UNDERSTANDING THE CHEMICAL AND MECHANICAL PERFORMANCE OF SNOW AND ICE CONTROL AGENTS ON POROUS OR PERMEABLE PAVEMENTS

Submittal: Task 8: Field Testing Recommendations - Draft

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1. Introduction

Laboratory testing demonstrated that compacted snow bonds more strongly to porous and permeable pavements (PPPs), yet friction of PPPs was significantly greater than traditional dense graded pavements (DGPs) after snow removal, even without the use of salt. The PPPs appeared more white and snowy, and this appearance may be contributing to unnecessarily high application rates of salt. Field testing is needed to understand the frictional behavior of PPPs during a variety of winter storm conditions and deicer applications.

2. Field Testing Recommendations

Pavements and Road Classification

Traditional dense graded asphalt pavement, open graded friction course and ultrathin friction course pavement surfaces should be included. Multiple sites will likely be needed because OGFC and UTFC pavements may not be adjacent, as most states use either OGFC *or* UTFC. Only New Jersey and California were identified during Task 3 Categorized Pavements as states with specifications for both types of PPPs, but the prevalence of each type in areas that receive winter storms is unknown. Task 4 interviews from New Jersey participants indicated OGFC was more common in the state than UTFC. DGP pavements should be included in the field tests to compare PPPs to DGPs – however, if DGP surfaces are not adjacent to PPPs and a secondary road with different traffic and winter operations is used, the comparisons could be more confounding than useful.

At least four sites in the US should be chosen for field testing. Site 1 with new OGFC pavements and Site 2 with old OGFC pavements, located in the same state (suggested states: Massachusetts, New Jersey or Virginia). Site 3 with ¾ inch maximum aggregate UTFC pavements (suggested states: Missouri or New York) and Site 4 with ½ or ⅝ inch maximum aggregate UTFC (suggested states: Kansas or New York). These are the minimum site suggestions – if multiple states or locations are willing to participate in the field testing, that would be preferable. Lab tests on UTFC pavements from Missouri and New York performed similarly, however, multiple UTFC pavements are recommended for field testing because of the inherent limitations of lab testing, and because the UTFC samples were made from the same asphalt lab compactor that may not mimic field construction and compaction conditions.

Multi-lane roads (at least 2 lanes in a single direction) with at least 8,000 AADT volume and posted speed limit of at least 45 mph are recommended. Higher speed and higher traffic volumes can help pump deicers trapped in pores of PPPs, bringing them back up to the surface which can help with continued snowfall. However, the pumping action of high speed traffic can also bring water to the surface, making the road appear wetter for longer than DGPs.

Data to be Collected

The following types of information should be collected during each field test to document test conditions and the effects of plowing and deicer application.

Weather Data

Meteorological data, ideally from a nearby RWIS which includes at minimum:

- air temperature,
- relative humidity,
- road surface temperature,
- wind speed and direction,
- solar radiation or visual observations of sunny, cloudy, partly cloudy, shade, etc.
- precipitation information including type (rain, graupel, sleet, wet snow, dry snow), intensity (in/hour), depth, density and snow–water equivalent.

Friction and Surface Conditions

A mobile optical road surface state sensor (such as Luft MARWIS, Teconor RCM411, Innovative Dynamics Mobile Ice Sight, Vaisala vehicle-mounted DSC111) that provides surface state condition (such as Dry, Wet, Slush, Snow, Ice, or similar variety) and friction or grip. Sensors that also indicate depth of water, ice or snow are preferable.

Physical friction measurements should be collected in addition to the optical non-contact sensor because snow trapped in the pores of PPPs may affect optical friction results and actual physical friction is critical to the success of the field tests. The following options for physical measurements should be considered, depending on budget and availability of equipment and personnel:

- Friction “wheels” These are trailers with sensor-enabled wheels attached to a patrol vehicle. Examples include: Halliday Technologies RT3, ASFT T-5, Neubert Aero Corp Dynamic Friction Tester, and the Transtec Group GripTester.

- Deceleration Devices These are simple devices that use a sensor mounted inside a vehicle to calculate friction while the driver brakes or decelerates. Commercial options include

Vericom RFM4000 and Neubert Aero Corp Dynamic Friction Decelerometer. Smart phones and tablets have accelerometers and several commercial Android and iOS mobile apps are available, including Teconor µTEC and Neubert Aero Corp Dynamic Friction Decelerometer Mobile App.

