RESEARCH UPDATE
FEBRUARY 2013

MDOT Partners With University Researchers to Speed Innovation

The Michigan Department of Transportation (MDOT) is responsible for developing, operating and maintaining a transportation system that is safe and reliable, supports the state’s economy, and improves the quality of life for residents and visitors. To fulfill these responsibilities, MDOT not only maintains the excellence of the state’s current system but constantly strives for new and better ways of doing business.

MDOT recognizes that achieving a world-class transportation system requires “all hands on deck.” Thanks to partnerships with university researchers around the state, MDOT staff are able to access nationally respected faculty and testing facilities that complement in-house skills and tools.

“We have a tremendous opportunity – and obligation – to leverage the skills and expertise available to us through our universities to improve transportation in Michigan,” says MDOT Chief Operations Officer Greg Johnson. “We’re not only building better roads and bridges. We’re working together to create the next generation of transportation professionals.”

MDOT’s Research Administration office facilitates and promotes partnerships with the university community through short and long-term research projects. MDOT staff are able to turn to universities for support in all aspects of roadway transportation including planning, design, construction, operations and maintenance. Universities assist MDOT staff with assessing the benefits, costs and impacts of various technologies and strategies.

On the following pages, we highlight examples of the strides MDOT is making to improve the safety, efficiency, and longevity of Michigan’s transportation system through partnerships with university researchers. MDOT is proud of its close collaboration with the research community in Michigan and looks forward to continuing this team approach to innovation.

Find More Online
Final reports for the studies featured in this newsletter are available on the MDOT Research Administration Web site at www.michigan.gov/mdotresearch.
Employing an Innovative Design to Increase Bridge Service Life

Motor recently completed construction of two side-by-side box beam bridges using an innovative new design developed by Lawrence Technological University to help reduce cracking and other problems. Located on the Southfield Freeway in Detroit and on M-50 in Jackson, these bridges are expected to last twice as long as bridges with traditional designs.

Cracking is common in side-by-side box beam bridges, which consist of prestressed box girders placed an inch apart and held together by cables running transversely through hollow ducts. The openings of these ducts occur at diaphragms that have been integrated into beams at regular intervals. Cables are tightened using a hydraulic jack that squeezes beams together, which increases the structural integrity of the bridge as a whole.

While these bridges are cost-effective and easy to construct, they are subject to longitudinal cracking on the deck slabs above the grout-filled gaps between beams. This cracking can unbalance the live load distribution of tensioning cables and lead to other forms of deterioration. It also can make it easier for water to infiltrate and corrode the steel reinforcements within the beams. Repairing or replacing damaged beams is labor-intensive because steel cables are covered in grout to prevent such corrosion, making detensioning difficult.

The design developed by Lawrence Technological University uses cables made of a carbon fiber composite that is not susceptible to corrosion, along with a design that optimizes the number and placement of diaphragms and the force of post-tensioning. Researchers developed this design using computer modeling as well as constructing and testing a half-scale bridge model.

“Not only do carbon fiber composite cables resist corrosion,” says Steve Kahl, supervising engineer for experimental studies at MDOT’s Operations Field Services Division, “they also can be used to apply a greater level of tensioning than with steel strands.” Researchers found that increasing transverse post-tensioning improves bridge performance, with the optimum force dependent on bridge width and the optimum number of diaphragms dependent on bridge length.

The two new bridges constructed by MDOT are pilot projects and have been outfitted with instruments that collect performance data. Beyond their expected increased durability, the new bridges should also be much easier to maintain.

“The use of carbon fiber composite cables makes grout unnecessary,” Kahl says. “Consequently, we can easily detension unbonded cables to replace or repair beams as needed.”

For more information about this project, contact Steve Kahl at kahls@michigan.gov.

Improving Unbonded Concrete Overlays

For years, MDOT has constructed unbonded concrete overlays on selected highways to rehabilitate deteriorating pavements and extend service life. The process involves applying a new layer of concrete over the existing pavement with a hot-mix asphalt layer separating the two. However, MDOT engineers noted poor performance in some of the overlays and wanted to identify the source of the problem. Areas of concern included longitudinal cracking originating at the transverse joint and scaling at cracks and joints.

