Emerging Technologies in Winter Road Maintenance - Improving Safety While Minimizing Environmental Impacts

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Most of your construction projects are buttoned up for the winter and you are finally able to relax and get ready for the next construction season. However, the Michigan Department of Transportation (MDOT) works year-round seeking better ways to manage highway storm water runoff and reduce environmental impacts. In Michigan, that often means reviewing our winter road maintenance activities.

As the birthplace of automobile manufacturing, Michigan has long appreciated its roads and highways. Michigan's highway network consists of nearly 120,000 miles. While only 10,000 of these miles fall under MDOT jurisdiction, they carry close to half of the total vehicle miles traveled in Michigan each year.

To ensure efficient and safe use of our roads in winter, MDOT primarily uses road salt (sodium chloride) to melt snow and ice, and sand to provide traction for vehicular traffic. While much can be said about the environmental impacts of using salt and sand, their application is effective, convenient, and inexpensive. To create a balance between safety and environmental protection, MDOT uses a variety of strategies to enhance winter road maintenance, including improving operational practices, implementing new technologies, and using state-of-the-art equipment.

Improved Operational Practices

MDOT follows a sensible salting program. The goal is to use just enough material and no more. By limiting the use of salt, sand, and chemicals, the amount of polluted storm water entering our waterways is decreased. MDOT snow removal crews are trained in environmental awareness, equipment maintenance, effective salt and sand application, and the use of alternative de-icing and anti-icing products. The *Sensible Salting Handbook* provides guidelines for truck spreader calibration and when and where to apply material.

Many environmental problems associated with highway salt stem from improper storage. Salt needs to be covered, preferably in a building, or if not feasible, under a waterproof covering. The salt should be stored on an impermeable pad, such as asphalt. If concrete is used, it must be high quality, air-entrained and treated with sealers to reduce chloride penetration. The storage pad should slope to let water drain away, with runoff discharging into detention ponds or sanitary sewer systems. All newly constructed MDOT salt sheds are built so that loading and dumping is done inside the shed.

Blue Water Bridge Salt Storage and Maintenance Facility in Port Huron
Photo courtesy of Hubbell, Roth & Clark, Inc.

New Technologies

Pre-wetting

In Michigan's Upper Peninsula, MDOT's Superior Region crews are using a technique called pre-wetting to increase the effectiveness of road salt in melting ice. The process involves spraying a brine solution made up of water and salt on to dry salt as it is applied to roads. The salt uses the moisture to begin the reaction that generates heat and melts snow and ice. The combination of brine and salt works faster than salt alone. Unlike granular de-icers, which tend to bounce off surfaces, pre-wetted de-icers remain on the surface and less salt is needed to break the ice's bond with the pavement.

Alternative De-icing and Anti-icing Products

De-icing chemicals are applied to roads after ice has already formed on the surface. The de-icer lowers the temperature at which water freezes, causing the ice to melt. Anti-icing chemicals work on the same principle; however, anti-icers are applied prior to snowfall to prevent snow and ice from bonding to the pavement. Because it is easier to prevent a bond from forming than it is to break a bond that has already formed, anti-icing techniques are more effective and require less volume of chemical spray. Many studies have been conducted to evaluate the effectiveness of alternative de-icing and anti-icing chemicals and MDOT has been using these alternative compounds on some of its highways, particularly on highway ramps and bridges that are susceptible to corrosion and are near rivers. One alternative product success story comes from the Zilwaukee Bridge near Saginaw, MI.

Zilwaukee Bridge ©*State of Michigan – Michigan Department of Transportation*

Application of Anti-Icing Solution
photo courtesy of Cryotech Deicing Technology

CMA® (calcium magnesium acetate) and Cryotech CF7® (liquid potassium acetate) have been the only chemical de-icers used on the Zilwaukee Bridge, since its completion in 1988. To date, there is no evidence of chloride-induced corrosion. The CF7 is used to pre-wet CMA as it is being applied. When pre-wet at the time of application, CMA does not bounce and roll, allowing it to stay on the bridge surface longer. Since CF7 is a high performance de-icer, there is an immediate effect. MDOT has also modified equipment for direct application of CF7 for anti-icing and frost conditions. CF7 readily biodegrades, and results in little environmental impact.

ALTERNATIVE DE-ICING AND ANTI-ICING PRODUCTS

Sodium chloride (rock salt) and calcium chloride each have advantages and disadvantages. Sodium chloride costs less but doesn't work as well as calcium chloride at lower temperatures. Calcium chloride doesn't have the chemical additives that rock salt has (2 to 5% of road salts consist of other elements, such as phosphorus, nitrogen, copper and even cyanide) and is less harmful to vegetation. Both sodium chloride and calcium chloride are corrosive.

Magnesium chloride is similar to calcium chloride, but twice as much is needed. It has a low cost and low freezing point, making it suitable as both a de-icer and anti-icer. It is less corrosive on roads and safer for the environment compared to sodium chloride and calcium chloride. However, magnesium chloride is corrosive to floors when tracked into buildings. If over applied, the road surface can become slippery.