- Static Friction Devices These are manually operated rubber-bottom weighted friction devices. Small, easily portable versions can be made with steel blocks and a rubber membrane glued to the bottom. A hook or eyelet is needed to attach a spring scale for horizontal force measurements (static friction is calculated by the maximum horizontal pulling force divided by the weight of the friction tester). Another option is to make one from a trailer tire cut in half and partially filled with concrete, adding a handle for portability and an eyelet for the spring scale (or purchase the Braker Box Drag Sled). Static friction devices are manually operated and more time is usually needed to collect a sufficient amount of data. Data should be collected within wheelpaths of the lanes, requiring traffic control for each test section during measurements.

Winter Maintenance Actions

All winter maintenance activities should be documented, which are expected to include liquid, dry solid and/or prewet solid material application and plowing. All spreaders should be re-calibrated within a few weeks of the field tests to ensure accurate application rates. The spreading pattern should also be documented. The type of plow truck, plow blade, and whether shoes are used on the plow should also be documented.

Photographs

Photographs of the test sections should be taken before and during the field tests, specifically during all winter maintenance activities and at regular intervals (10 or 20 minutes) after deicer application. Light trailers should be available at each test section to provide sufficient light for photographs during the night. Bridges can provide a nice vantage point for photographing test sections. All cameras should be set to the current time. Camera white balance setting should also be performed multiple times during a test when light conditions change (daylight to shade to dusk to light trailers turned on, etc.) using card stock with the same type of brightness and weight for all site locations (e.g., 110 lb, 92 bright or 65 lb 95 bright – just be consistent).

Winter Storms

Several types of winter weather events should be included in the suite of field tests, including light snow, heavy snow, freezing rain and frost. A light snow event has a maximum snowfall intensity of ½ to 1 in/hr, less than 4 in total snow in a duration less than 24 hours with temperatures above 25 °F. A heavy snow has snowfall intensity around 1.5 to 2 in/hr, at least 6 in total snow, and temperatures above 25 °F. Tests should be conducted during freezing rain to observe the drainage characteristics of PPPs and see if deicers are washed through the pavement or remain in the pores. PPP surfaces have a greater tendency than DGPs of frost growth because of their greater surface area and being a cooler surface. Frost conditions can be difficult to predict, but road sections located in low areas or valley and near ponds or lakes are more likely to experience frost or icing during cold clear nights with light winds. Field tests are needed during frost conditions to determine friction on a frosted surface and the best actions for prevention and treatment during frost conditions.

Test Sections, Controls and Treatments

Test sections should be at least 500 ft long and separated by a buffer of at least 500 ft. Multiple test sections should be identified and marked with cones or poles. All test sections should be located within a small enough region to ensure similar traffic and weather conditions. Friction should be measured at times after deicer application that is consistent across test sections, which may require plow/spreader trucks to pause and wait between test sections if a drag sled device is used because the manually operated friction devices require more time (and traffic control) for measurements. The buffer needs to be long enough for the material spreader truck to be able to change the material application rate and be applying product before and after the test section boundaries and travel at a consistent speed within each test section.

Multiple deicer application rates should be included in each field test: a low application rate appropriate for the prevailing conditions (e.g., 20 gal/LM salt brine or 50 lb/LM solid salt), a medium application rate that is 25% more than the low rate, and a high application rate that is 50% more than the low rate. The actual material, application rates, and timing of treatments depends on the actual temperature and precipitation during the field test. Test sections on public roads during winter storms will be the most realistic with respect to pavement wear/surface conditions and traffic action. The disadvantage of this is that all test sections should be treated with deicers and a no-salt scenario can't be safely conducted, unless appropriate signage and possibly reduced speed limits are posted. If the PPP surface treatment exists on the shoulder, and snow can be plowed from the shoulder in a manner consistent with the test sections, then friction and photographs can be collected from the shoulder and considered a control, no-salt scenario. At least 3 light snow, 2 heavy snow, and 2 freezing rain field tests should be conducted on each UTFC and OGFC pavement surfaces. The DGP test sections should be as close as possible to the PPP. The number of application rates needed during the storm depends on the storm duration and normal cycle time for the plow/material trucks at the site chosen for testing. Once test sites and test sections have been identified, all 3 light snow, 2 heavy snow, and 2 freezing rain tests should be conducted at those locations.

