2011 TRB Annual Meeting: Papers Related to Winter Maintenance

Materials

Prediction of Salt on Road Surface—A Tool to Minimize Salt Use
Paper number 11-0202, http://amonline.trb.org/12jirj/1

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Abstract: The balance between conflicting goals of winter maintenance as safety, accessibility and environment together with limited funding, increases the need for more cost-effective use of the resources. One way to minimize the amount of salt used within winter maintenance would be to have better possibilities to predict the amount of residual salt on the road surface. This paper combines an empirical model developed in Sweden with data of residual salt, road surface wetness and traffic from 18 Danish field cases. The resulting model is both presented as a mathematical function, and visualized in a graph that is suggested to be used by decision makers as a tool for understanding the durability of a salt dose under different conditions of traffic and road surface wetness, and hence, be able to minimize the amount of salt needed. The results show that the decay of residual salt can be modeled with traffic as independent variable with fairly to very well fit. Also, it is shown that the road surface wetness is positively related to the rate of residual salt loss from the wheel tracks. The wetter surface, the faster the salt will leave the wheel tracks.

Field Observations on the Quantity of Salt on Road Surfaces After Salt Application
Paper number 11-2394; http://amonline.trb.org/12khcj/1

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Abstract: The work presented in this paper is part of a project to study the quantity of salt on road surfaces after salt application. Field observations were conducted and the quantity of salt was measured, as well as data on weather, road surface conditions and traffic. The quantity of salt is presented as a function of traffic. The results show significant differences in the quantity of salt after application between the various observations and some of these differences can clearly be explained by the quantity of water on the road surface. The quantity of water on the road surface determines the quantity of salt after application. Wet road surfaces both dissolve and lose salt more rapidly than moist road surfaces. The data also shows that there is a surprisingly rapid loss of salt, especially on wet road surfaces. After 200 to 400 passing vehicles, the quantity of salt equals that before application. A physical based model is used to model the salt quantity as function of traffic. The model produced an acceptable fit to the date, but it is concluded that the data scatter is too large for the model to be precise enough for decision-making purposes. Despite this, the data allows some conclusions to be drawn and some operational advice to be given.

Processes That Control the Development of Salt Quantity on Road Surfaces After Salt Application
Paper number 11-2372; http://amonline.trb.org/12kh5r/1

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Abstract: This paper is part of a project to study how the quantity of salt on road surfaces develops after salt application. The goal of the work presented in this paper was to identify the physical processes that control the development of salt quantities on road surfaces. Field observations have been made to study the salt quantity after application. Based on the results from field observations, the authors suggest that the development of salt quantity after salt application is controlled by three processes; the initial loss, the

dissolution of salt and the loss of salt. A theoretical approach to investigating the process of salt dissolution is made. A principal, physical based model for the measured salt quantity on road surfaces as a function of traffic is presented. The dissolution of salt is proposed to be expressed by an exponential equation and the rate of dissolution is mainly dependent on the water quantity on the road. The loss of salt caused by blow-off and spray-off is considered to follow an exponential curve. The resulting equation incorporating both the dissolution and loss is finally compared with field observation for moist and wet road surfaces.

A Multi-Criteria Decision Making Approach to the Formulation and Selection of Anti-icing Liquids
Paper number 11-1992, http://amonline.trb.org/12kbsi/1

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Abstract: To effectively fight snow storms in the challenging funding environment, many maintenance agencies in North America have started to produce their own anti-icing liquids, instead of procuring commercial anti-icers. This work demonstrates a systematic approach to data-driven, multi-criteria decision-making, by conducting a set of laboratory tests to assess twenty blended chloride-based anti-icing formulations. The laboratory data were then used to establish predictive models correlating the multiple design parameters with the anti-icer performance and impacts or with an anti-icer composite index. We used artificial neural networks for modeling and examined anti-icer performance (characteristic temperature and ice-melting capacity at 30°F and 15°F respectively) and impacts (splitting tensile strength of concrete after ten freeze-thaw cycles and corrosivity to mild steel). The anti-icer composite index was calculated for four different user priority scenarios (cost-first, performance-first, impacts-first, or a balanced approach), each of which placed a different set of decision weights on various target attributes. Three-dimensional response surfaces were then constructed to illustrate such predicted correlations and to guide the direction for formulation improvements.

