19/09	12/31/12	LRRB	$27,608	$27,608	100%	X
2012-14	89261 W0136	Highway Cost Allocation and Determination of Heavy Freight Truck Permit Fees	University of Minnesota	Diwakar Gupta	John Tompkins	Daniel Warzala	3/26/09	9/30/12	SRP, COPTRS	$179,752	$170,764	95%	X
N/A	89261 W0209	Assessing Neighborhood and Social Influences of Transit Corridors	University of Minnesota	Yingling Fan	Aaron Tag	Daniel Warzala	5/18/10	1/31/12	SRP	$12,500	$12,500	100%	
N/A	89261 W0193	Bike, Bus and Beyond: Extending Cyclopath to Enable Multimodal Routing	University of Minnesota	Loren Terveen	Greta Alquist	Shirlee Sherkow	7/6/10	9/30/12	SRP, COPTRS	$60,627	$50,000	82%	
N/A	89261 W0194	Investigation of Pedestrian/Bicyclist Risk in Minnesota Roundabout Crossings	University of Minnesota	John Hourdos	Peter Buchen	Shirlee Sherkow	6/8/10	9/30/12	SRP, COPTRS	$65,500	$50,000	76%	
2012-19	89261 W0204	Benefits of Mileage-Based User Fees to the Freight Industry and Industry Concerns	University of Minnesota	Ferrol Robinson	Kenneth Buckeye	Shirlee Sherkow	2/8/11	8/31/12	SRP, COPTRS	$50,000	$33,299	67%	

Multimodal [cont.]

Report Number	Contract Number	Title	Contractor	Investigator	Technical Liaison	Project Coordinator	Start Date	End Date	Funding Source	Total Cost	Amount Paid	% Paid	TS
N/A	89261 W0239	Transportation, Environmental and Health Impacts of Transitways: A Case Study of the Hiawatha Line	University of Minnesota	Jason Cao	Aaron Tag	Daniel Warzala	2/15/11	3/31/13	SRP	$37,500	$37,500	100%	
N/A	89264 W04	INV 911: Best Practices Synthesis and Guidance in At-Grade Trail Crossing Treatments	University of Wisconsin – Madison	David Noyce	Lisa Austin	Bruce Holdhusen	6/14/11	10/31/12	SRP, LRRB	$96,866	$51,662	53%	
N/A	89264 W07	INV 915: Implications of Modifying State Aid Standards: Urban, New or Reconstruction (Mn Rules 8820.9936) to Accommodate Various Roadway Users (Complete Streets)	University of Wisconsin – Madison	David Noyce	Paul Stine	Bruce Holdhusen	6/28/11	11/30/12	LRRB	$117,700	$17,246	15%	
N/A	98383 Task 1	INV 645 Task 1: ADA Transition Plan for Local Agencies	SRF Consulting Group, Inc.	Mike Marti	Mitch Rasmussen	Farideh Amiri	6/20/11	7/31/14	LRRB	$29,119	$29,119	100%	
N/A	99008 W08	Methodologies for Counting Bicyclists and Pedestrians in Minnesota	University of Minnesota	Greg Lindsey	Lisa Austin	Daniel Warzala	10/10/11	11/30/13	SRP	$99,948	$13,407	13%	
N/A	99008 W011	INV 909: Planning and Implementation of Complete Streets at Multiple Scales	University of Minnesota	Carissa Schively Slotterback	Scott Bradley	Bruce Holdhusen	10/4/11	6/30/13	SRP, LRRB	$101,271	$11,252	11%	
N/A	99008 W015	Mitigating Highway Construction Impacts Through the Use of Transit	University of Minnesota	Carol Becker	Donald Mohawk	Shirlee Sherkow	10/17/11	5/31/13	SRP	$39,800	$34,800	87%	
N/A	99008 W035	MPR-1(012): Statewide Cycloplan: Bicycle Planning Tool and Participatory GIS	University of Minnesota	Loren Terveen	Greta Alquist	Shirlee Sherkow	2/6/12	4/30/14	SP&R, SRP	$130,000	$0	0%	
N/A	99008 W059	INV 645 Task 13: 2012 Truck Weight Enforcement Training Program	University of Minnesota	Jim Grothaus	Richard Kjonaas	Daniel Warzala	4/12/12	8/31/13	LRRB, Other State Funds, SRP	$30,000	$0	0%	

Multimodal Pooled Fund Study

Study #	Title	Technical Liaison	Project Coordinator	Lead State or Agency	Number of Participating States	Current MN Commitment End Date	Total Cost	MN 2011 Commitment	MN 2012 Commitment	Total MN Commitment	TS
TPF-5(156)	Mid America Freight Coalition Pooled Fund	John Tompkins	Deb Fick	WI	10	2013	$1,325,000	$25,000	$25,000	$150,000	

Policy & Planning

Report Number	Contract Number	Title	Contractor	Investigator	Technical Liaison	Project Coordinator	Start Date	End Date	Funding Source	Total Cost	Amount Paid	% Paid	TS
2012-05	89261 W0201	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	$100,000	100%	X
TRS1102	89261 W0273	Estimating Non-Automobile Mode Share	University of Minnesota	Carol Becker	Lynne Bly	Shirlee Sherkow	6/2/11	6/30/11	SRP	$7,500	$7,500	100%	
TRS1103	89261 W0274	Small MPO Funding	University of Minnesota	Carol Becker	None	Shirlee Sherkow	6/2/11	6/30/11	SRP	$7,500	$7,500	100%	
TRS1104	N/A	Use of Social Media by Minnesota Cities and Counties	CTC & Associates LLC	Patrick Casey, Brian Hirt	Linda Taylor	Shirlee Sherkow	N/A	N/A	LRRB	N/A	N/A	100%	
N/A	89261 W0258	INV 913: LRRB Workshop: Shaping Research on Systems Planning for Local Roads	University of Minnesota	Linda Preisen	Susan Miller	Farideh Amiri	2/4/11	11/30/11	LRRB	$22,093	$22,093	100%	

Policy & Planning [cont.]

Report Number	Contract Number	Title	Contractor	Investigator	Technical Liaison	Project Coordinator	Start Date	End Date	Funding Source	Total Cost	Amount Paid	% Paid	TS
N/A	89261 W0114	Development of a Weigh-Pad Based Portable WIM System	University of Minnesota – Duluth	Taek Kwon	Benjamin Timerson	Nelson Cruz	12/30/08	12/31/12	SRP, COPTRS	$160,000	$98,550	62%	
N/A	89261 W0196	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	1/31/13	COPTRS, SRP	$89,378	$67,927	76%	
N/A	89261 W0197	Economic Benefits of Telework for Employers	University of Minnesota	Adeel Lari	Kenneth Buckeye	Shirlee Sherkow	6/30/10	4/30/13	COPTRS, SRP	$145,600	$36,400	25%	
N/A	89261 W0198	Quality of Life: Assessment and Evaluation to Develop Transportation Performance Measures	University of Minnesota	Ingrid Schneider	Karla Rains	Shirlee Sherkow	7/14/10	4/30/13	COPTRS, SRP	$262,249	$213,072	81%	
N/A	89261 W0227	MPR-0(003): Reporting Capabilities for Continuous Vehicle Class and WIM Data	University of Minnesota – Duluth	Taek Kwon	Benjamin Timerson	Nelson Cruz	11/18/10	12/31/12	SRP, SP&R	$35,268	$8,298	24%	
N/A	89261 W0251	What is the Risk to the Traveling Public and MnDOT Operations from Transmission Lines Along Our ROW?	University of Minnesota – Duluth	Seraphin Chally Abou	Valerie Svensson	Shirlee Sherkow	3/22/11	6/30/13	SRP	$67,511	$11,000	16%	
N/A	95029	TPF-5(192): Loop and Length Based Classification Pooled Fund	SRF Consulting Group, Inc.	Erik Minge	Gene Hicks	Deb Fick	1/27/10	10/31/12	SP&R, Partnership Funds	$469,191	$447,095	95%	
N/A	98383 Task 2	INV 645 Task 2: Complete Streets	SRF Consulting Group, Inc.	Mike Marti	Jeff Hulsether	Farideh Amiri	6/20/11	7/31/14	LRRB	$45,708	$12,680	28%	
N/A	98383 Task 3	INV 645 Task 3: Unpaved Roads	SRF Consulting Group, Inc.	Mike Marti	TBD	Farideh Amiri	6/20/11	7/31/14	LRRB	$48,336	$0	0%	
N/A	99008 W013	INV 912: Improved Approach to Enforcement of Road Weight Restrictions	University of Minnesota	Rajesh Rajamani	Benjamin Timerson	Nelson Cruz	9/21/11	11/30/13	SRP, LRRB	$90,000	$20,000	22%	
N/A	99008 W052	MPR-2(005): Value Increase and Value Capture Study—TH 610 Case Study	University of Minnesota	Zhirong Jerry Zhao	Matthew Shands	Nicole Peterson	6/29/12	3/31/14	SP&R, SRP	$81,000	$0	0%	
N/A	99373	INV 922: System Preservation Guide—A Planning Process for Local Government Management of Transportation Networks	SRF Consulting Group, Inc.	Brian Shorten	Susan Miller	Farideh Amiri	1/19/12	11/30/14	LRRB	$698,876	$53,854	8%	

Policy & Planning Pooled Fund Studies

Study #	Title	Technical Liaison	Project Coordinator	Lead State or Agency	Number of Participating States	Current MN Commitment End Date	Total Cost	MN 2011 Commitment	MN 2012 Commitment	Total MN Commitment	TS
TPF-5(192)	Loop and Length Based Classification Pooled Fund	Gene Hicks	Deb Fick	MN	15	2008	$510,000	$0	$0	$40,000	
TPF-5(198)	Urban Mobility Study, 2009 Continuation	Paul Czech	Deb Fick	TX	12	2012	$310,000	$30,000	$30,000	$265,000	X

Traffic & Safety

Report Number	Contract Number	Title	Contractor	Investigator	Technical Liaison	Project Coordinator	Start Date	End Date	Funding Source	Total Cost	Amount Paid	% Paid	TS
2011-21	98468	INV 908: Minnesota's Best Practices and Policies for Safety Strategies on Highway and Local Roads	CH2M Hill	Howard Preston	Mark Vizecky	Farideh Amiri	3/30/11	9/30/11	LRRB	$61,272	$61,272	100%	X
2011-24	89256 W07	Pavement Marking Compatibility with Chip Seal and Micro Surfacing	Iowa State University	Neal Hawkins	Mitchell Bartelt	Alan Rindels	3/1/10	10/31/11	SRP	$39,991	$39,991	100%	X

Traffic & Safety [cont.]

Report Number	Contract Number	Title	Contractor	Investigator	Technical Liaison	Project Coordinator	Start Date	End Date	Funding Source	Total Cost	Amount Paid	% Paid	TS
2012-04	89261 W0169	Development of Freeway Operational Strategies with IRIS-In-Loop Simulation	University of Minnesota – Duluth	Eil Kwon	Brian Kary	Daniel Warzala	10/1/09	1/31/12	SRP, COPTRS	$86,000	$86,000	100%	X
2012-06	89261 W0139	INV 890: Vehicle Speed Impacts of Occasional Hazard (Playground) Warning Signs	University of Minnesota	John Hourdos	Amy Marohn	Shirlee Sherkow	6/30/09	2/28/12	LRRB	$79,647	$79,647	100%	X
N/A	89264 W06	TPF-5(190): North/West Passage Corridor-Wide Commercial Vehicle Permitting—Phase II	University of Wisconsin – Madison	Teresa Adams	Cory Johnson	Deb Fick	2/15/11	3/31/12	SP&R, Partnership Funds	$24,968	$24,968	100%	
N/A	96125	TPF-5(093): North/West Passage Website Maintenance	North Dakota State University	Amy Scott	Cory Johnson	Deb Fick	3/24/10	3/1/12	SP&R, Other DOTs, Other State Funds	$6,039	$6,039	100%	
N/A	99008 W010	ITS Institute MnDOT Match—2012	University of Minnesota	Max Donath	Linda Taylor	Linda Taylor	9/23/11	6/30/12	SRP	$300,000	$200,000	67%	
N/A	00714	Power Sources for Automatic Traffic Recorders—TRS	Bolton & Menk, Inc. Consulting Engineers & Surveyors	Bryan Nemeth	Chu Wei	Shirlee Sherkow	3/13/12	10/31/12	SRP	$9,923	$432	4%	
N/A	00976	TPF-5(190): North/West Passage—Phase III	University of Wisconsin – Madison	Teresa Adams	Cory Johnson	Deb Fick	5/29/12	7/31/13	SP&R, Partnership Funds	$25,000	$0	0%	
N/A	00977	TPF-5(190): North/West Passage—Phase III	North Dakota State University	None	Cory Johnson	Deb Fick	5/29/12	4/30/14	SP&R, Partnership Funds	$7,056	$882	13%	
N/A	89256 W08	Implementation, Training and Outreach for MnDOT Pavement Marking Tool—Phase II	Iowa State University	Omar Smadi	Mitchell Bartelt	Alan Rindels	5/7/09	10/31/12	SRP	$86,970	$67,970	78%	
N/A	89256 W010	Rumble Strip: Evaluation of Retroreflectivity and Installation Practices	University of Iowa	Neal Hawkins	Kenneth Johnson	Nelson Cruz	5/26/11	2/28/14	SRP	$65,000	$0	0%	
N/A	89261 W0143	Portable, Non-Intrusive Advance Warning Devices for Work Zones With or Without Flag Operators	University of Minnesota	John Hourdos	Randy Reznicek	Daniel Warzala	7/30/09	10/31/12	SRP	$61,986	$58,887	95%	
N/A	89261 W0178	MPR-9(006): Research Implementation of the SMART Signal System on TH 13	University of Minnesota	Henry Liu	Steven Misgen	Alan Rindels	12/17/09	2/28/13	SP&R, SRP	$239,000	$222,000	93%	
N/A	89261 W0195	INV 898: Estimating the Crash Reduction and Vehicle Dynamic Effects of Flashing LED Stop Signs	University of Minnesota	Gary Davis	Bradley Estochen	Shirlee Sherkow	6/28/10	11/30/12	LRRB, ITS Institute, COPTRS	$112,000	$40,000	36%	
N/A	89261 W0202	Improving Traffic Signal Operations for Integrated Corridor Management (ICM)	University of Minnesota	Henry Liu	Steven Misgen	Alan Rindels	2/2/11	9/30/13	SRP	$163,000	$0	0%	
N/A	89261 W0203	Expanding and Streamlining the RTMC Freeway Network Performance Reporting Methodologies and Tools	University of Minnesota	John Hourdos	Jesse Larson	Shirlee Sherkow	10/28/10	1/30/13	SRP	$89,000	$49,000	55%	
2012-22	89261 W0240	Investigating the Effectiveness of Intelligent Lane Control Signals on Driver Behavior	University of Minnesota	Kathleen Harder	Jesse Larson	Daniel Warzala	5/12/11	9/30/12	SRP	$144,500	$137,275	95%	
N/A	89261 W0247	Evaluation of the Effect MnPASS Lane Design has on Mobility and Safety	University of Minnesota	John Hourdos	Julie Johnson	Daniel Warzala	5/31/11	11/30/13	SRP	$169,000	$60,600	36%	
N/A	89261 W0271	INV 917: Two-Lane Roundabout Field Research Regarding Signing and Striping	University of Minnesota	John Hourdos	Kristin Asher	Shirlee Sherkow	6/30/11	10/31/13	LRRB	$105,000	$25,000	24%	
N/A	91150	TPF-5(093): North/West Passage Program Support and Phase II Work Plan Projects	Athey Creek Consultants, LLC	Dean Deeter	Cory Johnson	Deb Fick	9/14/07	8/31/12	SP&R, Partnership Funds	$487,250	$415,447	85%	
N/A	96737	INV 900: Hennepin/Minneapolis LED Light Study	Hennepin County	Robb Luckow	Susan Zarling	Shirlee Sherkow	6/25/10	9/30/12	LRRB	$50,000	$48,000	96%	

Traffic & Safety [cont.]

Report Number	Contract Number	Title	Contractor	Investigator	Technical Liaison	Project Coordinator	Start Date	End Date	Funding Source	Total Cost	Amount Paid	% Paid	TS
N/A	97078	MPR-9(005): Changeable Message Signs (CMS)/Digital Message Signs (DMS) Manual of Practice Development, Implementation and Training	Iteris, Inc.	Lisa Raduenz	Jesse Larson	Alan Rindels	11/3/10	11/30/12	SP&R, SRP	$96,302	$74,271	77%	
N/A	98039	INV 903: Best Practices for Sign Reduction on the Local System 2009-2011 RIC Task 15 (Phase 2 of Task 10)	CH2M Hill	Howard Preston	Mark Vizecky	Farideh Amiri	6/6/11	7/31/12	LRRB	$26,515	$19,081	72%	
N/A	98383 Task 4	INV 645 Task 4: Toward Zero Deaths	SRF Consulting Group, Inc.	Mike Marti	TBD	Farideh Amiri	6/20/11	7/31/14	LRRB	$94,304	$0	0%	
N/A	98623	TPF-5(190): Use of Mobile Sensors and Maintenance Decision Support for Automated Road Condition Reporting—RFP	Meridian Environmental Technology, Inc.	Ben Hershey	Kenneth Hansen	Deb Fick	11/7/11	7/30/12	SP&R, Partnership Funds	$50,000	$39,059	78%	
N/A	99004 W02	Evaluation of Pavement Markings on Challenging Surfaces	Iowa State University	Neal Hawkins	Mitchell Bartelt	Nelson Cruz	6/13/12	4/30/15	SRP	$108,929	$0	0%	
N/A	99006 W01	MPR-2(008): Measuring Minnesota's Traffic Safety Culture	Montana State University, Western Transportation Institute	Nicholas Ward	Katie Fleming	Shirlee Sherkow	6/22/12	8/31/14	SP&R, SRP	$235,217	$0	0%	
N/A	99007 W02	MPR-1(008): Developing Performance Measures Using GPS Arterial Travel Time Data	Texas Transportation Institute	Shawn Turner	Paul Czech	Deb Fick, Alan Rindels	4/9/12	5/13/13	SP&R, SRP	$125,000	$0	0%	
N/A	99008 W03	Development of Active Traffic Management Strategies for Minnesota Freeway Corridors with Enhanced Variable Speed Limit Control System	University of Minnesota – Duluth	Eil Kwon	Brian Kary	Daniel Warzala	9/23/11	11/30/13	SRP	$98,700	$0	0%	
N/A	99008 W025	INV 925: Advanced LED Warning Signs for Rural Intersections Powered by Renewable Energy (ALERT) System—Phase II	University of Minnesota – Duluth	Taek Kwon	Victor Lund	Alan Rindels	12/14/11	6/30/14	LRRB	$86,596	$0	0%	
N/A	99008 W032	MPR-1(010): Vehicle-Mounted Robotic Roadway Message and Symbol Painter	University of Minnesota – Duluth	Ryan Rosandich	Randy Reznicek	Alan Rindels	12/8/11	5/31/13	SRP, SP&R	$95,000	$0	0%	
N/A	99008 W043	MPR-2(003): MnPASS Modeling and Pricing Algorithm Enhancement	University of Minnesota	John Hourdos	Brian Kary	Farideh Amiri	6/29/12	7/31/14	SP&R, SRP	$150,000	$0	0%	
N/A	99008 W057	MPR-1(016): Field Implementation, Testing and Refinement of Density-Based Coordinated Ramp Control Strategy	University of Minnesota	John Hourdos	Brian Kary	Deb Fick, Alan Rindels	5/3/12	4/30/14	SP&R, SRP	$103,735	$0	0%	
N/A	99542	MPR-1(007): Commercial Freight Weight Enforcement Innovation	SRF Consulting Group, Inc.	Brian Scott	Benjamin Timerson	Deb Fick, Alan Rindels	9/22/11	11/30/12	SP&R, SRP	$96,613	$23,109	24%	

Traffic & Safety Pooled Fund Studies

Study #	Title	Technical Liaison	Project Coordinator	Lead State or Agency	Number of Participating States	Current MN Commitment End Date	Total Cost	MN 2011 Commitment	MN 2012 Commitment	Total MN Commitment	TS
TPF-5(093), TPF-5(190)	North/West Passage—Phase III	Cory Johnson	Deb Fick	MN	9	2011	$600,000	$25,000	$25,000	$100,000	X
SPR-2(207)	Transportation Management Center Pooled Fund Study	Brian Kary	Deb Fick	FHWA	33	2012	$5,632,267	$50,000	$50,000	$350,000	
TPF-5(029)	High Occupancy Vehicle (HOV)/Managed Use Lane (MUL)	Brian Kary	Deb Fick	FHWA	12	2013	$1,990,000	$25,000	$25,000	$225,000	
TPF-5(114)	Roadside Safety Research Program	Michael Elle	Deb Fick	WA	9	2013	$1,565,000	$50,000	$50,000	$500,000	
TPF-5(193)	Midwest States Pooled Fund Crash Test Program	Michael Elle	Deb Fick	NE	16	2013	$2,667,005	$66,700	$66,700	$190,100	
TPF-5(231)	ITS Pooled Fund Program (ENTERPRISE)	Jon Jackels	Deb Fick	MI	11	2012	$1,585,000	$30,000	$30,000	$60,000	

Traffic & Safety Pooled Fund Studies [cont.]

Study #	Title	Technical Liaison	Project Coordinator	Lead State or Agency	Number of Participating States	Current MN Commitment End Date	Total Cost	MN 2011 Commitment	MN 2012 Commitment	Total MN Commitment	TS
TPF-5(245)	2012 Multi-State Asset Management Implementation Workshop	Cassandra Isaackson	Deb Fick	FHWA	11	2011	$120,000	$10,000	$0	$10,000	
TPF-5(258)	Traffic Signal Systems Operations and Management	Steve Misgen	Deb Fick	IN	10	2014	$525,000	$0	$25,000	$75,000	
TPF-5(262)	Evaluation of Guide Sign Fonts	Cory Johnson	Deb Fick	MN	5	2013	$165,000	$0	$15,000	$30,000	

Administrative

Report Number	Contract Number	Title	Contractor	Investigator	Technical Liaison	Project Coordinator	Start Date	End Date	Funding Source	Total Cost	Amount Paid	% Paid	TS
N/A	163	E-Book Project	Law Library Consultants, Inc.	Kathleen Bedor	Sheila Hatchell	Sheila Hatchell	11/4/11	4/30/12	Other State Funds	$5,000	$5,000	100%	
N/A	89261 W0210	INV 998: FY2011 Operational Research Program for Local Transportation Groups (OPERA)	University of Minnesota	Jim Grothaus	Mark Maloney	Farideh Amiri	9/9/10	9/30/11	LRRB	$90,000	$90,000	100%	
N/A	89261 W0219	INV 999: RSS Report Publication Services, FY2011	University of Minnesota	Arlene Mathison	Sandra McCully	Sandra McCully	7/15/10	8/31/11	SRP, LRRB	$35,913	$35,913	100%	
N/A	89261 W0225	INV 668 LTAP 0001(210): Local Technical Assistance Program (LTAP), FY2011	University of Minnesota	Jim Grothaus	Julie Skallman	Farideh Amiri	8/30/10	10/31/11	Other Federal Funds, LRRB	$440,500	$440,500	100%	
N/A	95936	MPR-6(003): Strategic Program Development	David Johnson	Dave Johnson	Nicole Peterson	Nelson Cruz	12/22/09	3/31/12	SRP, SP&R, Other State Funds	$49,977	$49,977	100%	
N/A	96048	Library Development	Law Library Consultants, Inc.	Kathleen Bedor	Sheila Hatchell	Sheila Hatchell	4/7/10	7/31/11	SRP, COPTRS	$59,995	$59,995	100%	
N/A	97585	MPR-6(019): Technology Transfer Material Development	CTC & Associates LLC	Patrick Casey	Sandra McCully	Sandra McCully	9/17/10	9/30/11	SP&R, SRP	$100,789	$99,791	99%	
N/A	00147	MPR-6(019): Technology Transfer Material Development Marketing Plan	Strategic Toolbox, LLC	Janese Evans	Ann McLellan	Sandra McCully	3/27/12	7/31/13	SP&R, SRP	$149,575	$10,000	7%	
N/A	340	INV 927: LRRB Outreach Website	HNTB Corporation	Timm Claudon	Lowell Schafer	Sandra McCully	2/2/12	1/31/14	LRRB	$99,991	$24,589	25%	
N/A	01351	MPR-6(019): Technology Transfer Material Development FY2012 and FY2013 Annual Reporting	CTC & Associates LLC	Patrick Casey	Sandra McCully	Sandra McCully	6/13/12	1/31/14	SP&R, SRP	$88,358	$1,123	1%	
N/A	89261 W0263	Librarian Services, 2011-2012	University of Minnesota	Arlene Mathison	Sheila Hatchell	Carole Wiese	3/21/11	7/31/12	SRP, COPTRS	$97,295	$46,604	48%	
N/A	93463	INV 645: RIC Implementation of Research Findings, FY2009-FY2011	SRF Consulting Group, Inc.	Mike Marti	Rich Sanders	Farideh Amiri	4/17/09	12/31/12	LRRB	$497,697	$482,022	97%	
N/A	94156	MPR-6(005): Next Generation of ARTS Tech Support and Maintenance Services	ArchWing Innovations, LLC	Ryan Anderson	Nelson Cruz	Ann McLellan	5/13/09	2/28/13	SP&R, SRP, Other State Funds	$179,400	$124,850	70%	
N/A	94376	MPR-6(003): Business Assessment of RSS Processes and Tools	Trissential	Steve Beise	Nicole Peterson	Ann McLellan	11/4/09	1/31/13	SRP, SP&R, Other State Funds	$172,080	$132,480	77%	
N/A	95501	INV 999: Local Road Research Board Website Hosting and Maintenance, 2010-2011	MIS Sciences Corp	Jeff Willis	Farideh Amiri	Sandra McCully	3/17/10	7/31/12	SRP	$17,200	$16,100	94%	

Administrative [cont.]

