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Smart speed warnings alert drivers nearing freeway work zones

Far too often, freeway work zones catch drivers by surprise. Drivers traveling at highway speed may come upon unexpected congestion, resulting in sudden braking and the risk of rear-end collisions. Unfortunately, posting advisory speed limit messages near these freeway work zones has not been effective.

Speed warnings continued on page 7

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An alternative bridge repair research project has received a 2019 State Government Innovation Award. The Minnesota Department of Transportation (MnDOT) Bridge Office received the honor for its use of a novel repair method and subsequent testing. The project included an evaluation by U of M researchers that confirmed the effectiveness of the method.

MnDOT estimates it has saved at least $1.3 million to date through its use of the technique, which repairs the damaged ends of reinforced concrete bridge beams. These beams typically perform well for decades, but when they show distress, it’s often at the beam ends under expansion joints. Water and road salt can degrade the concrete and corrode the reinforcing steel in these areas.

During a routine repair of the Nine Mile Creek Bridge in 2013, MnDOT construction inspectors encountered two concrete beams with severe deterioration. Needing to rethink their plans, MnDOT decided to adapt a method that the Michigan DOT had developed for lower levels of deterioration. The method places steel reinforcement cages around the damaged beam ends and encases the ends in concrete through a process known as “shotcrete.” This process sprays a concrete mix through a hose and adds water at the exit nozzle, projecting the mixture at high velocity.

The repair performed well for three years. When the bridge was selected for replacement, a unique opportunity for testing the repair method fully was made possible. During the scheduled bridge replacement in 2017, MnDOT salvaged two pairs of beams, each containing one repaired beam and one beam in good condition.

After being removed and cut to appropriate test lengths, all girders were brought to the U’s Theodore V. Galambos Structural Engineering Laboratory. There a team led by structural engineering professor Carol Shield began a MnDOT-funded evaluation.

Shield’s team cast a new, high-strength concrete deck for each of the girders, simulating the beams’ field configuration. Each beam was loaded by a hydraulic ram pushing down on the beam. Beams were tested until they failed by applying a load in 25,000-pound increments—up to almost 500,000 pounds—on each girder.

The researchers found that the repaired girders were actually slightly stronger than the undamaged ones. “It was very satisfying to see that the repair performed as good as or better as beams that were in good condition,” says Paul Pilarski, MnDOT bridge construction engineer.

The shotcrete repair method costs only about $10,000, compared with $300,000 for traditional repairs that require removing a portion of the bridge deck, and it eliminates several weeks of lane closures. There’s also an advantage for worker safety, since the repairs take place under the bridge deck. And by extending the service life of bridges, fewer bridge replacements—and less concrete—are needed annually. “Less concrete use means a much lower annual carbon footprint for the DOT to meet transportation needs,” Pilarski says. “Cement production is at least 5 percent of the world’s carbon footprint.”

Since the testing, MnDOT and the City of Saint Paul have used the shotcrete method to repair three additional bridges, including one on Interstate 94 in downtown Minneapolis.

The Minnesota State Government Innovation Awards recognize the work of state government entities and encourage an environment of experimentation and innovation in Minnesota. The 2019 awards were administered by the Public and Nonprofit Leadership Center at the U’s Humphrey School of Public Affairs with support from the Bush Foundation. The bridge project was one of the top four innovations this year in state government.

“We look for ways to be cost-effective,” says Kevin Western, MnDOT state bridge engineer. “If we have even two of these a year, we’re going to see pretty substantial savings.”
New president learns about transportation innovations at the U of M

New University of Minnesota President Joan Gabel got an up-close look at the latest advances in transportation during her inauguration week in September. On a day focused on creativity and innovation, President Gabel and CTS director Laurie McGinnis took a ride in a semi-autonomous vehicle provided by VSI Labs. The Minnesota-based company is one of many partners working with the U of M on transportation research, including technical and policy issues related to automated vehicles (AVs).

The 2018 Ford Fusion, driven by U of M student Jacob Miller, was equipped with LiDAR, radar, thermal cameras, GPS, and other technology. The group was also joined by VSI AV solutions engineer and U of M grad Mohamed Isse, who gave a demo of the vehicle’s LiDAR technology.

“LiDAR is a sensor that uses spinning lasers to natively see the world around it in three dimensions,” Isse explained. This gives the vehicle a highly detailed and precise view of the objects around it, including other vehicles and pedestrians.