Researchers at the University of Michigan conducted a field forensic investigation of the overlays and found that both types of distress were caused by trapped surface water in the pavement structure. In some cases, the path to the inplace drainage system was blocked and did not allow water to escape, which led to premature deterioration.

The study also confirmed that the overall performance of unbonded concrete overlays in Michigan has been good, and the overlays can effectively extend pavement life. The recent use of an open-graded asphalt interlayer between the old and new concrete is having significant beneficial effects by contributing to positive drainage of surface water entering the pavement through joints and cracks. By ensuring that the interlayer and its accompanying drainage system are properly connected and functioning as intended, the likelihood of premature distress will be greatly reduced.

Project Manager Ben Krom anticipates MDOT will revise design and construction practices as a result of this study, enabling MDOT to extend the expected service life of unbonded concrete overlays.

For more information about this project, contact Ben Krom at kromb@michigan.gov.
Using Recycled Concrete for Sustainable Roadways

Transportation departments increasingly are using recycled materials to help reduce the costs and environmental impacts of road construction. One such material is crushed concrete aggregate (CCA)—the byproduct of demolished concrete pavements that have reached the end of their service lives. Since the 1980s, MDOT has used CCA in the foundational layers beneath road pavements.

However, care must be taken when processing CCA to ensure that the quality and long-term performance of roads are not compromised. To this end, MDOT recently created a manual of practice for engineers that details applications and methods for successfully incorporating CCA into roadway construction projects. Researched and developed for MDOT by Michigan Technological University, the manual focuses on CCA processing, mechanical and chemical properties, and the use of CCA within the pavement structure.

The possible environmental effects of using CCA also are addressed in the manual. “One of the most important lessons from this study was to be more aware of the possible impacts of byproducts from the CCA being dissolved and transported into surrounding groundwater,” says John Staton, manager of MDOT’s Materials Section.

Guidance from the new manual and MDOT’s partnership with Michigan Technological University will ensure that transportation departments increasingly are using recycled materials to help reduce the costs and environmental impacts of road construction. One such material is crushed concrete aggregate (CCA)—the byproduct of demolished concrete pavements that have reached the end of their service lives. Since the 1980s, MDOT has used CCA in the foundational layers beneath road pavements. CCA continues to be a cost-effective and environmentally sound approach to improving the sustainability of Michigan’s transportation infrastructure despite these environmental concerns.

“By focusing on the proper selection of materials for the application, and best practices in quality and process control, we can responsibly optimize the use of recycled concrete,” says Staton. “This will help us manage the risk of potential negative performance or environmental impacts that may arise as a result of incorporating CCA into our transportation infrastructure.”

For more information, contact John Staton at statonj@michigan.gov or see report RC-1544 online.

Beam Cracking Study May Lead to Changes in Prestressed Girder Fabrication Specifications

Not long ago, MDOT discovered excessive cracking at the ends of some prestressed bridge beams, leading to construction delays and quality concerns. The agency turned to research to seek out and test possible solutions.

A study led by a Michigan State University research team uncovered the problem, which involved the soft polymer sheathing at the ends of the steel prestressing strands in the beams. Researchers proposed a rigid polymer sheathing as an alternative to better provide the desired debonding between the strand ends and the concrete. Through bench testing and computer-based finite element analysis, investigators provided the data that supported the effectiveness of this low-cost solution.

Since the completion of the research, MDOT has moved forward with implementing the results. “The MDOT bridge committee has met to discuss these research results, and we’re updating MDOT specifications to reflect the findings,” says Steve Kahl, supervising engineer for experimental studies at MDOT’s Operations Field Services Division. As a first step, Kahl expects a special provision to be ready this March that requires the use of the stiffer sheathing material for the prestressing strands.

“This is what you hope to get out of research: a specific answer to a specific question—and one that you can put to use.”