Equipment and Facilities

Evaluation of Light-Emitting Diode Warning Beacons for Maintenance Vehicles
Paper number 11-0490; http://amonline.trb.org/12jmpo/1

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Abstract: Rotating warning beacons containing filament light sources have long been used on highway maintenance vehicles to indicate the presence of the vehicle to other drivers. Flashing warning beacons containing light-emitting diodes (LEDs) are beginning to be used in place of rotating warning beacons, in part because they use considerably less power. To help ensure that LED warning beacons will provide a comparable warning signal to drivers approaching vehicles outfitted with them, their photometric and temporal characteristics were measured and compared to human response time data. In addition, several LED warning beacons were compared to a conventional incandescent rotating warning beacon in terms of the distance at which observers could detect that a vehicle had moved closer to the observer. Pairs of LED warning beacons provided equivalent closure detection distances to a pair of conventional rotating beacons. While single LED warning light configurations were not tested, the pairs of LED beacons tested reliably outperformed a single conventional beacon configuration in terms of both energy use and closure detection distance. Overall, the results suggest that LED warning beacons provide comparable visual information to other drivers, while using substantially less power than conventional rotating beacons.

Determining of Optimal Location of Deicing Material Storage Facilities Using the AHP and GIS-Based Method
Paper number 11-0973, http://amonline.trb.org/12jtjh/1

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Abstract: A study of the determination of optimal location for deicing material (NaCl and CaCl2) storage facilities was conducted through integration of the Analytical Hierarchy Process (AHP) and Geographical

Information System (GIS). In the early 2010, unpredicted heavy snowfall had continued during a few days in the Korean peninsula. This caused the major arterial roadway networks of the nation to be temporarily paralyzed and inflicted great damage both socially and economically. Driven by this incident, the Ministry of Land, Transport, and Maritime Affairs in South Korea which handles snow removal operations of major arterial roadways has initiated and continuing in efforts to strengthen the national snow removal capability. From detailed perspectives, in order to prevent a situation nearly of a national catastrophe, the entire nation was divided into 4 main areas base on administrative districts. The amount of deicing materials and the number of auxiliary deicing chemical storage facilities needed for each area were properly estimated. In order to determine the optimal location for storage facilities, the AHP was used to calculate the relative importance for evaluation criteria such as population density, snowfall amount, and road length managed by regional offices. The relative importance was utilized as weights for Geographical Information System (GIS) overlay analysis, and since reliable data could be obtained through consistency ratio (CR), the entire procedure and results of this study were believed to be rational.

Road Weather Information Systems and Technology

Integration of Aviation Weather Information Systems with Roadside Weather Information Systems (RWIS)

Paper number 11-2815; http://amonline.trb.org/12knhn/1

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Abstract: Western Transportation Institute (WTI) at Montana State University, in partnership with the Mineta Transportation Institute (MTI) at San Jose State University, conducted a research and development study of the proof-of-concept system for integrating aviation weather information systems with Roadside Weather Information System (RWIS). The project was started in 2008. The goal of the project is to meet the potential needs of providing airport managers, air traffic controllers, pilots, and related operators of air ambulance services with more comprehensive and accurate meteorological data by integrating currently used weather systems with systems used by related agencies. Implementing such an integrated system is expected to improve safety and increase efficiency. The project is targeted at small, underserved rural airfields and heliports. In particular, data from the two aviation weather information systems: Automated Weather Observing System (AWOS) and Automated Surface Observing Systems (ASOS) and the surface transportation RWIS could be integrated to provide greater coverage for multiple agencies. Treating these (currently) independent systems as a larger, integrated system could achieve greater levels of efficiency and lead to cost savings through coordination of operations and maintenance as well as planning for future deployment. This relatively small ITS project follows a small scale systems engineering process. Literature review, AWOS/ASOS and RWIS sites analysis, user survey and requirements analysis, and cost benefits analysis research activities have been conducted during phase I of the project. In addition, a proof-of-concept system was developed and evaluated, and the second phase has been planned for expanded geographic coverage, improved functionality, and more extensive evaluation.

