Title: Need Statement 611: Idea 428: Short and Long Term Impacts of Winter Maintenance Ice Breakers on Pavements.

Date: June 24, 2020

Prepared for: Marcus Bekele

Prepared by: Sheila Hatchell

Resources searched: TRID, PooledFund.org, Transport, Internet, Google Scholar, ASCE database

Search Terms: Mechanical ice breaker, Effect of snow-removing equipment on pavement performance, ice breaker effects on pavements, Abrasion of pavement surface by snow removal, Surface texture orientation before and after snow/ice removal, Snow removal effect of pavement skid resistance, Benefit/cost of pavement ice breakers, snowplow blade damage to pavements, winter maintenance to pavements

Summary: I expanded my search to include Google Scholar, the ASCE database, and the Internet. I expanded my search terms by quite a few, and was still able to locate very few documents or studies on this topic. Most of the research is regarding pavement markings, especially raised pavement markings and how they stand up to snow plowing. Other than what I did find, the results were either too old or pertaining to ice breaking on waterways.

Most Relevant Results

Title: PROJECT: Develop a Guidebook for the Use of Non-Chemical Methods for Removing Snow and Ice from Roadways. NCHRP 06-19.

Project Manager: Hanna, Amir

Sponsoring Organization: National Cooperative Highway Research Program and Federal Highway Administration

Start Date: 20200520

Abstract: The FHWA compiled statistics that showed that during the 10-year period 2005-2014 approximately 321,000 vehicle crashes per year were attributed to icy or
snow-covered roads. These same statistics showed 5,650 fatalities per year were attributed to adverse weather. This is approximately 10 times more fatalities than all the other adverse weather fatalities tracked by the National Weather Service. While participation fluctuates from year to year, 44 state DOTs and one Canadian Province rely on AASHTO’s SICOP Technical Service Program, the Clear Roads, and/or Aurora Pooled Fund Studies to help them fulfill their winter maintenance mission. This clearly demonstrates the impact winter weather has on the transportation network across North America. Road maintenance agencies employ a variety of strategies to maintain safe, passable roadways during wintertime weather events. In general, these strategies can be categorized into those that rely on the use of chemicals (primarily sodium chloride --salt) and non-chemical-based strategies utilizing mechanical means (e.g., brooming, plowing, scraping, or mechanical ice breaking). The reliance on deicing chemicals alone has presented issues for agencies as some salt supplies are becoming irregular with some agencies not able to secure sufficient quantities and the resulting increases in salt prices adversely affecting state wintertime budgets. In addition, some agencies are under increasing scrutiny from environmental and other user groups who question the impacts to the environment, durability of motor vehicles, as well the roadway infrastructure. During very low temperatures the effectiveness of sodium chloride is diminished, and alternative chemicals may not be available or affordable in large quantities. For these reasons, agencies have identified the need to develop methods to reduce the dependence on these chemicals by exploring cost effective non-chemical strategies. This research and resulting guidebook will assist state DOTs and other agencies across North America in providing a safe and reliable transportation network during winter weather events while reducing the amount of chemicals utilized and the resulting impact deicing chemicals have on the environment. This will be accomplished by evaluating new, non-chemical deicing systems such as specialized brooms, plow blades, motor-graders, and mechanical icebreakers, and developing best practices for their use. These best practices will be incorporated into a guidebook and implemented through training. Since the initial work on improved cutting edge research was conducted during the Strategic Highway Research Program (SHRP) in the 1990s (W. A. Nixon, Improved Cutting Edges for Ice Removal, National Research Council, SHRP Report, SHRP-H-346, 1993, 98 pages), little research has been accomplished on this topic until the California Department of Transportation published an in-depth Preliminary Investigation (PI) on the subject (Using Mechanical Ice Breakers to Improve Snow and Ice Removal Operations, Produced by Duane Bennett, Advanced Highway Maintenance & Construction Center Technology Research Center for the Caltrans Division of Research, Innovation and System Information, February 18, 2016). This PI
indicated the need to research new snow fighting technology to find ways to improve snow and ice removal while minimizing the use of deicing materials. The outcome of this research will be a best practice guide for snow removal operations utilizing non-chemical strategies. It will include methods that reduce the dependence on deicing chemicals during winter weather events. The research will then be implemented by holding training events. The objectives of this research are (1) A literature review of non-chemical snow and ice removal techniques; (2) Review practices and interview operators at agencies who have adopted various types of non-chemical snow and ice removal techniques, including but not limited to Caltrans, Ontario, Minnesota, Alaska, and Utah; (3) Evaluate (a) Effectiveness in the removal of snow and ice pack, and improvement in time-to-bare-pavement; (b) Operational considerations including speed of operation, equipment maintenance, carrier vehicle requirements, and transport; (c) Impacts to pavement and other roadside infrastructure; (d) Identification of safety issues, and (e) Benefits and cost of ownership; (4) Develop a final report; (5) Create a guidebook and training syllabus covering appropriate application of non-chemical strategies; (6) Perform the training as part of, or in conjunction with at least two winter Maintenance Events (e.g. Clear Roads meeting, National Winter Maintenance Peer Exchange, APWA North American Snow Conference).