—Steve Kahl, Supervising Engineer, Experimental Studies, MDOT Operations Field Services Division

University who not only had all this necessary expertise, but who had worked in these same areas for an MDOT project a few years ago on prefabricated composite steel girders,” he says.

Full implementation of the results is not quite complete. “It takes some time before newly adopted requirements make their way into construction projects,” Kahl adds, “but soon more beams of this type will use the rigid tubing.”

See final report RC-1546 online for more information, or contact Steve Kahl at kahls@michigan.gov.
New Design Recommendations Could Reduce Cracking in High Skew Jointless Bridges

MDOT engineers have observed problems with cracking in jointless bridges that are highly skewed—bridge decks having an angle to their supporting structures that deviates from a right angle by more than 20 degrees. But recent research by Western Michigan University will help MDOT reduce cracking in these bridges.

Jointless designs are intended to increase the durability and rideability of bridges by reducing the problems associated with the expansion joints used in traditional designs. To accommodate movement caused by temperature changes and other factors, traditional designs provide bridge decks and supporting girders with expansion joints on the bridge allowing for movement. Underneath each expansion joint (or nearby in the case of pin and hangar superstructures) is a support where the girders on either side of the gap accommodate movement via bearings that allow the segments to slide as needed.

Because expansion joints allow water and deicing chemicals to reach and corrode the underlying structure supporting the bridge, jointless designs avoid this issue by moving expansion joints off the bridge deck. Decks are made continuous using a link slab, a segment of reinforced concrete that covers the underlying gap between girders. Movement of the deck is then accommodated using abutment configurations that allow sliding.

Jointless bridge designs can be problematic for high skew bridges because these bridges have a pattern of stresses, including high torsion, that leads to cracking in link slabs.

To address this problem, Western Michigan University conducted computer modeling and field monitoring of bridges to develop new design recommendations. These included details for restraint systems that keep high skew bridges aligned along their vertical axis, and abutment configurations that allow either the deck to slide over the backwall or a combined deck-backwall system to slide over the remaining part of the abutment.

MDOT’s bridge committee currently is reviewing recommendations for inclusion of these design procedures in the MDOT Bridge Design Guide. The committee also is considering pilot implementation projects to evaluate the performance of new designs.

“These designs could help us achieve longer service lives and lower maintenance costs in high skew link slab bridges,” says Steve Kahl, supervising engineer for experimental studies at MDOT’s Operations Field Services Division. Additional benefits include smoother rides for travelers and fewer traffic disruptions for maintenance.

To learn more about this project, contact Steve Kahl at kahls@michigan.gov or see report RC-1563 online.

Exploring Digital Imaging for Aggregates

The coarse and fine crushed aggregates that go into highway construction—rocks, gravel and sand—are critical to the structural integrity and long-term durability of pavement systems. Traditional methods for characterizing aggregate size (one of several important characteristics) involve mechanical sieve tests that sift samples through a series of screens of increasingly fine mesh to separate aggregate by grain size. These tests can be time-consuming and and labor-intensive.

A recent MDOT study explored alternative approaches to measuring aggregate size through the use of imaging systems developed at the University of Michigan. For fine sands and small aggregates up to 2 mm in size, the researchers developed a “sedimaging” method. Aggregate samples are separated with water in a tall square tube; and the digital camera/software calculates particle size distribution. The second method, for larger aggregates, uses a backlit table fitted with bars of graduated height. The table is tipped to sort the aggregate, and the camera/software calculates the size of each particle.

The MDOT research and similar national efforts hold the promise of a more automated aggregate characterization method that may increase accuracy while saving time and money. MDOT will watch with interest the continuing research on this cutting edge-technology at the University of Michigan.

To learn more, contact Richard Endres at endresr@michigan.gov or see report RC-1557 online.
MDOT Moves Closer to Mechanistic-Empirical Design Rollout

MDOT has targeted 2014 to begin its transition to the American Association of State Highway and Transportation Officials (AASHTO) new pavement design method based on mechanistic-empirical (M-E) principles. Research recently completed by Michigan State University brings the agency one step closer to that goal.