Weather or Not? State Liability and Road Weather Information Systems

Paper number 11-0077; not available online

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Abstract: The National Conference of State Legislatures will report on a recent collaborative research project—conducted with the Federal Highway Administration—about the benefits, concerns, and strategies related to DOT uses of state-generated road weather data. Such data generally reduces DOT exposure to liability, but as with any innovation, it also raises new concerns. Real-life examples of strategies for state DOTs and legislators will be provided.

Development of a Visibility Forecast Model Based on a Road Visibility Information System (RVIS) and Meteorological Data

Paper number 11-2342; http://amonline.trb.org/12kgqr/1

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Abstract: The study proposes a model that forecasts visibility in winter by using either multiple-regression analysis or the Kalman filter. We have been developing the Road Visibility Information System (RVIS), which calculates road visibility information as the weighted intensity of power spectra (WIPS) and the present-time road visibility index (RVI) from daytime road images recorded by multiple closed-circuit television (CCTV) cameras along the roads. The objective of this study is to develop the visibility forecast model based on 1-km-mesh meteorological data. We used data of the WIPS values and RVI ranks recorded by the RVIS and 1-km-mesh meteorological data recorded by the Japan Weather Association during the winter of 2009-2010 at a 35-km section of National Route 40 in Hokkaido, Japan. A multiple-regression model and the Kalman filter were employed to reveal the relationship between WIPS data from road images as a dependent variable and the meteorological data as independent variables. The Kalman filter can be regarded as the preferable of the two visibility forecast models examined in the study. Also, the 1-km-mesh meteorological data of air temperature, wind speed and snowfall were determined to be informative independent variables in the forecast models.

Visibility Monitoring Using Conventional Roadside Cameras: Shedding Light on and Solving a Multi-National Road Safety Problem

Paper number 11-1831, http://amonline.trb.org/12k9c2/1

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Abstract: The measurement of atmospheric visibility is an important element for road and air transportation safety. We propose in this paper a novel estimator of the atmospheric visibility by already-existing conventional highway cameras, with a technique based on the gradient magnitude obtained by applying Lambert's law with respect to changes in lighting conditions. The response of this estimator is calibrated by non-linear regression with data from a visibility-meter installed in a test site which has been instrumented with a camera. Through our technique, atmospheric visibility estimates are obtained with an average error of 30% for images taken in the day, with lighting conditions between 10 to 8,000 cd.m-2 and visibility distances up to 15 km. Our emerging results indicate that a primary next step could be to deploy on current or future roadsides a practical implementation of our research results to determine local visibility for the benefit of drivers and the safety of our roads, while addressing the needs of meteorological observation and of air quality monitoring.

Program Management

Sweden's "The Road to Excellence" International Benchmarking Study of Customer Satisfaction for Winter Services and Pavements

Paper number 11-0213, http://amonline.trb.org/12jivq/1

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Abstract: The Swedish Road Administration commissioned an international benchmarking study to help understand why road user customer satisfaction survey results for winter services and pavements have been

stagnant or decreasing even when there has been no change in the maintenance standards and adherence to them. The technical data collected from road conditions assessments indicate that the roads are in satisfactory or good condition, but the customer satisfaction results were indicating otherwise. The objective of the international benchmarking study was to determine reasons for disconnect and how to measure customer satisfaction in relation to measurable road condition indicators. Several issues were addressed: what kind of customer survey would be most appropriate, what questions should be asked and how, and what factors affect road user attitudes. Research was needed to assess the problem and potential solutions. An international study was initiated to compare what was done in other countries and to benchmark customer satisfaction surveys. The study approach consisted of interviews in eight cold climate countries consisting of Norway, Sweden, Finland, Denmark, Scotland, Slovenia, Alberta (Canada) and Minnesota in the USA. Each country responded to questionnaires on winter services and pavement conditions, and was also visited to ensure accuracy of responses and for clarifications.