Report Number	Contract Number	Title	Contractor	Investigator	Technical Liaison	Project Coordinator	Start Date	End Date	Funding Source	Total Cost	Amount Paid	% Paid	TS
N/A	98383	INV 645: RIC Implementation of Research Findings, 2012-2014	SRF Consulting Group, Inc.	Mike Marti	Rich Sanders	Farideh Amiri	6/20/11	7/31/14	LRRB	$465,497	$92,581	20%	
	98383 Task 5	INV 645: RIC Task 5: Research and Implementation Roadmapping	SRF Consulting Group, Inc.	Mike Marti	TBD	Farideh Amiri	6/20/11	7/31/14	LRRB	$141,452	$0	0%	
N/A	98383 Task 6	INV 645: RIC Task 6: LRRB Outreach and Marketing	SRF Consulting Group, Inc.	Mike Marti	TBD	Farideh Amiri	6/20/11	7/31/14	LRRB	$60,826	$12,165	20%	
N/A	98725	INV 916: LRRB Technical Transfer Material Development	CTC & Associates LLC	Patrick Casey	Julie Skallman	Sandra McCully	5/20/11	9/30/13	LRRB	$71,804	$41,012	57%	
N/A	98726	MPR-6(019): Technology Transfer Material Development	CTC & Associates LLC	Patrick Casey	Sandra McCully	Sandra McCully	4/29/11	1/31/13	SP&R, SRP	$99,973	$91,331	91%	
N/A	98727	MPR-6(019): Technology Transfer Material Development—2011 Annual Reporting	CTC & Associates LLC	Patrick Casey	Sandra McCully	Sandra McCully	4/28/11	9/30/12	SP&R, SRP	$35,102	$35,083	100%	
N/A	99008 W05	INV 668 0001(211): Local Technical Assistance Program (LTAP), FY2012	University of Minnesota	Jim Grothaus	Julie Skallman	Farideh Amiri	9/23/11	11/30/12	LRRB, Other Federal Funds	$441,500	$220,750	50%	
N/A	99008 W018	INV 999: MnDOT RSS Report Publication Services, FY2012	University of Minnesota	Arlene Mathison	Farideh Amiri	Sandra McCully	10/11/11	11/30/12	SRP, LRRB	$36,861	$28,936	79%	
N/A	99008 W023	FY2012-FY2013 CTS Operations	University of Minnesota – CTS	Laurie McGinnis	None	Linda Taylor	12/14/11	9/30/13	SRP, PARI	$2,400,000	$1,100,000	46%	
N/A	99008 W060	INV 936: LRRB Focus Groups	University of Minnesota	Linda Preisen	Richard West	Linda Taylor	3/30/12	7/31/13	LRRB	$17,000	$4,257	25%	

Administrative Pooled Fund Studies

Study #	Title	Technical Liaison	Project Coordinator	Lead State or Agency	Number of Participating States	Current MN Commitment End Date	Total Cost	MN 2011 Commitment	MN 2012 Commitment	Total MN Commitment	TS
TPF-5(209)	Transportation Curriculum Coordination Council (TCCC)	Catherine Betts	Deb Fick	FHWA	16	2012	$1,100,000	$15,000	$15,000	$75,000	
TPF-5(237)	Transportation Library Connectivity and Development	Sheila Hatchell	Deb Fick	MO	24	2012	$905,528	$20,000	$20,000	$40,000	

Federal Program Support

Study #	Title	Technical Liaison	Project Coordinator	Lead State or Agency	Number of Participating States	Current MN Commitment End Date	Total Cost	MN 2011 Commitment	MN 2012 Commitment	Total MN Commitment	TS
TPF-5(240)	Core Program Services for a Highway RD&T Program—FFY2011 (TRB FY2012)	Linda Taylor	Deb Fick	FHWA	N/A	2013	N/A	$127,705	$128,915	N/A	
TPF-5(410)	National Cooperative Highway Research Program (NCHRP)	Linda Taylor	Deb Fick	FHWA	All	Ongoing	N/A	N/A	$701,985	$658,689	

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MnDOT Research: FY2012 Technical Summaries

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 use them as handouts at conferences, mailings to staff in areas that should be made aware of this research, information sheets for legislators or simply as quick-reference sheets.

You can access and download any of these summaries from **http://www.dot.state.mn.us/research**. For more information about Technical Summaries, please contact Sandy McCully at **Sandra.Mccully@state.mn.us**.

For more information about any of these projects, please contact the listed Technical Liaison or Research Services.

2011-19TS
Published February 2012

LRRB
LOCAL ROAD RESEARCH BOARD

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Bioproducts and Biosystems Engineering

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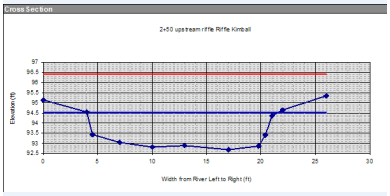
LRRB PROJECT COST:
$83,428



To determine bankfull width, researchers analyzed cross sections of channels upstream from culverts.

MINNESOTA DEPARTMENT OF TRANSPORTATION

RESEARCH SERVICES
OFFICE OF POLICY ANALYSIS, RESEARCH & INNOVATION

Accommodating Fish Passage at River Crossings

What Was the Need?

To allow streams to pass under roads, engineers build tunnel-like structures called culverts. However, some culvert designs can have an impact on the stability and ecology of streams. If the slope of a culvert is steeper than that of a stream or its cross-sectional area smaller, the velocity of water running through it will be greater. Increased water velocities impede fish and other aquatic organisms by hindering movement upstream and creating other conditions that overmatch their swimming abilities, including turbulence, inadequate depth and abrupt changes in water surface elevation at culvert inlets and outlets. A culvert may also destabilize the stream itself, with changes in water flow leading to erosion that propagates upstream in a process called head cutting.

Improving culvert design will benefit the environment by accommodating fish passage and preventing stream disruption as well as reducing culvert maintenance costs.

To minimize these effects, some culverts in Minnesota are recessed into the stream bed, allowing natural sediment to accumulate in a way that reduces water velocity so that it more closely matches stream velocity. Other design improvements include matching a culvert's slope to that of the stream and its width to the "bankfull width" of the stream. Bankfull width is realized during biennial flooding, when water completely fills the stream channel and the water surface height coincides with bank margins. Other methods for managing water velocity include the use of side barrels—additional culverts placed at a higher elevation to accommodate increased flow during flooding, relieving pressure on the main barrel.

While Minnesota is considering expanding the use of such environmentally friendly culverts, they can be more expensive than standard culverts, and there was little data on whether they are effective.

What Was Our Goal?

The objective of this project was to assess how well the use of recessed culverts in Minnesota makes hydraulic conditions, including reduced water velocities, more amenable to the passage of fish at river crossings.

What Did We Do?

Researchers conducted field surveys to evaluate the effectiveness of recessed culverts at 19 sites in various regions of Minnesota, chosen to cover the state's key geographic conditions and represent areas with important fish populations.

Researchers determined the effectiveness of culverts primarily by measuring the amount of sediment in the recessed culvert barrel. The lack of sediment indicated an improperly functioning culvert. Researchers also compared the stream's bankfull width, slope and water velocity to that of the culvert; evaluated whether the stream had been destabilized by the presence of the culvert; examined site work plans to determine whether culvert or stream channel dimensions had changed between installation and the time of the survey; and took photographs of each site.

continued

"The lesson of this study is that recessing culverts is not enough. Culvert widths must be matched as closely as possible to those of streams."

—Petra DeWall,
Assistant State Hydraulics Engineer, MnDOT Office of Bridges and Structures

"Implementing the proper culvert designs will not only improve ecology but reduce maintenance costs involved in removing debris."

—John Nieber,
Professor, University of Minnesota Bioproducts and Biosystems Engineering

Wide floodplains common in Minnesota sometimes require that culverts be designed with multiple barrels to handle additional flood capacity so that the water velocity in the main barrel does not become too great.

What Did We Learn?

Thirteen of the 19 sites surveyed used recessed culverts, and six of these were not functioning properly, with a lack of sediment in the recessed culvert barrel. This lack of sediment accumulation was caused by two factors: improperly sized culverts and an accumulation of sediment in side barrels. Researchers ruled out several other possible causes in each case, including an improper culvert slope, a recent large flood event, lack of sediment transfer from the riverbed and the culvert not in place long enough to accumulate sediment.

At 13 sites, including all six sites that had insufficient sediment accumulation, the recessed culvert width was less than the width of the bankfull channel. At seven sites, sediment had accumulated in side barrels to a depth that could reduce its flow during flooding, forcing water through the main barrel at greater velocities and so washing out its sediment.

These problems were most prevalent for wider channels, suggesting that it is more difficult in such cases to design a culvert that is wide enough to match natural stream conditions. Researchers recommend remedying such problems by collecting better data on streams so that culverts can be designed to more closely match their conditions as well as improving designs to address the challenges of Minnesota's wider channels and floodplains.

What's Next?

Researchers recommend developing a GIS-based tool that can be used collaboratively by local transportation agencies, MnDOT and the Minnesota Department of Natural Resources to determine what locations in Minnesota require culverts designed to accommodate the passage of fish. This tool would incorporate information about topography, geology, land use, stream characteristics and other factors.

Produced by CTC & Associates for:
Minnesota Department of Transportation
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This Technical Summary pertains to the LRRB-produced Report 2011-19, "Performance Assessment of Oversized Culverts to Accommodate Fish Passage," published August 2011. The full report can be accessed at http://www.lrrb.org/PDF/201119.pdf.

2012-09TS
Published September 2012

RESEARCH SERVICES

OFFICE OF POLICY ANALYSIS, RESEARCH & INNOVATION

TECHNICAL SUMMARY

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Principal Investigator:
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University of Minnesota

PROJECT COST:
$123,195

To visually inspect grout and post-tensioning strands within a duct, researchers inserted a borescope, which consists of a small camera lens mounted at the end of a flexible tube.

Identifying Grouting Problems on Post-Tensioned Bridges

This project improved public safety by identifying grouting and corrosion problems in some post-tensioned bridges in Minnesota, and by developing inspection procedures so that these problems can be routinely identified and addressed.

What Was the Need?

To strengthen concrete after it has hardened, engineers have sometimes used a method called post-tensioning, which involves running steel strands through a hollow plastic or metal duct within a concrete beam. Tension is then applied to these strands with a hydraulic jack, compressing the concrete beam and creating internal stresses that resist external traffic loads. Post-tensioning improves the durability of concrete and virtually eliminates cracking. It also allows the use of fewer and smaller beams and other elements when building structures such as bridges, reducing construction costs and environmental impacts.

However, the steel strands used in post-tensioning are susceptible to corrosion from contact with air, water and chlorides in deicing chemicals. To protect these strands, engineers use grout, a thick emulsion of water, cement and sand that hardens over time. Grout is used to fill in the gaps between the strands and the duct through which they run. Nevertheless, these voids, which leave strands vulnerable to corrosion, may remain if the duct is improperly filled or if water bleeds out of the grout mixture before it has fully hardened.

During the late 1990s and early 2000s, problems were found in grouted post-tensioned ducts in Florida bridges. As a consequence, in 2003 state transportation agencies significantly improved their grouting methods and began using a grouting material not susceptible to bleeding. However, in bridges built before 2003, voids around grouted strands are fairly common, leading to widely varying levels of deterioration depending on climate, construction practices and structure type.

What Was Our Goal?

The objective of this project was to conduct inspections of post-tensioned bridges built in Minnesota before 2003 and update current bridge inspection procedures so that potential problems in these bridges can be detected and remedied.

What Did We Do?

Researchers began by reviewing the plans and inspection reports for 40 of these post-tensioned bridges. Based on this information, they identified for further inspection 10 bridges most likely to have grouting-related corrosion problems. These bridges were chosen from across the different bridge construction types so that the sample would effectively represent Minnesota's post-tensioned bridge inventory.

Researchers visually inspected these bridges, focusing on signs of distress related to post-tensioning. These inspections consisted of an exterior examination from ground level, from the bridge deck or from a snooper truck—a vehicle equipped with a crane that allows access to the underside of bridges.

Researchers then chose three bridges for a more invasive inspection. Because the corrosion of post-tensioning strands typically provides few external visual indications of problems, traditional nondestructive inspection methods are not reliable for inspecting these bridges. Consequently, ducts were inspected using ground-penetrating radar to map their location and shape. Based on these maps, researchers drilled holes into the

continued

"This project is helping MnDOT ensure the safety of the traveling public by establishing bridge inspection procedures that take into account problems with grouting on some bridges built before 2003."

—Paul Kivisto,
Metro Region Bridge Engineer, MnDOT Bridge Office

"The problem with post-tensioned bridges is that the warning signs are not easy to see because they are hidden inside the concrete. This project developed a way of identifying signs for these bridges so we can be confident of their safety."

—Andrea Schokker,
Professor and Head of Civil Engineering, University of Minnesota Duluth Department of Civil Engineering

A borescope inserted into a duct reveals a large void, with post-tensioning strands covered only by a thin layer of grout. Ideally the grout would completely fill the duct, protecting strands from corrosion.

structure and used a borescope to visually inspect the duct interiors, including the grout and post-tensioning strands. After inspection, the holes were sealed with epoxy. When visual signs indicated a potential problem such as moisture, rust staining and cracking, a section of concrete was removed to expose a length of the duct for further inspection of grout and strand condition, and to take samples for chloride testing.

What Did We Learn?

Researchers summarized the characteristics of all 40 post-tensioned bridges built prior to 2003 in Minnesota. Each bridge summary includes an aerial view photograph, design drawings, inspection notes applicable to the post-tensioning system condition and a discussion of the bridge's characteristics.

Researchers also documented the results for the 10 bridges chosen for visual inspections and three chosen for invasive inspections, and made recommendations for follow-up inspections. In general, the inspected bridges were in good overall condition. Invasive testing showed that one of the three bridges showed no strand corrosion or grouting problems, one had major corrosion problems related to construction issues but appeared to have good grout, and one had significant problems with grouting and the beginning of corrosion. Researchers recommend a full investigation of the third bridge to identify and remedy the grouting problems and protect it from future corrosion.

Using these results, researchers developed a general inspection plan for post-tensioned bridges in Minnesota and a concise guide for MnDOT bridge inspection staff.

What's Next?

MnDOT has adopted the new bridge inspection procedures developed in this project and has started a follow-up implementation project as of summer 2012 to conduct a more detailed investigation of grouting in post-tensioned bridges.

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This Technical Summary pertains to Report 2012-09, "Development of Best Practices for Inspection of PT Bridges in Minnesota," published April 2012. The full report can be accessed at http://www.dot.state.mn.us/research/documents/201209.pdf.

2012-16TS
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PROJECT COST:
$100,000

Storage conditions for girders during winter months can subject them to high humidity, increasing their camber.

Improving Camber Estimates in Minnesota Bridge Girders

What Was the Need?

Since the 1950s, employing prestressed concrete girders has offered Minnesota bridge engineers an economical, low-maintenance design option for increasing girder strength, durability and stiffness. Prestressing involves casting the concrete around stretched steel strands. When the concrete hardens, the strands are released. The strands then contract, compressing the concrete. Because these strands are located primarily in the bottom of the girder, there is more compression there than at the top. This counteracts the tension created by traffic loads and the weight of the girder itself, helping to prevent cracking. The upward deflection caused by the prestress is called camber.

The new methods for predicting release and erection camber developed in this study improve their accuracy from 74 percent to 99 percent and 83 percent to 95 percent, respectively. Better camber prediction accuracy will ensure a good fit between a bridge deck and its girders, avoiding delays and increased costs.

Because of such factors as concrete shrinkage and temperature, the camber of a girder immediately after the release of prestressing strands, or release camber, can differ significantly from the camber it will have during construction, or erection camber. Engineers must take into account erection camber when designing bridges; if its design value is inaccurate, there can be construction problems in fitting the bridge deck to the girders and roadway profile, leading to delays and increased costs.

Engineers use a multiplier to calculate erection camber from the predicted release camber. Inherent uncertainty in some of the factors affecting these cambers can introduce errors in estimating the actual cambers from the predictions. It was recently observed that girders being erected at bridge sites in Minnesota often had much lower than predicted erection cambers despite MnDOT's modification of its multiplier method in 2007.

What Was Our Goal?

The objective of this study was to improve MnDOT's bridge girder camber prediction methods by investigating factors affecting both release and erection cambers, quantifying the relative uncertainty in the different factors and creating a new set of multipliers taking into account these factors.

What Did We Do?

Researchers began by analyzing:

- **Current release camber prediction accuracy** by examining camber records for more than 1,000 girders from two precasting plants and from measurements taken during the erection of Minnesota I-girders produced between 2006 and 2010 to compare measured camber values to design values.
- **Factors affecting release camber** by testing concrete samples at these precasting plants to determine the concrete compressive strength and elastic modulus over time, and comparing these values to the assumptions used in design.
- **Thermal effects** of concrete and ambient temperatures on the strand stress at release.

continued

"This project gave us a lot of insight into what can be done to improve camber predictions, including a range of options for multipliers."

—Brian Homan,
Assistant State Aid Bridge Engineer, MnDOT Office of Bridges and Structures

"Because the age of the girder and its storage conditions can significantly increase its camber, an important factor in improving camber predictions is associating the erection multiplier with an estimate of the time the girders spend in storage."

—Catherine E. Wolfgram French,
College of Science & Engineering Distinguished Professor, University of Minnesota Department of Civil Engineering

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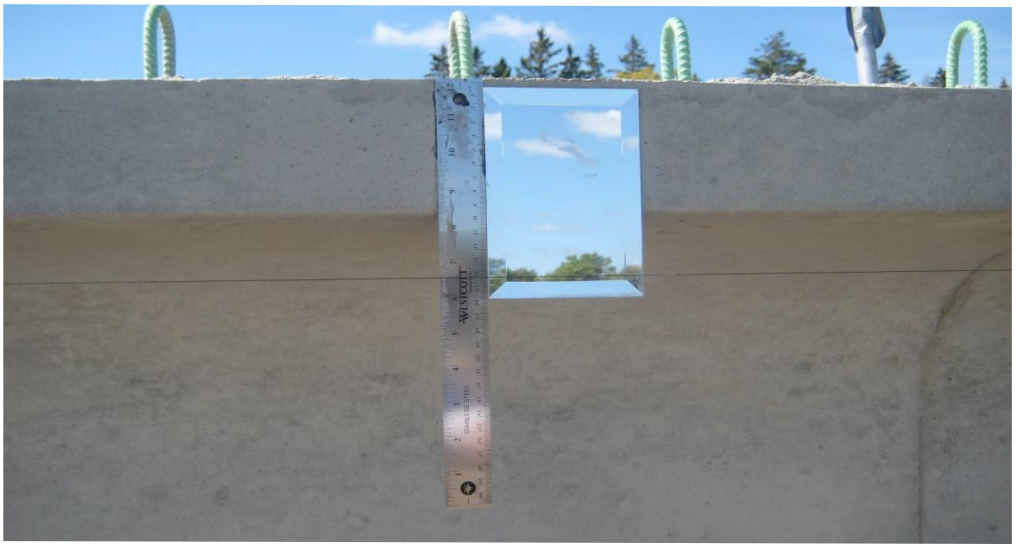

To measure girder camber to an accuracy of 0.5mm, researchers used a simple but effective method involving a stretch wire, mirror and ruler.

Researchers used these analyses to devise an improved method for predicting release cambers and tested it on a data set for which detailed fabrication information was known, including curing and temperature records.

Researchers then investigated factors affecting long-term and erection cambers, including solar radiation, relative humidity, concrete creep and shrinkage, length of cure and storage conditions. They used the resultant computer modeling to perform long-term predictions of camber for girders of varying depths and lengths. By comparing these predictions to current MnDOT and improved release camber predictions, researchers created four sets of multipliers, allowing the calculation of more accurate release and erection camber predictions. Researchers applied these multipliers to the historical girder data set and compared results to the measured erection camber data.

What Did We Learn?

From historical data, researchers found that measured camber values differed significantly from those for which they were designed. On average, the release camber of girders was only 74 percent of the design value, and the erection camber only 83 percent. Concrete compressive strength attained at the precasting plants was often greater than the design value, leading to greater stiffness and decreased camber. Current methods used in design underestimated the concrete modulus of elasticity from the concrete compressive strength. Also, strand stress at release was lower than predicted because of thermal effects and strand relaxation.

With better estimates for these factors, researchers created a more accurate method for predicting release cambers, improving the average discrepancy between measured and design release camber values from 74 percent to 99 percent. They also created sets of multipliers that, on average, improved the accuracy of erection camber predictions to between 95 percent and 97 percent of the design value. There is still scatter in the results due to inherent uncertainties involved in the construction process. The multiplier sets for erection camber include an option for using a single multiplier or various multipliers, depending on the age ranges of the girders at erection, to reduce the scatter in the results.

What's Next?

MnDOT is currently evaluating the multiplier options and other recommendations developed.

This Technical Summary pertains to Report 2012-16, "Validation of Prestressed Concrete I-Beam Deflection and Camber Estimates," published June 2012. The full report can be accessed at http://www.dot.state.mn.us/research/documents/201216.pdf.

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PROJECT COST:
$257,000

Each sump was placed on a wooden base and mounted on a steel frame sitting on load cells, with inlet pipes connected to a plumbing system supplying river water at controlled flow rates.

Standard Sumps and the SAFL Baffle as Economical Solutions for Stormwater Treatment

This study found standard sumps to be effective and economical at removing sediment from stormwater in urban areas. With a retrofit device developed in the second phase of this study, sumps also can retain much of this sediment, even under high flow conditions, at one-fourth the cost of most proprietary devices.

What Was the Need?

As part of their commitment to the environment, MnDOT and local agencies implement programs to minimize the effects of stormwater runoff on regional surface waters and groundwater. Runoff occurs when water from rainstorms or melting snow flows over surfaces such as paved streets and parking lots, collecting sediments that can carry pollutants such as phosphorus and heavy metals.

One of MnDOT's management practices for stormwater involves the use of pollution control devices within the storm sewer system to reduce runoff sediment. However, the proprietary devices available for these purposes can be expensive. MnDOT was interested in learning how effectively sediments can be removed by the significantly cheaper standard sumps, which are cylindrical tanks that are already a common feature of stormwater infrastructure.

These sumps are typically part of manholes that provide maintenance access to sewers. As water flows into these tanks, its velocity is reduced, causing some sediments to drop to the bottom of the tank as the water leaves through an outgoing pipe. Showing sumps to be effective as a sedimentation device would significantly lower the cost of complying with federal and state environmental regulations.

What Was Our Goal?

The goal of this project was to evaluate the effectiveness of standard sumps for stormwater management, including sumps retrofitted with the SAFL Baffle, a device designed to increase the effectiveness of sumps for removing and retaining sediments from stormwater runoff.

What Did We Do?

Researchers evaluated how well each of four laboratory sump configurations—4x4, 4x2, 6x6 and 6x3 feet—removed sediments from water moving through them at a number of different flow rates. To do this, they fed a known amount of sediment into a pipe carrying water into the sump, and at the conclusion of the test, they dried and weighed the sediment that remained at the bottom. Researchers then performed a similar test to evaluate washout rates for each configuration, or how well sumps retained captured sediments when water moved through them at high flow rates. Then they calculated the removal efficiencies and washout rates for sumps under a variety of conditions, including diameter and depth, sediment type, storm severity, water temperature and watershed size.

In a second phase of the project, researchers designed a retrofit to improve the performance of standard sumps in treating stormwater runoff. Called the SAFL Baffle, this retrofit consists of a porous grate that dissipates energy from water flowing into the sump, preventing a pattern of water circulation that increases washout. Researchers then repeated tests to evaluate sumps of various configurations for how well they

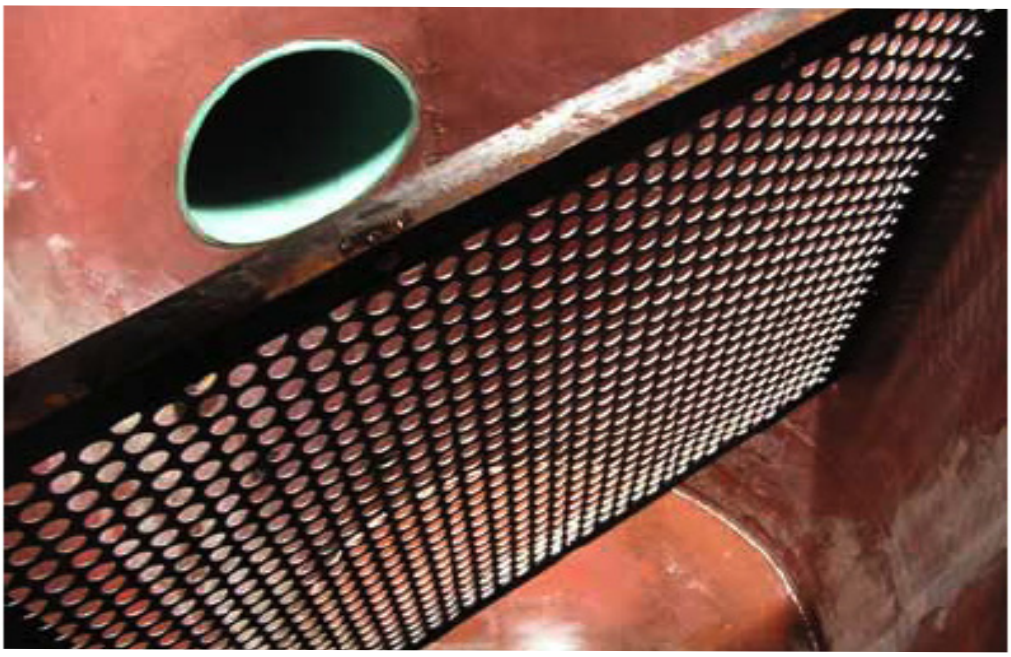
continued

"Standard sumps are a much less expensive solution for stormwater treatment than the proprietary devices that cities and counties have been purchasing for more than 10 years."

—Barbara Loida,
MS4 Coordinator Engineer, MnDOT Metro District

"With the retrofit device developed in the second part of this study, standard sumps can be very effective stormwater treatment devices with very little washout and have the potential to dramatically impact the industry."

—Omid Mohseni,
Adjunct Associate Professor, University of Minnesota Department of Civil Engineering



Typical baffles are impermeable, leading to a circulation of water that washes sediment out of sumps. The SAFL Baffle developed by the St. Anthony Falls Laboratory is porous, distributing the jet flowing from the inlet pipe more evenly across the sump, reducing its maximum velocity and so virtually eliminating washout.

captured and retained sediment. Some tests were conducted with the baffle clogged by debris such as trash and vegetation.

What Did We Learn?

Results showed that while standard sumps are effective for removing sediment from stormwater flowing at low flow rates, before installation of the SAFL Baffle they were unable to prevent captured sediments from washing out under high flow rates. The greater the depth of sumps and the larger their diameters, the greater their removal efficiency rates and the lower their washout rates. The formulas developed for calculating the efficiency of sumps can be used to determine how often they should be maintained and cleaned.

Tests of the SAFL Baffle showed that it dissipated the energy of water entering the sump, improving sediment capture by 10 percent to 15 percent and decreasing washout by a factor of 16, to nearly zero at high flow rates. Shallow sumps with baffles clogged by debris had significant washout, but this can be mitigated by increasing baffle hole diameters. Washout was also high in sumps with outlet pipes angled at 90 degrees to inlet pipes, but could be decreased by installing the baffle at an angle of 90 to 120 degrees to the inlet pipe. Additionally, researchers developed recommendations for using the SAFL Baffle in sumps receiving water from both inlet pipes and grates.

What's Next?

