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Correlating lab and field tests for evaluation of deicing and anti-icing chemicals: A review of potential approaches

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ABSTRACT

Numerous laboratory and field studies have been conducted to evaluate the performance of deicing and anti-icing products and the resulting friction coefficient of treated pavement. However, laboratory results often do not translate to the field performance due to varying temperatures, wind, traffic, etc. in actual field conditions. Also, the existing laboratory tests fail to address all the significant issues in the actual field environment or to provide actual performance of deicers to guide practitioners. This study sheds light on the challenges of developing a laboratory test that correlates to the field results and the results from the literature review and practitioner interviews may assist in developing a test method that would better mimic the actual deicer performance.

1. Introduction

Deicer products are used to remove the ice once it has formed, while anti-icing products are used to prevent the formation of ice. Numerous laboratory and field studies have been conducted to evaluate the performance of deicing and anti-icing products (a.k.a., deicers) and the resulting friction coefficient of treated pavement. Laboratory testing has been used extensively to quantify deicer performance because of the ease and low cost of the experiments and the relatively high reproducibility and transferability of results. However, laboratory testing often does not mimic the actual field conditions such as varying temperatures, wind, and traffic, which in turn does not provide the actual performance of the deicing and anti-icing products. Field testing is desirable over laboratory testing in terms of replicating the actual conditions. Yet it can be costly and difficult to reproduce because of ever changing conditions in the field environment where some variables are difficult to control or even to document. In this context, laboratory and field experiments need to be carefully designed to encompass all relevant variables so that better correlations can be developed.

While there are test methods that quantify deicer performance in the laboratory setting, results often do not translate to the field performance. There are many parameters in the real world that likely play a role in the effectiveness of deicer products used in winter maintenance. These include traffic, pavement type and condition, and meteorological conditions (as shown in Fig. 1). The amount and type of traffic influence road conditions, as do pavement temperature, type, texture, and condition. Meteorological conditions that are important include air temperature, wind speed and direction, solar radiation, humidity, rate and type of precipitation, water content of snow, etc. Also important are the physical and chemical properties of deicers such as gradation (for solids), heat retention and emission properties.

At this point in time, there is no laboratory test method for deicing or anti-icing performance and friction coefficient available that directly correlates with the performance and friction of deicer products in the field. As such, the existing laboratory tests can only provide a baseline to contrast various products under well-controlled conditions and the findings derived from such tests need to be used with caution.

The goal of this study was to utilize previous research to provide guidance on developing a laboratory test, tool or methodology that will quantify deicer performance and friction coefficient on pavement and correlate with results from the field. To accomplish it a literature review was conducted to provide direction for the design of laboratory and field tests. The objectives of the literature review were to identify existing laboratory and field test methods for evaluating deicer performance and pavement friction coefficient, and to provide guidance on which test methods may be used to develop a direct correlation. In addition, key individuals or experts from different department of transportation identified during the literature review were interviewed for additional information on previously conducted laboratory and field research, project costs, equipment design and cost, and important parameters and performance characteristics to consider.

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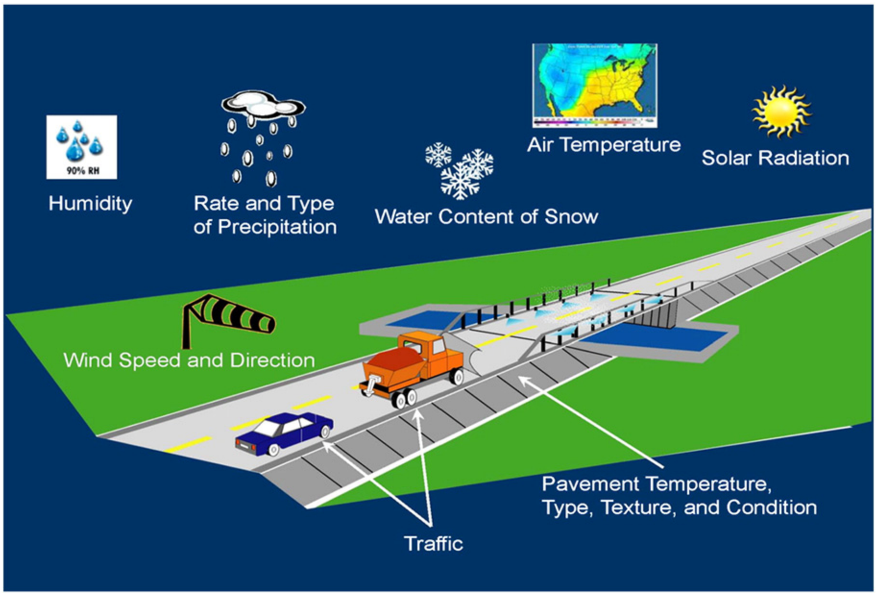

Fig. 1. Schematic diagram illustrating the major parameters that influence the deicer performance and friction coefficient on treated pavement.