During the ride, President Gabel also learned how CTS works with researchers across the University, as well as with partners like VSI, to foster transdisciplinary innovation and collaboration.

“CTS has a longstanding history of convening researchers and stakeholders on critical transportation issues such as AVs,” McGinnis said. “This was a wonderful opportunity to introduce President Gabel to the innovative work the University is doing to support research partnerships and workforce development for the future of transportation in Minnesota and beyond.”

Freight and Logistics Symposium to explore disaster response

The annual Freight and Logistics Symposium will be held Friday, December 6, from 7:30 a.m. to noon at the Delta Hotels Minneapolis Northeast. This year’s event will explore how the public and private sector can and should respond to natural disasters that cause disruptions in the freight system. It will also include a discussion of how public-private partnerships could be leveraged to improve disaster response.

This annual symposium is designed to bring together members of the private sector and government to discuss current issues in the freight and logistics industry and to share public and private initiatives intended to strengthen the freight transportation system.

Complete program information and registration will be available soon at cts.umn.edu/events/freight.
New chair offers insight on research and economic competitiveness

George Schember, vice president of Cargill Transportation & Logistics, became the chair of the CTS Executive Committee in July. Below, Schember shares his thoughts on how transportation research can help Minnesota maintain its economic competitiveness and provide pragmatic solutions to real-world problems.

What transportation challenges should be prioritized for Minnesota’s success?

Transportation has increasingly gained the attention of stakeholders in Minnesota. I believe that stems from both increasing awareness of its importance to our overall economic competitiveness as well as recognition of the impact it makes at the individual level. Our challenge is to continue to improve the system while prioritizing the largest positive impacts in an environment of constraint.

Expectations for the performance of our transit, bikeways, roads, ports, and so on are increasing. At the same time, I see other states and countries moving forward. Minnesota is a truly great place to live and do business in. The challenge is this: How do we ensure our transportation systems maintain that competitiveness and meet our expectations well into the future?

How can U of M research help leaders address these challenges?

I get excited hearing about the research projects that are creating new insights or pragmatic ways to solve current problems. Whether it’s a study highlighting transit access to available jobs or new ways to improve road safety at lower cost, researchers create that unique insight that leads to new and innovative ways to solve very real-world problems.

So many elements—from environmental sustainability to equity to quality of life to economic and public policy—intersect at the crossroads of transportation policy, planning, and execution. Research leaders bring forward a fact-based, insightful lens to create options. Some say all transportation is local. That is true, but so is the fact that all transportation is connected.

How can the U of M and the private sector collaborate to improve transportation?

While collaboration is occurring, more can be done. Most private-sector entities think of their transportation issues and opportunities individually, as in, “How do I maximize my opportunity or solve my problem?” I think the role the U of M can play is in aggregating and prioritizing those issues to then apply research that has the greatest leverage potential.

The U of M also can play a role in bringing together the various viewpoints of stakeholders, all of whom are sharing the same asset—Minnesota’s transportation system. Lastly, I am a big advocate of bringing “the outside in.” Other states and universities are working on many of the same issues. The U of M and its researchers certainly play a role in bringing the best thought leadership to the state.

What changes do you anticipate for supply chains and the freight industry, and how can the U of M support these changes?

The changes we are seeing currently are immense, and the speed of change is increasing. For decades, transportation was thought to be a sleepy little thing that was always there in abundance at a very low cost. But now business supply chains are putting more and more pressure on transportation systems. That will only continue.

Everyone likes to focus on electric vehicles, automated vehicles, and other things on the horizon. While these are definitely worth pursuing, I think the availability and usage of data related to our systems is the next boundary to cross that really makes a significant difference. Supply chains strive to optimize costs and value delivery. More and more, data are becoming available to assist in both of these outcomes. Incorporating data on transportation utilization and effectiveness will yield strong benefits to those that pursue it. Research can both enable this connection as well as draw the picture for the potential outcomes.

