Adding Pre-Treated Salt to the Winter Maintenance Tool-Kit

Winter weather can have a significant impact on road conditions, affecting the safety and mobility of road users. Area Maintenance Contractors (AMCs) working for the Ministry of Transportation (MTO) follow Best Practices and Contract Specifications to plow, anti-ice and de-ice highways to provide safe driving conditions in winter. Applying dry rock salt to the roadway is a common method for snow and ice control.

MTO’s winter maintenance practices include pre-wet salt. Salt is pre-wetted by spraying it with winter maintenance liquid as it is being applied to the roadway. The typical ratio of liquid to rock salt is about five per cent. This method allows lower application rates because the liquid coating promotes the adhesion of salt to the roadway and faster melting of snowpack, and the flexibility to use dry rock salt when conditions are suitable to it. A 1998-2001 field trials program showed pre-wet salt to perform equivalently to rock salt when applied at rates up to 30 percent lower.1

Recently, vendors have promoted pre-treated salt as an alternative to pre-wet salt. Salt is pre-treated by applying brine directly to the salt. This practice eliminates the requirement for brine storage tanks at patrol yards and spraying equipment mounted on winter maintenance vehicles. Intuitively it could be expected to work similar to pre-wetting to improve the performance of rock salt.

The ministry and other road agencies have developed a good understanding about the relative performance of dry rock salt and pre-wet salt. However, no formal documentation was available about the comparative performance of pre-treated salt. The ministry, in partnership with its AMCs, elected to conduct trials to compare the benefits of each method.

A comparative testing and analysis program was developed by the Winter Materials Working Group, a joint industry-ministry body that meets twice a year to review issues related to the use of road salt and winter sand on provincial highways. The goal of the program was to establish equivalent application rates for dry rock salt and pre-treated salt, similar to the 1998-2001 testing program that established the current equivalent application rates for rock salt and pre-wet salt.

**Location**

The Working Group retained an independent consultant, CIMA+ to collate data and conduct the comparative analysis of dry and pre-treated salt. Four contract areas were used initially to gain experience under a variety of operating conditions, at patrols near Harriston, Verner, Morrisburg, and Huntsville. Four Area Maintenance Contractors were involved; Miller Maintenance, Broadspectrum (formerly Transfield), Carillion and Highroads Maintenance. At each site, adjacent highway sections with similar traffic and weather conditions

Adding Pre-Treated Salt to the Winter Maintenance Tool-Kit, continued

were designated as either a control section using only rock salt (or winter sand when appropriate) or a test section using pre-treated salt.

In season two, testing was limited to Highway 17 in the Verner area to obtain a more intensive data set.

Materials

Application rates used for each storm varied depending on local precipitation, temperature and road conditions. Application rates of 130 kg per 2 lane km and 170 kg per 2 lane km were used for dry salt depending on road and weather conditions.

The application rates used for the pre-treated salt were 90, 105 or 130 kg/2 lane km depending on road and weather conditions. This ensured that there was a multitude of spreading rates data captured over the course of the winter. The same rock salt and liquid materials were used on the test and control sections. The liquid was a concentrated solution of primarily MgCl₂ and was applied at two-to-three per cent by mass, while salt in the pre-wetted sections had liquid added at five per cent by mass.

Data Collection

The program included specific performance measures collected by regular patrol staff and by a specially outfitted patrol truck with a Mobile Data Collection Unit (MDCU). Patrol staff observed and recorded Winter Operations Records (WOR) showing the activities of maintenance vehicles each time they left the patrol yard, Winter Patrol Records (WPR) recording weather and road conditions along the route, diary observations about relative conditions in the test and control sections, and electronic records of material application in each section based on Automated Vehicle Location (AVL) system, from on-board electronic spreader controllers and infra-red thermometers.

The AVL records provided precise geographic records at ten second intervals, of material application and plow position on each traverse of each route. The patrol truck was equipped with a friction trailer used to measure roadway friction in the left wheel track behind the truck, and a spectral camera, which measured surface temperature and estimated the road cover type, depth, and friction in the left wheel track ahead of the truck. All data were recorded at approximately one second intervals, with GPS coordinates.

