2008 TRB Annual Meeting DVD
Papers related to winter maintenance

Application of Road Visibility Information System (RVIS) to Winter Maintenance
Yasuhiro Nagata and Keiji Araki, Japan Weather Association; Toru Hagiwara, Hokkaido University; Yasuhiro Kaneda, Hokkaido Development Engineering Center; Hirokazu Sasaki, Hokkaido Regional Development Bureau.
Paper Number: 08-2701
From: Introduction
Based on previous studies, the researchers developed a Road Visibility Information System (RVIS) for calculating the road visibility index in real time from daytime road images recorded by CCTV cameras along roads. The RVIS can change still images into quantitative data, judge visibility from road images and function in place of the road administrator's eyes. Visibility data were reliably collected using the RVIS from still images transmitted by multiple CCTV cameras at a mountain pass on National Route 230 during winter 2006. The objective of this study was to determine whether the RVIS is accurate regardless of year and terrain.

Assessment of Wash-water Quality Beneath Salt-spreader Racks: Lubricant and Salt Quantification
Megan Fuller and James Smith, University of Virginia; G. Michael Fitch, Virginia Transportation Research Council.
Paper Number: 08-2657
From: Abstract, Purpose and Scope
Virginia DOT currently stores its salt spreaders on hanging racks that allow for lubrication, but not washing and rinsing. If washing, rinsing, lubrication and storage could occur at a single location, spreader maintenance would require significantly fewer steps and less time. The purpose of this research effort was to determine if VDOT should provide an impermeable surface to prevent contamination resulting from lubrication and, if so, to determine if washing could occur over the same impermeable surface.

Association of Highway Traffic Volumes with Cold, Snow and Their Interactions
Sandeep Datla and Satish Sharma, University of Regina, Saskatchewan.
Paper Number: 08-0843
From: Abstract, Introduction, Summary and Conclusions
The main objective of this study was to investigate highway traffic volume variations due to severity of cold, amount of snowfall and various combinations of cold and snowfall intensities. Detailed consideration is given to factors such as highway type and location. The study is based on hourly traffic data from 350 permanent traffic counter sites and weather data from 598 weather stations in Alberta, Canada from 1995 to 2005. Results indicate that the impact of cold and snow on traffic volume varies with day of week, hour of day, type of highway and adversity of cold.

Effect of Winter Events on Highway Performance in the Province of Alberta
Lynne Cowe Falls, University of Calgary, Alberta; Roy Jurgens and Jack Chan, Alberta Infrastructure and Transportation.
Paper Number: 08-1886
From: Abstract
Using data from weigh-in-motion sensors and regional weather data from Environment Canada, the effect on mean vehicular speed of various winter events was determined at six sites across the Alberta provincial highway system. Reduction in vehicular speed and the duration of the speed reduction (time to recovery) were calculated for five event types and differences noted. The methodology developed shows promise for future development of robust, repeatable and easily understood performance measures that can be used to monitor winter events and to develop future benchmarks.

Development of New Performance Measure for Winter Maintenance Using Vehicle Speed Data
Wei-Yin Loh and Xiao (Shaw) Qin (Chin), University of Wisconsin-Madison; Mike Sproul, Wisconsin Department of Transportation.
Paper Number: 08-1887
From: Abstract
This study investigated vehicle speed changes during winter weather events. A total of 954 winter maintenance logs in 24 counties over three winter seasons were analyzed. Several variables of interest were developed such as "Storm Duration," "Maintenance Operation Hour," "Crew Delayed," "Maximum Speed Reduction" and storm start and end times. Also, "t1," which represents the start of vehicle speed reduction, and "t3," the time when vehicle speeds recover to normal winter driving speeds, were measured from ATR data. The study confirms that vehicle speed appears to be a good measure for representing driving conditions during winter weather events and winter maintenance performance. Speed Recovery Duration was found to be a dependent variable, defined as a possible evaluation of winter maintenance operations using vehicle speed data.

Effects of Adverse Weather on Traffic Crashes: Systematic Review and Meta-analysis
Lin Qiu and Wilfrid Nixon, University of Iowa.
Paper Number: 08-2320
From: Abstract
It would be very valuable to quantify the extent to which weather conditions impact the crash rate. The researchers conducted meta-analysis to generalize research findings on this subject and attempt to quantify the impact of weather on traffic crashes. The results indicate that crash rate usually increases during precipitation. Snow has a greater effect than rain on crash occurrence: snow can increase the crash rate by 84% (95% confidence interval [CI] = 0.68, 0.99), and injury rate by 75% (95% CI = 0.54, 0.96).