The M-E pavement design method draws from a database of such parameters as building materials, climate and traffic loading. Use of regional or site-specific values helps to produce the most accurate M-E designs.

A recent MSU research project established stiffness (resilient modulus) values for pavement subgrades across the state. Researchers drew from a variety of sources, including existing data from decades of Falling Weight Deflectometer testing, U.S. Geological Survey data and new field testing, to build a comprehensive database and map of subgrade stiffness values. Accounting for regional variability—not just for subgrade stiffness but also for aggregates and weather—is a strength of the M-E design methodology, according to MDOT Pavement Design Engineer Mike Eacker. “We know the same materials may not perform the same way across the state, in the Upper Peninsula versus Detroit, for example,” Eacker says, “but the old methodology doesn’t always take that into account. M-E pavement design does.”

The stiffness values established in this project will feed into a larger research effort—also being conducted by MSU—in support of M-E deployment. “Preparing to roll out M-E pavement design in Michigan has been a deliberate multistep process,” Eacker explains. “The final piece prior to implementation in Michigan will be calibration and validation of the M-E design method and software. MSU is scheduled to begin that step in February 2013 and complete it about a year later.”

For more information, contact Michael Eacker at eackerm@michigan.gov or see report RC-1531 online.

Slippery Road Detection Project Supports Major Research Initiatives

Vehicle instrumentation for the MDOT slippery roads study included a pavement temperature sensor mounted through the trunk, shown here in a test with an ice-water bath to calibrate the sensor.

MDOT recently undertook a targeted research project to detect slippery road conditions using onboard vehicle data collection. The results were promising and already have led to the agency’s central role in national data collection efforts.

In the study, the University of Michigan Transportation Research Institute (UMTRI) collected data from two MDOT vehicles during the winter of 2011-2012, using several integrated data collection devices. These included a dashboard-mounted smartphone to provide vehicle positioning and motion data; vehicle-mounted sensors to measure pavement and air temperature and weather conditions; and the vehicle’s own internal electronics that record such factors as anti-lock brake engagement, electronic stability control and headlight use.

Though this was a relatively small project, MDOT Project Manager Steve Cook describes it as a success in validating the use of this technology to collect data. “We do not know yet precisely how we’ll use all of the data that we can collect,” Cook says, “but I can see a range of value-added applications that MDOT could use to support and enhance current data collection systems in the areas of operations, maintenance and asset management. I expect some applications will be easier to implement than others.”

The research effort fits within the larger MDOT initiative of the Data Use Analysis and Processing (DUAP) project, which is evaluating the uses and benefits of data generated through connected vehicle technologies. It also has led to a new proposed MDOT research project to correlate pavement condition values collected subjectively by inspectors and data collected automatically with instrumentation.

At the national level, the research served as a bridge for a significant national study of enhanced safety and vehicle connectivity. “We leveraged what we learned in slippery roads to implement the Integrated Mobile Observations (IMO) 2.0 project funded by [the Federal Highway Administration] (FHWA),” Cook says. “MDOT in partnership with UMTRI is leading the effort, which will involve the instrumentation of 40 MDOT light and medium duty vehicles and 20 snowplow trucks.” Data collection along the I-94 corridor began this winter and will end some time in the spring of 2014.

Cook also pointed out that the FHWA IMO project will provide data to the Maintenance Decision Support System (MDSS) pooled fund study, an effort supported by MDOT and 16 other winter weather states. MDOT is currently using MDSS as a pilot project along I-94 for the next two winter seasons.

Contact Steve Cook at cooks9@michigan.gov or see report RC-1573 online to learn more about this project.
Identifying New Pedestrian Safety Treatments

A recently developed MDOT guide, *Best Design Practices for Walking and Bicycling in Michigan*, details several dozen promising safety treatments and is a testament to the agency’s commitment to pedestrian safety. Ultimately, though, advanced countermeasures are only worth the investment if they work as intended.