In 2011 the SAFL Baffle was installed in more than 50 sumps by MnDOT, Minnesota cities and counties, and private entities, and many more are on order in 2012. On average, a sump equipped with the SAFL Baffle reduced the cost of removing sediment to one-fourth its prior cost. Researchers are continuing to share the results of this project in journals and at conferences.

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This Technical Summary pertains to Reports 2011-08 and 2012-13, "Assessment and Recommendations for the Operation of Standard Sumps as Best Management Practices for Stormwater Treatment, Volumes 1 and 2," published February 2011 and May 2012, respectively. The full reports can be accessed at http://www.lrrb.org/PDF/201108.pdf *and* http://www.lrrb.org/PDF/201213.pdf.

2011RIC01TS
Published February 2012

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LRRB IMPLEMENTATION PROJECT COST:
$51,748

Underground treatment devices such as sump catch basins do not require much land area, but require frequent maintenance to be effective.

MINNESOTA DEPARTMENT OF TRANSPORTATION

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Putting Research into Practice: Selecting Optimal Stormwater Treatment Strategies

What Was the Need?

One common cause of water pollution is stormwater runoff, which occurs when water from rain and thawing snow flows across paved surfaces or soils that are too saturated to allow more water to pass through them. As runoff flows over the surface, it can accumulate pollutants and carry them into waterways.

The decision tree tool developed in this project will help city and county public works employees more efficiently select stormwater BMPs appropriate to their projects to protect the environment with the most cost-effective available methods.

To manage stormwater, engineers use a number of treatment strategies, typically referred to as best management practices. As state and federal regulations for stormwater management have become more stringent, the number of available BMPs has increased significantly. However, not all BMPs perform the same treatment functions or remove pollutants with the same efficiency. They also vary in cost of construction and maintenance. Consequently, choosing between BMPs can be a complex task, and research was needed to develop a tool that would assist stormwater managers in selecting BMPs to meet the needs of specific projects.

What Was Our Goal?

The goal of this project was to create a tool to assist city and county public works employees in selecting stormwater BMPs appropriate to their projects.

What Did We Implement?

This tool implements and is intended to work in conjunction with Report 2009RIC12, "Stormwater Maintenance BMP Resource Guide," and the 2005 "Minnesota Stormwater Manual." The resource guide describes the five most commonly used stormwater facilities in Minnesota and details the best inspection and management practices for each.

How Did We Do It?

Investigators created a planning-level decision tree tool to assist practitioners in selecting BMPs for stormwater management. The decision tree incorporates a cost-benefit analysis using whole-life costs as determined by the Water Environment Research Foundation and covers methods commonly or increasingly used in Minnesota, including:

- Stormwater ponds, which capture runoff to mitigate its effects on downstream water quality or quantity.
- Bioretention basins, such as bioswales, rain gardens and filtration basins, which are landscaped depressions that remove pollutants from runoff using plants, soils and naturally occurring microbes found in the soil.
- Underground treatment devices, which remove pollutants and debris from underground drainage systems. They are typically used as pretreatment systems with other BMPs.
- Underground detention systems, which store runoff temporarily and regulate its flow. These can be used in conjunction with underground treatment devices to provide additional water quality treatment.
- Infiltration systems, which temporarily trap runoff and allow it to seep into the soil. These can be surface sand filters or underground pipe galleries.

continued

"We wanted to create a tool to help engineers quickly zero in on the relevant part of BMP manuals—which can be large or difficult to navigate—based on the circumstances of their particular project."

—Mel Odens
State Aid Engineer, MnDOT District 8

"This guide simplifies the task of deciding between the large number of available stormwater BMPs by presenting a series of questions that can be answered in a step-by-step fashion to narrow the options."

—Michael Marti
Principal, SRF Consulting Group Inc.

Stormwater ponds are a commonly used BMP in Minnesota and have the benefits of effectively reducing many pollutant loads and controlling runoff rates. However, because they require a large amount of space, they are not a feasible BMP in all situations.

- Porous/pervious/permeable pavements, which reduce runoff pollution by allowing water to filter through pavements into the underlying soil or underdrain system.
- Tree or planter boxes, which consist of containers filled with a soil mixture, mulch layer, underdrain system and a shrub or tree. These boxes can be used to temporarily store and filter runoff in urban areas.

What Was the Impact?

This tool is a five-step BMP selection process that narrows BMP choices according to physical constraints, the regulatory environment, capital costs and other factors. It is especially intended for projects where there is no regional stormwater facility downstream designed to provide treatment. The five steps are:

1. **Select Your Project Type** by determining how much space will be available for BMPs after a project is completed and whether the project is a site project (involving residential, commercial or other development) or roadway/linear project.
2. **Describe Your Project** according to location, receiving waters, soil types, setting and special site considerations.
3. **Determine the Regulatory Environment for Your Project** by determining which of the state, local and federal agencies might have jurisdiction over the project, with the intent to identify the most stringent design criteria.
4. **Create a Preliminary BMP Toolbox** by using information from previous steps to help narrow a matrix of seven BMPs to two or three that are most appropriate for the project.
5. **Refine BMP Selection/Select the Right Tool** by comparing factors such as maintenance, life-cycle costs and aesthetics.

Appendices to this tool contain a list of further resources as well as the cost-benefit analysis on which it is based.

What's Next?

Investigators are presenting this tool at numerous conferences and are monitoring its reception among practitioners. As stormwater management practices continue to evolve, the decision tree will be updated so that it continues to help practitioners select the most effective measures for managing stormwater runoff.

This Technical Summary pertains to the LRRB-produced Report 2011RIC01, "Decision Tree for Stormwater BMPs," published March 2011. The full report can be accessed at http://www.lrrb.org/PDF/2011RIC01.pdf.

The research being implemented via this project can be found mainly in the LRRB-produced Report 2009RIC12, "Stormwater Maintenance BMP Resource Guide," published January 2009. This report can be accessed at http://www.lrrb.org/PDF/2009RIC12.pdf.

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LRRB PROJECT COST:
$20,000

Workshop attendees collaborated in teams on various scenarios to create street tree plans balancing genetic diversity with infrastructure needs.

MINNESOTA DEPARTMENT OF TRANSPORTATION

RESEARCH SERVICES
OFFICE OF POLICY ANALYSIS, RESEARCH & INNOVATION

Street Tree Planning for Healthier Community Landscapes

What Was the Need?

As urban communities develop, they benefit from greening measures that make them more livable, including the use of open space, public parks and trees planted along streets. Trees reduce energy costs by sheltering buildings from the sun during the summer and from the wind in winter; reduce pollution from stormwater runoff and filter the air; fence roads from snow drifts; provide a habitat for birds and other organisms; and delineate curves and intersections, increasing the safety of motorists and pedestrians.

However, poor tree placement can lead to roots damaging pavements and branches impinging on power lines, requiring costly pavement repairs and pruning. Poor species selection can make communities vulnerable to having their entire population of trees decimated by a single disease. In 2008, to help improve street tree planning by landscape architects, city planners and other community decision makers, the LRRB sponsored the production of a manual, "The Road to a Thoughtful Street Tree Master Plan," which outlines objective criteria for street tree design and plant selection. Because of the large amount of information contained in this manual, a follow-up project was needed to heighten awareness of its existence and communicate its core principles to target audiences.

The presentation developed by this project can be used to teach community decision makers how to avoid common street tree design and selection mistakes, saving communities significant maintenance costs while helping to improve quality of life.

What Was Our Goal?

The objective of this project was to create brochures and a PowerPoint presentation to increase awareness of best practices for street tree planning among Minnesota community decision makers.

What Did We Implement?

This project implements 2008-32, The Road to a Thoughtful Street Tree Master Plan, which provides a step-by-step, pragmatic method for planning street landscapes. It also implements MnDOT's online Plant Selector tool, developed to ease the frustration of selecting the best trees for the most variable street landscapes by providing a user-friendly interface allowing search queries to be narrowed easily by region, species and environmental factors. The Master Plan and Plant Selector tools guide users through:

- Planting in spaces that accommodate healthy trees.
- Matching tree species to locations with size restrictions.
- Planting trees for longevity since only at maturity do trees realize their full environmental potential.
- Developing a planting arrangement that enhances traffic flow and guides pedestrian and motorist behavior.

How Did We Do It?

Researchers developed a PowerPoint presentation using information from 2008-32. This presentation was refined through beta-testing at workshops with several audiences, including the exhibit area at the 2011 Shade Tree Short Course; volunteer

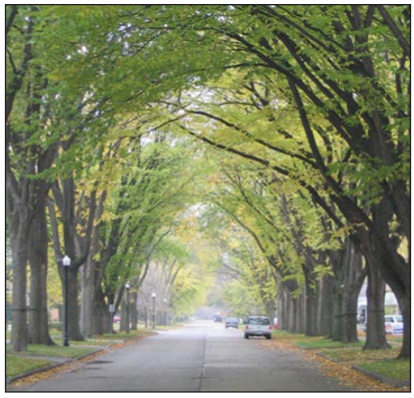
continued

"The manual and presentation developed by this project are ahead of their time. As tree loss more severely affects Minnesota communities in the next few years, it will be important to re-establish street tree populations according to the principles set forth in these tools."

—Dan Gullickson,
Urban and Community Forester, MnDOT Office of Environmental Services

"Proper street tree planning saves communities money, helps keep pedestrians safe and attracts economic activity."

—Gary Johnson,
Extension Professor, University of Minnesota Department of Forest Resources



Elm trees have long been popular in urban areas because they grow quickly, thrive in harsh environments and have canopies that grow above utility lines. But relying too heavily on them can leave communities completely barren if the trees are affected by Dutch elm disease, with the added expense of removing and replanting trees.

training sessions at the University of Minnesota; and community training presentations in Grand Rapids, Rochester and Crookston, Minnesota.

To increase awareness of the Master Plan, Plant Selector and presentation, researchers also developed two brochures that advertised these tools to appointed or elected officials, and to landscape architects, city planners and engineers, arborists and park staff. These brochures were sent to 826 communities in Minnesota.

What Was the Impact?

The PowerPoint presentation includes 10 lessons covering the most common issues leading to the success or failure of a street master plan, and provides users with a practical primer showing them how to avoid common street design and tree selection mistakes by following a step-by-step process. Issues include community receptiveness to street trees, the functions street trees should perform, the practical degree of species diversity for street tree populations, tree selection and placement, creating a master plan and planting. Complete with notes, the presentation can be used in its entirety as the basis for a comprehensive workshop or its individual lessons can be used for more focused workshops.

Researchers used three chapters from the PowerPoint presentation to conduct a half-day workshop in Rochester focusing on tree placement and species selection. The workshop was very well-received by attendees and showed that a combination of prework-shop homework assignments and hands-on problem-solving during the workshop can be a successful training model.

What's Next?

The PowerPoint presentation developed in this project is most effectively used as a teaching tool in classes or workshops, and parts of it are currently used for tree inspector training in several Minnesota communities. Researchers recommend continued publicity about the manual and presentation to city managers, engineering departments and conferences. They also recommend the development of performance measures for roadside vegetation management so that its benefits can be quantified.

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This Technical Summary pertains to the LRRB-produced project 2011TREE01, "Outreach Program for a Thoughtful Street Tree Master Plan," published September 2011. The presentation and brochures produced for this project can be accessed at http://www.myminnesotawoods.umn.edu/2011/12/the-road-to-a-thoughtful-street-tree-master-plan-slideshow-series-2011/.

The research being implemented via this project can be found mainly in the LRRB-produced Report 2008-32, "The Road to a Thoughtful Street Tree Master Plan," published August 2008. This report can be accessed at http://www.lrrb.org/PDF/200832.pdf.

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PROJECT COST:
$99,000

A snow fence can be as simple as two rows of corn that form a barrier to snow drifting onto roadways.

Evaluating the Costs and Benefits of Living Snow Fences

What Was the Need?

Blowing or drifting snow on roadways is a major transportation safety and efficiency concern, causing accidents and requiring expensive snow removal and other maintenance. This issue can be especially problematic near farmlands, where snow can drift onto roadways from harvested fields. To address this problem, MnDOT has operated a program that pays landowners in identified problem areas to plant living snow fences. LSFs consist of trees, shrubs or standing corn rows designed to serve as windbreaks to reduce the volume of snow that blows or drifts onto the roadways. MnDOT traffic safety data suggest that using LSFs can reduce snow- and ice-related accidents by 40 percent on roadways with super-elevated curves.

By contracting 40 percent of sites with snow problems to the Living Snow Fences program, MnDOT could save $1.3 million per year. LSFs improve driver visibility and road surface conditions, and have the potential to reduce accidents, snow removal costs and removal equipment emissions.

However, inducing landowners to participate in the LSF program has been difficult, and as of 2011 MnDOT had only used 12 percent of its LSF budget, obtaining contracts for just 2.3 percent of problem sites. The current level of payments offered to landowners may not be a sufficient incentive to establish and maintain LSFs, and research was needed to determine a payment structure that will increase adoption rates while remaining cost-effective.

What Was Our Goal?

The goal of this project was to develop a calculator for estimating optimal LSF program payments to landowners by identifying costs, benefits and obstacles to implementing the program.

What Did We Do?

Researchers began by conducting focus groups to get input from landowners about their costs for establishing and maintaining snow fences, and the constraints that limit landowner participation in the LSF program. Researchers also conducted an online survey of key staff at MnDOT and other agencies to get their perception of the value of LSFs, their familiarity with the LSF program, and whether they had sufficient resources and time to implement LSFs.

Researchers then conducted a detailed financial analysis to improve estimates of LSF costs to landowners by examining agency records, conducting interviews with agency representatives and conducting on-farm interviews with current LSF participants. They quantified the benefit of LSFs in terms of reduced greenhouse gas emissions from reduced use of snow removal equipment and carbon sequestration by vegetation as well as costs avoided due to the reduced number of crashes caused by blowing and drifting snow.

Using all of the data collected in this study on costs and benefits of LSFs, researchers developed the Living Snow Fence Payment Calculator, a software tool that allows users to calculate optimal LSF payments to landowners by analyzing per-acre cost-benefit ratios in terms of avoided road maintenance and safety costs and reduced carbon emissions.

continued

"Of about 3,800 possible LSF sites in Minnesota, not all have the same traffic, crash rates and snow problems. The tool developed in this project will allow personnel to prioritize LSF funding to target the most critical sites."

—Dan Gullickson,
Living Snow Fence Program Coordinator, MnDOT Office of Environmental Stewardship

"The Living Snow Fence Payment Calculator will help agency staff work with local landowners to arrive at a realistic, economical and cost-effective payment for land practices protecting state and local highways."

—Gary Wyatt,
Agroforestry Extension Educator, University of Minnesota Extension

Greg Mensen, MnDOT District 8

Segments of roads with LSFs (right) have better driver visibility and road surface conditions than those without (left), leading to lower road maintenance costs and fewer accidents. LSFs can also benefit the atmosphere by storing carbon dioxide and reducing emissions from snow removal operations.

What Did We Learn?

Focus group participants discussed a variety of costs and constraints to landowner participation in the LSF program and most frequently mentioned life-cycle costs associated with the implementation, maintenance and removal of snow fences. Some participants said compensation was insufficient to cover all costs.

Agency survey results indicated great interest in LSF and a high confidence that it is effective. While agency staff has the technical competence needed to promote and implement the program, time and funding are limited, and 36 percent of agencies felt they were not equipped to conduct LSF plantings.

Based on agency and landowner feedback, researchers recommend improving the LSF program in the following ways:

- **Payments.** Create shorter and more flexible contracts with a flexible formula that accounts for varying maintenance costs, inflation of land values, crop yield, production costs, inconvenience factors, income or financial benefit received, and the price of corn. Consider increasing payments in the first three years to reflect greater maintenance costs, compensating for the removal of trees at the end of the agreement, paying for the entire area between the snow fence and right of way to reduce the difficulty of farming around it, and allowing a single strip of standing corn rather than the recommended two strips.
- **Prioritization.** Target landowners in problem areas by considering bonus payments for locations with high potential benefits, such as those with high accident rates.
- **Promotion.** Promote LSFs by improving education materials to give a clear and complete presentation of the program to landowners, showing concrete information about what is required of them and expected payments and benefits. Consider door-to-door visits to landowners, providing incentives and training to LSF participants to promote the program to other landowners, and establishing a dedicated LSF staff member in each agency office.

What's Next?

Researchers suggest that once MnDOT snowplows are fully equipped with GPS, resulting data should be used to quantify sand and salt applications to determine where snow fences are needed most and what impact they are having. Further research is also needed on the effectiveness of various plant species for use as LSFs.

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This Technical Summary pertains to Report 2012-03, "Economic and Environmental Costs and Benefits of Living Snow Fences: Safety, Mobility, and Transportation Authority Benefits, Farmer Costs, and Carbon Impacts," published February 2012. The full report can be accessed at http://www.lrrb.org/PDF/201203.pdf.

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RESEARCH SERVICES

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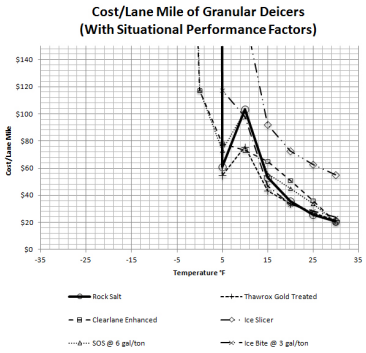
Minnesota State University, Mankato

PROJECT COST:
$69,000



The cost and performance evaluation tool produces a line graph that compares the cost per lane mile of the selected deicers at various temperatures.

New Temperature-Based Cost Model Compares Effectiveness of Deicers

Researchers developed a spreadsheet-based evaluation tool to compare the relative ice melt capacity and cost-effectiveness of up to 50 deicer compounds and blends across a range of temperatures. Maintenance supervisors can use the tool to guide preseason purchasing and select the most effective product to fight a specific winter event.

What Was the Need?

With shrinking budgets, rising prices for winter maintenance materials and an interest in limiting environmental impacts, MnDOT and other transportation agencies are seeking tools that can help snowplow operators apply deicers and anti-icers in "the right amount at the right time in the right way."

While researchers have long been examining the effectiveness of deicers under laboratory conditions to predict how they will perform in the field, relatively few studies have examined the temperature-specific ice melt capacity of deicers: the amount of ice melted—or brine created—given the amount of deicer applied. Coupling an assessment of ice melt capacity with performance factors such as application rates and roadway surface will help winter maintenance supervisors reduce reliance upon anecdotal observations and vendor claims when trying to select the most appropriate deicer for a given situation.

What Was Our Goal?

The objective of this research was to develop a temperature-based cost model for comparing the relative field performance of deicers and deicer blends by evaluating the ice melt capacity and other factors that can contribute to deicer performance.

What Did We Do?

Researchers began by meeting with MnDOT staff to assess existing winter maintenance practices and identify samples for testing based on differences observed among deicers and deicer blends most often used by MnDOT. The test method, developed specifically for this study based on Strategic Highway Research Program methodology, analyzed more than 1,200 samples of 20 granular and liquid deicers of three types:

- Individual deicers.
- Salt brine blends (a liquid deicer blended with salt brine).
- Rock salt stockpile treatments, in which a liquid deicer is applied to rock salt as an additive.

Samples were tested at 11 temperatures that ranged from +30 °F to -30 °F, in 5 °F increments. In addition to ice melt capacity, researchers examined four other factors that could contribute to better relative performance of the deicers: bounce, ice penetration, ice undercutting and grain size.

What Did We Learn?

Researchers found that of these factors, ice melt capacity has the greatest impact on deicing, with the ice melt capacities of both individual deicers and brine blends closely related to application temperature. However, in the temperature range tested (5° F to 30° F), none of the three deicer types tested demonstrated substantial improvement in ice melt capacity over the control (rock salt). While some of the individual deicers showed a dramatically reduced ice melt capacity as compared to rock salt, researchers

continued

"We strive for more effective and efficient use of all types of snow and ice treatments on our roadways as we operate under a higher expectation to balance our safety, environmental and budgetary priorities."

—Tom Peters,
Research and Training Engineer, MnDOT Maintenance Operations

"The model we developed, which considers ice melt capacity, cost and temperature in addition to subjective factors that contribute to deicer effectiveness, offers practitioners a structure to evaluate and provide feedback."

—Stephen Druschel,
Professor, Minnesota State University, Mankato, Department of Mechanical and Civil Engineering

Water-filled beakers covered with foil were placed in thermal stabilization units and housed in a laboratory freezer for a minimum of 16 hours to create ice specimens for testing.

noted that the other benefits of these deicers, such as improved adhesion to the roadway and a low chloride content that limits environmental impacts and corrosion, may outweigh the products' more limited ice melt capacity.

Using the results of the ice melt analysis, researchers developed a spreadsheet-based cost model that compares the cost and effectiveness of a deicer or deicer blend with a commonly known control—rock salt at 28 °F—across a range of temperatures to generate a cost per lane mile. The model can be used with neutral field conditions so that only ice melt capacity, cost and temperature are considered. Alternatively, other performance factors such as application rate, ice thickness, pavement material and sun/wind conditions, which have been given subjective weights by the research team, can be added to the cost per lane mile equation.

The spreadsheet tool's input screen allows users to select or specify:

- Deicers to consider and show on graphs.
- Delivered costs of deicers.
- Performance factors to be considered.

A graphical output displays two graphs (one each for granular and liquid deicers) with deicer cost per lane mile by temperature with and without performance factors. The model can analyze products used in deicing, anti-icing and prewetting applications.

What's Next?

This study provides strong evidence that ice melt capacity is a substantial factor in determining the cost-effectiveness of deicers and anti-icers at a given temperature. A second phase of this project, expected to begin by early 2013, will expand on the results of the current project's lab studies of ice melt capacity with real-world tests on actual pavements under conditions comparable to those tested in the lab. By quantifying the significance of other factors affecting deicer performance—traffic levels, truck volumes, weather, pavement type and age, plow cutting edge, application frequency and others—researchers will refine an evaluation tool that can help MnDOT's winter maintenance managers select the most effective treatment for a wide range of winter conditions.

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This Technical Summary pertains to Report 2012-20, "Salt Brine Blending to Optimize Deicing and Anti-Icing Performance," published July 2012. The full report can be accessed at http://www.dot.state.mn.us/research/documents/201220.pdf. *The spreadsheet tool, when available, will be accessible at* http://www.dot.state.mn.us/maintenance/training.

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TRANSPORTATION POOLED FUND PROGRAM

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TOTAL STATE CONTRIBUTIONS TO DATE:
$2,755,000

MnDOT CONTRIBUTIONS TO DATE:
$225,000

PARTICIPATING STATES:
CA, CO, IA, ID, IL, IN, KS, MA, ME, MI, MN, MO, MT, ND, NE, NH, NY, OH, PA, UT, VA, VT, WA, WI, WV, WY

Clear Roads developed an instructional video to accompany its Field Testing Guide for Deicing Chemicals.

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 the effectiveness of these tools 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 them under real-world conditions, and assessing their practicality and ease of use within varied highway maintenance organizational structures.

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

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 managers and crews.*

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 numerous research ideas for consideration and select five or six to fund as projects. To date, 11 projects have been completed and 11 more are under way or scheduled to begin soon. While all Clear Roads projects serve to advance the practice of winter maintenance, some projects have had a particularly significant impact on MnDOT.

A research project completed in 2008 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 materials more effectively.

MnDOT used the Clear Roads calibration guide as a baseline to develop its own user-friendly how-to manual that MnDOT and local governments can use to calibrate their material spreaders. "We use the guide's step-by-step instructions for calibrating both automatic and manual controllers during the hands-on portion of our training classes," said Kathy Schaefer, MnDOT's Circuit Training and Assistance Program coordinator. "And we give copies of the guide to participants in the training program to take back to their own shops."

A 2010 Clear Roads project identified the circumstances and most effective methods for using liquid deicers during winter storm events. Optimizing material use and minimiz-

continued

"MnDOT continues to find great value in Clear Roads. We reaffirmed our commitment to Clear Roads by taking over as the lead state, which we continue today while remaining active in its many research initiatives."

—Tom Peters,
Research and Training Engineer, MnDOT Maintenance Operations

"A Clear Roads project that standardized test procedures for carbide insert blade wear is helping six MnDOT districts compare the cost-effectiveness and durability of multiple plow blades."

—Ryan Otte,
Research Project Manager, MnDOT Maintenance Research

A Clear Roads project found direct liquid application during a winter storm can be an effective addition to an agency's winter maintenance toolbox, especially for use in milder weather.

ing environmental impacts are among the benefits of using liquid deicers to treat winter roadways. Joe Huneke, MnDOT Maintenance Operations winter coordinator, reported that results from the Clear Roads research coupled with warmer winter temperatures prompted last year's evaluation of liquid-only plow routes in MnDOT Districts 3 and 7.

MnDOT's own research program has also benefited from Clear Roads-funded research. A MnDOT research project that produced a temperature-based cost model for comparing the relative field performance of deicers and deicer blends began with an examination of the results of a 2010 Clear Roads project that correlated lab testing and field performance of deicers and anti-icers.

What's Going On Now?

Six research projects are under way, including a follow-up study to enhance a cost-benefit analysis toolkit developed in 2010. The enhanced tool will include more materials, equipment and methods for analysis and more flexible reporting options. Last year MnDOT began incorporating the original cost-benefit tool in its training program. Costs are the subject of another project in process that is developing a tool to estimate the true costs for snow and ice removal.

A project examining the toxicity of deicing materials fits well with MnDOT's commitment to reducing the environmental impact of winter operations. A MnDOT technical expert who oversees MnDOT's lab and field tests of alternative winter chemicals is providing feedback to Clear Roads researchers.

Clear Roads activities go beyond traditional research, including coordinating a national winter driver safety campaign, "Ice and Snow…Take It Slow," to educate drivers about driving safely in winter conditions and a variety of partnership projects.

What's Next?

In 2013, five scheduled research projects will address a range of winter maintenance topics: establishing effective salt and anti-icing application rates, understanding how winter chemicals perform on special pavement types, training snowplow operators and supervisors, comparing materials distribution systems and improving snowplow design.

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/details/study/446, http://www.pooledfund.org/Details/Study/317 *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.

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Principal Investigator:
Diwakar Gupta, University of Minnesota

LRRB PROJECT COST:
$30,000

PBCs help foster innovation by giving contractors flexibility in choosing materials and construction methods.

MINNESOTA DEPARTMENT OF TRANSPORTATION

RESEARCH SERVICES
OFFICE OF POLICY ANALYSIS, RESEARCH & INNOVATION

Designing Performance-Based Contracts for Pavement Construction and Maintenance

By using carefully designed incentives and disincentives to encourage contractors to perform preventive maintenance, PBCs could help align the interests of contractors and state transportation agencies to produce better quality roads with lower life-cycle costs.

What Was the Need?

Most highway pavement construction work is performed by contractors. To ensure that these contractors produce high-quality pavements with long service lives, MnDOT contracts include performance-based specifications: Constructed pavements are tested to determine performance and life-cycle cost predictions, which are then compared to those called for in the pavement design. Bonuses are paid or penalties are assessed, depending on whether pavement quality exceeds or falls short of design expectations, respectively.

