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Limitations of the Use of Abrasives in Winter Maintenance Operations

Prepared for
Bureau of Highway Operations

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Request for Report

In the interest of developing more effective winter maintenance operating procedures, WisDOT's Bureau of Highway Operations is interested in knowing more about the limitations of the use of sand in winter maintenance operations. As the lead state for the Clear Roads winter maintenance pooled fund, WisDOT will share the results of this research with the Clear Roads member states.

Summary

While sand, the most common abrasive used in winter maintenance, cannot melt snow and ice, it does play a role in many winter maintenance programs. According to NCHRP Report 526, *Snow and Ice Control: Guidelines for Materials and Methods*, "the primary function of abrasives is to provide temporary traction (friction) improvement on snow/ice surfaces." Many agencies use sand to maintain safety at hills, curves, intersections and low-volume roads, and on packed snow or ice that is too thick for chemicals to penetrate. We summarize **WisDOT's Current Practice** in the use of abrasives in winter maintenance below.

Sand's use over time has declined due to a variety of **Limiting Factors**, including its **Effectiveness**, **Environmental Impacts**, **Safety Implications** and **Cost**. See below for findings from reports and studies that address the limitations of the use of sand in winter maintenance operations. We conclude with **Recommended Best Practices** for the use of abrasives in winter maintenance programs compiled from two 2001 documents.

WisDOT's Current Practice

Chapter 35 of the State Highway Maintenance Manual provides recommendations for the use of abrasives in winter operations. Sand and other locally available abrasive materials can be used when high winds or storm conditions preclude the use of salt, or when pavement temperatures are too low (10°F or less) for deicing agents to work effectively. When conditions warrant, abrasives may be applied to predetermined low-speed areas such as certain grades, curves, intersections, structures and isolated areas where hazards exist. Abrasives should not be used where vehicle speeds exceed 45 mph. Prewetting of abrasives with a deicing agent is recommended to improve adherence to the roadway. Contact the WisDOT Library at library@dot.state.wi.us for a copy of WisDOT's State Highway Maintenance Manual.

Limiting Factors

Effectiveness

Sand has exhibited limited effectiveness at higher vehicle speeds, especially when it has not been prewetted. Mixing sand with salt to keep it from freezing also limits sand's effectiveness.

- Studies suggest that at highway speeds sand is swept off the road after relatively few vehicle passes (eight to 12) and that friction gains from sanding (when the sand remains on the road) are minimal (Nixon 2001b, page 1).

- Snow- and ice-covered roadways that have been treated with abrasives provide friction values that are far less than "bare" or "wet" pavement (NCHRP, page 25).

- During storm periods when anti-icing operations are successful, abrasive applications provide no consistent or apparent benefit in hard-braking friction, traction or pavement condition (FHWA 1998, page 208 of the PDF).

- Mixing sand with 50 to 100 pounds of salt per cubic yard is necessary to prevent freezing and keep it workable (Wisconsin Transportation Center, page 4).

- A mix of abrasives and chemical will usually be no more effective as an anti-icing treatment during snowstorms than the same amount of chemical placed alone (FHWA 1996b; click on *2.5 Abrasives Use*).

- A 1973 study (Keyser, pages 4-6 of the Word file) indicates that the melting of snow and ice will be delayed by using a mixture of salt and sand.

- In a blend, sand and salt often work against each other. The salt in the mix may blow away as vehicles travel the roadway. If the sand remains on snow, tires can push the sand down into the slush, making it ineffective for improving traction. Also, salt melts less ice when mixed with sand (Wisconsin Transportation Center, page 4).

- Use of salt/abrasives mixes at moderately or much higher application rates than straight chemical does not lead to corresponding improvements in hard-braking friction or pavement conditions. Comparisons of test and control operations using identical salt/abrasives mixes show that more frequent applications at similar rates also do not lead to corresponding improvements in friction or pavement conditions and even indicate that the more frequent applications can lead to slightly worse conditions (FHWA 1998, Section 7.4.1 on page 208 of the PDF).

Environmental Impacts

Studies have shown that sand remains in the environment after its application, resulting in negative impacts on land, water and health.

- An Oregon DOT study in the early 1990s found that 50 to 90 percent of sand applied to pavements remains in the environment after cleanup (FHWA 1996c).

- Up to 70 percent of sand entering Lake Tahoe was shown to be from snow and ice control. Sand was being carried by snowmelt into culverts that drained into the lake (FHWA 1996a).

- Sand creates debris deposits on roadways, mixing with oil, grease and other automotive byproducts. Sand remaining on roadways clogs storm water catch basins and fills streambeds, clouding the water, hurting aquatic animals and leading to an increase in microorganisms. If collected at the end of winter maintenance, sand may have to be disposed of as a hazardous waste. Sand is also ground into a fine dust by traffic, which can trigger respiratory problems like asthma (EPA).