Deicing, App Rate Field Tests (7 tests at each site) 3 light snow, 2 heavy snow and 2 freezing rain tests	
Test Section 1 (PPP): Deice with low app rate	Test Section 5 (DGP): Deice with low app rate
Test Section 2 (PPP): Deice with medium app rate	Test Section 6 (DGP): Deice with medium app rate
Test Section 3 (PPP): Deice with high app rate	Test Section 7 (DGP): Deice with high app rate
Test Section 4 (PPP shoulder): Do not deice (plow only)	Test Section 8 (DGP shoulder): Do not deice (plow only)

At least one field test at each site (2 UTFC locations and 2 OGFC locations) should include test sections that do and do not get anti-iced with salt brine (or other liquid product) at least 8 hours before snowfall. DGP test sections are not required for this testing. Two types of nozzles should be tested – fan and stream nozzles. Friction should be measured before anti-icing, within 15 minutes of anti-icing, 4–12 hours after anti-icing, and then at regular intervals after snowfall begins. If the anti-icing nozzle type testing is conducted during a light snow or heavy snow event, and deicing is required during the storm, then a total of nine test sections is required. If deicing is performed with liquid products, the nozzle type used for deicing a test section should be the same as the one for anti-icing, which would require multiple liquid trucks to avoid switching nozzles during the winter storm.

Anti-icing, Nozzle Type Field Test Appropriate for light snow or heavy snow		
Test Section 1 (PPP): Anti-ice using stream nozzles Deice with low app rate	Test Section 4 (PPP): Anti-ice using fan nozzles Deice with low app rate	Test Section 7 (PPP): Do not anti-ice Deice with low app rate
Test Section 2 (PPP): Anti-ice using stream nozzles Deice with medium app rate	Test Section 5 (PPP): Anti-ice using fan nozzles Deice with medium app rate	Test Section 8 (PPP): Do not anti-ice Deice with medium app rate
Test Section 3 (PPP): Anti-ice using stream nozzles Deice with high app rate	Test Section 6 (PPP): Anti-ice using fan nozzles Deice with high app rate	Test Section 9 (PPP): Do not anti-ice Deice with high app rate

Field tests for frost conditions may be the most difficult to conduct. If the sites identified for the other winter tests (light snow, heavy now, freezing rain) are not frost-susceptible, then other locations will need to be identified. The frost testing should have multiple test sections to determine if pre-treating, post-treating, or both are required, and the best type of product (liquid only, prewet solid, or a combination). Frost tests should be conducted after the anti-icing nozzle type tests and use either stream or fan nozzles, depending on which type is preferred for PPPs. In the table below of possible test sections to include, pre-treat refers to material application before frost conditions and post-treat refers to material application after frost has occurred on the shoulder or other untreated PPP test sections.

Frost Field Test	
Test Section 1 (PPP): Pre-treat with liquid at low app rate Do not post-treat	Test Section 8 (PPP) Do not pre-treat Post-treat with liquid at low app rate
Test Section 2 (PPP): Pre-treat with liquid at low app rate Post-treat with liquid at low rate	Test Section 9 (PPP) Do not pre-treat Post-treat with liquid at medium app rate
Test Section 3 (PPP): Pre-treat with liquid at low app rate Post-treat with prewet solid at low app rate	Test Section 10 (PPP) Do not pre-treat Post-treat with liquid at high app rate
Test Section 4 (PPP): Pre-treat with liquid at medium app rate Do not post-treat	Test Section 11 (PPP) Do not pre-treat Post-treat with prewet solid at low app rate
Test Section 5 (PPP): Pre-treat with liquid at high app rate Do not post-treat	Test Section 12 (PPP) Do not pre-treat Post-treat with prewet solid at medium app rate
Test Section 6 (PPP): Pre-treat with prewet solid at low app rate Do not post-treat	Test Section 13 (PPP) Do not pre-treat Post-treat with prewet solid at high app rate
Test Section 7 (PPP): Pre-treat with prewet solid at medium app rate Do not post treat	Test Section 14 (PPP shoulder) No material application

3. Concluding Remarks

The field testing recommendations presented herein include a variety of pavements, winter storm conditions and material application type and equipment. The suite of field tests should provide sufficient data to finalize recommendations for winter maintenance practices on porous and permeable pavements. Site location and physical friction measurements are critical to the success of the field testing. Sites with cooperative and enthusiastic maintenance and operations personnel are preferable. Field testing requires personnel dedicated to remain on site throughout the storm, with only short breaks for eating and sleeping. Training is essential for the friction measurements to ensure accurate data is collected. An estimate budget for field testing is highly dependent on the number of sites at which testing will occur, whether DOT staff can assist with data collection, and whether friction devices need to be borrowed, rented or purchased for testing. A realistic budget likely falls in the range of $250,000–$400,000.