These contracts typically do not include long-term agreements for pavement maintenance. MnDOT either performs this maintenance or creates new agreements with contractors. Other transportation agencies and industries suggest that it may be beneficial to enter into longer term contracts that include such maintenance. Called performance-based contracts, or PBCs, these agreements give contractors leeway in how a pavement is designed but hold them accountable for its actual performance over the pavement's entire service life. Instead of being paid in full upon completion of construction, contractors receive a series of payments that are modified with bonuses or penalties based on how well pavements meet desired performance targets over time. These payments are designed to encourage contractors to perform preventive maintenance during the life of the structure, which improves operational performance and prolongs pavement life.

Despite their potential, PBCs are not widely used by state transportation agencies, and their implementation requires complex calculations to estimate the expected performance of pavements and determine the timing and amounts of bonuses or penalties. Research was needed to establish guidelines for designing these contracts.

What Was Our Goal?

The objective of this project was to develop a method for designing PBCs for highway construction projects by estimating pavement life-cycle costs and determining the amount and timing of incentives and disincentives to influence contractor behavior.

What Did We Do?

Researchers began by investigating different kinds of procurement contracts and their use in a variety of industries, including health care, defense and transportation. Then they developed a method for predicting certain kinds of pavement distress, such as rutting and cracking, to determine a pavement's expected service life and life-cycle costs. The method uses computer simulations allowing a variety of inputs, including pavement design specifications and such factors as expected weather and traffic. In developing this method researchers used closed form solutions—mathematical equations that take less computational time to arrive at predictions than those used in the Mechanistic-Empirical Pavement Design Guide, the typical method for predicting distress in pavements.

Finally, researchers developed a framework for implementing PBCs by determining the structure of penalties and bonuses to contractors that will provide the optimum control

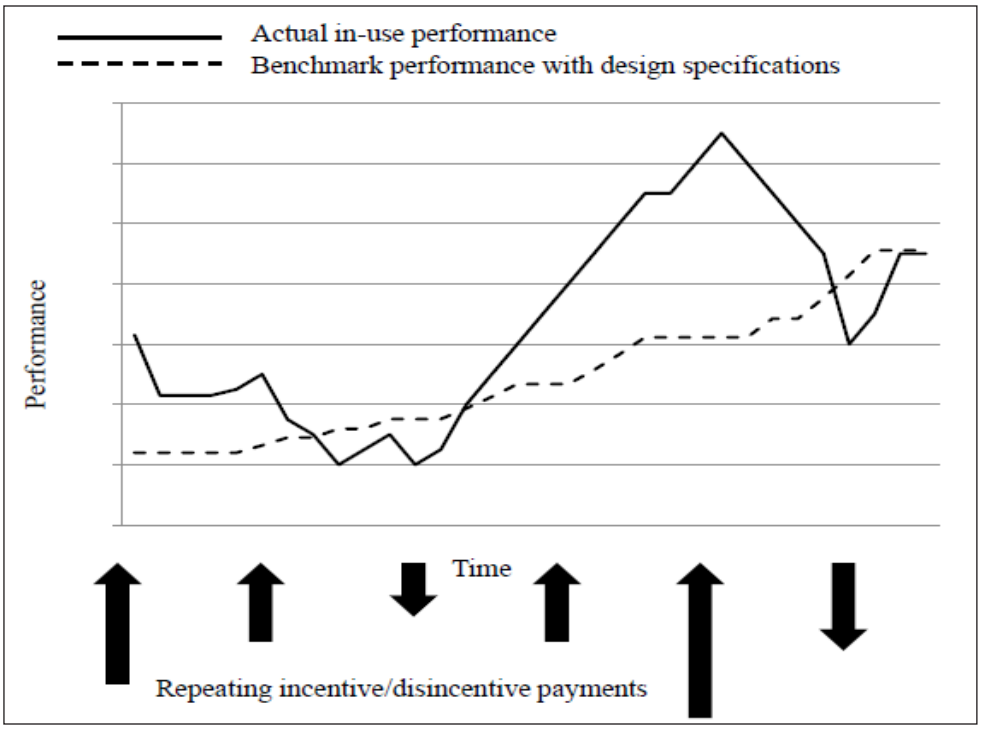
continued

"Performance-based contracts would shift the risk to contractors, giving them a little more flexibility on design but holding them responsible for the final product."

—Rick Kjonaas,
State Aid Engineer, MnDOT

"One advantage of PBCs is that they allow agencies to price out the true cost of pavements—including maintenance—upfront. It's more efficient for contractors to take responsibility for maintenance for the life of the contract without going through another bid process once maintenance is required."

—Diwakar Gupta,
Professor, University of Minnesota Department of Industrial and Systems Engineering



PBCs require determining the frequency and magnitude of payments to contractors. By basing incentives on how well actual performance meets criteria specified in the contract, these contracts reduce errors associated with predicting the as-built performance of structures.

of their maintenance policies so that these match agency goals. They also identified PBC implementation issues.

What Did We Learn?

Results suggest that using PBCs would encourage contractors to implement the best construction methods and perform timely preventive maintenance activity, significantly improving the quality and long-term performance of their products. However, the implementation of these contracts is challenging, requiring more contract parameters and implementation effort than traditional contracts. The project report includes an inventory of performance metrics that agencies can use to evaluate contractor performance and a set of actions that contractors can use to control the quality of the final product and increase its usable life. To produce stronger pavements, contractors can control mix design, reduce variability in construction practices and control the timing and extent of preventive maintenance activities.

Researchers developed a mathematical model for selecting incentives that would elicit the desired responses from contractors without being too costly. Incentives would be smaller and disincentives larger near the beginning of a pavement life cycle, when good performance was expected. Incentives for good performance would grow as the pavement aged, when poorer performance such as cracking was expected. Researchers argued that if a competitive bidding mechanism were used to award contracts and optimal incentives were selected, agencies would pay only for improved quality and contractors would not earn unreasonable excess profits.

What's Next?

MnDOT will continue to evaluate the possibility of using PBCs and other innovative contracting methods, but further research is required before implementation. Researchers recommend conducting a field evaluation of the effect of PBCs and maintenance activities on the performance lives of pavements. One possibility for implementing further research is a new pooled fund study involving MnROAD partners.

This Technical Summary pertains to the LRRB-produced Report 2011-18, "Optimal Contract Mechanism Design for Performance-Based Contracts," published August 2011. The full report can be accessed at http://www.lrrb.org/PDF/201118.pdf.

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LRRB PROJECT COST:
$30,000

Geotextiles have been used widely on roads in northeastern Minnesota.

RESEARCH SERVICES
OFFICE OF POLICY ANALYSIS, RESEARCH & INNOVATION

Using Geosynthetics to Improve Road Performance

What Was the Need?

To increase performance, roads are sometimes reinforced with geosynthetic polymer materials, including geogrids and geotextiles. Geogrids consist of polymers formed into relatively rigid, gridlike configurations. They are commonly placed between the subgrade and base or base and subbase layers of roads to add strength and stiffness and to slow deterioration. Geotextiles are polymer fabrics that may also provide some reinforcement, but are used primarily to:

The use of geogrids in road foundations clearly benefits pavement performance, potentially leading to longer service lives for roads and reduced maintenance costs.

- Facilitate filtration and water drainage through road foundation soils without the loss of soil particles.
- Provide separation between dissimilar base materials, improving their integrity and functioning.
- Provide a stable construction platform over soft or wet soils, facilitating the movement of equipment and the process of soil compaction.

Of several kinds of geotextiles, Type V is the most commonly used in Minnesota, primarily as a separator. Despite the relatively widespread use of geosynthetics in reconstructing paved county roads and state trunk highways as well as in constructing new roads, their performance has not been well documented in Minnesota. Research was needed to obtain field data that would indicate whether geosynthetics extend the service lives of roads and reduce the need for maintenance.

What Was Our Goal?

The objective of this project was to quantify the pavement performance benefits of geosynthetics in pavement base and subbase layers, including improved ride quality and reduced cracking and rutting.

What Did We Do?

From 2001 to 2011, researchers monitored the performance of several paved county state-aid highways in northeastern Minnesota. Several test sections covering approximately 44 miles and incorporating geogrids and Type V geotextiles were compared to 12 miles of control sections without them. For both the test and control sections, the subgrade soil was typically heavy clay (a soil classification of 130). Researchers also tested one section built with saw-and-seal construction, in which joints are sawed into the pavement at regular intervals, reducing the tensions that lead to cracking and other distress as pavements expand and contract from temperature fluctuations.

This monitoring involved an annual inspection of each road segment using MnDOT's Pathways digital inspection vehicle, a van with digital cameras mounted on top of it to capture pavement distresses such as cracking and patching. This vehicle also has four lasers mounted across its front bumper to measure the pavement's smoothness, which can be used to determine both ride quality and rutting. The van takes measurements at short intervals while traveling on the roadway at high speed.

Researchers analyzed this data for trends in ride quality, rutting and cracking over the 10-year period. This analysis provided both a snapshot of average pavement performance in 2010 and long-term performance trends for individual test sections.

continued

"This project shows that geosynthetics can be used to increase road performance, potentially leading to savings in maintenance costs."

—Tim Clyne,
Research Forensic Engineer, MnDOT Office of Materials and Road Research

"If roads are to perform well, it's critically important that they have good foundations—and geosynthetics are one more tool to help accomplish this goal."

—Lou Tasa,
Research Fellow, HumanFIRST Program, University of Minnesota

Where geogrids (left) consist of polymers such as polyester or polystyrene formed into open grids that provide support, geotextiles (right) have the quality of woven fabrics, making them good solutions for facilitating separation, filtration and drainage.

What Did We Learn?

Results show that geogrids clearly benefit pavement performance, with test sections showing a better ride quality and surface rating than control sections. Surface rating is a composite measure of surface distresses including rutting and cracking. Test sections also had slightly less rutting than control sections, indicating an increased structural capacity. The saw and seal sections also had a better ride quality than control sections and an even higher surface rating than geogrid sections, but had more rutting than control sections.

However, Type V geotextiles did not provide increased strength or better pavement performance, performing only as well as and sometimes worse than control sections. Test sections had more rutting and about the same ride quality and surface rating as control sections. While the use of Type V geotextiles did lead to less transverse cracking than in control sections, they exhibited more longitudinal cracking. Type V fabrics also had the most variation in performance, with some sections performing poorly and others well, whereas geogrid sections had a much more consistent performance. However, problems with this project, including problems with data for the project's first few years, make these conclusions tentative and project specific. Knowledge of the use of geotextiles has advanced since these test sections were constructed, and more recent research projects have shown them to be beneficial.

What's Next?

Based on these results, researchers recommend geogrids in situations where increased pavement strength or better pavement performance is needed. And while this project did not show increased performance for pavements with Type V geotextiles, recent developments in the use of geotextiles suggest that they can be beneficial for reinforcement and for separating fine from coarse materials.

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This Technical Summary pertains to the LRRB-produced Report 2011-20, "Monitoring Geosynthetics in Local Roadways (LRRB 768) 10-Year Performance Summary," published August 2011. The full report can be accessed at http://www.lrrb.org/PDF/201120.pdf. *For related studies, see* http://www.lrrb.org/PDF/PP07GEOTS.pdf.

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RESEARCH SERVICES

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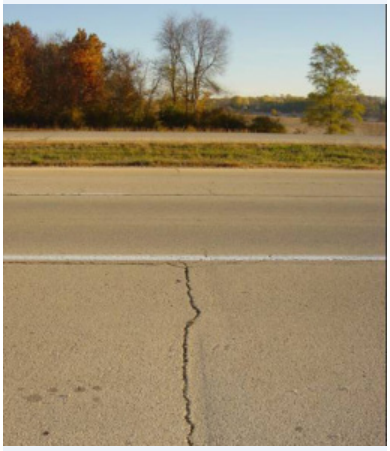
PROJECT COST:
$20,000



The use of a performance test in material specifications could help prevent the most common type of pavement distress in Minnesota—cracking caused by low temperatures.

Laboratory Tests for Predicting the Performance of Asphalt Concrete

What Was the Need?

To ensure the quality of its asphalt mixtures, MnDOT sets requirements specifying ingredients, quantities and mixing procedures. These specifications, like those of most departments of transportation, do not require that mixtures be tested in the laboratory for mechanical properties such as stiffness and strength.

If feasible, including a laboratory performance test in MnDOT's asphalt mixture specifications would improve the longevity of asphalt pavements and reduce the risk of early cracking, rutting and other deterioration. Research was needed to identify candidate tests based on how well they predict field performance.

Including a laboratory performance test in asphalt mixture specifications would improve the longevity of asphalt pavements and reduce the risk of early cracking, rutting and other deterioration.

What Was Our Goal?

The goal of this project was to synthesize research and implementation efforts related to asphalt performance tests as a first step toward identifying a suitable test for material specifications.

What Did We Do?

Researchers began by determining the current state of practice for asphalt performance tests by reviewing material specifications of various state transportation agencies. Investigators then reviewed technical literature on the relationship between laboratory tests and pavement performance to determine the current state of the art for the topic, and reviewed previous MnDOT research projects dealing with asphalt performance tests. This information was synthesized to:

- Determine the suitability of including mechanical tests in material specifications.
- Identify potential laboratory tests used by other DOTs as performance indicators, and evaluate their labor intensiveness and potential for predicting field performance. Researchers focused on tests that measure cracking, which is the most common form of asphalt pavement distress in Minnesota.
- Make recommendations for future studies that can be undertaken to evaluate the suitability of a performance test and develop implementation plans.

What Did We Learn?

The literature review showed that several agencies have routinely made use of performance test requirements in standard material specifications, typically to evaluate the likelihood of rutting or damage caused by moisture. However, a few demonstration projects have shown that the use of performance testing-based material specifications is feasible for predicting asphalt pavement cracking.

The review of laboratory tests used by other DOTs to predict field performance indicated that few of these tests have undergone a satisfactory validation, and fewer are simple enough to be used on a routine basis. Most tests tackle one or more kinds of asphalt pavement distress, but none can be used as a global performance indicator. The availability of vetted tests that satisfy the requirements for use as a simple cracking performance test is limited.

continued

"By scanning the practices of other departments of transportation, researchers from this project identified a few promising performance tests that warrant further investigation."

—Tim Clyne,
Senior Research Engineer, MnDOT Office of Materials and Road Research

"Once it can specify that manufacturers produce asphalt not just with a certain constitution but with predetermined mechanical properties, MnDOT will improve the performance of its pavements."

—Eshan Dave,
Assistant Professor, University of Minnesota Duluth Department of Civil Engineering

One promising performance test is the indirect tensile strength test, which can be used to measure tensile strength by applying a load across the diameter of a cooled, cylindrical specimen and increasing the load until the specimen fractures.

Most research at the national level has focused on the development of an asphalt mixture performance test. The results for this test correlate well with rutting, and some studies have shown that it can successfully predict cracking with the use of mechanistic models.

Tests with the greatest potential for use in performance-based material specifications for asphalt mixtures in Minnesota include:

- The indirect tensile strength test, in which specimens are loaded to the point of failure.
- Fracture energy tests, including the disk-shaped compact tension and semi-circular bend tests, in which specimens are loaded and the resulting cracks measured.
- The Texas overlay tester, which measures the number of cycles it takes for a specimen to fail.
- The four-point bending beam fatigue test, which is used to evaluate cracking.

Fracture energy tests have shown very good correlation with cracking in the field, particularly thermal and reflective cracking, which are prominent distresses on flexible and composite pavements in Minnesota. However, fracture test procedures need to be simplified to be well-suited to routine use in performance-based specifications.

What's Next?

A second phase of this study will evaluate the candidate tests identified in this project. Researchers recommend:

- Evaluating indirect tensile strength for use as a performance measure since it is already used as part of MnDOT's mix design process and would require no additional implementation if used for performance-based specifications.
- Evaluating fracture energy tests for asphalt mixtures for routine use in Minnesota. This evaluation should include an analysis of required equipment, specimen preparation and data postprocessing.
- Further reviewing and synthesizing the significant amount of test and field performance data available from previous MnDOT projects to help identify candidate tests for further validation and implementation studies.
- Trial projects to evaluate the feasibility of using performance-based specifications.

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2011-26TS
Published January 2012

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LRRB PROJECT COST:
$99,998

Researchers cast and cured concrete samples to test hardened air content, compressive strength and freeze-thaw durability.

MINNESOTA DEPARTMENT OF TRANSPORTATION

RESEARCH SERVICES
OFFICE OF POLICY ANALYSIS, RESEARCH & INNOVATION

Extending the Delivery Time of Concrete Mixtures

Extending the allowable delivery time of concrete mixtures would make some construction projects less costly. Before changing MnDOT specifications, it was important to verify that the use of additives to delay setting would not compromise concrete performance.

What Was the Need?

To transport concrete from mixing plants to construction projects, workers use trucks with large rotating drums, which keep the plastic concrete agitated, maintain its workability and delay the process of setting. Setting occurs as water reacts with portland cement, which then gradually hardens and binds the aggregates together.

Agitating concrete in transit delays setting but does not halt it altogether. The longer this process goes on, the less the concrete is workable enough to be placed and finished during construction. While workability can be restored by adding water, doing so decreases the final product's strength and durability.

Setting can be delayed by using chemical additives, including water reducers, retarding admixtures and hydration stabilizers. Water reducers lower the amount of water necessary in a mixture, making it possible to extend the setting time without compromising workability and durability. Retarding admixtures—which are usually also water reducers, called water-reducing retarders—slow the reaction of water with cement. Hydration stabilizers delay the onset of setting. Concrete mixtures typically also contain air-entraining agents, detergent-like additives that increase the durability of hardened concrete by promoting the formation of a matrix of air bubbles within the concrete.

MnDOT limits the transport time of concrete mixtures containing air-entraining agents to 60 minutes. However, other states allow transport times as long as 90 minutes for similar concrete mixtures. Research was needed to verify whether hauling times for concrete mixtures used in Minnesota could likewise be extended without compromising concrete performance.

What Was Our Goal?

The objective of this project was to evaluate how the performance of air-entrained concrete mixtures containing water reducers, water-reducing retarders or hydration stabilizers would be affected by extending their transit time from 60 to 90 minutes, with a potential for additional testing up to a 120-minute delivery time.

What Did We Do?

Researchers began by batching 23 concrete mixtures using the same mix design with various kinds and combinations of cement, fly ash, water reducer, water-reducing retarder, hydration stabilizer and air-entraining admixtures. Then they conducted laboratory tests to evaluate the consistency and plastic air content of these mixtures directly after initial mixing and after 30, 60, 90 and 120 minutes.

The compressive strengths of concrete cast directly after initial mixing were then compared to concrete cast after waiting 120 minutes. Compressive strengths were determined for all mixes at one, seven and 28 days. Similarly, a portion of the concrete was used to cast a set of two 15-inch-long rectangular beams to compare the freeze-thaw durability of the samples cast directly after initial mixing to concrete cast after waiting 120 minutes. In addition, researchers compared the hardened air content of the mixes.

continued

"As MnDOT is planning reconstruction of many bridges in less accessible rural areas, extending the delivery time for concrete will potentially allow more flexibility for the contractor, making these and similar projects less costly."

–Maria Masten,
Concrete Engineer,
MnDOT Office of Materials

"One unanticipated benefit of this project came from getting out into the field and communicating with ready-mix concrete suppliers to exchange ideas and resolve other issues."

–Dan Vruno,
Senior Engineer,
American Engineering Testing, Inc.

Researchers measured workability using the slump test (left), in which an inverted cone-shaped mold is removed from soft concrete and the resulting slumping measured. They measured plastic air content by using a pressure gauge (right) to calculate the percentage of the soft mixture composed of air bubbles.

Researchers then batched four mix designs at a single ready-mix concrete control plant in the field, using laboratory results from the first 23 batches to refine the use of chemical additives. Researchers supervised the mixing process and then repeated tests from the laboratory phase of this project.

Researchers oversaw seven additional ready-mix plants located throughout Minnesota design and produce similar mixtures using locally available materials and repeated the same testing on these samples.

Finally, researchers conducted a statistical analysis of data from laboratory, control plant and regional testing to determine how the performances of concrete mixtures was affected both by their ingredients and by extending their delivery time from 60 to 120 minutes.

What Did We Learn?

Final field results showed that extending the delivery time of air-entrained concrete mixtures from the current 60 minutes to 120 would not significantly affect compressive strength or freeze-thaw durability, and researchers recommend updating MnDOT specifications to allow a longer delivery time. This adjusted specification, however, must offset expected losses in plastic air content and slump, as results showed small decreases in some concrete properties with the additional time.

What's Next?

In the final report, researchers recommend that suppliers be required to develop a quality control plan for plastic concrete testing to make sure mixtures meet MnDOT specifications prior to being placed on a project. This plan should include slump and air content testing at the concrete plant and delivery location, and a mix modification procedure at the delivery location if the concrete does not meet specification requirements after being transported.

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PROJECT COST:
$192,000

Researchers evaluated several local aggregate samples for size and shape properties using the University of Illinois Aggregate Image Analyzer.

Best Value Local Aggregates for Road Foundations

What Was the Need?

To achieve long-lasting roads, materials are typically mined from gravel pits and rock quarries. Because these materials are becoming increasingly scarce and expensive in many parts of Minnesota, it is important to better predict how aggregates affect road performance. The quality of an aggregate is determined by how well particles interlock to provide structural support for upper pavement layers and protection to lower subgrade soils, and also how stable the aggregate is under freeze-thaw and wet-dry cycles. These functions in turn depend on properties including aggregate shape, surface texture and angularity.

Better quantifying the quality of local aggregates will help Minnesota make the most efficient use of its resources, achieving better value for its construction dollars and promoting sustainability.

By better understanding the quality of local aggregates, the mechanistic-empirical pavement design software application MnPAVE was used to determine where and how these aggregates can be used most effectively in roads. This requires establishing the relationship between aggregate properties and MnPAVE inputs such as shear strength and resilient modulus.

What Was Our Goal?

The goal of this project was to determine how mechanistic-empirical design procedures can be used to make effective use of local Minnesota aggregates in the unbound layers supporting flexible pavements by determining:

- How an aggregate's properties affect its quality, as measured by resilient modulus and shear strength, and consequently how they affect the design thickness of unbound aggregate layers.
- Where locally available materials with defined quality should be placed.
- What traffic design levels are appropriate for locally available aggregates.
- How to combine high quality and marginal quality aggregates for optimal performance.

What Did We Do?

Researchers began by analyzing the properties of aggregate materials from gravel pits and rock quarries throughout Minnesota. They supplemented this data by analyzing images of aggregate samples to determine their shape, angularity and surface texture. They correlated this data with laboratory and field tests of aggregate strength and resilient modulus from MnDOT-sponsored research studies using computer modeling to establish resilient modulus as a function of aggregate properties.

Researchers then classified aggregates used in Minnesota into three representative quality ranges based on resilient modulus and peak deviator stress at failure. Then they used MnPAVE to determine the expected service lives of flexible pavements using aggregate bases with varying properties. They also explored the relationship between the gradation and mechanical properties of aggregates.

Finally, researchers established target mechanistic design input values for aggregate base and subbase layer strength and modulus under various design scenarios using various locally available aggregate materials. They also made recommendations to facilitate aggregate source management, property determination and cost-effective source selection.

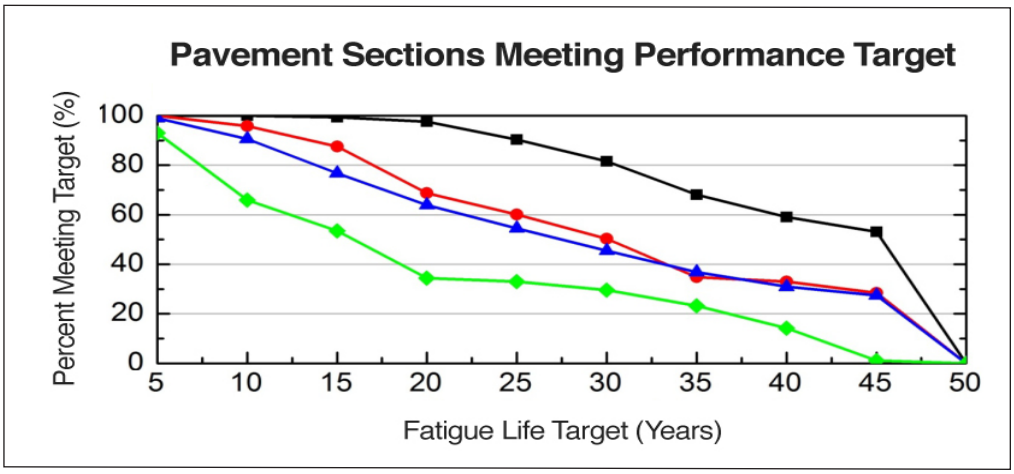
continued

"This project helps us get better value from our aggregates by using them more efficiently to construct more miles of road with the same quantity of materials."

—John Siekmeier,
Research Engineer,
MnDOT Office of Materials

"On low-volume roads, lower road layers that don't receive the highest loads don't always require the highest quality aggregates, making the sustainable use of local sources a good option."

—Erol Tutumluer,
Professor, University of Illinois Department of Civil and Environmental Engineering



This graph illustrates the estimated effect of unbound granular quality on the fatigue life of pavement sections in Beltrami County given an estimated 1.5 million equivalent single-axle loads per 20 years: high quality base and subbase (black), high quality base and low quality subbase (red), low quality base and high quality subbase (blue), and low quality base and subbase (green).

What Did We Learn?

Results showed that aggregate angularity and surface texture were important in determining the resilient modulus of aggregates and far better correlated to this property than gradation alone.

Analyses using MnPAVE showed that use of locally available materials can be cost-effective for low-volume roads provided that the 20-year design traffic level does not exceed 1.5 million equivalent single-axle loads. Most state and local roads have traffic levels less than this. Analyses confirm that the quality of base layer materials directly impacts the predicted service lives of roads. Increasing the thickness of a base layer with low quality materials did not improve the fatigue life expectancy of a road, although it did significantly improve subgrade rutting performance. The quality of aggregates used in the subbase had a much greater effect on rutting performance. Researchers concluded that a high quality, stiff subbase has a bridging effect and can offset some of the negative effects of low base stiffness.

What's Next?

MnDOT is currently incorporating the results of this study into MnPAVE, including design inputs for surface texture and angularity, and equations for predicting resilient modulus from them. Researchers recommend continuing to build a database of properties for an increasing number of local aggregate sources to improve the correlations developed in this study. They also recommend establishing guidelines for using visual inspection to characterize aggregate properties and developing rapid field imaging technologies for the same purpose. MnDOT is currently conducting a related project to improve concrete pavement foundations.

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PROJECT COST:
$110,000

UBCOs can be placed quickly and efficiently to restore the ride quality and structural capacity of aging pavements.

