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RESEARCH SERVICES

OFFICE OF POLICY ANALYSIS, RESEARCH & INNOVATION

TECHNICAL SUMMARY

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PROJECT COST:
$160,000

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

Automating Friction Measurement and Applicator Control for Snowplows

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

What Was the Need?

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

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

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

What Was Our Goal?

The objectives of this research included:

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

What Did We Do?

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

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

continued

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

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

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

What Did We Learn?

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

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

What's Next?

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

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

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

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

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

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

–Farideh Amiri,
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