MDOT undertook a research project to assess selected new countermeasures already in use across the state. “Our goal was to learn if the success rates seen elsewhere in the United States were being reproduced in Michigan,” says MDOT Project Manager Deirdre Thompson. “If not, we wanted to know the best options for Michigan.”

The study, conducted by Western Michigan University, analyzed performance of treatments to protect pedestrians at multilane crossings. Data pointed to the clear effectiveness of the most intuitive treatments, including in-street yield signs and pedestrian countdown timers. The research suggested that the limited effectiveness of other treatments when compared with national research findings may be due to a poor understanding of their use by Michigan motorists and pedestrians.

Beyond effectiveness, cost is a necessary concern for MDOT. “The high cost of treatments like the rectangular rapid flashing beacon and the pedestrian hybrid beacon limits how many we can install,” Thompson says.

One low-cost countermeasure identified by the research was the use of multiple in-street yield signs, also called the gateway treatment. “That hadn’t been part of the original research statement,” says Thompson, “but the investigators saw the opportunity to incorporate this treatment while the study was ongoing, and it turned out to be a promising idea to pursue.” Results from the research study show that this treatment can be effective on its own or in combination with other pedestrian safety treatments.

Thompson notes that the gateway treatment led to a new research project planned for the next MDOT research cycle. “We will further study the effectiveness of in-street yield signs—including the gateway treatment and possibly other configurations—as a low-cost countermeasure for multilane pedestrian crossings,” she says.

The project also illustrated the vast expertise that Michigan’s universities offer MDOT well beyond engineering disciplines. In this case, a professor from the Western Michigan University Department of Psychology led the investigation. “Our principal investigator was a specialist in behavioral analysis,” Thompson says, “and had a great deal of experience in using traffic safety technologies to implement those behavioral principles.”

Contact Deirdre Thompson at thompsond@michigan.gov or see report RC-1585 online to learn more about this project.

Developing a Congestion Mitigation Toolbox

Transportation agencies are turning to a variety of mitigation strategies to cope with congestion problems, all designed to increase the efficiency of road networks or reduce demand. Not all mitigation strategies are appropriate for a given congestion problem, however, and choosing the right strategy can be a complex task. To address this challenge, MDOT partnered with the Texas Transportation Institute to create *A Michigan Toolbox for Mitigating Traffic Congestion*.

Written in a user-friendly format, this comprehensive guide serves as a desk reference for practitioners and a tool to help policymakers better understand the development, planning and implementation of congestion mitigation strategies. The toolbox presents 47 strategies for handling both supply and demand management, such as freight rail improvements, smart growth, car sharing and multi-modal transportation centers.

“It’s so helpful to have all of the information in one place,” says MDOT Project Manager Jason Firman. The toolbox includes both commonly known strategies as well as promising new approaches. “As more people use it, something might catch their eye that is unfamiliar and cause them to experiment,” he says.

MDOT distributed the toolbox to the regional Transportation Service Centers and encouraged further distribution to local agencies that could benefit. Additional outreach with the toolbox is expected in 2013 to support an agencywide emphasis on strengthening operations.

For more information, contact Jason Firman at firmanj@michigan.gov or see report RC-1554 online.
Meeting the Needs of Michigan’s Aging Drivers

By 2030, the U.S. Census Bureau projects that older adults will represent about 20 percent of Michigan’s population. Recognizing the need to prepare for this change, MDOT initiated a project in 2010 with the University of Michigan Transportation Research Institute (UMTRI) to identify:

• Measures to help keep older drivers in their cars as long as they can drive safely.
• Services and support that offer good alternatives to driving for older adults who are no longer able or choose not to drive.

In this award-winning project, UMTRI researchers developed 20 recommendations that they translated into low-cost, high-impact measures that MDOT and other Michigan agencies can work on cooperatively to improve older adult mobility in Michigan.

