Safety and Mobility Impacts of Winter Weather – Phase 3

tech transfer summary

Identifying, or prioritizing, sites for additional safety review or improvement within a road network is an essential task for engineers in state agencies to ensure efficient allocation of limited resources for mitigating possible safety issues.

Problem Statement

Highway agencies spend millions of dollars to ensure safe and efficient winter travel. However, the effectiveness of winter-weather maintenance practices on safety is somewhat difficult to quantify. When crashes are viewed over multiple years, some locations appear to have an overrepresentation of crashes.

Background

Safety and Mobility Impacts of Winter Weather - Phase 1 investigated opportunities for improving traffic safety on state-maintained roads in Iowa during winter weather conditions. The primary objective was to develop several preliminary means for the Iowa Department of Transportation (DOT) to identify locations of possible interest systematically with respect to winter weather–related safety performance based on crash history.

Specifically, four metrics were developed to assist in identifying possible habitual winter weather-related crash sites on state-maintained rural highways in Iowa. In addition, the current state of practice, for both domestic and international highway agency practices, regarding integration of traffic safety- and mobility-related data into winter maintenance activities and performance measures was investigated.

In Phase 2, a combination of the Phase 1 results and Iowa DOT maintenance field staff input were employed to evaluate three Iowa DOT high-priority sites. Winter-weather crash-mitigation analysis procedures were developed and applied for three sites. Realistic maintenance and operations mitigation strategies were also identified.

Objectives

The three primary objectives of the Phase 3 project were as follows:

- Develop and investigate a more systematic site prioritization protocol
- Develop crash frequency prediction models
- Analyze winter weather and crash history at the prioritized sites

Research Description and Methodology

Site prioritization techniques, for identifying roadway segments with the potential for safety improvements related to winter-weather crashes, were developed through traditional naïve statistical methods by using raw crash data for seven winter seasons and previously developed metrics.

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RESEARCH PROJECT TITLE
Safety and Mobility Impacts of Winter Weather – Phase 3

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Crash frequency models were developed using integrated crash data for four winter seasons, with the objective of identifying factors that affect crash frequency during winter seasons and screening roadway segments using the empirical Bayes technique. Empirical Bayes accounted for the regression to the mean (RTM) phenomenon by overcoming the limitations introduced by traditional methods.

Safety performance functions (SPFs) were developed for three types of roadways in Iowa to predict winter weather-related crashes as a function of several factors related to winter-weather conditions such as visibility, pavement temperature, air temperature, and wind speed.

The empirical Bayes approach was used to combine the predicted number of crashes from the SPFs with the observed crash counts at a location to produce an improved estimate of the expected number of crashes.

The difference of the empirical Bayesian adjusted crash frequency and the predicted crash frequency from an SPF is referred to as the potential for safety improvement (PSI). The higher the PSI value for a road segment, the higher potential for improving safety on that road segment.

Considering the PSI, the roadway segments were ranked or prioritized so that highest possible safety improvement can be achieved.

Based on these prioritization techniques, 11 sites were identified for more in-depth analysis in conjunction with input from Iowa DOT district maintenance managers and snowplow operators and the Iowa DOT Road Weather Information System (RWIS) coordinator.

Key Findings

Weather factors such as visibility, wind speed, and air temperature were found to have statistically significant effects on crash frequency along different types of roadways.

The ranking of roadway segments for PSI also differed from the ranking produced by simple crash frequency, which does not take into account the RTM; however, similarities did exist among the techniques.

While crash data served as a foundation for site analysis meetings, insight from Iowa DOT maintenance field staff was invaluable, particularly with respect to their maintenance practices, observations of events under various conditions, possible mitigation strategies, and impacts of the roadside environment. While some of the feedback may have been anecdotal in nature, maintenance staff are uniquely qualified to discuss winter-weather safety, given their nearly exclusive experience in maintaining the roadways and sharing them with motorists during a wide array of different weather conditions.

Additionally, site analysis meetings serve as a forum to increase awareness as well as facilitate open discussion of concerns, mitigation alternatives, and opportunities for coordination and improvement. The final project report provides details on the following issues that were identified:

- A prominent issue among all sites, through their entire extent or in localized areas, was blowing snow
- Poor roadway condition and/or macro texture of pavements along several sites may contribute to winter weather–related crashes
- Challenges in maintenance operations focused on snowplow runs and potential solutions, but were also reflected in crash experience as follows:
  - Glazing of wheel tracks between 8:00 a.m. and 10:00 a.m.
  - Refreeze between 4:00 p.m. and 6:00 p.m.
  - Slushy road conditions between 25 and 32 degrees Fahrenheit, intermittently moving in out and out of a frozen state
  - Roadways typically do not become icy or slick at low temperatures, such as between 10 and 15 degrees Fahrenheit

Implementation Readiness and Benefits

In this study, a primary objective was prioritizing segments for additional analysis to determine if, and what types of, safety improvements may be feasible.

The PSI ranking produced by employing the empirical Bayes technique can be useful to identify roadway segments to consider for PSI and allocate agency resources in an effective manner to mitigate winter weather-related crashes. SPFs developed in this research can be used to produce a ranking based on PSI by using crash observations made over a specific number of years for winter-weather crashes.

There are multiple benefits associated with identification and analysis of locations with the potential for safety improvements related to winter-weather crashes. In general, the effort supports the Iowa DOT's safety and mobility initiatives.

Possible Mitigation Strategies

Several possible mitigations strategies were identified and discussed in the site meetings. Strategies may be considered broadly as roadway or roadside-related, informational, or operational in nature. Some of these strategies, and possible limitations, are covered in more detail in the final project report.

Expansion of snow fence installation was a commonly recommended strategy, including entirely new installation, filling in of gaps, and increasing heights. Limited right-of-way (ROW) availability may impact the ability to implement this strategy at all locations. But, standing stalk programs were suggested as a viable alternative, if participation can become more attractive.

From an operational standpoint, reevaluation of snowplow run turnaround locations, length of snowplow runs, snowplow run overlap, dedicated ramp trucks, cooperation or partnering with neighboring maintenance garages, and material use during different conditions were suggested mitigation strategies. Lastly, improving driver information, particularly in advance of locations prone to rapidly changing or different conditions, was proposed as a possible mitigation strategy. Information may be conveyed via permanent or portable dynamic message signs (DMSs). Locations of devices (specifically, portable DMSs), appropriate activation protocol, and message content would need to be established. Consistency among locations throughout the state may be an additional consideration.