Oregon Department of Transportation

Stage 1 Research Problem Statement

Number*: 25-09*

Proposed Title: Quantifying the Influence of Climate Change and Mitigation Strategies on the Deterioration of ODOT Asphalt Pavement

1. Concisely describe the **transportation issue** (including problems, improvements, or untested solutions) that Oregon needs to research.
Climate change has not been evaluated for asphalt pavements in terms of determining whether or not ODOT's current designs, both pavement structural designs and mix designs, will be able to handle potential climate change that Oregon may experience. As a major threat in the 21st century, climate change may accelerate pavement deterioration (due to changing conditions) and complicate pavement management (due to changing patterns). Specifically, extreme weather events may cause devastating and irreversible damage on pavement and compromise its basic functionality and resilience. For asphalt pavement, climate is especially important since both instantaneous and long-term behaviors of asphalt mixture rely heavily on climatic factors such as temperature, temperature swings and precipitation. Research is lacking in the quantification of cause-and-effect relationships between climate factors and individual distresses of ODOT asphalt pavement, let alone the ability to predict the impact on the service life of ODOT asphalt pavement and recommend effective adaptation strategies.

2. Document how this **transportation issue** is important to Oregon and will meet the Oregon Research Advisory Committee Priorities
The proposed research involves the **climate** and its effect on the **asset maintenance**, both of which fall within the ODOT research focus areas. The investigated object is asphalt pavement which accounts for 95% of ODOT's state highway network. Approximately $280 million per year is needed over the long term to make major repairs needed on routes with the worst pavement conditions in Oregon State. However, if proactive maintenance, in the form of preventive maintenance and minor rehabilitation, is performed during the initiation and early propagation stages of distresses, life-cycle cost might be greatly reduced. Therefore, it is crucial to establish updated distress development models with the changing climate conditions. Such models will enable timely and optimized maintenance and rehabilitation (M&R) activities leading to effective and efficient asphalt pavement management.

3. What **final product or information** needs to be produced to enable this research to be implemented?
This project will produce climate-informed predictive models of asphalt pavement distress development using historical records in Oregon State. For each distress (rutting, cracking, IRI, etc.), the predictive model will contain climate factors with the most relevancy to the distress development obtained from the feature selection. Then, we can quantify the effects of climate change on asphalt pavement distress development (e.g., distress onset and degree) from the predictive models of distress and regional climate change.

This project will inform development and implementation of cost-effective approach to dealing with climate change in terms of designing (both structural and materials) and evaluating pavement deterioration that may be different than we are used to. ODOT can use the research findings to update the designs and M&R strategies for asphalt pavements to improve their life-cycle performance and resilience to climate change. Better data will translate to making better pavement management decisions, and thus saving money for taxpayers.

4. (Optional) Are there any individuals in Oregon who will be instrumental to the success of implementing any solution that is identified by this research? If so, please list them below.

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John Coplantz	State Pavement Management Engineer	John.S.COPLANTZ@odot.oregon.gov	503-986-3119

5. Other comments:

The influence of changing climatic factors on pavement vulnerabilities and potential adaptation strategies has been summarized (Meyer et al., 2014) and climate change has been considered in the framework of pavement performance evaluation and life cycle assessment (LCA) (Knott et al., 2019; Stoner et al., 2019; Blaauw et al., 2022). However, these studies are still in the early stages of understanding and mitigating the true impact of climate change on pavements that needs to be realized as soon as possible for design purposes. Current structural design and material selection adopted by ODOT may not adapt to the changing climate. For example, the average annual temperature and precipitation are expected to increase by 5.3 °F and 4% by the end of 21st century in the Pacific Northwest (Mote and Salathé, 2010). Accordingly, the binder grade, mix and structural designs of newly designed asphalt pavements may need an update to improve the rutting and moisture susceptibility and achieve the expected service life. Second, the changing climate is likely to affect the deterioration pattern of existing asphalt pavements. For example, the increased temperature and precipitation can accelerate the process towards the limits of accumulated rut depth and cracking severity, calling for adjustments of the timing and type of M&R strategies for timely and cost-effective pavement management.

Researchers applied various measures to quantify climate change effects and provide corresponding adaptation strategies. Knott et al. (2019) utilized temperature-dependent resilient modulus of hot mix asphalt (HMA) to evaluate the effect of the rising temperature to pavement life. Accordingly, increasing asphalt layer thickness was the recommended adaptation strategy. Kwiatkowsk et al. (2020) utilized freeze–thaw (FT) cycle-dependent frost damage of porous asphalt pavement to estimate the impact and adaptation costs from future changes in FT cycles. Swarna et al. (2021) updated binder grade for asphalt pavements in Canada according to climate change data and quantified changes in pavement distresses from the pavement ME design software. Gulzar et al. (2021) transformed pavement performance reliability to binder grade reliability and assessed vulnerability of asphalt pavements to temperature rise. Chen et al. (2021) applied LCA to evaluate the environmental and economic impacts of asphalt pavements with consideration of climate change scenarios, which are mainly the warming temperatures. The climate change effect on asphalt pavement distresses such as rutting, cracking and roughness were obtained from the pavement ME design software. Mahpour and El-Diraby (2021a) incorporated climate change represented by the temperature rise into the calculation of Pavement Condition Index (PCI) for the guidance of maintenance policies. The researchers also utilized different ML algorithms to predict future pavement condition with climate factors and pavement properties (Mahpour and El-Diraby 2021b). Zhang et al. (2022) assessed the rutting resilience of asphalt pavements to climate change from the baseline and revised rutting development curves.

Prof. Xianming Shi and Dr. Yong Deng of Washington State University have nearly completed a two-year project for Idaho Transportation Department that establishes improved predictive models of asphalt pavement performance in the State of Idaho, by mining the historical data through statistical analyses and machine learning (ML) approaches. Their expertise and hands-on experience will benefit this proposed project.

6. Corresponding Submitter's Contact Information:

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