The benchmarking study shows that road administrations are sophisticated users of customer surveys. They use a variety of surveys and have tailored them to serve their objectives. The results indicate that the survey type, the survey method, and the way questions are phrased do affect the results and their subsequent interpretation. The surveys provide subjective information at a point in time, which may not coincide with the road condition survey. Part of disconnect between customer satisfaction and road condition is explained by this anachronism. Another part has to do with the difference between the expected and provided level of service. Increasingly the road administrations appear to conduct measurable road condition surveys for processing payments in performance-based maintenance contracts, and subjective customer attitude and opinion surveys to develop maintenance standards and performance measures. The former employ increasingly complex, but cost-effective technologies, while for the latter employ focus groups, driving panels, and special studies in novel ways. Responsive customer complaint centers are common and found useful. In the workshop that concluded the study it was voiced that the challenges in measuring customer satisfaction are similar in the participating countries, but approaches gauging them, especially for winter services, differ. The benchmarking study showed that countries and states can learn from each other and while practices are rarely directly transferable, improvements are possible. It is not only useful to benchmark road management processes and practices, but utilized wisely they may provide motivation for better road budgets.

Analysis of Snow Removal Contractors' Financial Risk from Scant Snowfall by Using a Snow Removal Cost Estimation Model

Paper number 11-1352; http://amonline.trb.org/12k2uu/1

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Abstract: In recent years, fluctuations in annual snowfall possibly because of global warming pose financial risks to road administrators and to snow removal contractors. To minimize the risk of an unexpected increase in snow removal expenditures due to unusual heavy snowfall, various budgetary measures are prepared. In contrast, for a winter with scant snowfall, measures to minimize snow removal contractors' risk that they cannot gain the expected profit from snow removal work have been largely limited to weather derivatives. When fluctuations in annual snowfall were not extreme, snow removal contractors could offset the loss in a winter with scant snowfall by the surplus profits in a winter with heavy snowfall. However, extreme fluctuations in annual snowfall have made the loss incurred by contractors in a year with unusually scant snowfall too great to offset with the profits from a snowy year. The authors developed a snow removal cost estimation model that is based on the relationship between snow removal costs and cumulative snowfall. The model uses a linear regression line of "unit cost of snow removal" (UCSR) to analyze that relationship. The analysis has found that UCSR decreases with increases in cumulative snowfall, and the authors' previous study found that their model enabled snow removal costs to be compared among different regions. Using the model, the present study proved that the financial risk to contractors in a year with scant snowfall may not be covered by their profits in another snowy year, and the study sought solutions for this issue.

Pavements and Bridges

Factors Affecting Snowplowable Raised Pavement Marker Failures in Virginia

Paper number 11-0208; http://amonline.trb.org/12jll0/1

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Abstract: Snowplowable raised pavement markers (SRPMs) are commonly used in Virginia to supplement lane lines on the interstate and portions of the primary system. While the SRPMs improve lane delineation at night and during inclement weather, the SRPMs can become damaged or detached from the pavement after prolonged exposure to traffic and snowplows. Prior to 2009, Virginia had no formal method or schedule for routinely inspecting these markers following initial installation.

In April 2006, a fragment of an SRPM metal casting became dislodged and injured a motorist. In response to this incident, a statewide study was initiated to determine if there were systemic problems with SRPMs becoming damaged or detached on Virginia's interstates. Casting condition, reflector condition, epoxy condition, and installation adequacy were inspected on 78 1-mile segments of interstate pavement containing SRPMs. The study found that nearly 8 percent of all SRPM castings inspected were either missing or damaged. Approximately 35 percent of reflectors inspected were either missing or damaged. An analysis of risk factors showed that total traffic since installation and initial installation adequacy were most strongly correlated with casting failures. These data were used to develop an SRPM casting inspection program and schedule that has been adopted by the Virginia Department of Transportation. The study also recommends increased training for installers and inspectors.