2. Test methods to characterize deicer performance

Deicer performance can be described in several ways, such as

- melting and penetration ability (when used as a reactive strategy),
- anti-bonding ability (when used as a proactive strategy),
- time until bare pavement is achieved,
- persistence on the road, and
- performance relative to other products.

It is crucial to clearly define the term “deicer performance” based on prevailing user requirements prior to conducting laboratory and field research. This would enhance the usefulness of the data obtained from the laboratory and field testing. The performance measure or criterion is important in the context of measuring the effectiveness of winter road operations; however, currently there is still a lack of consensus on the subject. The more practical criteria may be the time until bare pavement is achieved or a certain level of friction is achieved; yet they are not as easy to measure as some other criteria.

It is also important to differentiate the advantage of using the deicers in conjunction with other maintenance strategies such as plowing operations and abrasive spreading. Winter maintenance strategies can vary as a function of the local road weather scenarios, rule of practice, and other constraints. As such, a laboratory experiment that attempts to accurately predict field performance must be able to reasonably simulate plowing, deicing, and/or anti-icing, and the seemingly infinite number of combinations of parameters (such as temperature, traffic levels, and pavement condition) that could be present in the field.

In 1992 the Strategic Highway Research Program (SHRP) sponsored the development of the *Handbook of Test Methods for Evaluating Chemical Deicers* (referred to as SHRP *Handbook* from this point forward), which provided test methods for eight principal features of deicers, including deicing performance. Three types of test methods for deicing performance were created: ice melting test for solid and liquid deicers (SHRP H-205.1 and H-205.2, respectively), ice penetration test for solid and liquid deicers (SHRP H-205.3 and H-205.4, respectively), and ice undercutting test for solid and liquid deicers (SHRP H-205.5 and H-205.6, respectively) (Chappelow et al., 1992).

2.1. Ice melting tests

The SHRP ice melting test (H-205.1 and H-205.2) measures the amount of ice melted by deicers over time. In this test, liquid or solid deicers are uniformly spread over the prepared ice and the melted liquid is removed for volume measurements (Chappelow et al., 1992). The SHRP *Handbook* has a strict limit for variation (±0.5 °F) of the set temperature and also requires the ice surface to be melted and refrozen to produce smooth, uniform ice samples. The SHRP ice melting test was modeled after tests conducted by McElroy et al. (1988a,b,c). There are inherent difficulties presented by any ice melting test such as the inability to separate the entire melted portion from the remaining ice due to 1) entrapment within ice cavities and 2) absorption of brine on the ice surface and undissolved deicer particles. Other factors affecting reproducibility include the dependence on the rate of dissolution of solid deicers (which also depends on the particle size) and the amount of brine needed for reasonably accurate measurements. Thus, ice melting tests try to strike a balance between generating enough brine for accurate measurements and avoiding too much deicer, which may not represent a realistic application rate for highway operations (Chappelow et al., 1993).

Several authors performed SHRP ice melting tests with a few modifications based on their applications. Nixon et al. (2005) performed the SHRP ice melting test to compare seven liquid deicers by varying water and deicer level at four different temperatures. The test helped in providing the best deicer at the given temperature based on the volume of melted ice (Nixon et al., 2005). Shi et al. (2009) performed the SHRP ice melting test by reducing the surface area (3.5 cm radius) to limit the absorption rate as recommended by Chappelow et al. (1993). The results show that the rate of dissolution of solid deicers, which is dependent on the particle size and the amount of brine needed for reasonably accurate measurements, may have been a factor affecting reproducibility. Akin and Shi (2012) recommend the SHRP ice melting test be implemented for liquid and solid deicers with brine volumes collected at only 20 and 60 min after application. Furthermore, brine volumes should only be reported to the nearest tenth mL, coefficient of variation to the nearest percent, and standard deviation to the nearest tenth mL to discourage inappropriate comparisons determined from this test method. A