State of Wisconsin/Department of Transportation
RESEARCH PROGRESS REPORT FOR THE QUARTER ENDING: March 31, 2009

Program: TPF-5(092)	**FHWA Pooled Fund Research Program**
Project Title: Development of Standardized Test Procedures for Evaluating Deicing Compounds	**Project ID:** Clear Roads 07-02/WisDOT 0092-08-32
Administrative Contact: Colleen Bos	**Sponsor:** Clear Roads Pooled Fund
WisDOT Technical Contact: Kim Linsenmayer	**Approved Starting Date:** November 2007
Project Investigator (agency & contact): Xianming Shi, PhD, PE Western Transportation Institute (WTI) Montana State University PO Box 174250 Bozeman, MT 59717-4250 phone 406.994.6486	**Approved Ending Date:** August 2009

Percent complete (budget and hours): 83%

- **Hours and budget expended to date:** 1855 hours, $82,769
- **Hours and budget expended for current quarter:** 283 hours, $13,957
- **Hours and budget balance:** 463 hours, $17,231

Brief project description:

Every year manufacturers introduce new deicing chemicals, additives or mixtures for use in snow and ice operations. Users do not currently have a comprehensive methodology for evaluating the performance of these new products prior to purchasing. The goal of this project is to establish laboratory tests that can be applied to all deicing chemicals, additives and mixtures to measure performance. Manufacturers would then be required to have the tests run at independent laboratories before they can be marketed or used by Clear Roads states. A standard set of performance tests for deicing chemicals, additives and mixtures that will help agencies anticipate how products may work in their specific environment is expected.

Progress this quarter (include specific tasks completed):

During this quarter the research team primarily focused their efforts on Tasks 3 and 4, as described below.

Task 0: Project Management (80% completed)
This task involved periodic communications within the research team as well as between the research team and the sponsor. The last quarterly progress report was submitted to Clear Roads in December 2008.

Task 1: Comprehensive Literature Search (100% complete)
This task was complete prior to this quarter.

Task 2: Needs Identification and Recommendations (100% complete)
After a year of repeated contact and a reminder during Clear Roads' January 2009 meeting, there is still one survey response not submitted by a Clear Roads member state. The project TAC agreed to allow us to finalize the survey results after the diligent attempts failed to solicit the last response.

Task 3: Develop Testing Protocols, Procedures and Ranges (70% complete)
As a result of findings from Tasks 1 & 2, four test methods were proposed for development, modification, and evaluation. These were approved by the TAC during the interim report meeting and are the following:

- differential scanning calorimetry (DSC) thermogram testing for liquid deicers,
- an improved SHRP Ice Melting Test for solid and liquid deicers,
- an improved SHRP Ice Penetration Test for solid and liquid deicers, and
- a modified ice undercutting test (as described by Mauritis et al., 1995) for solid deicers

An appropriate DCS protocol was previously developed. To recap, the pertinent test parameters are: volume of 10 µL (measured with a micropipette), dilution ratio of 1.5:1 from an as-received (typically eutectic)

concentration for liquid deicers or a saturated aqueous solution for solid deicers, cooling & heating rate of 3.6°F/minute, and temperature range of 77 to -76°F.

As identified in the literature search, the SHRP test methods are fairly well developed. However, according to the survey, the test methods do not appear to be widely used. The intentions behind improving two test methods are to increase the ease with which the tests can be conducted and implemented as well as to improve the test's reliability. As communicated in the last progress report, the Ice Melting test was improved by using readily available laboratory equipment instead of fabricating custom Plexiglas dishes; this required concurrent changes to the amount of water and deicer used. To improve the test's sensitivity to variations in temperature and humidity, four ice samples are tested simultaneously, three with the "test" deicer and one with reagent-grade 23% NaCl as a control. This concept has been modeled after the Pacific Northwest Snowfighters corrosion dip test (NACE Standard TM0169-95 as Modified by PNS) which uses both distilled water and 3% NaCl as controls. For the Ice Penetration test an alternative apparatus has not been identified. However, the dye used to indicate penetration depth is more difficult to acquire. Tests using readily available food coloring have so far shown no adverse implications.