Investigation of Portland Cement Concrete Exposed to Automated Deicing Solution Applications on Colorado's Bridge Decks

Paper number 11-1906, http://amonline.trb.org/12kai2/1

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The Colorado Department of Transportation (CDOT) has identified potential performance problems in some portland cement concrete (PCC) bridge decks and approach slabs in the form of pattern surface cracking, spalling, and joint/crack deterioration, which are suspected to be materials-related distress (MRD). External factors, such as the use of deicing/anti-icing chemicals, have the potential to initiate and increase the rate and magnitude of deterioration due to MRD, thereby shortening the life of the structure. This paper details the results of a study conducted to investigate whether the application of highly concentrated deicer solutions through fixed automated spray technology (FAST) automated bridge deck deicing/anti-icing systems is disproportionately contributing to the deterioration of PCC bridge decks and adjacent concrete approach slabs in Colorado and whether mitigation strategies being employed by CDOT are addressing the problem. The approach to this investigation involved the use of visual inspection techniques, materials sampling, and the evaluation of the sampled concrete using petrographic methods. In the bridges studied, the concrete evaluated appears to be sufficiently resistant to damage from the intrusion of deicer chemicals, though where full-depth cracking was present, obvious signs of the movement of moisture and deicers through the deck were observed. In addition, some initial signs of possible chemical deicer attack were noted, and continued exposure to highly concentrated deicers may contribute to long-term durability concerns. However, the use of polymer-modified asphalt/fabric membranes in conjunction with a hot mix asphalt (HMA) overlay appears to be very effective in preventing the ingress of chlorides into the underlying concrete deck.

Safety

Interaction of Road Type, Road Surface Condition, and Driver Age on Winter Crashes in Maine
Paper number 11-2915, http://amonline.trb.org/12kp6a/1

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Abstract: Driving on roads that are covered with ice or snow is hazardous for all drivers, but there may be disproportionally high risks for certain age groups on certain road types and different winter maintenance practices may also have a greater influence on drivers of certain ages. Three two-way chi-squared analyses are used to examine the inter-dependence of road classification, road surface condition, and driver age on all police reported winter road surface condition crashes in the state of Maine for a five-year period. Special focus is paid to the relatively new practice of anti-icing that the Maine Department of Transportation is using, and its effect on the number of crashes experienced by drivers in different age groups. It was found that all age groups experience more winter crashes on rural roads where the speed limits are higher, regardless of whether de-icing or anti-icing is used. Younger drivers (16-17 yrs.) are especially susceptible on urban townways (roads maintained by the town). On urban state highways, where anti-icing is used, every age group is experiencing fewer winter crashes than expected. Most municipalities in the state of Maine are still using a de-icing strategy for winter roadway maintenance, and it is possible that the crash numbers could be reduced if more of them switch to the anti-icing technique that is practiced by MaineDOT.

Effects of Adverse Winter Weather on Drivers in High Risk Age Groups: Statewide Analysis
Paper number 11-1397; http://amonline.trb.org/12k3hc/1

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Abstract: Using new state-level data our research shows that young (<19) and older (65+) drivers are significantly overrepresented in crashes during winter road conditions. Drivers in Maine are, on average, involved in 93 crashes per day, about one crash per 10,000 drivers. The daily number of crashes varies with many factors, including two that are the focus of this study: temperature and snowfall. Winter-maintenance activities also influence safety and mobility and are costly. Maine spent $98 million in 2008-2009 on winter road maintenance efforts to improve safety and mobility. In order to efficiently allocate winter road maintenance resources, managers and policy makers need to understand the relationship between road safety and varying levels of adverse winter weather. Our analysis improves on past studies by exploring the relationship between winter weather and vehicle crashes for different age groups on a state level rather than a national level where it is more difficult to control for confounding variables. The methodology advances past efforts by employing a model allowing for greater heterogeneity and using more detailed weather, traffic volume and crash data. Results indicate that young drivers have the highest crash risk with below freezing temperature and mid-levels of daily snowfall amongst all age groups. Crash risk is also shown to increase for young drivers by 13% on Fridays with trace amounts of snowfall.