Forecasting of Road Surface Temperature Using Time Series, Artificial Neural Networks and Linear Regression Models
Liping Fu, Behzad Hashemloo and Valeri Kim, University of Waterloo, Ontario; Yumei Fu, Chongqing University, P. R. China.
Paper Number: 08-2384
From: Abstract
This research investigates the feasibility of applying simple statistical models for forecasting road surface temperature at locations where RWIS data are available. Three commonly used modeling techniques are considered: time-series analysis, linear regression and artificial neural networks (ANN). A dataset from a RWIS station is used for model calibration and validation. This paper describes the major findings with a specific focus on the generalization capability of the models. The analysis indicates that multivariable and ANN are the most competitive technique with lowest forecasting errors.

Durability of Brine Applications for Winter Maintenance on Asphalt and PCC Pavements
Andrew Russ, Gayle Mitchell and Wallace Richardson, Ohio University.
Paper Number: 08-2608
From Abstract, Conclusions
Experiments on asphalt concrete and Portland cement concrete pavements were conducted to determine the lifetime of brine residue from pretreatment. The amount of salt residue on the road was measured using Boschung SOBO-20 salt measuring devices with rehabilitated electronics. The decay of salt over time on both pavements was found to be consistent with an exponential decay. Research results also suggest that brine pretreatment wears off (or disappears into voids within) asphalt more quickly than grooved PCC, meaning that for asphalt roads it is more important that pretreatment be timed closer to an anticipated winter weather event. In cases where pretreatment must be scheduled earlier than the day before the event, a higher application rate may be warranted.

Decision Tree for Pretreatments for Winter Maintenance
Andrew Russ, Gayle Mitchell and Wallace Richardson, Ohio University.
Paper Number: 08-2810
From: Abstract, Introduction
This study addressed pretreatment protocol for winter maintenance of roadways using brine. Ohio DOT specified two pretreatment applications per week based on six warranting conditions in its draft Snow and Ice Pretreatment Plan [Swearingen, 2003]. The Ohio Research Institute for Transportation and the Environment was asked to validate the plan and recommend potential adjustments depending on research findings. This paper sketches the extensive research report [Mitchell, Richardson and Russ, 2006] and presents a decision tree for making pretreatment decisions.

Probabilistic Models for Discriminating Road Surface Conditions Based on Friction Measurements
Liping Fu and Feng Feng, University of Waterloo, Ontario; Max Perchanok, Ontario Ministry of Transportation.
Paper Number: 08-2208
From: Abstract, Conclusion and Future Research
This paper presents two statistical models for discriminating different types of road surface contaminants based on friction measurements and other road condition data. The first is a disaggregate logit model which can be used to predict the probability that a road surface is covered by snow or in bare condition based on direct friction measurements and other available road weather data. The second is an aggregate logit regression model that uses aggregated measures over a section of road as input to distinguish two sub snow cover states, namely full cover and partial cover. The proposed models are calibrated using field data collected from a maintenance route in Ontario and show high discrimination power based on holdout datasets. This research has confirmed the feasibility of applying friction measurements along with other available data to discriminate road surface conditions.

Recycling of Salt-contaminated Stormwater Runoff for Brine Production at Virginia Department of Transportation Road Salt Storage Facilities
Vinka Craver and James Smith, University of Virginia; G. Michael Fitch, Virginia Transportation Research Council.
Paper Number: 08-2413
From: Abstract
Virginia DOT captures a large volume of salt-laden stormwater runoff at its 300-plus salt storage facilities and disposal options for this water are limited and costly. This research was undertaken to determine the possibility of recycling salt-contaminated stormwater runoff for brine production. Laboratory and field tests were conducted using bench-scale brine generation equipment. Results show that the optimum conditions for brine production are low hydraulic retention time (high flow rates) and high temperatures. Total suspended solids in the stormwater runoff did not diminish brine quality in field tests. Economic and environmental benefits can be obtained by applying this recycling strategy.

