Research Problem Statement

ODOT Research Section
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I. TITLE

17-001 Guidelines for preserving ODOT concrete bridge decks exposed to magnesium chloride deicers

II. PROBLEM

Over the last decade or so, ODOT has used magnesium chloride ($MgCl_2$) products to help maintain safe mobility on winter highways (Gong et al., 2014). These products, however, have posed potential risks for ODOT concrete bridge decks. An ODOT study completed in 2014 revealed significant reductions in strength and other properties of concrete decks after years of exposure to $MgCl_2$ usage. Such deterioration was mainly chemical in nature and featured no sign of surface distress. It can be aggravated by the joint action of freeze/thaw cycles, with symptoms of scaling, map cracking, or paste disintegration. The study also suggested ODOT to use surface treatments, especially penetrating sealers and water repellents, to protect new concrete and existing concrete without too much chloride contamination (Shi et al., 2014). Laboratory results also revealed that high resistance to both gas and water penetration is a crucial property for a good surface treatment applied to concrete (Dang et al., 2015). Currently ODOT uses concrete sealers, crack sealants, and thin overlays for preserving concrete decks, but these treatments do not specifically target the risk of magnesium chloride and their effectiveness are poorly understood.

In addition to *surface treatments*, ODOT concrete decks may benefit from *pressure washing operations*, especially right after the winter season. Note that if the old deck has significant amount of water and chloride contamination, sealing the deck alone may no longer provide the expected benefits as chemical attack would be actively ongoing even without further ingress of external chlorides. The benefits of pressure washing, especially coupled with *salt removers*, have been demonstrated in the laboratory, when it comes to removing residual chlorides from hidden areas and protecting metals from deicer corrosion (Shi et al., 2013; Li et al., 2013; Monty et al., 2014).

In this context, there is an urgent need to identify various concrete deck preservation options for ODOT and evaluate their performance and cost benefits as a function of typical scenarios of interest to ODOT. The goal is to develop guidelines for ODOT to adopt the cost-effective concrete deck preservation treatment(s) based on the existing level of chloride contamination and cracking in concrete, mix design and age of concrete deck, local rainfall, etc.

III. PROPOSED RESEARCH, DEVELOPMENT, OR TECHNICAL TRANSFER ACTIVITY

This research project will mainly consist of practitioner surveys and laboratory investigation. It will start with a literature review and nationwide agency survey of best practices during the life cycle of concrete bridge decks and pavements, with a focus on preservation against freeze-thaw damage, NaCl and $MgCl_2$ deicers. Subsequently, some of the identified best practices and their likely combinations (e.g., annual water washing vs. annual washing with chloride removers, vs. sealing vs. sealing and annual washing) will be further evaluated in the laboratory, using deck specimens fabricated to represent typical ODOT concrete mix designs at various ages, cracking density/width, and $MgCl_2$ contamination levels. In addition to the use of pressure washing and salt remover, preservation tools to evaluate in the laboratory may include penetrating sealers, hydrophobic impregnants, and densifiers (Franzoni et al., 2013; Pigino et al., 2012; Sandrolini et al., 2012), ideally including those on the ODOT Qualified Products List (QPL). The effectiveness of the preservation treatments will be evaluated in terms of their ability to slow down the chloride ingress, reduce corrosion of embedded rebar, and mitigate the deterioration of deck specimens, in the presence of $MgCl_2$ applications, freeze–thaw cycling, wet–dry cycling, or abrasion. The simulation of service conditions (e.g., amount of annual rainfall and freeze-thaw cycles in various ODOT districts) will be incorporated to be part of the test program. A finite element method (FEM) based model will be developed to link the results of accelerated laboratory tests to field performance of selected preservation treatments. Subsequently, the model will be used to establish acceptance tests for sealers, sealants, impregnants, and densifiers and to predict the beneficial life of selected preservation treatments and their life cycle cost. For various selected scenarios, the most cost-effective

treatment(s) will be identified. All the findings from the project will be leveraged to develop guidelines for preserving new and old ODOT concrete bridge decks exposed to magnesium chloride deicers.

IV. POTENTIAL BENEFITS

By identifying cost-effective preservation measures/products, the service life of ODOT concrete deck assets will be prolonged and repairs can be reduced, resulting in cost savings to the Department and less congestion and delays to the driving public. Without this research, ODOT will continue to bear the direct and indirect costs associated with premature concrete deterioration and the associated safety risk, reliability risk and environmental footprint. This research is urgently needed in light of the increasing reliance on chloride deicers for highway winter operations and the challenge of maintaining a state of good repair with limited bridge and pavement maintenance budgets.

V. IMPLEMENTATION

This research will modify the approach to concrete deck preservation by ODOT bridge engineers (e.g., Preservation Team within the Bridge Section) and enable ODOT to make informed and better choices on preserving the quality and life of concrete infrastructures. The findings will help ODOT revise the requirements for concrete preservation products to be included in the QPL and relevant sections in the Bridge Design and Drafting Manual.

VI. LIST OF REFERENCES *(optional)*

Dang, Y., Xie, N., Kessel, A., McVey, E., Pace, A., Shi, X. (2014). Accelerated Laboratory Evaluation of Surface Treatments for Protecting Concrete Bridge Decks from Salt Scaling. Construction and Building Materials, 2014, 55, 128-135. DOI: 10.1016/j.conbuildmat.2014.01.014.

Franzoni, E., Pigino, B., Pistolesi, C. (2013). Ethyl silicate for surface protection of concrete: Performance in comparison with other inorganic surface treatments. *Cement and Concrete Composites*, 44, 69-76.

Gong, J., Huang, J., Wang, S., Soltesz, S., Shi, X. (2014). Potential Deicer Effects on Concrete Bridge Decks: Developing Exposure Maps. Climatic Effects on Pavement and Geotechnical Infrastructure: pp. 66-77. ASCE Construction Institute.

Li, Y., Fang, Y., Seeley, N., Jungwirth, S., Jackson, E., Shi, X. (2013). Corrosion of Chloride Deicers on Highway Maintenance Equipment: Renewed Perspective and Laboratory Investigation. *Transportation Research Record* 2361, 106-113.

Monty, C., et al. (2014). Evaluation of the Effectiveness of Salt Neutralizers for Washing Snow and Ice Equipment (No. FHWA/OH-2013/18).

Pigino, B., Leemann, A., Franzoni, E., Lura P (2012). Ethyl silicate for surface treatment of concrete Part Ⅱ: Characteristics and performance. *Cement and concrete composite*, 34(3), 313–321.

Sandrolini, F, Franzoni, E., Pigino, B. (2012). Ethyl silicate for surface treatment of concrete Part 1: Pozzolanic effect of ethyl silicate. *Cement and concrete composite*, 34(3), 306-312.

Shi, X., et al. (2013). Identification and Laboratory Assessment of Best Practices to Protect DOT Equipment from the Corrosive Effect of Chemical Deicers. Final report prepared for the Washington State DOT.

Shi, X., et al. (2014). Understanding and Mitigating Effects of Chloride Deicer Exposure on Concrete. Final report for the Oregon Department of Transportation, Salem, OR. September 2014.

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