SPR RESEARCH PROGRAM
SECOND-STAGE PROBLEM STATEMENT
FY 2009

ODOT Research Unit
200 Hawthorne Ave. SE
Suite B-240
Salem OR 97301-5192

Phone (503) 986-2700
Fax (503) 986-2844

I. PROBLEM NUMBER

CM-09-03

II. PROBLEM TITLE

Field Investigation of the Effects of Magnesium Chloride Exposure in Oregon

III. RESEARCH PROBLEM STATEMENT

Magnesium chloride is a popular deicing chemical because it is both effective and relatively safe for the environment. To maintain safe snow/ice free roads during winter months, the Oregon Department of Transportation (ODOT) applies the chemical for both anti-icing and deicing in accordance with guidelines established by the Pacific Northwest Snowfighters. Laboratory studies have demonstrated that magnesium chloride deicers cause deterioration of mortar and concrete specimens (*Cody 1996; Lee 1998; Mussato 2004; Sutter 2006*). In general, three primary impacts to concrete have been attributed to magnesium chloride: 1) exacerbated freeze-thaw cycling and scaling, 2) corrosion of reinforcing steel, and 3) weakening of the cement paste. These laboratory studies have used accelerated conditions, submerging and ponding the fresh mortar specimens in a magnesium chloride solution. The relative effects of real-world magnesium chloride application are mostly unknown. There are no known field studies that have linked the damage seen in laboratory analysis with real-world application rates and conditions. Therefore it is unknown what effect magnesium chloride has on Oregon's roads and bridges, and if any infrastructure damage is occurring.

IV. RESEARCH OBJECTIVES

The objectives of the research are the following:

- Develop an exposure map showing the history of magnesium chloride applications on ODOT concrete pavements and bridge decks
- Collect and examine field core samples to determine, characterize and describe any damage that can be attributed to the application of magnesium chloride
- Attempt to link the effects of magnesium chloride, seen in previous laboratory studies, to what is observed in this Oregon field study
- Establish a method for predicting future infrastructure damage, if any

V. WORK TASKS, COST ESTIMATE AND DURATION

To accomplish the proposed objectives, this research will consist of the following tasks:

Task 1. Literature Review (cost estimated at $13,500; month 1 – month 3). A comprehensive literature review of existing laboratory studies will provide relationships between chemical concentration, exposure duration, mineralogical changes, and concrete damage. Papers and reports published by TRB, SHRP, FHWA, NCHRP, UTCs, and state highway agencies will be targeted in the review process. A detailed Internet search will also be conducted, using TRIS online, Google Scholar, and SCIFinder Scholar as a starting point.

Task 2. Identify Field Sample Locations (cost estimated at $30,000; month 3 – month 8). A geographical "exposure map" will be developed to show the duration and extent of magnesium chloride exposure to ODOT concrete pavements and bridge decks. The map will be developed by surveying ODOT maintenance personnel or examining the ODOT maintenance management system, and reviewing weather data. Locations will be selected to collect cores from in-service pavements using the exposure map. In addition to magnesium chloride exposure, other factors such as mix design, construction practice (including mixture and curing), age, maintenance treatments, weather (e.g. rainfall and temperature), traffic, and exposure to other winter maintenance materials will be taken into consideration to allow a diverse array of field samples to be collected.

Task 3. Field Sampling (cost estimated at $9,500; month 9 – month 11). Cores will be extracted from in-service pavements and bridge decks by ODOT. Approximately 100 core samples will provide a reasonably good cross-section of the possible combinations of various influential factors. If possible, more than one core will be taken from each selected site location to allow for statistical reliability.

Task 4. Laboratory Testing of Field Cores (cost estimated at $75,000; month 11 – month 14). The field cores will be examined using X-ray Photoelectron Spectroscopy (XPS) to develop chloride and magnesium penetration profiles. XPS will also potentially allow the quantification of magnesium silicate hydrate, magnesium hydroxide, and other mineralogical changes. Visual examination of distress will be augmented by strength testing. Field cores will also be subjected to a modified Rapid Chloride Permeability Test to quickly determine the apparent diffusion coefficient of $MgCl_2$ in each sample. Petrographic evaluation will be conducted to investigate freeze-thaw damage. When reinforcing elements are present in the sample, the steel will be examined for corrosion.

Task 5. Data Analysis (cost estimated at $17,000; month 14 – 18). A correlation will be determined between field exposure to magnesium chloride and concrete damage. A threshold for acceptable damage will be obtained, if possible, by integrating the magnesium chloride penetration data with the strength data of concrete samples.

Task 6. Final Report (cost estimated at $12,000; month 19 – month 22)

ODOT support and project management: $38,000

Project cost: $157,000 (+ ODOT: $38,000=Total: $195,000) Duration: 22 months

VI. IMPLEMENTATION

A report and presentation will be given to key ODOT personnel that discusses if and how the application of magnesium chloride affects Oregon's roads and bridges. A forecasting tool will be made available to appropriate staff members who can use the tool to plan for long-range infrastructure repair and replacements.

VII. POTENTIAL BENEFITS

Existing laboratory evidence indicates magnesium chloride could be potentially damaging to concrete. This purposed study will link laboratory testing with actual field exposure. The results will allow ODOT to predict the level of infrastructure damage to expect, if any. ODOT personnel can then use the damage forecasts to plan for long-range infrastructure repair and replacements.

VIII. SUBMITTED BY

Stage 1 submitters:
Keith Johnston (ODOT Champion)
Structural Services Engineer
ODOT Construction Section
800 Airport Rd SE
Salem, OR 97301
Keith.R.Johnston@odot.state.or.us

and

Amanda Bush
ODOT Research Unit
Amanda.Bush@odot.state.or.us
200 Hawthorne SE, Suite B-240
Salem, OR 97301

Stage 2 submitter:
Xianming Shi, Ph.D., P.E.
P.I., Corrosion & Sustainable Infrastructure Lab (CSIL)
Western Transportation Institute (WTI)
PO Box 174250, Montana State University
Bozeman, MT 59717-4250
xianming_s@coe.montana.edu