Carbohydrate-based solutions (corn or beet byproducts), when blended with magnesium chloride, are effective de-icers and anti-icers. The combination is not as slippery as magnesium chloride alone, and may even cause surfaces to become tacky. The mixture costs less and is less corrosive than straight magnesium chloride. These solutions are also safe for the environment.

Calcium magnesium acetate (CMA) is recommended for use as an anti-icer on bridges to minimize corrosion and environmental impact in sensitive areas. Compared to salt, CMA is more expensive and twice the amount is needed. Although CMA may have less adverse impact on the environment, high concentrations can still reduce oxygen levels in lakes and streams.

Potassium acetate can be used as a pre-wetting agent for solids including salt, sand or CMA. It works well as a de-icer and anti-icer at very low temperatures. It is not corrosive and is biodegradable. It costs eights times more than sodium chloride, can cause pavement slickness, and can lower oxygen levels in waterbodies.

Automated Anti-icing Spray Systems

As US-131 passes through downtown Grand Rapids, it makes a tight s-curve around 100-year-old buildings. The freeway carries 120,000 vehicles per day and is the fourth busiest in the state. The s-curve spans over a mile and includes five bridges - one crossing the Grand River. In 2000, MDOT reconstructed the highway and incorporated an anti-icing system. The roadway and bridge decks have 175 spray nozzles that distribute anti-icing chemicals which improve winter driving safety. The system starts the automated spraying cycle of potassium acetate (CF-7) anti-icing solution when manually activated by phone. The automated spraying system pumps fluid through the nozzles onto the roadway and takes approximately 30 minutes to complete the cycle. With each nozzle dispensing approximately 1.8 gallons, each automated cycle places about 315 gallons of material on the roadway, bridges, and ramps. The fluid is less corrosive than road salt and is environmentally safe. This anti-icing system is the largest of its type in the U.S. and it is the first to treat roadway surfaces as well as the bridge deck.

US-131, S-Curve in Downtown Grand Rapids

Surface Overlay Systems
This year, MDOT is trying something new; a smart bridge that can de-ice itself. The SafeLane ™ Surface Overlay system was installed on the Looking Glass River Bridge on U.S. Highway 127 just north of Lansing. This is the first test site in Michigan for the new technology developed at Michigan Technology University to produce safer roads with less maintenance. SafeLane™ is made up of a patented combination of epoxy and aggregate. Liquid anti-icing chemicals are applied to the overlay before a snow storm hits. The material acts like a rigid sponge, storing the chemicals inside, and then automatically releasing them as conditions develop for the formation of ice. SafeLane™ keeps releasing the anti-icing chemicals over multiple events, greatly reducing the need to send out highway maintenance crews in the midst of a storm. Installation costs for SafeLane™ average a few dollars more per square foot than standard epoxy overlays. However, the SafeLane™ overlay material extends bridge life by minimizing water seepage and intrusion of corrosive agents like chlorides, while improving skid resistance and surface appearance.

Road Weather Information Systems (RWIS)
RWIS, originally developed by the Strategic Highway Research Program (SHRP) unit of the National Research Council, can be used to maximize ice removal effectiveness by prioritizing areas in need. These systems include meteorological and pavement sensors, communications, and planning. Real-time readings can help operators decide whether to apply salt as liquid brine during dry, icy conditions or as dry salt in freezing rain. If the temperature is really low, other de-icers such as calcium chloride, magnesium chloride, or potassium acetate can be added to the mix. Maintenance crews can also take wind into consideration when spreading materials. With RWIS, less salt and chemicals are needed. To help highway agencies adopt these technologies, SHRP developed guidelines on purchasing, installing, and using RWIS, and on implementing anti-icing strategies.

MDOT's Superior Region, under the Intelligent Transportation Services (ITS) program is currently developing a special provision for RWIS stations for deployment throughout the Region. These sensors will be used for assistance in decision support systems for winter maintenance activities, bridge operations, and traveler information systems. Deployment of these stations will be phased over multiple years.

Improved Equipment

Global Position Satellite (GPS) Systems

In Kalamazoo, MDOT is using an anti-icing truck equipped with a 5,000-gallon tank. The truck can cover 165-250 lane miles with anti-icing material in one tank load. The truck cab is equipped with a GPS system and a computer-controlled spray bar. The system's monitors provide real-time readings of the route, road temperature, truck speed, and rate and time of chemical application. This ensures uniform coverage of anti-icing material and allows drivers to pick up where a previous driver ended.

State-of-the-art Ground Speed Control

MDOT has salt trucks equipped with state-of-the-art ground speed control which maintains a consistent flow of material out of the spreader chute at any speed. When the truck slows down or stops for an intersection, the flight chain simultaneously slows down or stops. This eliminates excessive salt spread at low speeds. Calibrated spreaders are also used that eject salt onto the road surface at zero velocity relative to the roadway thereby reducing the bouncing action that can throw the salt off the roadway surface.

Summary and Conclusion

With dedication to safety and environmental awareness, Michigan is at the forefront of implementing innovative winter road maintenance techniques, while preserving our streams, rivers, and lakes to enjoy year round.