Road-Weather Information System (RWIS) provided records of air and road temperature, wind speed/direction, and precipitation, approximately every 15 minutes. Two RWIS stations are in place in the Verner test area, one east of the pre-treat section and the other west of the dry salt section.
Adding Pre-Treated Salt to the Winter Maintenance Tool-Kit, continued

Data Processing, Integration and Quality Control

Twenty-six winter events having complete data sets were included in the combined analysis of de-icing materials - five events from the 2014/15 winter trials and twenty-one events from the 2015/16 winter trials. The collected data from RWIS, MDCU, the friction trailer and spectral camera were integrated to form a single dataset which included all corresponding information required for analysis.

Data analysis was completed qualitatively, through AMC observations, and quantitatively, through exploratory and statistical analysis. The statistical analysis involved a comprehensive modelling effort comparing the effectiveness of the applied snow removal treatments.

Measures of Effectiveness

The exploratory analysis involved a detailed review of the time trends observed in the adopted measure of effectiveness. The performance of the de-icing materials was compared using a range of measures indicative of their effectiveness in restoring safe driving conditions. These measures include bare pavement regain time (BPRT) and roadway friction.

<table>
<thead>
<tr>
<th>Measure # 1: Bare Pavement Regain Time (BPRT)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Definition: The time between the secession of snow or freezing rain and the time when road maintenance has ended.</td>
</tr>
<tr>
<td>Note: MTO considers bare pavement regained “when 95% of the driving surface (edge line to edge line) is free of snow, slush, and/or ice”</td>
</tr>
<tr>
<td>In this analysis, the end of plowing and spreading operations is considered as a proxy of 95% regain time.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Measure # 2: Friction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Definition: Friction coefficient, or ( \mu ), is a value between 0.0 and 1.0, which relates horizontal force to normal force and represents the maximum attainable acceleration on a specific road surface.</td>
</tr>
<tr>
<td>How is it measured?</td>
</tr>
<tr>
<td>Road friction, or grip, is a measured value in the wheel track and relates directly to the distance required to stop a vehicle on a highway. For example, the friction value of a dry, good quality road might be 0.80 and that of an icy road might be 0.20.</td>
</tr>
<tr>
<td>Two types of data collection equipment in this study report friction values: the friction trailer and the spectral camera. The trailer measures the friction directly using the calibrated tire; the spectral camera calculates friction from identified cover type and depth.</td>
</tr>
<tr>
<td>Spectral camera data were used for the analysis in this study as they provided a more complete data set.</td>
</tr>
</tbody>
</table>

---

1 aurora-program.org, Completed Project 1997-03, Appendix C.
2 Provincial Maintenance Memorandum #2015-06, Bare Pavement Definitions, Maintenance Management Office, MTO
3 Experiences of Mobile Road Condition Monitoring, Taisto Haavasoja, Juhani Nylander and Pauli Nylander, SIRWEC 2012, Helsinki, 2012
Comparative Analyses Results

The following conclusions and recommendations were made from the qualitative, exploratory, and statistical analyses:

Qualitative Analysis (from 2014/15 study):

- Concerns were raised about apparently more frequent occurrence of re-freezing events after pre-treated salt application than after dry salt and pre-wet salt applications; and
- A maximum cost-effective application rate for pre-treated salt was estimated as 105 kg per 2 lane km, in comparison with dry rock salt at 130 kg per 2 lane km.
- For the majority of the storm events, pre-treated salt application rates were lower than those of the dry salt while obtaining similar BPRT, implying similar performance with lower pre-treated salt application rates.

Statistical Analysis:

- The exploratory analysis identified certain road sections that were susceptible to snow drifting or to intersection traffic characteristics that could potentially bias the analysis. The end points were identified and the potentially biased sections were automatically excluded from the statistical analysis using GPS coordinates.
- Average friction number on individual traverses and through a storm event was identified as the key performance indicator for comparison of dry and pre-treated salt. A multiple regression analysis was used to estimate the coefficients of relative performance of dry and pre-treated salt when applied at different rates during the storms included in the analysis, and variable interaction was used to account for differences in performance associated with different road surface temperature conditions. The graphs in Figure 5 summarize the results for the analysis based on average friction on each traverse of the test and control sections. Similar results were obtained using an event level analysis.
- Each line on the graphs is based on traverse level averages of all the friction values measured at one second intervals through all traverses of all storms included in the analysis, and the associated road surface temperatures. Each of the lines shows the estimated friction value at a given surface temperature. The graph on the left shows results during heavier snow cover conditions (road was plowed during that traverse) and the graph on the right shows results during light snow conditions (plow was not in use), and each graph includes only cases within 30 minutes or less elapsed between the time of material spreading and the time of friction measurement.
- A higher position of the performance estimate line on the graph indicates higher friction and implies better snow clearing performance. Thus, under heavier snow conditions, pre-treated salt at application rate 130 performed best at all temperatures. Pre-treated salt at application rate 105 performed better than dry salt at application rate 130 in warmer conditions but not at colder conditions.
- Crossing of performance estimate lines implies equal performance between the two treatment types at specified application rates. The crossing of the pre-treat 105 and dry 130 performance lines under plowed conditions suggest that they performed equally at -4°C, implying that pre-treat could be used at 20 per cent lower application rate.