- The use of abrasives can contribute to increased levels of ambient PM_{10}, the very small airborne particulate matter that is inhaled into the lungs and can cause respiratory problems. Researchers found that the use of abrasives increased the rate of road dust re-entrainment. Street sweeping, a practice intended to minimize air quality impacts of roadway abrasives, was found to actually increase the observed emission rate (Gertler, page 5984).

- Uncovered sand piles mixed with salt are susceptible to leaching. One study indicated that 10 inches of precipitation leached out 50 percent of the salt (Walker, page 2).

Safety Implications
Some research has concluded that sand used in a salt-abrasive mixture does not contribute to accident reductions.

- Accident rate reductions on two-lane highways were less with salt-abrasive mixtures than with salt only. Accident rates dropped dramatically after achievement of bare pavement with salt only but more slowly with salt-abrasive mixes. Accident reductions for freeways were much less and took much longer to occur when salt-abrasive mixtures were used, as compared with the use of salt only (Kuemmel and Bari, page 9 of the PDF).

Cost
Research indicates that salt is more cost-effective than sand in winter maintenance operations.

- Abrasives must be used in large quantities and applied frequently, making abrasives more expensive than salt in terms of material and manpower (Salt Institute 2004, page 8).

- When mixed with enough ice control chemical, abrasives will support anti-icing and deicing strategies; however, this is very inefficient and costly, as the abrasives for the most part are "going along for the ride" while the chemical portion of the mix is doing the work (NCHRP, page 14).

- A loaded salt truck, spreading at the rate of 500 pounds per two-lane mile for general storm conditions, can treat a 22.5-mile stretch of roadway, traveling a total of 45 miles. A sand truck requires seven loads, must travel a distance of 187 miles to treat the same section of road, and requires four times more fuel (Salt Institute 1995, page 3).

- Benefit-cost calculations showed that the application of salt-abrasive mixtures did not recover winter maintenance costs on two-lane highways during the 12-hour analysis period. Benefit-cost calculations showed that freeway operations recovered costs in six hours, substantially longer than the 35 minutes with salt only (Kuemmel and Bari, page 11 of the PDF).

- Cost analyses indicate that, where cleanup is performed, the most significant reduction in operational costs will result from the elimination of the use of abrasives as an anti-icing treatment (FHWA 1998, page 208 of the PDF).

- The cost for distributing abrasives on roads is several times higher than those for distribution of salt. Tests carried out on selected road sections in Zurich and Chur, Switzerland, indicate that in a normal winter, the costs for distributing abrasives over a 1-kilometer section are approximately six times higher than those for distributing salt. In a severe winter this factor rose to as high as 10 (Schlup and Ruess, page 49).

- Windshield damage from airborne particulates is 365 percent higher in areas using sand and abrasives instead of salt (Salt Institute 2004, page 9).

Recommended Best Practices

Two 2001 reports published by Wilfrid Nixon provide recommendations for the use of abrasives based on road type. The first report offers general recommendations for the use of dry abrasives (see pages 20-22 of the PDF). The second report expands on those recommendations to consider three different abrasive types: dry abrasives, abrasives prewetted with liquid deicers at the spreader or tailgate, and abrasives applied using a hot method (see pages 44-45). Examples of hot methods include heating abrasives to high temperatures (approximately 180°C) just before application and mixing the abrasives with hot water (about 90°C) as they are placed on the road. Nixon considers the hot application methods experimental, though promising. Nixon's guidelines for abrasive use include:

Rural Roads. Rural roads can see high-speed traffic. For this reason, if electing to apply dry abrasives, limit application to hills and curves on low-speed, low-volume roads. Application of prewetted abrasives on paved roads allows the abrasives to stay on the roadway longer than if the abrasives had been applied dry. Prewetted abrasives can also melt the snowpack and provide for extended increase in road surface friction.

Rural Intersections. Given the low speeds associated with rural intersections, abrasives could be applied dry. However, if the intersection is not gravel, prewetting the abrasive will allow the treatment to remain in place longer.

High-Speed Urban Roads. No benefit is expected when applying dry abrasives to these roads where posted speed limits exceed 30 mph. Application of prewetted abrasives may be appropriate for this road type; hot abrasives may also be considered.

Low-Speed Urban Roads. Limit dry abrasive application to the parts of the road where braking, accelerating or maneuvering is done, and only use this approach when the snowpack is expected to persist. Application of prewetted abrasives will allow the material to remain on the road surface longer. Again, hot application methods may be appropriate.

Urban Intersections. Dry abrasives can be used where the intersection is likely to be snow- or ice-covered for a longer-than-normal period of time. Prewetted abrasives will remain in place longer; hot application methods might also be considered.

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