In recent months, the CTS Executive Committee welcomed these new members:

- Margaret Anderson Kelliher, commissioner, Minnesota Department of Transportation
- Alexandra Cattelan, vice president of engineering, Polaris
- Christopher B. Clark, president, Xcel Energy—Minnesota, North Dakota, South Dakota
- Robin Hutcheson, director of public works, City of Minneapolis
- Joseph Konstan, associate dean for research, College of Science and Engineering, University of Minnesota
- Wes Kooistra, general manager, Metro Transit
- Wendall Meyer, division administrator, Federal Highway Administration, Minnesota Division
- Kim Norton, mayor, City of Rochester
- Nora Slawik, chair, Metropolitan Council
With the development of two new decision tools guiding the selection of sediment control logs, U of M researchers have helped address a widespread erosion control challenge.

Whenever the Minnesota Department of Transportation (MnDOT) or its contractors substantially disturb the soil at a project site, they are required to use practices that reduce sediment discharge when it rains. Sediment control logs—linear rolls filled with material such as straw, coconut fiber, compost, or rocks—are a commonly used method. However, these devices often fail because their performance is not well-defined or understood, and they are frequently installed incorrectly or at inappropriate locations.

“Sediment control log failure is a worldwide problem,” says Bruce Wilson, a professor with the Department of Bioproducts and Biosystems Engineering. “Our new research takes a substantial step toward a better understanding of the parameters within which sediment control logs can be effective, clarifying with data their capabilities as well as their limitations.”

For transportation agencies like MnDOT, sediment control logs represent a significant cost. To help control costs, MnDOT teamed up with U of M researchers to learn actual performance parameters as well as optimum locations and installation methods. Their goal was to improve practitioners’ ability to select the appropriate sediment control log for a specific purpose and location.

Researchers began with a literature review of studies that looked at a variety of sediment control methods. Next, they used a large hydraulic flume at the U of M's Biosystems and Agricultural Engineering Laboratory to examine the hydraulic characteristics of 12 sediment control logs filled with a diverse range of materials. Then, they investigated the sediment removal effectiveness and longevity of five representative logs using a smaller flume constructed specifically for this project.

In addition, researchers examined field installations of sediment control logs at different locations to learn how the devices were installed and, if they were failing, how they had failed.

The final products were two sediment control log selection tools and training materials for sediment control log use. The two tools—one for ditch checks and one for perimeter control—will guide practitioners to select the correct sediment control log using watershed area, basin, and ditch slope. Researchers also adapted the results of the investigations into a set of training materials for erosion control and stormwater management.

The guidance developed through this study is currently making a difference at MnDOT, where the training materials have already been implemented in erosion control and stormwater management certification workshops.

“This new knowledge will allow us to reduce costs in all areas of sediment control and more effectively protect the environment,” says Dwayne Stenlund, an erosion control specialist in MnDOT’s Office of Erosion Control and Stormwater Management.

This sediment control log was correctly installed on a wood fiber blanket.
explore extending the battery range of these vehicles—and in doing so, increase both their fuel economy and appeal to consumers.

The research team was led by Earl Sharpe, co-founder of the Minneapolis start-up Macchina LLC, and Will Northrop, associate professor of mechanical engineering and director of the Thomas E. Murphy Engine Research Laboratory (MERL) at the U of M.

According to Northrop, the idea for this project sprang from other U of M work in progress involving hybrid delivery trucks. “We were developing algorithms that can optimize how frequently the engine charges the battery on board a delivery vehicle, and from there, save fuel, because it uses the engine less and the battery system more,” he explains. “We thought it would be interesting to take that same technology from delivery trucks and move it into passenger cars—in particular, plug-in hybrids.”

Plug-in hybrids have an electric motor and internal combustion engine that are used synergistically to reduce fuel consumption while maintaining a near-constant battery charge; they can also be charged externally to enable electric-only operation (EOO). However, how far a PHEV can be driven in electric-only mode before depleting the battery charge depends on a number of factors, such as driving style and the outside air temperature, Northrop says. So the goal of the current project was to increase the all-electric range by using a cloud-connected intelligent energy management strategy as an aftermarket solution for PHEV owners. “If you can get a higher all-electric range, then you’re saving fuel and money,” Northrop says.

The partnership combined Macchina’s expertise in vehicle communication device (VCD) hardware and the U of M’s expertise in vehicle powertrain and routing co-optimization (VPRO) technology. VPRO technology uses data (historical travel data plus information such as weather and traffic conditions), machine-learning algorithms, and modeling to determine when a plug-in hybrid should be in EOO mode for a given route.