Record: https://apps.trb.org/cmsfeed/TRBNetProjectDisplay.asp?ProjectID=4943

Title: Using Mechanical Ice Breakers to Improve Snow and Ice Removal Operations.
Author: Bennett, Duane
Publisher: California Dept. of Transportation, Feb. 18, 2016
Abstract: An extensive body of work exists regarding the utilization of mechanical ice breaking technologies which have been specifically developed to effectively cut through ice pack bonded to highway pavement surfaces. The ideal performance objective is the ability to mechanically scrape down to bare pavement with little or no damage to pavement and without waiting for a salt treatment to soften a layer of bonded ice before effective removal can be achieved. Attaining this capability implicitly delivers an associated reduction in highway salt usage and more quickly provides motorists with the higher level of service and safety bare pavement provides. The diversity of ice breaking technologies under development does not appear to be converging on a single best solution, but instead is increasingly becoming tailored to the distinctive needs and weather conditions of the individual State DOTs. The list of mechanical ice breaking technologies, which have been DOT-proven as efficient at cutting through ice pack on the highway, are categorized and ordered based on their apparent adaptability to the
Title: Using Mechanical Ice Breakers to Improve Snow and Ice Removal Operations. A research proposal by Herby Lissade, Division of Maintenance, Caltrans. February 18, 2016. This is the proposal for the study immediately above.

Summary of Findings: An extensive body of work exists regarding the utilization of mechanical ice breaking technologies which have been specifically developed to effectively cut through ice pack bonded to highway pavement surfaces. The ideal performance objective is the ability to mechanically scrape down to bare pavement with little or no damage to pavement and without waiting for a salt treatment to soften a layer of bonded ice before effective removal can be achieved. Attaining this capability implicitly delivers an associated reduction in highway salt usage and more quickly provides motorists with the higher level of service and safety bare pavement provides. The diversity of ice breaking technologies under development does not appear to be converging on a single best solution, but instead is increasingly becoming tailored to the distinctive needs and weather conditions of the individual State DOTs. The list of mechanical ice breaking technologies, which have been DOT-proven as efficient at cutting through ice pack on the highway, are categorized and ordered based on their apparent adaptability to the existing Caltrans winter operations fleet.


Less Relevant Results

Title: Changes in Pavement Friction Levels During Winter Maintenance Operations and Its Impact on Driving Safety

Authors: Bandara, Nishantha and Jensen, Elin

Publisher: Transportation Research Board 95th Annual Meeting, 2016.
Abstract: The tire-pavement friction is drastically reduced during winter storm events. Loss of tire pavement friction during winter storms causes severe safety hazard to the motoring public. Every year more than 117,000 people are injured and more than 1,300 people have died on snowy, slushy or icy roadways (1). The coefficient of friction between the vehicle tire and the pavement can be dramatically improved by winter maintenance activities such as snow plowing, deicing, anti-icing and sanding of the roadway. Although in the United States friction testing is not primarily used as a winter performance measure, a number of European countries and Japan uses this technology regularly. Friction can be determined using three methods; predicting friction using climate, traffic and other roadway conditions, direct friction measurements using an extra wheel installed on vehicles, or by traction control systems. NCHRP Web Document 136 lists three operational uses of friction measuring devices in winter operations; they can be used to measure quality of winter maintenance operations, can be used as a source of road user information to inform motorists of hazardous locations and also to determine the amount of deicing materials to be used on the roadway (2). In this study, pavement friction behind snow plows were measured during different snow events. The measured friction values were compared to base friction levels obtained during the summer months along the same roadway. As a pilot study, Interstate 96 roadway and US-23 in Livingston County, Michigan were selected and friction data were collected during snow storms during the 2013-2014 and 2014-2015 winter seasons. The study demonstrates the variation in pavement friction levels during different types of winter storms and its effect on winter driving safety.

Record: https://trid.trb.org/Results?txtKeywords=%22changes%20in%20pavement%20friction%20levels%22&txtTitle=&txtSerial=&ddlSubject=&txtReportNum=&ddlTrisfile=&txtIndex=&specificTerms=&txtAgency=&txtAuthor=&ddlResultType=&chkFulltextOnly=&recordLanguage=&subjectLogic=or&dateStart=&dateEnd=&rangeType=emptyrange&sortBy=publissheddate&sortOrder=DESC&rpp=25#/View/1392617

Title: Effect of Temperature and Prewetting for Ice Penetration with Sodium Formate
Authors: Trzaskos, Mateusz Piotr and Klein-Paste, Alex
Publisher: Journal of the Transportation Research Board, 2020.
Abstract: Granular sodium formate (NaCOOH) is a popular deicer used at airports. It is mainly used to weaken compacted snow/ice and thereby facilitate mechanical ice removal. Earlier research has developed a set of methods quantifying deicer performance, but linking these test results to operational guidelines is difficult. The main objective of this study is to increase the knowledge of how temperature and prewetting affect the ice penetration performance of granular sodium formate. A new method to evaluate the development of ice penetration process is presented here. Ice penetration tests were performed with single grains on large, optically clear ice cubes, and digital image analysis is used to quantify the initial waiting time, penetration rate and depth, and melted volume. Eighteen tests including dry and prewetted sodium formate grains were performed at three different temperatures (–2°C, –5°C, and –10°C). Prewetting reduced the initial waiting time (the time it takes before the particles started to penetrate) by a few minutes at –10°C, but at higher temperatures, this reduction was insignificant. The particles penetrated the ice at a constant rate. At –10°C, the particles penetrated at 10–15 mm/hour, while at –2°C this speed is about five times higher. Prewetting does not seem to have a clear beneficial effect on the penetration rate. Suggestions are given on how to capture the results from this study into operational guidelines for deicing operations at airports, using sodium formate as deicer.
Full text: https://journals.sagepub.com/doi/pdf/10.1177/0361198120917974

Clear Lake (Iowa) Council To Consider Purchasing Mechanical Ice Breaker To Help With Winter Roads [press release]