Using Computer Modeling to Improve the Design of Unbonded Concrete Overlays

What Was the Need?

As pavements age, they are subject to cracking, rutting and other deterioration that decreases their ride quality and ability to sustain traffic loads. Since completely reconstructing pavements is costly, transportation agencies sometimes extend their lives and restore their ride quality using rehabilitation techniques that involve overlaying an existing road with new pavement layers.

One such method, called unbonded concrete overlays, or UBCOs, involves applying a layer of asphalt to an existing surface followed by a layer of portland cement concrete, or PCC. The asphalt interlayer of UBCOs helps prevent reflective cracking in which the deterioration of the original pavement surface transfers stress and damage to the new concrete layer. UBCOs can also be placed quickly and efficiently, making them an increasingly popular method of pavement rehabilitation.

By using advanced computer modeling that employs fracture mechanics to better predict cracking in pavements, it may be possible to design thinner, more cost-effective unbonded concrete overlays that achieve the same performance as more conservative designs.

However, current UBCO design procedures for determining layer dimensions and materials use models that do not account for the effect of the asphalt interlayer on limiting the propagation of cracks between layers. Researchers are interested in refining these models to design pavements that are no thicker than necessary for their intended performance lives since thinner pavements are less costly and also more environmentally friendly because they reduce the carbon footprint of construction.

What Was Our Goal?

The objective of this project was to develop a method for designing UBCOs using fracture mechanics to model crack propagation through pavement layers.

What Did We Do?

Researchers began by reviewing Minnesota procedures for UBCO design. Then they analyzed crack propagation using finite element computer modeling and the cohesive zone model, or CZM, which uses nonlinear fracture mechanics to predict how existing cracks will spread into cohesive zones or uncracked areas. Linear fracture mechanics account for only the strength, stiffness and dimensions of materials, while nonlinear fracture mechanics also account for fracture energy, which is the energy required to crack a given surface area and is a measure of resistance to crack propagation.

Researchers used CZM to relate the ultimate load capacity of a pavement—or the load at which it will fail—to its dimensions and material properties. Then they verified the accuracy of CZM by using ABAQUS software to model two sample structures and compare the results to available theoretical and experimental data.

Researchers used CZM to conduct failure simulations for various single-layer PCC pavement designs to derive equations relating pavement load-carrying capacity to material properties and structural dimensions. They established design recommendations for UBCOs, including layer thicknesses and material properties, that would yield the same load capacity using the same equations. Then they compared the expected performance of these designs to observations of four thin-layer UBCO test sections at the MnROAD pavement research testing facility.

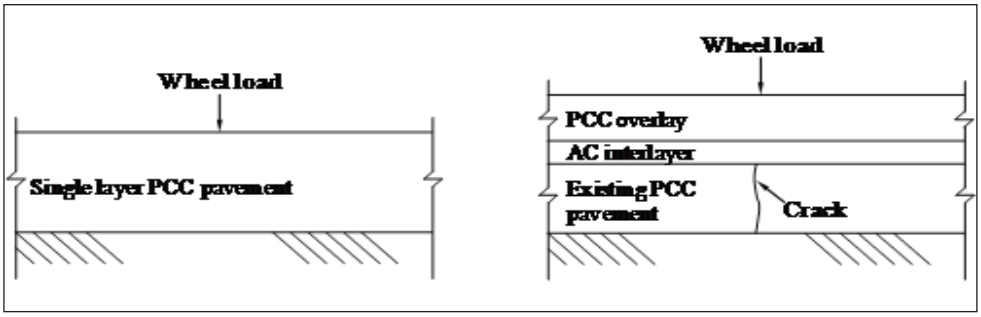
continued

"As MnDOT districts make increasing use of UBCOs, this study is a step toward optimizing their design."

—Shongtao Dai,
MnROAD Research Operations Engineer

"We developed a model that more accurately simulates the propagation of cracks in pavements than existing methods. This is critical to developing thinner overlays."

—Roberto Ballarini,
James L. Record Professor and Head, University of Minnesota Department of Civil Engineering



The model developed in this study allows engineers to design a UBCO (right) with the same load capacity as a single-layer pavement designed to current specifications (left).

What Did We Learn?

Results suggest that the fracture mechanics-based design procedure for UBCOs shows promise. The model developed in this project can be used as an additional tool to assist in the design of UBCOs by determining the load capacity of a new single-layer PCC pavement designed using current procedures, and then determining thickness and material properties for a UBCO that will yield the same load capacity.

The CZM model used in this study improves on traditional stress-based failure criteria used by other models, which are not capable of quantifying the loads required to initiate and propagate reflection cracks in PCC pavements. Use of this model suggests that increasing the strength of the interlayer or overlay and decreasing the stiffness of the interlayer are effective ways of improving the load-carrying capacity of the UBCO pavement in terms of crack propagation. However, this method does not consider the effects of temperature, moisture and traffic loads.

The UBCO test sections observed at MnROAD only cracked near poorly designed joints separating the sections. This suggests that thus far the design of these sections is sufficient to resist reflective cracking.

What's Next?

Further research is needed to assess the model developed in this study by comparing its predictions to field observations of UBCO test cells. Research is also needed to evaluate the effects of climate conditions and traffic loading. With further investigation, three-dimensional fracture mechanics simulations could provide additional insights into whether UBCOs can be made thinner and more cost-effective.

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TOTAL PROJECT COST:
$275,239

TPF-5(148) CONTRIBUTIONS:
LRRB: $105,000
MnDOT: $105,000

TOTAL TPF-5(148) COST:
$1,000,258

Heavy farm equipment can put damaging loads on rural roads.

MINNESOTA DEPARTMENT OF TRANSPORTATION

RESEARCH SERVICES
OFFICE OF POLICY ANALYSIS, RESEARCH & INNOVATION

Effects of Agricultural Equipment on Pavement Performance

What Was the Need?

In Minnesota, as in many other states, rural roads bear the brunt of heavy agricultural equipment loads. These otherwise low-volume roads may rarely be built to withstand such occasional but significant stresses. Over the years these stresses have increased as the size of farms and farm equipment has grown. A particular challenge has been the increased application of liquid manure, which has led to larger and heavier equipment.

This study isolated the impact of heavy farm equipment on roadways by loading test sections. Results of this study will support policy decisions and construction practices to save money and enable longer-lasting rural roads.

Studies of such loading conducted in Iowa in 1999 and South Dakota in 2001 led to more restricted use of rural roadways in those states. In Minnesota, a preliminary investigation of damage to rural roads, which was generally blamed on large agricultural equipment, found it difficult to distinguish between the impact of agricultural equipment and that of other large vehicles, such as those used for gravel hauling. Damage to these roads makes transportation difficult for area residents, and road repair and replacement are costly for local road agencies.

A rigorous examination of the impact of heavy agricultural equipment would require a controlled setting of test roads subject only to loads directed by a research team. Only then would it be possible to determine causes of such damage and examine possible solutions to an expensive problem.

What Was Our Goal?

The Minnesota Local Road Research Board, in cooperation with MnDOT, other state departments of transportation and a number of industry organizations represented by the Professional Nutrient Applicators Association of Wisconsin initiated pooled fund study TPF-5(148) to examine the impact of heavy agricultural equipment on rural asphalt roads.

The current project, funded by that ongoing effort, aimed to measure the effects of different types of farm equipment on instrumented pavement test sections and compare these to the impact of a typical five-axle tractor-trailer. The results of this effort would be used to generate design or policy recommendations to mitigate the damage caused by heavy agricultural equipment.

What Did We Do?

Test sections were constructed at the MnROAD facility, including one section with 3.5 inches of asphalt over 8 inches of gravel, and one section with 5.5 inches of asphalt over 9 inches of gravel—both common rural configurations in recent years. Each was instrumented with strain gauges and soil pressure cells. Two instrumented concrete pavements were used as controls.

Loading included 20 vehicle configurations: three standard heavy vehicles, including a five-axle, 80,000-pound truck; and 17 farm vehicles, from 29,400-pound tractors to tanker trucks to tractors pulling 140,000-pound grain carts on a total of three axles. Investigators from MnROAD, the University of Minnesota and Iowa State University focused on axle loads, vehicle weights and speeds, wheel types and traffic wander. Testing was

continued

"When county engineers asked us to study the impact of heavy agricultural equipment on rural roads, we found that axle loads matter far more than vehicle weight. Implementation of these findings will fall to county engineers."

—Shongtao Dai,
Research Operations Engineer, MnDOT Office of Materials

"Upgrading all roads to handle heavy agricultural equipment isn't practical. We recommend keeping excessively heavy loads off the roads when they are the weakest, or temporarily making the road a one-way so heavy vehicles can drive in the middle of the road, away from the vulnerable edges."

—Lev Khazanovich,
Associate Professor, University of Minnesota Department of Civil Engineering

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Failures on test sections like this one in March of 2009 show how heavy agricultural equipment driven near the edge of a rural pavement can cause structural failure.

conducted in March and August of 2008 and 2010 to match spring thaw conditions and high farm traffic periods, with additional testing in November 2010.

What Did We Learn?

Investigators found that pavement structure, axle weights, seasonal effects, traffic wander, and vehicle type and configuration all significantly impact pavement responses:

- Pavement thickness was critical to resisting failure. The thinner asphalt sections suffered extensive cracking, severe rutting and failure in spring and fall of 2009. The thinner concrete pavement suffered several corner breaks.
- Pavement damage can be reduced if heavy loading avoids sensitive conditions like high asphalt temperature and fully saturated or thawed base and subgrade. November testing and morning testing both proved less damaging than August and afternoon testing, respectively.
- The most stress-inducing of the agricultural vehicle configurations are not recommended by manufacturers for use on paved surfaces when fully loaded. But even vehicles designed for use on paved surfaces caused greater stress than the standard five-axle, 80,000-pound vehicle.
- Axle weight was far more important than overall vehicle weight in stressing pavement. Increasing the number of axles while maintaining even load distribution is the primary recommendation for heavy vehicles on rural roads.
- Traffic wander and vehicle wheel path had significant impact on gauge responses.
- Use of paved shoulders reduced damage potential. In the absence of a paved shoulder, vehicles should be permitted to drive in the middle of the roads.
- Modeling led investigators to recommend that on concrete pavement, farm implements should be driven 18 to 24 inches from slab edges to minimize damage.

What's Next?

Recommendations from this study can be implemented immediately. Some townships in Wisconsin, a study partner-state, already have designated select roads as one-way for two- to three-day periods of high farm traffic or sensitive temperatures.

This Technical Summary pertains to the LRRB-produced Report 2012-08, "Effects of Implements of Husbandry (Farm Equipment) on Pavement Performance," published April 2012. The full report can be accessed at http://www.dot.state.mn.us/research/documents/201208.pdf. *Information about the ongoing pooled fund study TPF-5(148) can be found at* http://www.pooledfund.org/Details/Study/375.

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LRRB PROJECT COST:
$80,500

The first step in studying porous asphalt pavement was to build two sections of it around a section of regular asphalt pavement.

MINNESOTA DEPARTMENT OF TRANSPORTATION

RESEARCH SERVICES
OFFICE OF POLICY ANALYSIS, RESEARCH & INNOVATION

Porous Asphalt Pavement Performance in Cold Regions

What Was the Need?

Porous asphalt pavements, designed with higher air voids, allow water to drain directly through the open-graded pavement structure into the underlying layers, reducing runoff. These mixes have been commonly used in parking lots and thin surface courses but have been less studied as full-depth roadway pavements, particularly in cold climates. Full-depth porous pavements may lack the strength necessary for urban high-volume roads but are desirable for low-volume road applications because of their potential benefits.

Porous asphalt pavements have potential to improve stormwater management. Research found that even in a cold climate, porous pavements can perform reasonably well on low-volume roads.

Potential porous pavement benefits include drainage directly into the soil and groundwater, reducing the need for costly drainage structures and rights of way; reduction in stormwater runoff volume and damaging surges like those responsible for the dramatic road damage in Duluth, Minnesota, in 2012; reduction in sediment loading in the runoff that harms water quality; faster snowmelt and drainage of meltwater prior to refreezing; reduction in tire spray and hydroplaning; absorption of noise from tires and engines; reduction in summertime high-temperature runoff, which is harmful to nearby surface water environments; and improved transfer of water and oxygen to nearby plant roots.

Porous pavements also present challenges. Porous asphalt typically contains high binder content, requires thicker lifts and involves construction challenges, all potentially adding to costs. Porous pavements eventually clog with dirt and organic debris, reducing permeability advantages. Vacuuming and other cleaning methods employed to reduce the clogging add to costs. Toxic spills would have a more direct path to groundwater through porous pavements; in such incidents, pavements may have to be removed to address the problem. Deicers also drain directly through porous pavements. Finally, porous pavements often provide less strength and shorter life spans than standard dense-graded mixes.

What Was Our Goal?

Researchers sought to evaluate the performance of full-depth porous asphalt pavements on low-volume roads in a climate as cold as Minnesota's. The investigation studied durability, maintenance requirements, hydrologic benefits and environmental considerations for full-depth porous pavements.

What Did We Do?

Research began at the MnROAD facility with the construction of three test sections: a 6-inch, full-depth porous asphalt pavement over granular subgrade; a 6-inch, full-depth porous asphalt over cohesive subgrade; and a dense-graded asphalt over mixed materials as a control. Loading and data collection ran from December 2008 through December 2011. The sections received about 40,000 equivalent single-axle loads (ESALs) over that period, considered to be substantial loading for porous pavements.

What Did We Learn?

MnROAD results demonstrated that the porous pavements performed reasonably well and may suit certain applications.

continued

"Porous pavement is a good tool in the toolbox for stormwater management. However, it needs to be used in the right application."

—Larry Matsumoto,
Department of Public Works, City of Minneapolis

"We designed a very robust porous asphalt mix and structure. There were construction and durability challenges, but it performed well considering the amount of applied loading."

—Matthew Lebens,
Research Project Engineer, MnDOT Office of Materials and Road Research

Permeability tests in which water is flushed through the pavement structure were central to the investigation of porous asphalt pavements. The tests confirmed that porous asphalt drains and filters water effectively through the pavement structure.

Performance and Durability

- After 40,000 ESALs, the porous pavements developed significant rutting in the loading lane, and seasonal vertical movement was observed across the entire loading lane.
- The top inch of pavement experienced significant surface raveling, which may be partially attributed to temperature segregation at the time of construction.
- Investigators identified no cracking or other significant distress in any of the three sections after three years.
- Porous HMA showed lower resiliency and more strain than the dense-graded control, but the lack of cracking discourages conclusions about the impact of these findings.

Maintenance

- MnROAD is a cleaner facility than most road environments, and surface clogging was not significant. Therefore, vacuum maintenance efforts were not conclusive.

Hydrologic Performance

- Surface permeability fell, but in the end averaged 0.5 inches per second—a much more than adequate rate for expected rainfall. No overflows were observed in the open-graded base in either the sand or clay subgrades.

Environmental Performance

- The porous pavements proved quiet and about 50 percent better for skid resistance, offering an excellent surface for friction testing with bald tires.
- Snow and ice melted faster on the porous pavements, and copper and zinc concentrations were reduced in water filtered through the porous structures.
- Temperature measurements indicated porous pavements would cool stormwater before discharge into sensitive areas.

What's Next?

The porous sections at MnROAD will remain in place for monitoring through 2014, and investigators may look into rehabilitation and continuing research after that point. Research findings will inform the design and maintenance of porous asphalt pavements in Minnesota and other cold climates. Overall, the porous pavement sections performed well in terms of ride quality, permeability, stiffness, strain response, safety and quietness. Porous asphalt remains, however, more sensitive to traffic loading and clogging issues than standard asphalt pavement. This research has shown that full-depth porous pavements can be effectively utilized in Minnesota in certain situations, particularly in applications with limited heavy loading.

This Technical Summary pertains to the LRRB-produced Report 2012-12, "Porous Asphalt Pavement Performance in Cold Regions," published April 2012. The full report can be accessed at http://www.dot.state.mn.us/research/documents/201212.pdf.

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PROJECT COST:
$17,000

The expansion of MnDOT's laboratory testing of construction materials has complicated the unit bidding process for both MnDOT and contractors, making lump sum bidding an attractive alternative.

Assessing the Feasibility of Lump Sum Bidding

What Was the Need?

To ensure that taxpayers get the best value for their dollars, MnDOT solicits construction bids from contractors and selects the lowest bid that meets all project requirements. During this process, contractors typically bid on the price per unit of the construction materials that will be used on the project. While MnDOT employs various kinds of bidding processes, unit pricing is the most common.

The lump sum bidding process is designed to reduce quantity overruns—minimizing the cost growth of projects—and share the risk of potential additional material quantities with contractors.

The unit pricing bid method can be cumbersome since it requires that during construction, inspectors verify the number of units of each material placed by contractors, which is often a time-consuming task. Furthermore, if more units are required for a project than originally estimated by MnDOT engineers, the contractor is paid for them at the same price per unit (unless the quantity differs by more than 25 percent), making quantity overruns unnecessarily expensive. Finally, bidders can exploit the unit price bidding process by offering unbalanced bids with inflated prices of items for which they believe MnDOT has underestimated quantities.

For these reasons, MnDOT is exploring an alternative bidding method for some of its projects. Known as lump sum bidding, this process calls for contractors to submit a bid on the entire price of a project or bid category rather than on the unit price of each material. The lump sum method is designed to reduce quantity overruns and the administrative costs of contracting and tracking material quantities, allowing MnDOT personnel to spend more time on inspection and less on paperwork. A recent study shows lump sum bidding to have the lowest cost growth of all bidding methods.

What Was Our Goal?

The objective of this project was to evaluate the cost-effectiveness of changing from unit pricing process to a lump sum bidding process by comparing these methods with respect to total bid amount, time necessary for inspection, and the attitudes of contractors and MnDOT personnel.

What Did We Do?

Researchers asked a test contractor to submit a lump sum bid on a small bridge project for which actual unit price bids were solicited. The test contractor had the same bidding documents as regular contractors and developed unit quantities based on information contained in project plans.

In addition, researchers collected contractor and subcontractor feedback on the lump sum bidding process and tracked labor costs by asking the test contractor to break out hours spent on various tasks.

Researchers then conducted site visits with inspectors and project managers to evaluate the time required for various inspection tasks under projects with unit pricing. They also conducted similar assessments of required office work for the same projects.

Finally, researchers performed an electronic survey of 60 MnDOT field personnel to assess attitudes toward switching to a lump sum bidding system and the effect it would have on their task priorities.

continued

"With unit pricing, it can be cumbersome and time consuming to keep track of quantities. Lump sum bidding would allow more time to be spent on quality assurance and control."

—Tom Wiener,
Project Control Manager, MnDOT Office of Construction and Innovative Contracting

"With lump sum projects, contractors have an incentive to be more efficient, reducing the cost of the project and accelerating delivery."

—Brian Wasserman,
Assistant Professor, Minnesota State University, Mankato, Department of Construction Management

With a transition to lump sum contracts, the role of MnDOT inspectors would change from a focus on tracking quantities to a greater concentration on quality control and assurance.
(Image courtesy Stonebrooke Engineering)

What Did We Learn?

Results showed that the lump sum process is viable and produces similar bid results to the traditional process. Three contractors bid on the project using the regular bidding process; the winning lowest bid was $621,677. The lump sum test bid totaled $682,266, placing it between the first and second bidders and less than $200 off the MnDOT engineer's estimate. The proposed quantities for this bid did not differ significantly from those estimated by MnDOT.

For labor costs, researchers also found that the lump sum method required more time and care on the part of the bidder since there is no recourse if additional work is required. The reaction of the test contractor and subcontractors to the bidding process was mixed, with many concerned about the time involved in determining quantities and whether the project plan sheets would provide sufficient detail to accurately reflect project-specific requirements. The use of lump sum bidding would require an improvement in the accuracy of construction plans, and contractors may be unwilling to bid for some items using this process.

The results of the time study demonstrated that there would be some time savings for the field inspector on lump sum projects since they would not be required to track quantities. The focus of inspectors would shift instead to quality control and quality assurance, requiring new guidance and training from MnDOT.

The electronic survey found that MnDOT staff believes that transitioning to a lump sum bidding process would require less time to quantify materials and perform clerical work, and allow more time for inspection work.

What's Next?

Researchers recommend a side-by-side cost comparison of lump sum and unit pricing for similar projects as well as a more comprehensive study of how inspectors use their time. MnDOT has instituted a lump sum committee, which is determining the next steps for implementing lump sum contracting on smaller pilot projects.

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2012-17TS
Published September 2012

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LRRB PROJECT COST:
$25,000

The SMC requires that even materials such as guardrails be tested in the laboratory, which can be an unnecessary expense for smaller projects.

MINNESOTA DEPARTMENT OF TRANSPORTATION

RESEARCH SERVICES
OFFICE OF POLICY ANALYSIS, RESEARCH & INNOVATION

Reduced Materials Testing Requirements for Low-Volume Road Projects

What Was the Need?

To ensure the performance and longevity of Minnesota highways, MnDOT requires that samples of materials used in highway construction undergo inspection or laboratory testing. The minimum sampling and testing required for these materials is described in MnDOT's Schedule of Materials Control (SMC).

The Schedule of Materials Control for low-volume roads developed in this project reduces materials testing rates for state-funded local projects, mitigating their costs without compromising quality.

The SMC is used not only for MnDOT projects, but also for projects by city and county agencies that have received funds for construction under the State Aid for Local Transportation (SALT) program. However, local projects are usually smaller in scope and involve roads with much lower traffic volumes than the state highways for which SMC requirements were designed. Consequently, the SMC might call for more testing than is necessary for projects on low-volume roads, leading to significant unnecessary costs for local agencies. Research was needed to review the applicability of SMC requirements to SALT projects.

What Was Our Goal?

The objective of this project was to review existing SMC requirements in order to establish reduced materials testing rates for low-volume road projects without an unacceptable increase in risk and to create draft SMC specifications specifically tailored to SALT projects.

What Did We Do?

In November 2010, researchers conducted an online survey and an identical paper-and-pencil survey of field inspectors, project engineers and contractors about the SMC for low-volume roads. Of the total respondents to the online survey and paper survey, 33 were field inspectors, 56 were project engineers and eight were contractors.

Researchers then reviewed the MnDOT Office of Audit's annual audit of material control practices from June 2008 to June 2009. They also reviewed the pass-fail rates and costs of testing for several material items to evaluate the risk associated with changing various materials testing requirements. The source of this data was MnDOT's Lab Information Management System program.

What Did We Learn?

Survey results suggested that the MnDOT SMC can be impractical for the kinds of smaller projects conducted under SALT. Respondents noted that some results from currently required testing may take longer to get back from the lab than it takes to complete some smaller construction projects, making the results unusable. Respondents also expressed frustration at the redundancy of requiring inspections and testing for products that come from certified, qualified or approved sources. Further, it may take a long time to inspect materials that are low cost and low risk, making little sense from a cost-benefit perspective. For this reason, many survey respondents would skip testing in the least critical categories of erosion control and landscaping if regulations allowed. However, mainline paving and structural concrete items were viewed as critical and in need of continued inspection.

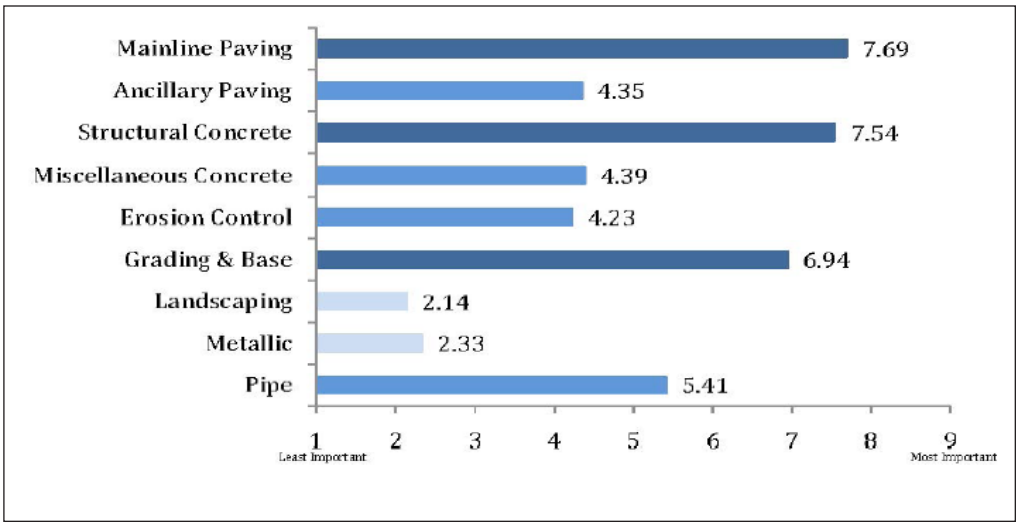
continued

"An MnDOT project might have hundreds of thousands of dollars in tree plantings where a city project might have a few thousand. The question was whether it made sense for such smaller projects to conduct testing that is more costly than it would be to replace the materials being tested."

—Joe MacPherson,
MnDOT State Aid Construction Engineer

"This project will lower costs for local agencies without a decline in service to the public."

—Brian Wasserman,
Assistant Professor, Minnesota State University, Mankato Department of Construction Management



Survey respondents thought landscaping and metallic materials (including guardrails) to be least in need of inspection, while mainline paving, structural concrete, and grading and base ranked highest in need of inspection.

Review of the audit of material control practices showed that nine MnDOT Trunk Highway projects and nine local agency projects were audited. Results of the audit indicate that MnDOT and SALT substantially complied with applicable project requirements. The audit recommended that SALT implement a plan to ensure cities and counties follow the MnDOT SMC, making clear the need either to follow published SMC guidelines or change them.

A review of materials testing pass-fail rates revealed that the asphalt cement failure rate was less than 1 percent and the emulsion failure rate was 1.8 percent, with the cost for repair or replacement substantially less than the costs incurred by mandating testing of asphalt cement across all local projects. The total costs associated with SMC testing guidelines for these categories were more than $146,000 in 2010.

These results confirm that the smaller project scope and shorter timeline of SALT projects warrant a different set of guidelines than the current SMC. Researchers developed a new SALT SMC for low-volume roads tailored specifically to the construction project risks encountered by local agencies. These guidelines incorporate feedback from MnDOT, local agency representatives and the construction industry, and include changes that remove some testing and inspection requirements and make others less stringent.

What's Next?

The SALT SMC for low-volume roads is currently applicable to state-funded local projects, but not to projects that are federally funded or in the state trunk right of way. MnDOT will continue to evaluate the effectiveness of the new SMC to verify that there is no decline in service to the public, and eventually consider extending it to all state and federally funded projects. As technologies change, the document will continue to evolve with input from county and city representatives and MnDOT's materials laboratory.

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This Technical Summary pertains to the LRRB-produced Report 2012-17, "Material Testing Rates for Low-Volume Roads," published June 2012. The full report can be accessed at http://www.lrrb.org/PDF/201217.pdf.