A follow-up project is implementing one of the recommended measures—an educational component to help ensure that Michigan residents are aware of and have access to the transportation services they need to keep them safely mobile as they age. This three-year initiative, which is slated to begin in early 2013, will develop and implement self-assessment tools that will help Michigan residents plan for their retirement from driving in a manner similar to the way they plan for their retirement from work.

In Year 1, researchers will identify the resources available and those that will be needed to ensure that non-driving residents remain active and engaged in their communities. These resources will be included in a series of models that address the varying needs of non-driving residents in both rural and urban areas of Michigan. Pilot testing of the developed models will be completed in Year 2, and in the project’s final year, researchers will identify the most effective model, modify it as needed for specific regions and prepare for its statewide implementation.

To learn more about this project, contact Project Manager Kim Lariviere at larivierek@michigan.gov or see report RC-1562 online.

Spreading the Word about Roundabouts

While roundabouts are becoming more commonly accepted in Michigan as a safer and more efficient alternative to traditional signalized or stop-controlled intersections, their relative novelty can leave drivers feeling unsure of how to navigate them. MDOT partnered with researchers at Wayne State University’s Transportation Research Group to better understand driver behavior in roundabouts and to develop an educational program for roundabout users.

Armed with information about problematic driver behaviors and public perceptions gathered during the project, researchers developed a carefully designed public education campaign that includes presentations, brochures, animated videos and posters to help improve a road user’s ability to use roundabouts safely and smoothly.

MDOT continues to reap benefits from the results of this project with outreach efforts that are varied and ongoing. In addition to offering the roundabout educational materials at traffic safety conferences, senior expos and teen driving events, MDOT has provided 20,000 brochures to Secretary of State branch offices where Michigan residents obtain drivers’ licenses.

The brochure highlights the advantages of roundabouts with step-by-step instructions for pedestrians, drivers and bicyclists. It is available at some of the states’ 14 Welcome Centers and online at www.michigan.gov/roundabouts.

For more information, see report RC-1542 online or contact Project Manager Kim Lariviere at larivierek@michigan.gov.
Rest Area Study Reveals Safety, Economic and Service Benefits

MDOT operates and maintains 81 rest areas and welcome centers around the state, providing commercial, commuter and recreational travelers with a safe, convenient place to stop, rest and refresh. Shrinking state resources, however, have prompted MDOT to re-evaluate the value of rest areas, especially those located near commercial restaurants and gas stations.

To help MDOT understand the value of rest areas to users and the potential impacts of any closures, researchers at Wayne State University investigated the costs and benefits of operating and maintaining these facilities. The researchers demonstrated that systemwide benefits far exceed the costs, outlining overlapping safety, economic and service benefits of rest areas in Michigan. “The study strengthened the link between rest area performance and overall system safety and performance,” says MDOT Project Manager Lynn Lynwood. “We found that rest areas are an important part of our transportation system and need to be fully integrated with our other asset management strategies.”

In support of developing an asset management approach for the rest area system going forward, the researchers created an Excel tool that allows users to see the potential economic and functional impacts of adding or removing rest areas in different locations around the state. The tool has received widespread support from MDOT leadership and will be integral to the 2013 strategic planning process. In short, the results are helping MDOT make informed decisions about the appropriate level of rest area service and will guide future rest area investments based on accurately weighing the costs and benefits.

For more information, contact Lynn Lynwood at lynwoodl@michigan.gov or see report RC-1570 online.

MDOT Seeks New Research Partnerships

MDOT is committed to supporting innovation in the planning, design, construction, operation and maintenance of Michigan’s transportation system and has established strong partnerships with researchers across the state to support advancements in highway engineering.

MDOT’s Research Administration Office would like to expand these partnerships to help address challenges identified in public policy, finance and planning. In addition, we are interested in exploring the research needs of other modes of transportation, including rail, transit, bicycle, pedestrian and aviation. We invite public and private universities and consulting firms interested in partnering with MDOT in these areas to contact Mark Polsdofer at 517-636-0552 or polsdorfm@michigan.gov.