Figure 5: Friction estimated with variable interaction between salt type and application rate (kg/2 lane km), and surface temperature (°C)
Adding Pre-Treated Salt to the Winter Maintenance Tool-Kit, continued

for equal performance to rock salt, but only at relatively warm temperatures. The equivalency at -8°C is 15 percent lower application of pre-treated salt.

- Pre-treated salt generally outperformed rock salt under the heavier snow conditions but equivalency under the range of conditions experienced would restrict the reduction in application rates with pre-treated salt to 15% less than dry salt. The results for lighter snow conditions suggest that, except near freezing, rock salt performed better than pre-treated salt.

- The performance under heavier snow conditions in comparison to the 1998-2001 trials of pre-wet salt, corresponds roughly with the ratio of liquid to rock salt.

Conclusion
Ministry contractors were hopeful to use pre-treated salt at similar application rates to pre-wet salt (up to 30% less than rock salt) on the rationale of cost savings when compared to total cost of materials and equipment. However, results show that the performance of the pre-treated salt was intermediate between dry salt and pre-wet salt.

The difference in performance may relate back to the amount of liquid used on the salt. When salt is pre-treated, it holds one to three per cent of the applied liquid, while the remainder drains off. When salt is pre-wet during application, as much liquid as required can be used with no liquid loss.

While the final results indicate that the equivalent application rates do not provide economic justification at the present time for using pre-treated salt, the results are being incorporated into Maintenance Best Practices to allow application rate reductions up to 15% for pre-treated salt, compared with 30% for pre-wet salt, at the option of Area Maintenance Contractors.

The full details of the 2014-2016 trials, data collection and analysis were presented at the Transportation Association of Canada (TAC) Conference in September 2017.

The full Combined Analysis of Pre-Treated Salt Trials, April 2017 Report is available at the Ministry of Transportation Library.

For more information, contact:
Max Perchanok, Coordinator for Innovations and Sustainability, Provincial Highways Management Division, at (905) 704-3998, or at Max.Perchanok@ontario.ca

Winter Material Working Group

An industry-Ministry working partnership was established in 2014 in response to a ministry review of the winter maintenance program, with the purpose to review and improve practices for the use of winter maintenance materials. It includes representatives from all Area Maintenance Contractors, the Provincial Maintenance Management Office and all Regional Offices. The role of the Working Group was strengthened following a 2015 Report of the Provincial Auditor General about Winter Highway Maintenance.

The Terms of Reference are; to conduct literature reviews, discussions and scientific or practical research as needed to ensure that road salt and other anti-icing or de-icing chemicals and winter sand, are used in a cost-effective and environmentally sensitive manner for winter maintenance on provincial highways. Pre-treated salt was advanced by industry as a top study priority when the group was formed.

Other current priorities include: pre-wet winter sand; anti-icing with liquids in advance of snow accumulation and; innovative methods of mechanical removal of hard packed snow at very cold temperatures.

Sponsored projects have access to specialized equipment and personnel for precisely monitoring maintenance operations and resulting snow conditions or traction in live-testing situations on highways. Additional research and analysis expertise is obtained when needed, from consultants and universities. Study results are peer-reviewed and can be obtained through the ministry’s library or from conference presentations such as the Transportation Association of Canada or the U.S. Transportation Research Board.

More Road Talk issues can be found on the Ontario Ministry of Transportation website: http://www.mto.gov.on.ca/english/publications/road-talk.shtml

Subscribe to Road Talk: roadtalk@ontario.ca