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PROJECT COST:
$44,369

Self-cementing materials such as fly ash are mixed into subgrade soils to strengthen and stiffen them.

Quantifying Subgrade Stabilization's Improvement of Pavement Performance

The results of this project will help engineers design more cost-effective pavements by establishing mechanistic-empirical design parameters for the resilient modulus of underlying soils that have been stabilized with various materials.

What Was the Need?

To help improve the constructability and performance of Minnesota's roads, MnDOT often uses stabilizing materials to increase the strength and stiffness of the subgrade soils supporting the pavement. Typical additives include cement, foamed asphalt, lime and recycled materials such as shredded tires and fly ash, a byproduct of coal-burning plants. These materials facilitate construction and reduce the need for future maintenance.

While the use of these stabilizing materials has become more common in Minnesota, there has been no comprehensive quantification of how well they improve a soil's resilient modulus, a measure of stiffness. Resilient modulus is an important input for mechanistic-empirical design, a method that uses mathematical models to predict pavement performance from the properties of the materials used to construct them, along with other factors such as traffic and weather conditions. Because the effects of stabilization are not well-known, engineers currently use the resilient modulus of unstabilized soil as an input even for stabilized roads, leading to pavements that are thicker and more costly than necessary. Establishing improvement factors for stabilization methods would help to refine this parameter, allowing more cost-effective pavement design.

What Was Our Goal?

The objectives of this project were to investigate methods and materials for stabilizing pavement subgrades and to establish mechanistic-empirical design parameters for the resilient modulus of stabilized roads.

What Did We Do?

Researchers began by conducting a literature review and consulting a technical advisory panel to identify stabilization materials and techniques that have been used by MnDOT and local Minnesota agencies. Then they identified those materials and techniques of greatest utility to MnDOT and local agencies, and reviewed past research projects to evaluate them. This review focused on the design properties of stabilized materials from field and laboratory testing in previous research and included identifying available resilient modulus data for stabilized materials.

Because of variations found in the literature regarding the degree of stiffness improvement resulting from various factors, researchers developed a testing procedure to allow stabilized soils' stiffness values to be obtained on a project-by-project basis. These values can be used in the design phase to optimize pavement design.

What Did We Learn?

Researchers produced a comprehensive list of stabilization materials and techniques, and selected those of particular interest to MnDOT and local agencies, including various combinations of fly ash, cement, lime, gypsum and phosphogypsum, slag, polymers, pond ash, cement kiln dust, foamed asphalt and bitumen, and emulsion.

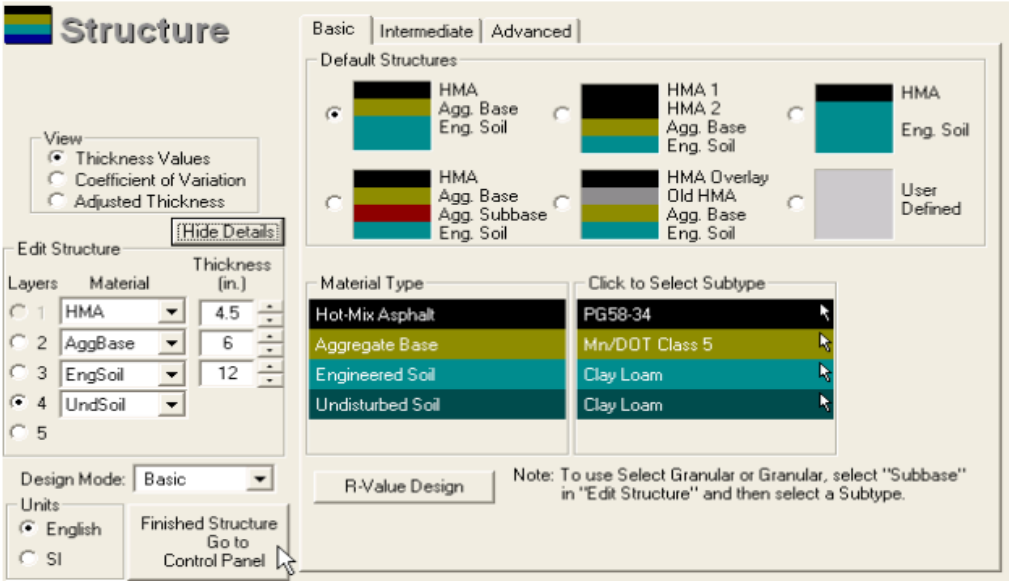
continued

"Establishing resilient modulus improvement factors for stabilized pavements will help in the design of better-performing, more cost-effective roads."

—Shongtao Dai,
Research Operations Engineer, MnDOT Office of Materials

"Currently engineers use parameters for nonstabilized materials when designing stabilized roads, leading to pavements that are more costly than necessary."

—Aaron Budge,
Associate Professor, Minnesota State University, Mankato, Department of Mechanical & Civil Engineering



Using software such as MnPAVE (which predicts the service life of a pavement from climate, traffic and structural data) to determine how stabilization improves pavement stiffness is important to mechanistic-empirical design.

The literature review showed that where data exist, there is a large variability in the degree to which stabilization improves the strength and stiffness of subgrade materials. This is due to variation in the amounts of stabilization material added to soils as well as subgrade properties such as moisture content, stabilization agent content, soil type and other variables.

In light of this variability, researchers considered it impractical to identify one factor of improvement to estimate the stiffness properties for a combination of material and stabilization method. Instead, they recommended that a procedure be followed on a project-by-project basis to identify an appropriate stiffness resistance factor during the course of project predesign and design. For each project, two mix designs should be created to identify the appropriate proportions of soil, water and stabilization material required to obtain the desired strength and stiffness properties: one with untreated subgrade material and the other with stabilized material. The resilient modulus should be established for both the stabilized and unstabilized materials so that a database of local and regional soil types and stabilization methods can be developed. Collecting this data will eventually allow MnDOT to establish a more general set of improvement factors for various stabilization techniques.

To show that the stiffness values obtained from lab testing are achieved in the field, researchers also recommended conducting field tests both during and after construction using the lightweight deflectometer and dynamic cone penetrometer. Long-term tests should also be conducted using the falling weight deflectometer to show how stiffness changes with time and to assist in determining long-term pavement performance.

What's Next?

The developed procedure can be used in the future for MnDOT's mix designs. This will allow MnDOT to improve its pavements by controlling stabilized material quality for subgrades.

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LRRB
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INNOVATION UPDATE

February 2012

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LRRB PROJECT COST:
$40,000

Larger limestone rocks from quarries in southern Minnesota may not need to be crushed as much as once thought necessary for use in road bases.

MINNESOTA DEPARTMENT OF TRANSPORTATION

RESEARCH SERVICES
OFFICE OF POLICY ANALYSIS, RESEARCH & INNOVATION

Research in Progress: Increasing the Gradation of Limestone Aggregate Bases to Increase Road Performance

Using a larger gradation for limestone aggregate bases is not only less expensive than crushing rocks to meet standard specifications, but may also improve the performance of roads and their resistance to freeze-thaw cycles.

What Was the Need?

To perform well, pavements must be constructed over good quality aggregate base layers. MnDOT sets specifications governing the allowable sizes, or gradation, of particles within these aggregates. Aggregates with excessive fine particles will tend to absorb and hold water, which can then damage the road by expanding and contracting during seasonal freezing and thawing, and provide insufficient support during wet periods.

However, MnDOT's current aggregate base specifications are geared toward granular materials obtained from gravel pits. In southern Minnesota, the most prevalent aggregate base material is quarry limestone, consisting of larger rocks that have to be crushed to meet current Class 5 specifications. The crushing effort needed to produce a Class 5 typically results in excessive fines, and this material is susceptible to further fragmentation during the compaction process and degradation beneath the pavement over time. Research was needed to see if the gradation of limestone aggregate bases should be increased to offset degradation during compaction. Using larger particles might not only improve the performance of roads but would require less initial crushing effort, potentially reducing production costs.

To evaluate the use of larger particle sizes in aggregates and other factors in road performance, in 2000 the Local Road Research Board and MnDOT jointly funded INV 767, Investigation of Flexible Pavement Performance in Relation to Aggregate Base and Asphalt Mixture Low-Temp Characteristics. Researchers built test sections for this project using different crushed limestone aggregate base gradations. Because these sections did not develop cracking or other distresses before the project's end in 2005, further study was required for continued monitoring from 2005 to 2010.

What Is Our Goal?

The objective of this project was to perform follow-up performance monitoring of Olmsted County Roads 104 and 117 to evaluate the effect on pavement performance of limestone aggregate base particle size, asphalt binder type and the use of saw-and-seal construction.

What Have We Done?

As part of INV 767, in 2000 researchers constructed six test sections on Olmsted County Roads 104 and 117 near Rochester, Minnesota, using three base materials:

- Standard Class 5, which consists primarily of ¾-inch rocks and smaller particles.
- Class 5 Modified, in which crushing was reduced to yield 2-inch top size.
- Permeable Aggregate Base, or PAB, with 3-inch top size particles.

Researchers also tested the effects on cold temperature cracking of two asphalt binders (PG 5-28 and PG 58-34) and saw-and-seal construction, in which joints are sawed into

continued

"This project suggests that by using larger particle sizes in limestone aggregates, we can both save money on production costs and produce a better quality road base."

—Matthew Lebens,
Research Project Engineer, MnDOT Office of Materials and Road Research

"For very little cost to the LRRB, this project resulted in a successful change in the specification for Class 5 limestone aggregates used in road construction in Olmsted County and southeastern Minnesota."

—Alan Rindels,
Research Development Engineer, MnDOT Research Services

Section 1b using Class 5 aggregate is experiencing worse transverse cracking than other test sections, suggesting that larger aggregate base particles should be used to offset degradation during compaction.

the pavement at regular intervals to allow expansion and contraction as temperatures fluctuate.

Researchers have monitored the test sections regularly since construction and used a variety of methods to measure:

- Layer stiffness, using the falling weight deflectometer.
- Ride quality, rutting, cracking and other forms of distress, using automated and visual pavement distress surveys.
- The effects of traffic loads, by recording traffic volumes and vehicle types.
- The properties of materials used, via laboratory testing.

What Have We Learned?

Performance of test sections has not yet differed significantly enough to form definitive conclusions about the relative quality of the asphalt binders or saw-and-seal construction techniques. However, despite its higher traffic loading than other sections, the non-sawed test section using a Class 5 Modified aggregate base and PG 58-34 binder is performing somewhat better than others.

Recommended Class 5 Modified gradation specification

Sieve Size	Total % Passing
2 inch	100
1½ inch	95-100
¾ inch	65-95
⅜ inch	35-70
#4	15-45
#10	10-30
#40	5-25
#200	3-12

Postcompaction gradation testing of the Class 5 Modified aggregates showed a material that approximates the desired Class 5 gradation specification. After winter freezing, the Class 5 Modified aggregate base also retained more stiffness during the spring thaw and recovered it more quickly than those with the standard Class 5 aggregate. The use of a larger gradation may maximize the effectiveness of load restrictions typically imposed during the spring to prevent heavier vehicles from damaging weaker roads.

These initial results suggest that reduced crushing is a better design procedure for the crushed limestone aggregate bases commonly used in counties in southeastern Minnesota.

What's Next?

Researchers will continue to monitor the test sections as part of a follow-up study (INV 899) expected to conclude in 2015. The tests used in this study will continue, including distress surveys, traffic counts and falling weight deflectometer measurements. Researchers will also add new tests for a more detailed local traffic analysis and the investigation of subgrade soils, allowing for forensic pavement and base material analysis if significant pavement distresses develop during the follow-up study period.

This Innovation Update pertains to LRRB projects INV 767, INV 825 and INV 899. For more information, including the Class 5 Modified crushed limestone base gradation specification developed from this project, contact Michael Sheehan at Sheehan.Michael@co.olmsted.mn.us *or Matthew Lebens at* Matthew.Lebens@state.mn.us.

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RESEARCH SERVICES

OFFICE OF POLICY ANALYSIS, RESEARCH & INNOVATION

INNOVATION UPDATE

February 2012

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American Engineering Testing, Inc.

PROJECT COST:
$17,472

The DOT600 is highly portable, easy to use and efficient.

Research in Progress: Evaluating New Technologies for Soil Moisture Measurement

This project is addressing a pressing need by MnDOT and other DOTs for a soil moisture measurement device that is less labor-intensive and more cost-effective than current methods, and has less regulatory and training constraints than nuclear methods.

What Was the Need?

During road construction, workers use rollers to compact subgrade soils to a density that will adequately support upper pavement layers. Optimizing compaction requires knowing the moisture content of soils and keeping water content as close as possible to the optimum moisture at which a compacted soil will reach its maximum density, which imparts stiffness and strength. To determine this optimum value, engineers typically use a laboratory method called the Proctor compaction test, or AASHTO T99, in which soil samples with varying moisture levels are compacted and measured for density. To compare the moisture content and density of soils in the field to this optimum, MnDOT uses the sand cone test.

However, drying and weighing samples in both of these tests, called the gravimetric method, is labor-intensive and especially inconvenient in the field. Consequently, many state departments of transportation make field measurements using the nuclear density gauge, which determines density by measuring the amount of radiation a material reflects and moisture content by measuring the amount of radiation reflected by the hydrogen atoms in the water molecules of a material.

While the nuclear density gauge is a more convenient field testing method than the sand cone test, its use involves potentially dangerous nuclear materials and numerous regulatory and training constraints. Consequently, MnDOT does not use this device, the FHWA has been trying to phase out its use, and other state DOTs are looking for viable alternatives. One such alternative is the DOT600—a portable soil moisture measurement technology, developed by Campbell Scientific at the request of MnDOT, that can be used in both the laboratory and the field.

What Is Our Goal?

The goal of this project was to compare the accuracy and effectiveness of the DOT600 for measuring soil moisture content to that of existing MnDOT procedures.

What Have We Done?

To operate the DOT600, soil samples are sifted into a cylindrical measurement chamber, compressed by a measured force and weighed. The device determines sample water content by measuring the oscillation frequency of the electromagnetic field created by the wave guides. The oscillation frequency is dependent on the dielectric permittivity of the moist soil in the sample chamber.

Using 270 soil specimens from 62 different soil samples, researchers compared DOT600 measurements to those taken using the standard Proctor laboratory tests. After each DOT600 test, operators also used a pocket penetrometer to measure the consistency of the soil and approximate its unconfined compressive strength. Researchers also documented observations by DOT600 operators on its ease of use.

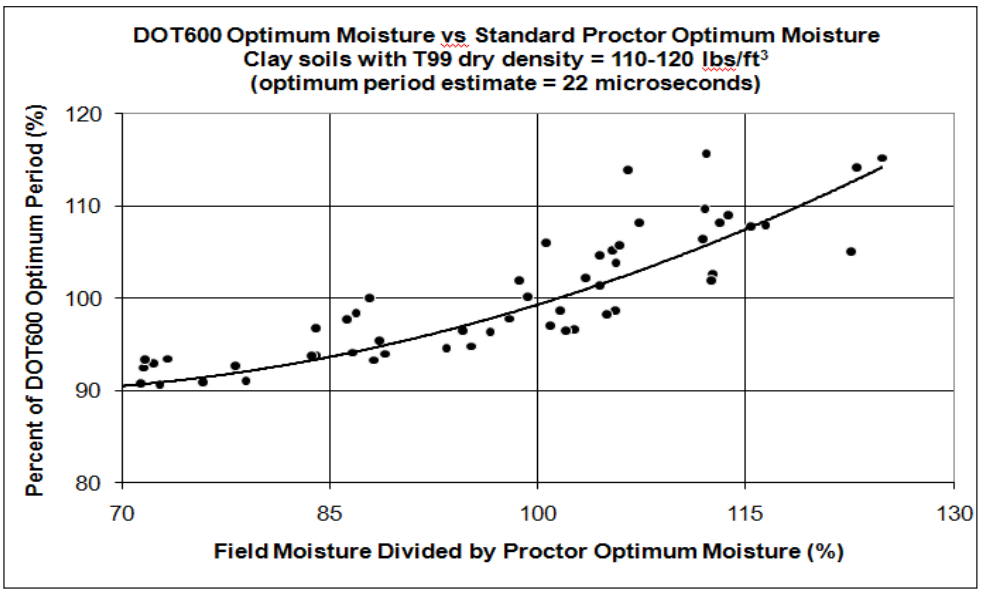
continued

"This project showed that the DOT600 can produce reasonably good measurements over a wide range of Minnesota soil types and is well worth further investigation and investment."

—John Siekmeier,
MnDOT Senior Research Engineer

"The DOT600 has the potential to be a cost-effective replacement not just for the sand cone and nuclear density gauge field tests, but also for the Proctor laboratory test."

—Dan Warzala,
Research Project Coordinator, MnDOT Research Services



The DOT600's measurement of field and optimum soil moisture content using electrical properties (measured as period) may be an accurate and workable replacement for existing methods, which compare field moisture measurements to an optimum gravimetric moisture level determined by the Proctor test.

What Have We Learned?

Results show that the DOT600 has the potential to be a workable and accurate replacement for MnDOT's current methods for measuring soil moisture. Comparisons of optimum moisture content using the DOT600's measurement of electrical properties—expressed as a percentage of the optimum target value for the period—are consistent with current optimum soil moisture content determined by the standard Proctor test.

Also, where the optimum gravimetric moisture value determined by the Proctor test varies considerably between soil types, the DOT600's optimum period seems far less variable. DOT600 results also correlate well to lightweight deflectometer deflections (a measure of soil stiffness) and suction (a measure of the energy state of soil water via the molecular forces that hold water molecules in the pores between soil particles).

With further development to make it rugged enough for regular field use, the DOT600 could meet a pressing need by MnDOT and other DOTs for a soil moisture measurement device that is less labor-intensive than the sand cone and Proctor tests but safer than the nuclear density gauge. State DOTs nationwide are actively looking for such a solution.

What's Next?

In a second phase of this project, MnDOT will continue to evaluate the DOT600 as well as other technologies for measuring soil moisture, including a heat dissipation sensor and a water potential meter. Researchers will develop draft specifications for using these methods; describe their advantages and disadvantages; and evaluate their accuracy, precision, cost, rapidity and ruggedness during field operations.

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This Innovation Update pertains to MnDOT project 2010-030, "Validation of DOT600 Soil Moisture Device," whose first phase was completed in July 2011. For more information about this project, contact John Siekmeier at John.Siekmeier@state.mn.us.

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TRANSPORTATION POOLED FUND PROGRAM

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TOTAL STATE CONTRIBUTIONS TO DATE:
$200,000

MnDOT CONTRIBUTIONS TO DATE:
$37,500

PARTICIPATING STATES:
IA, MI, MN, ND, NY, WI plus FHWA

One of TERRA's missions is to broaden the use of MnROAD, Minnesota's state-of-the-art pavement research facility consisting of two road segments next to I-94.

RESEARCH SERVICES

OFFICE OF POLICY ANALYSIS, RESEARCH & INNOVATION

Pooling Our Research: The Transportation Engineering and Road Research Alliance

Why a Pooled Fund Study?

To ensure a strong transportation network, MnDOT invests heavily in pavement research and innovation. A major portion of this investment is directed to MnROAD, Minnesota's state-of-the-art outdoor pavement research facility distinguished by its network of electronic sensors embedded in six miles of test pavements. MnROAD includes a 3.5-mile mainline consisting of a working interstate freeway carrying more than 26,000 vehicles a day; a low-volume, 2.6-mile closed loop where controlled vehicle weights and traffic volumes simulate rural road conditions; and a short farm-loop test track, which represents a typical low-volume rural road.

To broaden MnROAD's unique capabilities and to make it a regional, national and international resource, in 2004 MnDOT spearheaded the development of the Transportation Engineering and Road Research Alliance (TERRA). TERRA is a collaboration of MnDOT and several other states that brings together government, industry and academia in a dynamic partnership to advance innovations in road engineering and construction.

TPF-5(215): The Transportation Engineering and Road Research Alliance. *TERRA works to put research results into practice and supports MnROAD, where pavement research has saved Minnesota taxpayers $33 million or more per year and taxpayers nationwide $750 million.*

What is the Pooled Fund Study's Goal?

TERRA's mission is to:

- Develop, sustain and communicate a comprehensive program of research about pavement, materials and related transportation engineering challenges, including issues related to cold climates.
- Provide a network for collaboration and information sharing between industry, academia and public agencies.
- Expand entrepreneurial use of the capacity and capabilities of the MnROAD facility by pursuing opportunities to serve a broader research community.

What Have We Learned?

TERRA has sponsored numerous projects in such areas as construction, low-volume roads, pavement design and sustainability, and communicates lessons learned through its website and in fact sheets about various topics. Completed projects include:

- MnROAD Lessons Learned, which reviewed projects from MnROAD's first 10 years of operation involving more than 50 interviews; 300 published and unpublished reports, papers and briefs; and an online survey of pavement professionals.
- Pervious Concrete Pavement Study, which evaluated the performance of pervious concrete pavements in Minnesota's cold weather climate. Researchers constructed test cells on MnROAD's low-volume road and monitored their response to the environment. Results have shown that with regular maintenance, pervious concrete can provide many benefits in addition to stormwater management and reduced runoff, including a quieter ride.
- Field Investigation of Highway Base Material Stabilized with High Carbon Fly Ash, which examined the use of high carbon fly ash to increase strength and stiffness of

continued

"TERRA has had a dramatic effect on MnDOT's approach to research, increasing its focus on finding partners and existing solutions before commencing projects."

—Maureen Jensen,
Road Research Engineer, MnDOT Office of Materials

"By bringing partners together to collaborate on transportation research problems, TERRA both gives MnDOT a broader perspective and keeps it focused on results and implementation."

—Deb Fick,
Research SP&R Administrator, MnDOT Research Services

Using test cells in a TERRA-sponsored project on MnROAD provides a unique opportunity to monitor the environmental and load responses of thin unbonded concrete overlays.

pavement base layers consisting of recycled pavement materials and crushed stone. Results showed that fly ash significantly increased the resilient modulus of base materials.

What's Going On Now?

There are more than 25 ongoing projects planned and initiated through TERRA. Current projects of particular importance to MnDOT include:

- Performance of Thin Unbonded Concrete Overlays on High-Volume Roads, a five-year study to test the performance of thinner unbonded concrete overlays subject to interstate traffic and Minnesota's extreme climate. Two overlays were successfully constructed on MnROAD and on Trunk Highway 53 near Duluth, Minnesota, and are being monitored for their performance. These projects could lead to reductions in overlay thickness by nearly half compared to conventional designs.
- Investigation of Low Temperature Cracking in Asphalt Pavements–Phase II, a completed pooled fund study that evaluated different laboratory procedures, material properties and pavement features important for optimal selection of low temperature crack resistant materials. The project monitored two sections at MnROAD to validate Phase I development of a fracture mechanics-based specification for asphalt binders and mixtures that better resist crack formation and propagation.
- Permeable HMA Pavement Performance in Cold Regions, a completed project that evaluated the durability, hydrologic characteristics and environmental effects of porous asphalt pavement when used on a low-volume roadway in a cold climate. A fully instrumented MnROAD low-volume road test section was monitored for pavement performance and stormwater runoff volume and quality. Researchers also documented appropriate construction and maintenance procedures.

What's Next?

TERRA regularly hosts events such as recent webinars on chip sealing and HMA pavement warranties, and the TERRA Innovation Series, which shares findings from TERRA-sponsored studies. TERRA's 17th annual pavement conference will be held in February 2013 in St. Paul, Minnesota. TERRA will also continue to conduct regular board and committee meetings, screen potential research projects, seek partners, and communicate and disseminate research results. In the last few years TERRA has grown significantly and will increase its focus on research and implementation as it looks ahead to the next phase of MnROAD, which will begin in 2016.

This Technical Summary pertains to the ongoing Pooled Fund TPF-5(215), Transportation Engineering and Road Research Alliance. Details of this effort can be found at http://www.pooledfund.org/Details/Study/443. *More information is available at* http://www.terraroadalliance.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.

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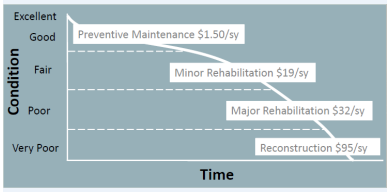
LRRB PROJECT COST:
$27,608



Preventive maintenance of trails while conditions are still good is far more cost-effective than waiting until rehabilitation or reconstruction is required.

MINNESOTA DEPARTMENT OF TRANSPORTATION

RESEARCH SERVICES
OFFICE OF POLICY ANALYSIS, RESEARCH & INNOVATION

Maintaining Recreational Trails

What Was the Need?

Minnesota's 25,000 miles of recreational trails provide Minnesotans with exercise and recreation opportunities critical to their quality of life. These trails also improve the economies of nearby communities by increasing property values, attracting tourists and encouraging the purchase of bicycles and other equipment.

For the last 20 years, most funding for recreational trails has been dedicated to construction rather than maintenance. Regular maintenance is important, and not just for trail preservation and the safety and enjoyment of users. It is also a requirement for federally funded trails and far more cost-effective in the long run than waiting to rehabilitate or reconstruct trails once their condition has become poor.

The workshop developed in this project will assist staff in establishing programs for the regular maintenance of recreational trails, which is far more cost-effective than rehabilitation and will help ensure the safety and enjoyment of trail users in Minnesota.

As the number of trail miles has expanded and the use of recreational trails increased, it has been difficult for local agencies to maintain them with limited funding. This is made more feasible when trail managers carefully budget and plan for the regular maintenance of trail systems. A training workshop was needed to help managers develop maintenance programs.

What Was Our Goal?

The objective of this project was to create a PowerPoint presentation-based workshop summarizing best practices for preserving recreational trails. The scope of the project widened from a focus on pavement preventive maintenance techniques to include preservation of trail features such as vegetation, pavement, benches and lighting.

What Did We Implement?

This project implements LRRB Investigation 876, Best Practices for Preventative Maintenance Treatments for Recreational Trails, which evaluated the effectiveness of using available pavement preventive maintenance techniques—including various surface sealing and crack treatments—for recreational trails. Investigators applied these treatments to several trails in Minnesota and compared them to untreated sections with regard to permeability and surface texture. Results showed that all of the treatments reduced permeability, while fog seals also consistently provided a high-quality surface for trail users.

How Did We Do It?

Investigators created workshop materials by adapting the implemented manual on preventive maintenance treatments for recreational trails and by conducting a literature review on corridor management strategies. With the input of an advisory panel of experts from MnDOT, cities and counties, the project team then refined the workshop presentation, which summarizes findings and provides assistance to agencies for developing a trail maintenance program. The investigators also created a maintenance schedule and checklist for use by agencies in managing a typical paved trail.

What Was the Impact?