Road Weather Information System Data Archiving and Access Tools in the WisTransPortal
Jing Jin, Steven Parker and Bin Ran, University of Wisconsin-Madison.
Paper Number: 08-2716
From: Abstract
This paper describes a RWIS data archive and Web access facility recently developed by the Traffic Operations and Safety (TOPS) Laboratory at the University of Wisconsin-Madison. Currently, Wisconsin DOT maintains a RWIS data collection system primarily to support winter maintenance operations activities. The objective of developing the TOPS RWIS data repository is to facilitate wider application of the RWIS data for research and operations such as integration with crash and traffic count data, performance analysis of the existing RWIS system itself, and support for WisDOT Clarus initiatives. The design of the archiving system addresses three major technical challenges: data archiving efficiency, data densification and data accessibility.

Modeling the Causal Relationships Between Winter Highway Maintenance, Adverse Weather and Mobility

Lin Qiu and Wilfred Nixon, University of Iowa.
Paper Number: 08-3101
From: Abstract

This paper explores the direct and indirect causal effects of adverse weather and winter maintenance actions on mobility as measured by traveling speed and traffic volume. Using Structural Equation Modeling with the particular Categorical Variable Methodology, researchers analyzed weather, maintenance and traffic data from 2001 to 2004 in Iowa. Separate structure models were fit simultaneously to subgroups, which are disaggregated by road classification, AADT and speed limit. The analysis results suggest that despite winter maintenance operations that might slow down traffic during the hour when they are performed, winter maintenance operations have significant positive effects on improving speed, and the positive effects have been fully mediated through road surface conditions. The analyses suggest that the influences are different across road classifications, speed limits and different levels of AADT.

Effects of Dry/Compacted Snow Conditions for Passing Behavior by Driving Tests on Rural Highways

Kazunori Munehiro, Seijyu Akimoto, Roberto Tokunaga and Motoki Asano, Civil Engineering Research Institute for Cold Region, PWRI, Sapporo, Japan.
Paper Number: 08-0718
From: Abstract, Introduction

This study had two objectives: 1) determine the difference in passing behavior for dry and compacted-snow road conditions, and 2) determine how the dry and compacted-snow conditions differ in terms of subjective safety evaluation. Ten drivers participated in a test on a road section in service. Among the researchers' findings: the variation in longitudinal and transverse acceleration was higher for the compacted-snow condition than for the dry condition; significant differences in velocity between dry and compacted-snow conditions were found for older subjects at all points; both younger and older drivers on compacted-snow conditions tended to be slower than on dry conditions with regard to the overtaking decision point and overtaking start point.

Benefit-Cost Analysis of Weather Information for Winter Maintenance: A Case Study

Christopher Strong and Xianming Shi, Western Transportation Institute.
Paper Number: 08-1359
From: Abstract

The Utah DOT implemented a Weather Operations Program which assists the UDOT operations, maintenance and construction functions by providing detailed, often customized, area-specific weather forecasts. This paper describes the application of an artificial neural network model using winter maintenance cost data from dozens of UDOT maintenance sheds for the 2004-05 winter to estimate the cost effectiveness of this program. The model estimated the value and additional saving potential of the UDOT weather service to be 11 to 25% and 4 to 10% of the UDOT labor and materials cost for winter maintenance, respectively. Based on the program's cost, the benefit-cost ratio was calculated at more than 11:1.

Performance and Impacts of Current Deicing and Anti-icing Products: User Perspective Versus Experimental Data
Laura Fay, Kevin Volkening, Chase Gallaway and Xianming Shi, Western Transportation Institute.
Paper Number: 08-1382
From: Abstract, Concluding Remarks
This paper reports on relevant information collected to date through an ongoing, two-year research project funded by the Colorado DOT with the goal of identifying alternative deicers to chlorides. The project consists of a synthesis of relevant literature coupled with laboratory tests and field investigations. Twenty-four deicer users participated in a survey representing Finland, New Zealand and 15 U.S. states and agencies. Among researchers' findings: literature and experimental data indicated that the negative impacts of acetates and formates were greater than perceived by survey respondents, especially with respect to pavement, structures and water quality damage.

Development of a Visibility Estimation Model Based on Visibility Information from Road Images Captured in Winter
Masato Minami, Ryo Kato and Toru Hagiwara, Hokkaido University; Keiji Araki and Yasuhiro Nagata, Japan Weather Association; Katsuyuki Takitani, Hokkaido Development Engineering Center.
Paper Number: 08-1497
From: Introduction, Discussion and Conclusions
The main objective of the study is to establish a model for estimating visibility using meteorological data. As a first step, the researchers propose a method for estimating WIPS at observed points using meteorological data. A multiple regression model is employed to reveal the relationship between WIPS from road images as a dependent variable and meteorological data as independent variables in a database.