The modified Mauritis ice undercutting test uses standard equipment (test tube, salt water bath, and digital multimeter) for a single test; the circuit is a closed loop until the deicer undercuts the ice causing the test tube to detach and break the circuit, which is read as Overload or Open Circuit with the meter. However, to reduce operator time, a data logger can be used to measure the electrical resistance (in ohms) of several concurrent test tubes. WTI had a data logger available and programmed it to collect data from ten test tubes.

Preliminary results at 30°F indicate this test may not have adequate reproducibility to distinguish the relative performance of various deicers. For instance, tests performed on February 18, February 20, March 17, and March 24 show average ice undercut times for 23% NaCl (with 10 test tubes for each test) of 65, 65, 39, and 21 minutes, respectively. Not only does this show a large variation between tests, the standard deviations within each test are also high: 32, 38, 21, and 12 minutes, respectively. These tests were initially conducted with the aqueous deicer to improve the uniformity. One test was conducted with solid granular NaCl and ice undercutting occurred between 0.5 to 3 minutes. Looking back at the original test results performed by Mauritus et al., this test method is likely not able to distinguish the relative performance of various deicers at 30°F. Instead, tests may need to be conducted at colder temperatures.

Task 4: Conduct Baseline Tests (60% complete)
This task involves testing following deicers:

- 23% Salt Brine
- 32% Calcium Chloride
- 29% Magnesium Chloride
- Geomelt 55
- Blend: 95% Salt Brine + 5% Calcium Chloride
- Blend: 90% Salt Brine + 10% Calcium Chloride
- Blend: 85% Salt Brine + 15% Calcium Chloride
- Blend: 80% Salt Brine + 20% Calcium Chloride
- Blend: 90% Salt Brine + 5% Calcium Chloride + 5% Geomelt 55
- Blend: 85% Salt Brine + 5% Calcium Chloride + 10% Geomelt 55
- Blend: 85% Salt Brine + 5% Calcium Chloride + 15% Geomelt 55

All blends were tested this quarter following the DSC and modified Ice Melting protocols developed in Task 3.

Task 5: Final Report (15% complete)
We have begun writing the draft version of the final report, which is due May 29, 2009. The final report will include the literature review and survey results, as well as the test protocols and baseline test results.

Tasks planned for next quarter:
During the next quarter the research team will finish Tasks 3 and 4.
The draft final report will also be finished next quarter and submitted to the TAC by May 29, 2009.

Identify any outstanding issues and barriers
In February a no-cost time extension was approved by the TAC to provide additional time to complete the laboratory tests and final report. The construction of the cold chambers at the Subzero Science and Engineering Research Facility took longer than originally anticipated. While we have been able to conduct tests in the cold chambers since December, problems were encountered intermittently with the chiller and defroster causing several interim delays. With the additional time granted for completion of the project, there are no foreseeable outstanding issues or barriers.

Gantt chart.

Tasks	*Milestones*	2007		2008												2009						
		11	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7
Task 0. Project Management																						
Project kickoff	*11/13/2007*																					
Quarterly progress reports	*End of each quarter*																					
Task 1. Comprehenstive Literature Review																						
Interim Conference Call Meeting/Presentation	*1/8/2008*																					
Task 2. Needs Identification and Recommendations																						
Interim Report: Needs Identification and Recommendations Summary	*5/28/2008*																					
Task 3. Develop Testing Protocols, Procedures and Ranges																						
Task 4. Conduct Baseline Tests																						
Task 5. Final Report																						
Draft final report	*May-09*																					
Conf Call -or- Face-to-face TAC meeting	*Jun-09*																					
Final report	*Jul-09*																					