The workshop developed in this project focuses primarily on the management and maintenance of the trail pavement, but also includes other elements such as vegetation, drainage, signing, striping, lighting and amenities. Presentation topics include:

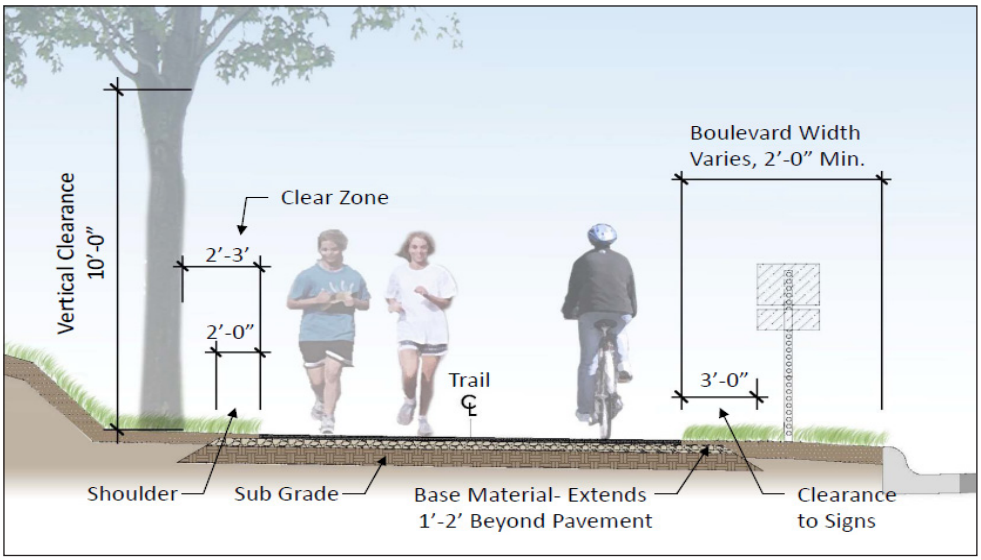
continued

"This comprehensive workshop not only will help the staff that maintains trails, but will also assist managers in tracking assets and establishing budgets for trail maintenance."

—Walter Leu,
District State Aid Engineer, MnDOT

"Nationally there is a push to include more trails in transportation infrastructure to accommodate pedestrians and bicyclists. This project will help Minnesota agencies manage the increasing number of these trails."

—Mike Marti,
Principal, SRF Consulting Group, Inc.



Recreational trails include a variety of elements that require maintenance, including vegetation, signage and the trail pavement itself.

- **Operational maintenance activities**, including the optimal frequency of various activities such as safety inspections and trash pickup, pavement maintenance, vegetation mowing, trimming and other maintenance, and drainage system repair. Included is an inspection template with a list of inspection items.
- **Trail pavement management**, including information about the pavement life cycle and causes of pavement failure such as damage caused by water and sunlight, traffic and improper construction. Also covered are typical trail pavement failure types and treatments, including cracking and crack sealing; surface deterioration and treatments such as fog sealing, seal coating, slurry sealing, micro surfacing and overlays; and potholes and depressions along with patching.
- **Asset management**, which is helpful in identifying and prioritizing maintenance needs, projecting current and future maintenance costs and making efficient use of resources. This section covers asset management software and data types, such as section identification, construction, maintenance and rehabilitation history, pavement characteristics and pavement conditions.
- **How to build a trail maintenance schedule**, which shows how to build a maintenance schedule based on industry estimates of pavement life spans, trail usage and level of service, and ongoing monitoring. This section also steps the audience through the use of the schedule and checklist created for agency use.

What's Next?

In March 2012, investigators presented this workshop in three Minnesota locations via the Minnesota Local Technical Assistance Program. The workshop has also been featured in several articles and presentations, and will be presented at the Fall 2012 American Public Works Association conference and other meetings. Investigators recommend keeping the workshop materials current as new technologies relevant to trail maintenance are introduced.

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This Technical Summary pertains to the LRRB-produced Report 2011RIC05, "Maintenance of Recreational Trails," published November 2011. The full report can be accessed at http://www.lrrb.org/PDF/2011RIC05.pdf. *For information about the LTAP course, see* http://www.mnltap.umn.edu/training/topic/maintenance/trails.

The research being implemented via this project can be found mainly in the LRRB-produced Report 2009-25, "Preventative Maintenance for Recreational Trails," published July 2009. This report can be accessed at http://www.lrrb.org/PDF/200925.pdf.

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PROJECT COST:
$179,752

Most U.S. commercial freight is transported by heavy trucks, which because of their weight have a greater effect on transportation infrastructure than passenger vehicles and light trucks.

Determining Equitable Vehicle Taxes and Fees Based on Costs to Highway Infrastructure

By conducting highway cost allocation (HCA) studies and improving HCA methodologies, MnDOT helps ensure that vehicle owners of all classes are being fairly assessed through taxes and permit fees for their relative contribution to the costs of state highway construction and maintenance.

What Was the Need?

MnDOT periodically carries out a highway cost allocation (HCA) study to estimate the relative contribution of different classes of vehicles to the costs of building and maintaining the state's highway system. An HCA study also estimates revenues generated by each vehicle class from state fuel and excise taxes and from overweight permit fees. Although fuel taxes and permit fees are determined by the state Legislature, calculation of the cost-to-revenue ratio helps inform MnDOT if changes to current policy could be justified.

MnDOT had not conducted an HCA study in 20 years, and a 2006 truck size and weight study commissioned by MnDOT suggested a need to develop a closer link between overweight permit fees and actual highway maintenance and construction costs. Research was needed to evaluate the pros and cons of different HCA methods and to develop a methodology best suited for conditions in Minnesota.

What Was Our Goal?

The objective of this project was to evaluate HCA methodologies, use this evaluation to customize the Federal Highway Administration's (FHWA's) HCA tool for Minnesota purposes and perform HCA studies using both the FHWA tool and the Minnesota-centric tools. Researchers also evaluated the best tax structures for equitably collecting revenue and a method for optimizing the pricing of heavy vehicle special permits.

What Did We Do?

Researchers began by conducting an HCA study using MnDOT data collected between July 2003 and June 2007, determining the costs and revenues attributed to various classes of vehicles. This study was conducted using a generalized HCA study tool created by the FHWA and took into account costs associated with repairing or replacing asphalt and concrete pavements, bridges, grading and drainage structures as well as other types of construction and maintenance.

Researchers also evaluated several taxing methodologies for their equity and efficiency. Equity is concerned with the distribution of benefits and costs to individuals based either on their road usage or on their socioeconomic status. Efficiency is concerned with determining the right pricing mechanisms for special freight permits based on industry demand.

Using the results of this evaluation, researchers developed the Minnesota Highway Cost Allocation Tool, a version of the FHWA's HCA tool that is customized to be consistent with Minnesota's tax structure and data formats. Researchers also developed and tested an auction-based permit system by which a state transportation agency such as MnDOT could learn the demand for special permits and freight companies' willingness to pay for them.

continued

"This project is one step in an ongoing effort by MnDOT to determine the best way to pay for the future maintenance and construction of Minnesota's highways."

—John Tompkins,
Freight Project Manager, Research and MFAC Coordinator, MnDOT Office of Freight and Commercial Vehicle Operations

"This study allowed MnDOT to identify the pros and cons of different HCA methods, forming the framework for further refining MnDOT's methodology in a second phase of this project."

—Dan Warzala,
Research Project Coordinator, MnDOT Research Services

HPMS Class	FHWA Class	Description	VMT (10^6)
AUTO	2	Automobiles	35620
LT4	3	Light trucks with 2 axles and 4 tires	17277
SU2	5	Single unit, 2-axle 6 tires trucks	1278
SU3	6	Single unit, 3-axle trucks	397
SU4	7	Single unit, 4-or-more-axle trucks	120
CB34	8	Tractor-semitrailer / truck-trailer combinations with 3 or 4 axles	215
CB5	9	Tractor-semitrailer / truck-trailer combinations with 5 axles	1888
CB6	10	Tractor-semitrailer / truck-trailer combinations with 6 or more axles	382
DS5	11	Tractor-double semitrailer combinations with 5 axles	33
DS6	12	Tractor-double semitrailer combinations with 6 axles	7
DS7+	13	Tractor-double semitrailer combinations with 7 or more axles	10
BUS	4	Buses (all types)	155

Minnesota has 12 vehicle classes (not including motorcycles), defined generally by the vehicle's size, number of axles and number of tires. In this study, class CB5—the most commonly used type of heavy truck—had the worst revenue-to-cost ratio, responsible for 17.48 percent of costs but only 12.17 percent of revenue.

What Did We Learn?

Using the FHWA's HCA tool, researchers found that heavy vehicle users are contributing a smaller share of highway revenues than their impact on highway costs would require. Passenger cars and light trucks contribute 81 percent of revenue but are responsible for only 63 percent of MnDOT highway construction and maintenance expenditures. By comparison, one class of heavy trucks contributed only 8 percent of revenue but was responsible for 21 percent of expenditures. The final report includes a calculation of the revenue-to-cost ratio for each vehicle class.

The evaluation of various tax scenarios showed that increasing overweight fees or diesel taxes on vehicles greater than 16,000 pounds by 25 percent had only a small impact on equity for highway users. However, assessing weight-distance fees on vehicles weighing more than 57,000 pounds could significantly improve tax equity. Weight-distance fees charge commercial vehicles a per-mile rate based on their travel distance, registration weight and axle configuration.

The Minnesota-centric HCA tool developed by researchers improves on the FHWA tool's outdated default parameters and inability to allocate external costs. Researchers recalculated revenue-to-cost ratios for each vehicle class using the Minnesota-centric tool and included a chart comparing these ratios to those calculated using the FHWA tool. These ratios are not equitable between vehicle classes because taxes are not currently collected based on actual road usage, while costs are heavily affected by vehicle miles traveled.

Tests of an auction-based system for the sale of special permits for heavy vehicles showed that a recommended mechanism is easy to implement and would allow MnDOT to learn how much road users would be willing to pay for such permits, resulting in more revenue.

What's Next?

A second phase of this project will continue to develop HCA methods and apply them to MnDOT data. MnDOT is planning to schedule information sessions with users to get feedback about project recommendations, including the use of weight-distance fees and the auction-based system for special permit sales.

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This Technical Summary pertains to Report 2012-14, "Highway Cost Allocation and Determination of Heavy Freight Truck Permit Fees," published July 2012. The full report can be accessed at http://www.lrrb.org/PDF/201214.pdf.

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PROJECT COST:
$100,000

The models developed in this study will help MnDOT determine how to prioritize its investments in transit and highway infrastructure to maximize accessibility.

Evaluating the Effects of Land Use and Transportation Infrastructure on Twin Cities Accessibility

This project will help MnDOT prioritize its transportation infrastructure investments and land use strategies to maximize accessibility, producing the greatest benefit per taxpayer dollar for Minnesota travelers.

What Was the Need?

A key goal of planning is accessibility, or the ability of travelers to reach their desired destination within a reasonable amount of time. Accessibility depends both on the efficiency of a city's transportation network and on its land use: the location of buildings for commercial, residential and other uses. Transportation and land use are interdependent, and understanding their relationship is important to planning transportation facilities and zoning.

Despite this interdependence, land use and transportation planning are typically conducted independently. The latter is often focused on improving congestion measures such as mobility and reliability without taking into account the effects on land use. Focusing on mobility may result in plans that favor the decentralization of populations from the inner city to the suburbs and may be automobile-centric, reducing options for people using other modes of transportation.

Since 2006 researchers at the University of Minnesota have been working with MnDOT and other Minnesota organizations on a line of research called Access to Destinations to remedy this problem and develop accessibility measures for use in transportation planning. A recent study under the umbrella of this effort uses accessibility as a performance measure to evaluate various combinations of land use and transportation plans for Minnesota's Twin Cities metropolitan area.

What Was Our Goal?

The objective of this study was to evaluate how accessibility in the Twin Cities region would be affected by various changes in land use (including population and employment trends) and the transportation network (due to proposed highway infrastructure improvements and public transit investments).

What Did We Do?

Researchers analyzed 60 different model runs combining six land use scenarios with 10 transportation network scenarios involving both highway and transit.

Land use scenarios involved different assumptions about the distribution in population and employment growth, specifically how centralized they are expected to be within the Interstate 494/694 Beltway. These also included a baseline scenario reflecting existing land use in 2010, and a 2030 scenario reflecting decentralized growth predicted by the Twin Cities Metropolitan Council.

Highway network scenarios made different assumptions about the use of high occupancy toll (HOT) lanes and congestion pricing. These also included a free-flow scenario assuming no congestion, a 2010 scenario reflecting existing conditions and a 2030 scenario reflecting mostly decentralized network improvements planned by the Metropolitan Council. Transit scenarios made different assumptions about the use of streetcars and rapid transit, and included 2010 and 2030 scenarios.

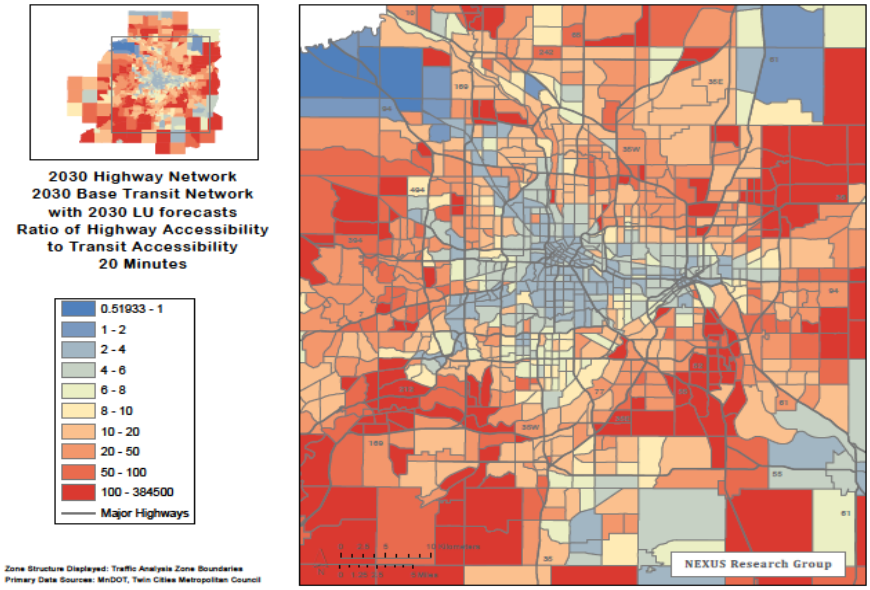
continued

"The product developed by this project will be an excellent tool for analysis, communications and policy development, and will help promote multimodal transportation practices that accommodate the diverse needs of all communities."

—Brian Gage,
MnDOT Access Management Coordinator

"Transportation and land use are interdependent, and understanding their relationship is critical to planning investments in transportation infrastructure."

—David Levinson,
Associate Professor, University of Minnesota Department of Civil Engineering



Researchers compared the accessibility of destinations by transit and highway for a scenario reflecting planned improvements by the Twin Cities Metropolitan Council. Some destinations were just or nearly as accessible by transit as by highway (bluer areas), but others were far less accessible (redder areas).

For each scenario, researchers calculated travel time using computer models to simulate highway and transit networks. Then they calculated each scenario's accessibility, defined as the sum of destinations reachable within a certain time threshold.

What Did We Learn?

Results showed that centralized growth in population and employment produced the highest accessibility, followed by centralized population and decentralized employment. Depending on the network configuration, fully centralized growth produced about 20 percent to 25 percent more accessibility than the forecast for 2030.

Of the highway scenarios, free-flowing highway networks had the highest accessibility, with 20 percent more accessibility than the forecast for 2030. The second most accessible were HOT lane scenarios, with congestion pricing not far behind.

Transit accessibility was about twice as high for the fully centralized as for the fully decentralized scenarios, illustrating that transit networks are significantly better at connecting people to jobs at higher densities. Similarly, transit scenarios that improved speeds in the central cities had more of an effect on systemwide accessibility than those that expanded service areas.

While the combination of centralized population and employment with a free-flowing highway network maximizes accessibility, it is likely not cost-effective or feasible with current technologies, and counters trends of increasingly decentralized population and employment. If these trends continue, an investment in congestion pricing or HOT lanes might be best. On the other hand, decentralized development renders the transit system ineffective and reduces the effectiveness of the highway system to connect people to jobs. A concentrated effort for higher densities and infill development in the central cities would most benefit accessibility.

What's Next?

MnDOT will use the methods developed in this study to further examine the accessibility of more specific scenarios, allowing it to prioritize transportation network and land use strategies based on how much accessibility they provide per unit dollar.

This Technical Summary pertains to Report 2012-05, "Using Twin Cities Destinations and Their Accessibility as a Multimodal Planning Tool," published February 2012. The full report can be accessed at www.dot.state.mn.us/research/TS/2012/201205.pdf. *More information about the Access to Destinations effort can be found at* www.cts.umn.edu/access-study.

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TRANSPORTATION POOLED FUND PROGRAM

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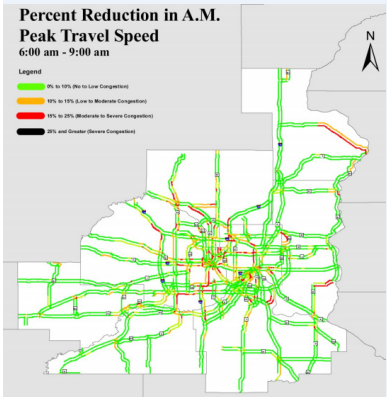
TOTAL STATE CONTRIBUTIONS TO DATE (SPR-3(049), TFP-5(198)):
$1,580,000

MnDOT CONTRIBUTIONS TO DATE:
$165,000

PARTICIPATING STATES:
CA, CO, FL, KY, MD, MN, NY, OH, OR, TX, VA, WA



The 2011 Urban Mobility Study documented congestion in Minnesota, including the Twin Cities.

RESEARCH SERVICES

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Pooling Our Research: Urban Mobility Study

Why a Pooled Fund Study?

In 2010, traffic congestion in the United States caused a waste of 1.9 billion gallons of gas and 4.8 billion hours of commuters' time. Congestion's inflation-adjusted costs have risen from $21 billion in 1982 to $101 billion in 2010, with the average cost per commuter rising from $310 to $710. To address this problem, MnDOT and other agencies typically develop programs to alleviate congestion within transportation systems by implementing cost-effective reliability and capacity strategies. This can include providing more mobility options such as public transit.

Finding the right improvements requires that their effects on congestion be accurately measured. Measurement in turn requires not only collecting traffic data using roadside sensors, but establishing the right performance measures, which can vary depending on the goals of travelers and agencies. Average travel time between two points is typically important to travelers, but so are cost and reliability.

TPF-5(198): Urban Mobility Study. By evaluating mobility performance measures and developing new sources of mobility data, this study helps MnDOT and other organizations develop cost-effective congestion mitigation measures to help address both travel time and public safety issues.

To help develop such performance measures and to collect and analyze the nation's urban congestion data in the most accurate and comprehensive way possible, in 1982 the Texas Transportation Institute established the Urban Mobility Study. In 1997, the study became a pooled fund effort involving a combination of state departments of transportation, metropolitan planning organizations and the Federal Highway Administration.

What is the Pooled Fund Study's Goal?

The study focuses on developing tools to monitor and evaluate urban congestion by identifying and evaluating the latest mobility data sources, developing and communicating comprehensive performance measures for congestion improvements and helping member agencies apply the study's research products to their congestion planning.

What Have We Learned?

The Urban Mobility Study is nationally recognized as the leading resource for traffic congestion research. Its database has for the most part relied on historical public data and public agency sources, but in 2010 the study dramatically increased the accuracy and comprehensiveness of its congestion estimates by adding data from INRIX, a private sector company that collects traffic information from GPS-enabled vehicles and mobile devices in every major U.S. metropolitan area.

Over the years, the study has used such data, along with increasingly descriptive and relevant performance measures, to produce and update numerous resources, including:

- The Urban Mobility Report, which has been published periodically since 1984 to provide users with information about congestion problems and historical trends nationwide. The 2010 report was the first to use INRIX data, which allowed it to show trends from 1982 to 2009 for all of the United States' 439 urban areas.
- The Keys to Estimating Mobility in Urban Areas, which outlines important mobility measurement concepts.

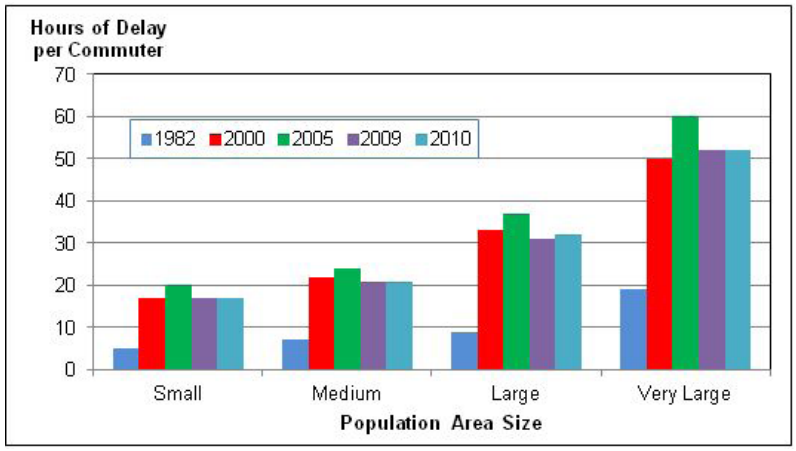
continued

"MnDOT's participation in the pooled fund study has resulted in significant benefits to the agency's efforts to measure, monitor and communicate the performance of the transportation system in a multimodal manner."

—Paul Czech
Planning Director,
MnDOT Metro District

"The use of private sector mobility data from GPS-enabled devices has allowed us to develop a more comprehensive assessment of urban mobility than ever before, giving agencies the information they need to choose the right mix of congestion mitigation measures."

—Tim Lomax
Senior Research Engineer,
Texas Transportation Institute Mobility Analysis Program



Study data shows that congestion impacts large and small cities, leading to 34 extra hours of commute time for the average urban automobile commuter in 2010. This data also reflects the economic recession; congestion will likely return to growth patterns seen in prior years when the recession abates.

- Twin Cities Metropolitan and MN Statewide IRC Arterial Travel Time Analysis: Use of Private Sector Traffic Speed Data, which demonstrated that private sector speed data can be a cost-effective way for monitoring and reporting mobility performance on MnDOT's statewide network.

The study has also recently focused on developing new performance measures for freight travel and for arterial surface streets, where mobility is harder to estimate than on instrumented freeways.

What's Going On Now?

The Urban Mobility Study is continuing to analyze the quality of emerging mobility data, including private sector sources for GPS, Bluetooth-enabled and other mobile devices; examining how the land use policies of state DOTs and metropolitan planning organizations affect congestion; evaluating affordable devices for collecting transportation data by their unit cost, life-cycle cost and effectiveness; and examining ways to communicate the benefits provided by non-capacity and short-term, lower cost projects, such as active traffic management and access management.

What's Next?

Moving forward, the Urban Mobility Study will continue to focus on its core missions of evaluating new sources of mobility data, refining performance measures and supporting member agencies. Other efforts under consideration include:

- Developing a tool for estimating greenhouse gas benefits for roadway improvements by correlating portable emissions measurement data with speed and start-stop traffic data.
- Refining the performance measure for total travel time, which will help in calculating the mobility benefits of biking, walking and working at home.
- Evaluating the use of private sector speed data to determine what speeds should be used to represent freely flowing traffic on arterial streets, analyze issues for off-peak and weekend congestion analyses, and determine how to get reliable measures from historical archived speed data.

This Technical Summary pertains to the ongoing Pooled Fund TPF-5(198), Urban Mobility Study Pooled Fund, continuing the project initiated under SPR-3(049). Details of this effort can be found at http://www.pooledfund.org/Details/Study/424, http://www.pooledfund.org/Details/Study/200 *and* http://mobility.tamu.edu/ums/.

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.

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IMPLEMENTATION PROJECT COST:
$61,272

Traffic signal confirmation lights help reduce red light running by making enforcement easier.

MINNESOTA DEPARTMENT OF TRANSPORTATION

RESEARCH SERVICES
OFFICE OF POLICY ANALYSIS, RESEARCH & INNOVATION

Putting Research into Practice: Safety Strategies for Local Agencies

What Was the Need?

In the last several years, MnDOT has implemented a range of safety strategies aimed at reducing traffic fatalities on state highways as part of the state's Toward Zero Deaths initiative. Since about half of the state's traffic deaths occur on county roads and county state-aid highways, MnDOT recognized the need to implement safety programs at the local level as well. The department undertook a comprehensive effort to assist counties with their safety planning efforts, funding the development of County Roadway Safety Plans for each of the state's 87 counties.

The guidebook is unique nationally in its targeted approach to helping local agencies implement safety best practices and policies that are consistent with national and state guidance.

In these risk-based assessments, consultants analyzed each county's roadway system, identifying at-risk locations and recommending high-priority, low-cost safety improvements. County engineers needed documentation of best practices and policies related to the high-priority safety strategies to assist them in their safety planning, safety project development and risk management efforts.

What Was Our Goal?

This project's objective was to create a guidebook for local agencies that describes best practices for implementing 15 high-priority highway safety strategies and provides sample policy language for each strategy. The guide was designed to serve as a resource for counties and municipalities as they work to reduce the number of severe crashes on their roads and highways.

What Did We Implement?

Investigators drew from dozens of state and national guidance documents and research reports to compile the guide. Two key national sources were the *NCHRP Report 500* guides, a 23-volume series of guidance on key safety emphasis areas, and the FHWA Crash Modification Factors Clearinghouse website. They also leveraged information from more than 25 MnDOT and LRRB research reports as well as other state and national research. Finally, they referenced state and national guidance documents such as the Minnesota Manual on Uniform Traffic Control Devices.

How Did We Do It?

Working with a technical advisory panel that included several representatives of city and county agencies, the investigators developed a list of 15 high-priority safety strategies for inclusion in the guide. They grouped the strategies into three categories:

- **General:** Access management and traffic signs.
- **Intersections:** Intersection treatments, rural lighting, traffic signal confirmation lights, pedestrian treatments, turn lanes and rural through/stop intersections.
- **Roadside:** Pavement markings, edge line rumbles, horizontal curve delineation, Safety Edge, clear zones, mailboxes, and guardrail and end treatments.

Investigators reviewed the considerable volume of guidance on the 15 strategies to identify the characteristics of successful implementations, including the strategies' impact on crashes. They documented these best practices in the guidebook. For each safety

continued

"The guidebook gets critical information on traffic safety strategies into the hands of city and county engineers who may not have a background in safety. This project was driven by local agencies asking for more safety information."

—Howard Preston,
Senior Transportation Engineer, CH2M Hill, Inc.

"This is the first time a comprehensive approach to implementing traffic safety strategies has been put together for local agencies. The sample policies are geared toward the way cities and counties conduct business."