Accident Prediction Models for Winter Road Safety: Does Temporal Aggregation of Data Matter?
Paper number 11-2610, http://amonline.trb.org/12kk8a/1

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Abstract: Accident prediction models are mostly developed using single-level count data models such as the traditional negative binomial models with fixed or varying dispersion parameter, assuming independency of data. For many accident data sets in road safety analysis, especially those of some highly disaggregated nature (hourly data), there often exists a hierarchical structure in the data which manifests itself in some form of correlation. Crash prediction models developed with aggregate data could produce biased results due to the assumption of data independence and inflation of the adequacy of the model's

explanation due to the use of aggregate data. This paper investigates the potential effects of data aggregation and correlation on accident prediction models. The analysis uses an accident database including hour-level and storm-level accident counts over individual winter snow storms at four highway sections in Ontario. Models of two different levels of aggregation: aggregated event-based models and disaggregated hourly-based models were developed. It was found that the effect of data aggregation has a significant effect on model results while the difference between the conventional regression and multilevel regression is inconsequential.

Speed Levels of Heavy Vehicles on a Norwegian Mountain Pass

Paper number 11-3628, http://amonline.trb.org/12l3hi/1

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Abstract: This paper presents results from a study of how speed varies for different vehicle categories under variable winter conditions and how incline affects traffic flow.

The study is divided into two parts. The first part is a case study with observations of traffic behavior influenced by weather events. These case studies form the basis for hypotheses about how winter conditions can influence speed. The last part of the study tests some of these hypotheses by combining information about traffic, climate, friction and winter maintenance activities during the past 2-4 years.

Some of the main results are that the speed for all vehicle categories is lowered when the coefficient of friction falls below 0.30. If there is falling snow as well, the speed is further reduced. For trucks it seems that it is snow with corresponding reduced visibility in combination with poor driving conditions that gives a substantial reduction in speed. On a straight stretch and no incline there is less difference in speed levels between different vehicle categories and load seems to have little or no effect at all on speed.

There is a concern that the speed level is not reduced more when the coefficient of friction falls below 0.3. This indicates that drivers of both passenger cars and trucks drive with elevated risk when the friction is reduced. When it is snowing it seems that the drivers adapt better to the driving conditions.

Driver Behavior

Evaluation of the Influences of Changes in Road Surface Conditions on Driving Behavior at Roundabouts

Paper number 11-0608; http://amonline.trb.org/12jo8o/1

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Abstract: To ensure safe driving, it is very important for drivers to appropriately perceive road alignment, pavement markings, various road accessories and road surface conditions. However, road surface conditions change with the weather, and in cold, snowy regions can vary widely from dry to wet to compacted snow during the winter months. Compacted-snow-covered roads pose a range of problems, including preventing drivers from seeing pavement markings and making roads slippery. As the northern part of Japan is characterized by the harsh weather conditions commonly seen in cold, snowy regions, there is increasing interest in the evaluation of drivability and safety for modern roundabouts in various weather and road surface environments. The authors installed a small single-lane roundabout for experimental purposes on the Tomakomai Test Track in Hokkaido, Japan, in autumn 2009 and winter 2010 to enable related driving tests. A total of 16 subjects participated in these tests and drove test vehicles, some of which were equipped with a driving-behavior monitoring system. The road conditions tested were those with dry and compacted-snow-covered surfaces. After a period of driving involving the roundabout, the drivers were asked to answer a questionnaire indicating subjective assessment of drivability and safety. The results showed that the speeds of vehicles approaching the roundabout when the road was covered in compacted snow were lower than in dry, thereby demonstrating a greater speed reduction effect. Subjective assessment

suggested that drivability and safety in compacted-snow-covered road conditions were much lower than those in dry road conditions.