The researchers designed a prototype VCD to collect the necessary vehicle data (such as vehicle speed, engine power output, and battery charge) and enable EOO mode in the test vehicle, a Chevrolet Volt. Data were collected from the vehicle on a representative commuting route of 20.7 miles. The team then created a vehicle model with the data to simulate energy consumption when driving in “normal” (EOO) mode versus fuel consumption in “hold” (charge-sustaining) mode.

The researchers simulated the commuting route using the model with different settings and estimated a miles-per-gallon fuel reduction of between 3.3 and 8.9 percent with the technology—and they believe the approach would be valid for other PHEVs besides the Volt.

The proposed implementation, Northrop says, would be a smartphone app that would alert the PHEV driver to the ideal time to be in a given powertrain operating mode.

Besides having interest for governmental agencies, fleets, and other potential customers, the results will inform future U of M research, Northrop says. “We’re looking at different types of vehicles and how to apply what we’re doing. All these projects kind of build on each other,” he says.

Sharpe says this was Macchina’s first time being involved on the research side of a project, rather than simply supplying the hardware University researchers use. “Electrification seems like the way the world is heading in terms of automotive,” Sharp says. “It’s still in the really early stage. So it was great for a company like us to be involved in something new and cutting edge.”

**Illustration showing the project approach, with a smartphone app as the proposed implementation**

**Delivering fuel savings along with packages**

In a related project, U of M researchers with the Murphy Engine Research Lab are developing technology to improve the fuel efficiency of delivery vehicles through real-time powertrain optimization using two-way vehicle-to-cloud connectivity. View an animation of their connected energy management system and learn more at vpro.umn.edu.
To combat this problem, the Minnesota Department of Transportation (MnDOT) developed a Smart Work Zone Speed Notification (SWZSN) system that informs drivers of the actual speed of slowed downstream traffic near large freeway work zones. Researchers from the Minnesota Traffic Observatory tested and evaluated the system over time in an actual highway construction work zone—and found that it works.

“Through the analysis of tens of thousands of data points collected from highway drivers, we were able to show that messages clearly informing drivers about slowed traffic ahead—unlike speed advisories— influence them to reduce their speed in a timely way in congested highway construction areas,” says John Hourdos, director of the U of M’s Minnesota Traffic Observatory.

The new system collects traffic speed data throughout a work zone, runs it through an algorithm, and generates a real-time message for drivers on a variable message sign, such as “35 MPH 1 Mile Ahead” or “Stopped Traffic Ahead.” The system was deployed at a large, multistage highway work zone east of downtown Saint Paul. New pole-mounted speed detectors were installed throughout the work zone, along with solar-powered cameras on mobile trailers.

“The cameras were important for capturing traffic flow images in strategic locations where traffic queues were forming because the work zone was complex, crowded, and often changing,” Hourdos says. “Processing the video with custom-developed machine vision applications, we were able to extract vehicle trajectories and calculate each vehicle’s deceleration rate when approaching traffic congestion.”

The MnDOT-funded project was completed in three phases during two construction seasons. During the first year of implementation, researchers found glitches in the speed notification algorithm. By the second construction season, they had made adjustments and reconfigured the speed sensors, significantly reducing those anomalies.

According to the team, the most significant results of this project showed that in situations where the messages communicated to drivers were consistent and accurate, deceleration rates in work zones declined more than 30 percent. “The speed notification system was clearly noticed by drivers, and it has a statistically significant influence on their behavior,” Hourdos says. “They slowed down sooner, and more smoothly.”

“This project allowed MnDOT to troubleshoot and improve its messaging to drivers about downstream traffic slowdowns,” says Brian Kary, director of traffic operations at MnDOT’s Regional Transportation Management Center. “We’ve already deployed the system at two current sites, with more planned for the future.”

### Don’t forget to register!

**CTS Transportation Research Conference**

**November 7**

**Graduate Minneapolis Hotel, Minneapolis, MN**

Join us for a day of discovery and innovation on the U of M campus! Full program information is available at [cts.umn.edu/events/conference/2019](cts.umn.edu/events/conference/2019).
MORE FUEL EFFICIENCY, LESS ANXIETY: extending the range of PLUG-IN HYBRIDS.

page 1

BRIDGE REPAIR research project wins state government INNOVATION AWARD.

page 2

New U OF M PRESIDENT learns about transportation innovation in an AUTOMATED VEHICLE DEMO.

page 3

Smart speed warnings alert drivers nearing freeway work zones.