—Mark Vizecky,
MnDOT State Aid Program Support Engineer

The best practices guide helps local agencies determine when to implement safety strategies such as curb extensions, which reduce the width of the roadway, make pedestrians more visible in the crosswalk and encourage vehicles to slow down.

strategy, the guidebook describes safety benefits, effectiveness, typical costs, candidate locations, design features and impact on roadway operations, and provides citations to related research and data. Each section includes a list of source materials that local agencies can consult for more information as they implement the strategies.

Finally, researchers developed sample policy language for each strategy that can be customized by local agencies.

What Was the Impact?

The best practices guide is a valuable resource for local agencies, providing tools to support their safety planning and policy development. The guide is unique nationally in its targeted approach to helping local agencies implement safety best practices and policies that are consistent with national and state guidance. As a component of MnDOT's statewide highway safety planning efforts, the guide has helped create a culture of safety planning at the local level in Minnesota.

The sample policy language gives local agencies a framework for drafting their own policies for implementing the strategies. Establishing safety policies can help local agencies explain engineering decisions to the public and can provide documentation to help limit agencies' exposure to legal claims.

Ultimately, the implementation of the best practices and policies in the guide is expected to reduce severe crashes and save lives.

What's Next?

MnDOT has distributed the guidebooks to all 87 counties and to more than 140 cities in Minnesota, providing outreach and training to encourage and facilitate the guide's use. In addition, the Minnesota Local Technical Assistance Program is using the guide to modify the content of its tort liability training course. The guide's format has been well received, and a related research project is under way to produce a similar best practices guide on bicycle and pedestrian treatments.

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This Technical Summary pertains to the LRRB-produced Report 2011-21, "Minnesota's Best Practices and Policies for Safety Strategies on Highways and Local Roads," published September 2011. The full report can be accessed at http://www.dot.state.mn.us/research/documents/201121.pdf.

The resources cited as source material for this guide include the NCHRP Report 500 *guides and the FHWA* Crash Modification Factors Clearinghouse *website.*

2011-24TS
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PROJECT COST:
$39,991

Studies have shown that pavement markings on rough surfaces exhibit less retroreflectivity than other markings.

Improving Pavement Marking Performance on Challenging Pavement Surfaces

Improving the performance and durability of pavement markings on seal coat and micro-surfaced roadways will reduce construction and maintenance costs for Minnesota agencies and increase traveler safety by improving marking visibility.

What Was the Need?

High-quality pavement markings at the center and edges of roadways are critical to public safety, helping to prevent accidents by delineating traffic lanes more clearly and providing information to drivers about lane changing and passing.

However, these markings do not perform well on roadways with rougher surfaces such as those with seal coat and micro-surface treatments, which are used to extend the service lives of pavements by covering an existing surface with asphalt emulsion and aggregate. It is hard to apply markings at the right thickness to these "challenging surfaces," and they tend initially to lose pieces of aggregate and attached markings to traffic, especially from the abrasion of snowplows. The service life of such a pavement marking can be up to 50 percent shorter than a comparable marking on a smooth surface, and its retroreflectivity—how well it reflects vehicle headlights—will be lower and degrade more quickly.

MnDOT's current pavement marking policies were developed for smooth pavements and do not apply well to challenging surfaces. Initial markings after a seal coat, for example, may need to be quickly replaced, in which case it may be advisable to use less expensive latex paint rather than the epoxy material called for by current policies. Local Minnesota agencies are currently using ad hoc strategies for addressing the rapid degradation of these markings, and research was needed to establish better guidance.

What Was Our Goal?

The objective of this project was to develop recommendations for improving the application of pavement markings on challenging surfaces by documenting the practices of MnDOT districts and other state departments of transportation.

What Did We Do?

Researchers began by conducting a literature review of published and unpublished sources along with a survey of other state DOTs concerning their pavement marking practices on challenging surfaces. Then they reviewed MnDOT technical guidance on this issue, surveyed agencies by email and phone about their experiences installing and maintaining markings, and performed a field visit in 2010 to observe the placement of pavement markings along I-94 in MnDOT District 3B. The field visit also included a review of existing pavement markings on other challenging surfaces within the district, including Highways 25, 47 and 71. At each site visited, researchers photographed surfaces and took retroreflectivity readings.

Researchers used this data to identify key problems and potential solutions, and outlined a future field trial to evaluate marking performance and installation practices for different combinations of pavement marking materials on various challenging surfaces.

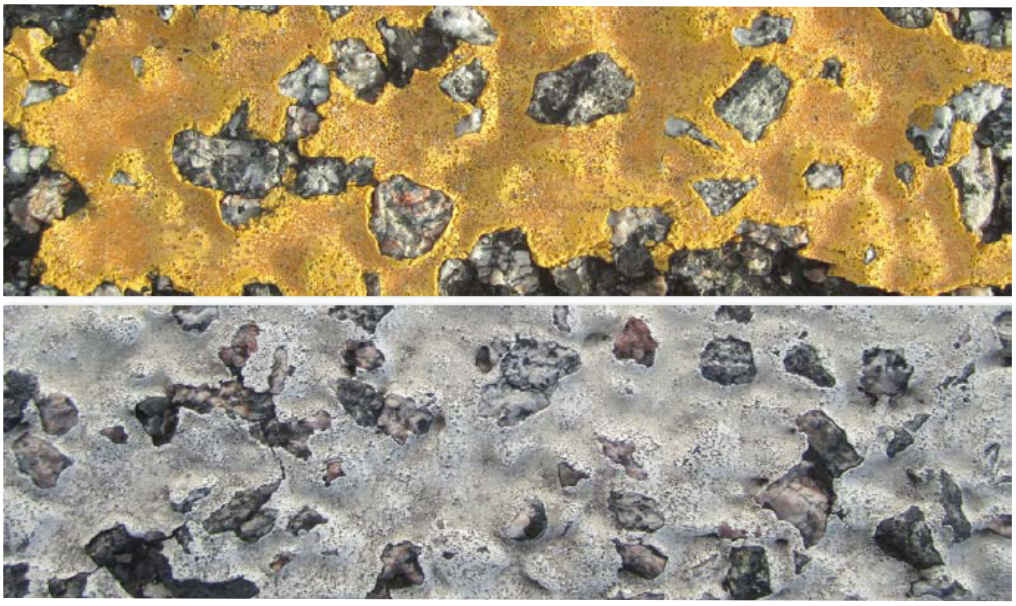
continued

"This project will allow MnDOT to improve its pavement marking policy to better serve its districts by providing more thorough guidance with respect to challenging surfaces."

—Mitch Bartelt,
Pavement Marking Engineer, MnDOT Office of Traffic, Safety & Technology

"Field trials will help us provide control in the evaluation of these markings on both seal coat and micro-surface roadways."

—Neal Hawkins,
Director, Iowa State University Center for Transportation Research and Education



Seal coat and micro-surface treatments experience a certain amount of rock loss after application, which also removes pavement marking material. And because the surfaces are coarse, it is difficult to apply markings at the right thickness.

What Did We Learn?

The literature search showed that pavement markings on challenging surfaces have an overall reduced service life of up to one year, worse uniformity and retroreflectivity, faster degradation of retroreflectivity and higher differences in directional retroreflectivity of yellow centerline markings. They require greater marking thickness, and marking performance is sensitive to both material thickness and aggregate size.

Phone interviews with Midwestern DOTs and field visits to MnDOT districts allowed researchers to document their maintenance treatment and pavement marking practices, and confirmed the problematic nature of using pavement markings on challenging surfaces.

MnDOT district email and phone surveys showed that districts are experimenting with a variety of marking materials, with little success in the first year. There is a desire to standardize methods and materials. Current strategies typically involve:

- Just after maintenance, using latex paint to stripe the centerline (for seal coating) or all lines (for micro surfacing).
- After two weeks, using all-weather paint to stripe all lines.
- After one to two years, using epoxy to restripe all lines.

What's Next?

Researchers recommend that MnDOT improve its guidance for pavement markings on challenging materials with a pavement marking strategy that matches the roadway life cycle. To do so, in 2012 they will conduct a comprehensive field evaluation of different pavement marking materials and installation practices on challenging surfaces. The trial will be conducted for up to three years on 500-foot test segments on four-lane divided and two-lane roadways with both micro-surface and seal coat treatments as well as both yellow and white pavement markings. Materials being considered for testing include latex, high build, VisiLock, thermo (sprayed and extruded), epoxy, MMA and polyurea. Researchers will consider the benefits of placing a primer coating before striping as well as different glass bead delivery systems for improving retroreflectivity and directionality. In each case they will measure both retroreflectivity and failure mechanisms such as loss of bond between paint and surface or loss of rock.

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2012-04TS
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PROJECT COST:
$83,000

The new ramp metering strategy improves mainline traffic congestion while preventing queues and wait times from becoming too long.

Improving Traffic Management on Minnesota Freeways

What Was the Need?

To minimize traffic congestion in the Twin Cities area, MnDOT uses a computerized system called the Intelligent Road Information System. IRIS collects real-time data from detectors placed along highways to measure the traffic volume and speed, and uses this data to automatically manage traffic control devices such as variable speed limit signs and ramp meters. Variable speed limit signs display varying speed limits electronically and can improve traffic efficiency and safety by gradually lowering the speed of drivers approaching bottlenecks, reducing rear-end collisions or the propagation of bottlenecks further up the traffic stream. Ramp meters are traffic lights that can reduce congestion by optimizing the number and timing of cars entering a highway.

This project significantly refines how MnDOT evaluates operational strategies for managing traffic on Twin Cities freeways and could lead to reduced congestion and improved traveler safety.

To manage these devices, IRIS uses software algorithms that make operational decisions based on traffic flow data. For many years, these operational strategies have needed improvement because they rely on performance measures that are not always adequately responsive to rapidly changing freeway conditions, including the effects of weather and accidents. Improving algorithms requires testing them by using computer models to simulate their effects on traffic, a task complicated by the need to replicate the IRIS operating environment within the simulation so that strategies work as expected when moved to IRIS for use in the field.

What Was Our Goal?

The goal of this project was to develop new software tools for managing and operating Minnesota's freeway corridors by:

- Integrating a computer traffic simulator with IRIS so that operational strategies can be emulated and refined in the simulated environment before being implemented in the field.
- Using this new simulation tool to develop and test new operational strategies for variable message signs and ramp meters on Minnesota highways.

What Did We Do?

Researchers began by developing the Traffic Information and Condition Analysis System, or TICAS, software and processes for evaluating highway performance using such measures as vehicle miles traveled, hours of traffic delay and speed variations. This system can be used to evaluate highway performance based on historical data or in real time using live traffic data to assist traffic operators in detecting traffic trends and abnormal traffic patterns. The software includes a graphical overview allowing easy identification of the location of bottlenecks and their effects.

Researchers then developed the IRIS-in-Loop Simulation System, or ILSS, a computer simulation environment for testing new traffic management strategies. To do so, they developed a communications interface to directly connect a traffic simulator to IRIS so that strategies will run on simulations just as they would in the field.

Finally, researchers developed new variable message sign and ramp meter strategies, and tested them using ILSS.

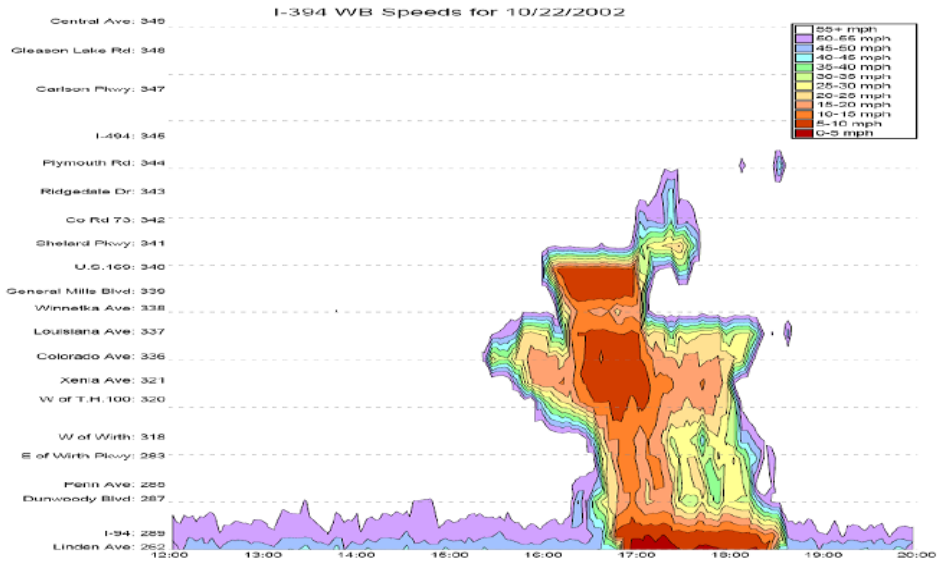
continued

"Evaluating the performance of our highways used to be a time-consuming process. Now it takes a couple of mouse clicks, and staff can devote their time to other duties."

—Brian Kary,
Freeway Operations Engineer, MnDOT Regional Transportation Management Center

"The new operational strategies developed in this project could substantially reduce congestion and improve safety on the Twin Cities freeway network."

—Eil Kwon,
Professor, University of Minnesota–Duluth Department of Civil Engineering



Traffic system operators can use TICAS to visualize a highway system's performance as in this contour plot of average vehicle speeds over time for various freeway corridors.

What Did We Learn?

TICAS improves the way MnDOT measures the performance of its freeway network, enabling more effective real-time traffic management, with continuous refinements to ramp metering, incident management and travel time information systems. ILSS will help MnDOT evaluate new operational strategies by accurately simulating them so they can be evaluated with TICAS' new performance measures.

The new variable speed limit strategy developed by researchers first identifies the locations of the bottlenecks by examining deceleration rates between two detector stations in a given corridor. It then calculates advisory speed limits by using a constant deceleration, which was determined to result in a minimum increase in travel times for drivers. An evaluation of this strategy with ILSS shows that it could significantly reduce sudden deceleration of traffic reacting to bottlenecks while keeping travel time increases relatively small.

The new ramp metering strategy is based on corridor density instead of volume since traditional volume-based methods do not take into account the way traffic is affected by narrow lanes and shoulders. The algorithm identifies bottlenecks every 30 seconds and is designed to prevent wait times from becoming too long and causing queues to extend for long distances into surface streets and intersections. A simulation with ILSS on two corridors showed that this strategy substantially reduces congestion travel delays while achieving the same total vehicle miles traveled.

What's Next?

A second phase of this project is already under way to analyze the effects of the new variable speed limit strategy on a segment of I-35W in Minnesota. Researchers will also conduct a field trial of the new ramp metering strategy in the spring of 2012. Using the field trials results, researchers will enhance these strategies to reduce bottleneck identification time and incorporate weather conditions, and then expand them to other corridors. Researchers also recommend further refinement of performance measures to improve the real-time prediction of congestion problems so that operators can respond proactively.

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LRRB PROJECT COST:
$79,647

According to state and federal rules, playground warning signs can be installed as needed based on engineering judgment.

MINNESOTA DEPARTMENT OF TRANSPORTATION

RESEARCH SERVICES
OFFICE OF POLICY ANALYSIS, RESEARCH & INNOVATION

Impacts of Playground Warning Signs on Vehicle Speeds

What Was the Need?

The yellow signs that warn drivers about nearby playgrounds are intended to alert drivers to slow down and watch more vigilantly for children and other pedestrians. Residents often request these warning signs from their local governments to make their neighborhood streets safer, but there has been little research to demonstrate the signs' effectiveness.

Agencies aim to install only the most necessary road signs. If too many signs are installed, drivers may pay less attention to all of them, or they may rely too heavily on signs to warn them of potential hazards. In addition, recent Federal Highway Administration regulations will require all signs to meet new minimum retroreflectivity standards, which means signs must be replaced more regularly than was required in the past at greater cost to taxpayers. Limiting the number of signs can lower the costs of complying with the new law.

Researchers found that playground warning signs did not cause drivers to significantly reduce their speeds, but drivers did slow down when playgrounds were busy and parked cars lined the street. These results can help local agencies evaluate the installation of these signs.

In responding to residents' requests for playground warning signs, city and county engineers must weigh these factors against the signs' potential benefits. Research was needed to investigate whether playground warning signs are effective at getting drivers to slow down.

What Was Our Goal?

This project's objective was to evaluate the impact of playground warning signs on vehicle speeds at three locations in Bloomington, Minnesota. Since the state and federal editions of the Manual on Uniform Traffic Control Devices currently leave the placement of these signs to engineering judgment, the study results would help local engineers determine whether the benefits of the signs justify the costs.

What Did We Do?

Investigators performed a literature review of related research, including studies of how vehicle speed relates to crashes and to pedestrian fatalities, and studies that address the speed and safety impacts of warning signs. Next, researchers reviewed 13 candidate study sites near playgrounds along residential streets in Bloomington. They selected three sites for collection of vehicle speed data before and after the installation of playground warning signs.

Three types of data at each study site were collected one month before a pair of the signs was installed and one week to one month after installation. Researchers used a pneumatic tube device to measure vehicle speeds. Since drivers might tend to slow down when children are visible at a playground or when cars are parked on the street, researchers also recorded data on playground activity levels and the presence of parked cars. Then they used linear regression analysis to estimate the change in average vehicle speed associated with the presence of the playground warning signs, controlling for the effects of varying amounts of playground activity and parked cars.

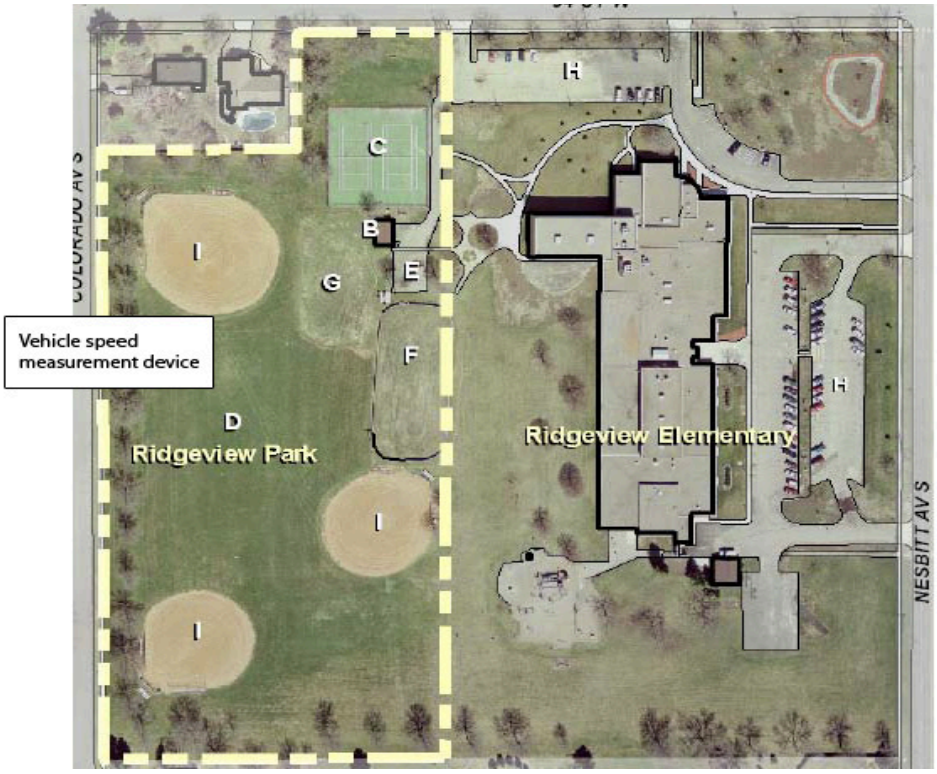
continued

"We found that actual playground activity is a much stronger indicator to drivers to be attentive than playground warning signs. This study gives local engineers quantifiable measures of the signs' impact to reference as they make decisions about sign installation."

—John Hourdos,
Director, Minnesota Traffic Observatory, University of Minnesota

"In Bloomington, we'll use this study as support for our current standard practice of not installing playground warning signs. The speed reductions achieved were not significant enough to justify installing them unless other unique conditions are present."

—Amy Marohn,
Civil Engineer—Traffic, City of Bloomington



Investigators gathered data at three sites in Bloomington, including this park on Colorado Avenue South, which is adjacent to an elementary school. At this site, researchers found no difference between vehicle speeds recorded before and after playground warning signs were installed.

What Did We Learn?

Installing playground warning signs did not have a large effect on average vehicle speeds at any of the three sites. At one site, the signs had no measurable effect, while signs at the other two sites led drivers to reduce their speeds by 0.9 mph and 1.5 mph on average.

However, researchers found that vehicle speeds were strongly related to levels of playground activity and parked cars. At one site, vehicles drove an average of 10 to 15 mph slower when playgrounds were busy, which appeared to be related to the greater number of cars parked along the street.

The impact of playground warning signs on vehicle speeds appeared to be site-specific. Researchers noted that some of the variability in the vehicle speed impacts is likely due to the differences in site characteristics and suggested that it may also be affected by subjective differences in how the field personnel categorized on-street parking levels for the study.

What's Next?

City and county engineers can use this research in their decision-making process when they consider whether to install playground warning signs. This study fills a gap in research on this topic, and serves as a timely, credible reference for engineers as they review their sign management policies in light of the new retroreflectivity requirements.

To help local engineers make decisions about signage as they comply with the new requirements, the Local Road Research Board recently produced a handbook on sign maintenance and management. A follow-up research project, "Best Practices for Sign Reduction on the Local System," is expected to be complete in 2012.

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2011-TPF-5(190)TS
Published June 2011

TRANSPORTATION POOLED FUND PROGRAM

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TOTAL STATE CONTRIBUTIONS TO DATE:
$750,000

Mn/DOT CONTRIBUTIONS TO DATE:
$200,000

PARTICIPATING STATES:
ID, MN, MT, ND, SD, WA, WI, WY

i90i94travelinfo.com includes a clickable map allowing users to view camera images of road conditions for key locations along the corridor as well as information about truck stops, rest areas and commercial vehicle restrictions.

RESEARCH SERVICES

OFFICE OF POLICY ANALYSIS, RESEARCH & INNOVATION

Pooling Our Research: Improving Road Condition Information for Interstate Travelers

TPF-5(190): North/West Passage Corridor. *Minnesota benefits both from pooled fund projects that improve the safety and efficiency of Minnesota travelers by integrating traveler information systems between states as well as the opportunity to develop contacts and exchange information with other member states.*

Why a Pooled Fund Study?

Interstates 90 and 94 between Wisconsin and Washington form a main corridor for commercial and recreational travel. Extreme winter weather conditions pose significant challenges for travelers within this corridor, so states typically provide real-time road and weather information via dynamic message signs, or DMSs; 511 phone systems; and the Web. Traveler information is supported in turn by Intelligent Transportation Systems, or ITS, which include a variety of technologies for collecting, processing and integrating travel-related data. ITS technologies are also important to roadway maintenance operations, traffic management and commercial vehicle operations.

Because states independently maintain their own ITS, it can be difficult to accomplish ITS-related goals that require sharing information between states. Recognizing this need, Minnesota initiated a meeting in 2002 with representatives from seven states along the I-90 and I-94 corridor to begin discussions on ITS collaboration. These states face similar travel-related issues because of their predominantly rural makeup. This group then established itself as the North/West Passage Corridor Pooled Fund Study TPF-5(093) in 2003, continuing in 2009 as TPF-5(190).

What is the Pooled Fund Study's Goal?

The goal of the North/West Passage Corridor pooled fund study is to develop effective methods for sharing, coordinating and integrating traveler information and operational activities between states along the I-90/I-94 corridor from Wisconsin to Washington.

What Have We Learned?

Since its inception, the North/West Passage Corridor pooled fund study has completed 18 projects, including the development of i90i94travelinfo.com. This website provides travel information for the entire corridor, including camera images, truck stop and rest area information, and weather conditions. Other accomplishments include helping North Dakota and South Dakota 511 callers receive information about Minnesota's highways, standardizing the terminology used to describe road events along the I-90/I-94 corridor, providing a forum for state patrol and DOT staff to discuss integration of systems, and identifying action items for increased cross-border maintenance and operations collaboration.

Recently completed projects include:

- Call Forwarding and Evaluation of Cross Border Information, which created recommendations to further enhance the ability of travelers using 511 systems to access traveler information from adjacent states.
- NWP Traveler Information Website Phase 2 and Center-to-Center Communications Concept of Operations, which enhanced i90i94travelinfo.com by adding the ability to acquire active event reports posted by member agencies and to display active corridor events.

continued

"This study's DMS project is a great example of the importance of sharing solutions across boundaries. Making dynamic message signs consistent between states is critical to drivers using them to make better travel decisions."

—Cory Johnson,
IntelliDrive Program Engineer, Mn/DOT Office of Traffic, Safety and Technology

"Just as valuable as this study's projects are the relationships it helps build between member states, leading to better cooperation on critical issues."

—Deb Fick,
Research SP&R Administrator, Mn/DOT Research Services

DMSs such as this one on I-94 in St. Paul are used to warn travelers about accidents, congestion, severe weather and other incidents. This study's ongoing DMS project aims to coordinate their use between member states. A possible future project would integrate them with other ITS technologies.

- Traveler Information Dissemination to Commercial Vehicle Operators, which created recommendations to enhance existing corridorwide trucker and traveler information dissemination systems.

For its leadership of this pooled fund study, Mn/DOT Research Services received the CTS 2010 Research Partnership Award and the 2010 Best of ITS Rural Award at the National Rural ITS Conference in the category *Best New Practice*.

What's Going On Now?

Member states continue to benefit from this study by developing contacts, sharing lessons learned and promoting the exchange of traveler information. The group is also currently working on six projects, including:

- Consistent and Coordinated DMS Use, initiated by Minnesota to establish coordinated use of dynamic message signs and other traveler information dissemination tools along the corridor.
- NWP Regional Permitting—Phase 2, initiated by Minnesota to identify options and next steps to move member states toward regional permitting.
- Citizen-Assist Reporting Feasibility Study, to share the results of Wyoming's current program for using road condition data reported by travelers, and to explore the possibility of its expansion to other member states.

What's Next?

The projects under consideration for this study's next work plan would continue to integrate ITS technologies and coordinate them between states, with possibilities including:

- NWP Regional Permitting—Phase 3, proposed by Minnesota to continue exploring regional permitting recommendations from Phases 1 and 2.
- Corridorwide Traveler Information Coordination—Operational Test, which would build on two current projects to conduct an operational test of traveler information coordination between DMSs, 511 phone, Web and other existing systems.

This Technical Summary pertains to the ongoing Pooled Fund TPF-5(190), North/West Passage Corridor Pooled Fund, continuing the project initiated under TPF-5(093). Details of this effort can be found at http://pooledfund.org/projectdetails.asp?id=412&status=4, http://pooledfund.org/projectdetails.asp?id=316&status=23 and http://www.nwpassage.info/.

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.

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Minnesota Local Road Research Board: www.lrrb.org

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Federal Highway Administration