Construction of a Passing Maneuver Model on a Two-Lane Highway with Consideration of Road Surface and Visibility Conditions

Paper 11-1679, http://amonline.trb.org/12k7e5/1

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Most national highways in rural parts of Hokkaido are two-way two-lane roads. In these highways, passing maneuvers using oncoming lanes are frequently observed. Such passing is even observed when road surfaces are covered with compacted snow in the snowy season. In the implementation of measures to optimize speed and safety on a certain road, it is necessary to conduct traffic simulations on passing maneuvers using the oncoming lane of a two-way, two-lane highway. However, there have been no traffic simulations on passing maneuvers with consideration of conditions on winter surfaces covered with snow and ice or poor visibility caused by snowfall, fog and other factors. In this study, a traffic simulation to model passing maneuvers was created using values measured in a passing-maneuver field study conducted on a two-lane highway in summer and winter. The field values for the number of passing maneuvers, traffic volume and speed distribution were compared with the simulation results. The outcomes confirmed that the difference between them was small. The sensitivity analysis results revealed that the number of passing maneuvers when the surface is covered with compacted snow and visibility is poor does not increase as much as that on the dry surface even when the traffic volume in the original lane becomes higher. The passing success rate tended to decrease with higher volumes of traffic in the oncoming lane regardless of surface conditions.

Traffic Modeling

Assessing Opportunities and Benefits of Alternative Winter Operation Timing Plans for Signalized Arterials

Paper number 11-0010; http://amonline.trb.org/12jgpu/1

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Abstract: Coordinated arterial signal timing plans are typically designed for normal weather conditions based on a number of assumed traffic flow characteristics. Qualitatively, during winter operations vehicle speeds decrease, arrival time of platoons shift, vehicle headway increases, platoon dispersion increases, and saturation flow rates decrease. As a result, good weather signal timing plans may be less than optimal during winter operations. Although there has been some research conducted regarding the effects of weather on some traffic flow parameters, these have been based upon manual field observations. There has been little work on developing automated methods of measuring these parameters or assessing of the benefits that could be achieved by implementing alternative timing plans during winter events.

This paper presents findings from the automated collection of high resolution signal controller data and Bluetooth probe vehicle travel times to characterize both the microscopic and macroscopic operation of a four intersection signalized arterial during winter weather conditions (snow and ice on pavement) as well as clear pavement conditions. An 83 second increase in median travel time through the system was measured during winter conditions. Platoon shifts of 15, 25, and 30 seconds were measured at three intersection links which corresponded to an approximate reduction in design speed of 7 to 11 miles per hour (MPH) on a corridor with a posted speed of 55 MPH. Alternative offsets were calculated that showed an opportunity to decrease overall vehicle delay by 26.7% for southbound vehicles during the AM peak snow event.

Quantifying Nonrecurrent Congestion Caused by Precipitation Using Archived Weather and Traffic Flow Data

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Abstract: Since precipitation causes negative impacts on traffic congestion, there have been various studies for modeling the relationship between precipitation and its impact on traffic flow. Due to existing data limitation issue, however, none of the previous studies has conducted for the estimation total delay caused by precipitation with respect to each weather event. The objective of this study is to estimate non-recurrent traffic congestion on freeways caused by precipitation. To accomplish this objective, archived weather and traffic data for the year 2008 collected from the Korean Freeway Systems were combined to estimate and analyze non-recurrent congestion impacts caused by precipitation. As a result, non-recurrent traffic congestion was about 1.6 million vehicle-hours for rainfall and 186,000 vehicle-hours for snowfall in 2008. In addition, the simple analyses were performed to describe average non-recurrent traffic congestion per unit distance as a function of the precipitation and a function of the time period of precipitation. Although the precipitation events might not be handled by human factors, these results will help in making strategic plans such as active speed management and contingency planning for mitigating traffic congestion due to precipitation.