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RESEARCH PROJECT TITLE

Measurements of Pavement Condition and Road Weather Environment within North Dakota using a Tow-Hitch-Mount Road-Grip Tester – Aurora Project 2007-02

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PROJECT TEAM

Jeffrey S. Tilley, Scott S. Kroeber, and Luke Johanneck
Surface Transportation Weather Research Center, University of North Dakota
tilley@rwic.und.edu

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MORE INFORMATION

Chris Albrecht
Iowa State University – InTrans
2711 S. Loop Drive, Suite 4700
Ames, IA 50010-8664
515-294-7684 calbrech@iastate.edu

ABOUT AURORA

Aurora is an international partnership of public agencies performing joint research, evaluation, and deployment initiatives related to road weather information systems (RWIS).

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Measurements of Pavement Condition and Road Weather Environment within North Dakota using a Tow-Hitch-Mount Road-Grip Tester

project summary

Background

Each year, many highway accidents are attributable to adverse weather conditions. These accidents result in significant loss of life, injuries, reduced roadway capacity, increase in travel times, and slowdowns in shipping and commercial activity.

Problem Statement

Hundreds of accidents nationwide are reported as attributable to a loss of vehicular traction. Many of these accidents are associated with snow and ice accumulation on roadways as a consequence of winter storms or by the formation of pavement frost or black ice during more quiescent weather regimes.

Research Description

A cooperative effort between the University of North Dakota (UND), the Ohio Department of Transportation (ODOT), Halliday Technologies,Inc , the Rural Geospatial Innovations program, and the Aurora Program, was undertaken to collect data on road surface friction conditions utilizing a test research vehicle equipped with a tow-hitch-mount road-grip test unit.

The focus of this study was the 2006-07 winter season (November 2006 to April 2007). The primary areas for data collection were segments of two eastern North Dakota routes, Interstate 29 (I-29) and U.S. Federal Highway 2 (US 2), extending southward and westward from Grand Forks, North Dakota, respectively (Figure 1).

The choice of these route segments was motivated by the fact that these segments coincide with test routes for the Federal Highway Administration (FHWA) Maintenance Decision Support System (MDSS) and other Surface Transportation Weather Research Center (STWRC) research activities, allowing for leveraging of resources for the project.

Methodology

The test unit (RT3) is mounted at an offset angle to the alignment of the remainder of the wheels on the research vehicle, thereby producing a net sideways drag force that varies with the amount of grip, which is a function of the pavement condition (Figure 3). A software console inside the vehicle provided road grip values at a 1 Hz frequency (Figure 4).

This document summarizes the real-time measurements on eastern North Dakota primary routes during winter weather events, utilizing the on-board global positioning system (GPS)-encoded video system for precise tracking and high resolution visual characterization of the roadway environment.

Conclusions

Because of funding and resource limitations, the study cannot be considered to be entirely comprehensive, but does add a considerable body of work to previous tests conducted in less extreme environments. In addition, a substantial data set has been created using multiple technologies that has unique applications in future pavement condition research and modeling, and the investigators are happy to make this data available upon request to any interested party.

The study can also be considered to be somewhat less comprehensive than hoped due to the existence of less severe winter weather during the test period than is typical for the northern plains, with fewer winter storms, generally warmer conditions, less snowfall, and less freezing rain than occurs in a climatologically normal winter. Nonetheless, the unit was exposed to some degree of subzero (Fahrenheit) conditions, numerous events with air and pavement temperatures subfreezing but above 0° F, and roadway surfaces containing a variety of pavement conditions.

We had hoped to conduct more extensive testing in conjunction with a separately funded project, but those tests proved more difficult to stage than anticipated. However, we feel we have made up for this aspect of the project by providing a much larger than originally planned number of road-mile real-time tests, providing us with a degree of confidence in how the RT3 unit would perform within a real-time operational maintenance environment where road grip might be utilized in some fashion as a performance measure.

Key Findings

- First, the RT3 unit proved to be a very reliable equipment platform. Despite adverse conditions on several days during which considerable snow and slush became compacted on all exposed surfaces (including the wheels), the unit reported reliably, though with a noticeable decrease in Halliday friction number (HFN) values, which was always a sure sign that excessive material was collecting on the unit. In such instances, we were able to pull the vehicle off the road, clear out the compacted material, and continue on with reasonable HFN values once again being reported. The RT3 tow unit proved more reliable than either the originally installed ThomTech GPS/data unit or the ODOT pickup itself, which was out of operation for nearly 10 days in January when it required servicing due to a problem related to prolonged exposure to cold. Such exposure to cold did not appear to affect the RT3's reliability; the unit operated at temperatures down to ~ -26o C with no maintenance required over the winter season.
- The analysis of the merged RT3-RedHen-Video dataset shows convincingly that the RT3 unit is capable of distinguishing changes in roadway traction conditions over very fine scales (~ O 15 m) with good fidelity and repeatability. When averaged out to larger scales (~ O 200 m and greater), the RT3 provides an excellent indicator of segments where pavement conditions require greater maintenance treatment as opposed to segments that have acceptable traction.
- In general, the RT3 measurements appear to capture the changes in road grip that would be expected for the variety of pavement conditions encountered. Only very weak relationships were found between the measured RT3 HFN values and the values of other variables (vehicle speed, vehicle heading, air temperature, pavement temperature, pavement age, pavement type) that might potentially produce biases in the road grip measurements. These weak relationships are generally consistent with previous ODOT testing as well as consistent with warm-season tests performed during the Runway Friction Workshop at the National Aeronautics and Space Administration (NASA) Wallops Island Flight Facility in Virginia in May 2007. The main difference between our results and the Wallops testing relates to the relationship between HFN values and vehicle speed, and these differences are not likely to be statistically significant given the weak regression coefficients seen in our dataset as well as the fact that different tires were used within the two studies.
- If anything, the relationships noted between HFN values and the other variables are substantially weaker than what was seen in previous ODOT testing, suggesting that the RT3 unit can be used as a robust measure of road grip/ roadway friction.
- When combined with a GPS-Video positioning system and/or automatic vehicle location (AVL) technologies, the RT3 has considerable potential for both real-time operational use (as a tool to help guide wintertime snow and ice control maintenance activities prior to, during, and after snow and ice events) and for use in research activities intended to develop friction/ road grip as a performance measure. We would hope in future studies to be able to pursue this course of research.