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research for winter highway maintenance

RESEARCH BRIEF

OCTOBER 2025

USING GRIP DATA FOR WINTER MAINTENANCE

RESULTS SUMMARY

States are using surface grip data to guide salt application rates and enhance winter maintenance operations. But models using the data need to be refined to maximize future use.

PROJECT DETAILS

Project Title: Grip Sensor Technology and Salt Applications

Project Number: CR21-01

Project Cost: $149,997

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Need for Research

Information and data that accurately identify the slipperiness of roads during winter storms are valuable for making decisions about salting operations. Surface grip information allows winter maintenance managers to optimize salt spreading and ensure sufficient levels of service while reducing costs and the negative environmental impacts of oversalting. This project examined the use and effectiveness of surface grip data sources to inform real-time decision-making to improve road conditions, enhance safety and optimize salt use.

Objectives and Methodology

This project's objectives were to evaluate roadway grip data as a viable source for informing winter maintenance operations and to develop models that use the data to identify the need for salt applications.

A literature review examined grip sensor technology, sources of grip data, the importance of data quality assurance and control, and sensor calibration to ensure the availability of accurate data. A survey of state and local transportation agencies then assessed the current use of collected grip data for winter maintenance operations.

Four case studies presented a closer look at how agencies are using grip data in winter maintenance operations to maintain sufficient levels of service and provide slippery road alerts while reducing environmental impacts.

Investigators developed two types of algorithm models: one using stationary-based grip data from road weather information systems and another using mobile-based grip data from sensors mounted on snowplows. The information was combined with salt application rate data from snowplows and road weather data for analysis. Five machine learning (ML) models were evaluated for their ability to predict changes in surface grip after salt application while incorporating weather variables during the snow events.

Results

The literature review found that nationally, roadway grip data is used extensively in Idaho and Utah and internationally in Finland, Norway and Sweden to

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Roadway grip data is a viable source for informing salt application rates in winter maintenance operations.

inform real-time decision-making, planning, and post-storm or post-season reviews. Specifically, agencies use the data to determine when roads need deicing treatment, identify or forecast roadway conditions, and inform treatment options.

The survey received responses from 18 states that use surface grip data. Most of the data is collected by stationary noncontact sensors, although many states also collect data from mobile noncontact sensors. Agencies use the data to inform real-time decisions, determine deicer application strategies, plan operations, and train and review operations and forecasting.

Case studies further examined agencies incorporating roadway grip data into their winter maintenance operations. The specific range of potential uses is currently unclear, highlighted by the potential use of third-party grip data that only recently became available in the United States. Agencies that have integrated grip data have improved resource efficiency, enhanced their measurement of winter maintenance operations performance and more effectively treated roadways by incorporating real-time feedback.

The stationary-based data model effectively predicted the impact of salt applications on surface friction, but implementing the model requires expertise, effective data management and accurate interpretation of the results. The random forest model performed the best of the ML models using mobile data. Analysis identified surface state before and after salt application, water thickness before application, and air temperature and surface temperature after application as the most influential variables.

Benefits and Further Research

Grip sensor modeling that uses both stationary and mobile data to support winter maintenance operations and decision-making has significant potential. While both data sources are advantageous, overall, the stationary-based model produced better results due to statewide coverage of road networks and more robust data. But this model can only provide point location data. The mobile-based data often has less coverage but can provide data wherever vehicles travel. Better results with mobile data will require data from more vehicles, repeated data from road segments and longer-term datasets.

Moving forward, investigators need to refine and further verify the ML models with data from a variety of storm events. Recommendations for future work also include the importance of incorporating quality assurance and validation of data, sensor calibration, uniformity of data collection and guidance to support these goals. Additional data for analyses could include snowplow-based data (such as plow up and down) and calibration records or certification for spreaders (solid and liquid) to improve grip change predictions after treatments.

"This research provides a great foundation for transportation agencies exploring the use of grip sensor technologies in their winter maintenance programs."

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