Oregon Department of Transportation

Research Stage 1 Problem Statement

Number 26-36 – "The Potential of Using Crack Attenuating Asphalt Mixtures in Oregon to Combat Long-Term Durability Issues"

1. Concisely describe the **transportation issue** (including problems, improvements, or untested solutions) that Oregon needs to research.

Fatigue cracking is the major distress mode in Oregon. Most asphalt-surfaced pavements fail from load-related fatigue cracking, which results in expensive maintenance processes over time. Fatigue cracking can start from the surface of the pavement due to high shear stresses applied by the heavy truck tires (called "top-down fatigue cracking") or start from the bottom of the pavement layer due to excessive tensile stresses as a result of the bending of the pavement system (called "bottom-up fatigue cracking"). Reflection cracking is another major distress mode in Oregon, resulting from the cracks in the underlying asphalt or concrete pavement layers reflecting to the new surface layer. Since reflection cracking can happen within the first years after construction, it can significantly increase the long-term cost (life-cycle cost) of the pavement structure.

The majority of the concrete pavements in Oregon are old and have low to moderate severity surface cracks and high surface roughness levels. To maintain concrete pavements, constructing thin asphalt surface layers is a common strategy to improve road user comfort and reduce roughness levels that can increase vehicle fuel consumption by 2% to 4% (Estaji et al. 2021). However, the existing cracks in the concrete pavements can reflect to the new asphalt surface layer and result in premature failures. For this reason, developing methods and strategies to improve the reflective cracking resistance of those pavement structures in Oregon are crucial. The same reflection cracking issue may still happen when the cracked asphalt surface layer is removed by milling and replaced with a new asphalt surface layer (the most common pavement construction method in Oregon called "mill&fill"). The milling process may not remove all the cracks in the old layer, or aggressive milling action might introduce microcracks into the old layer that may reflect to the new surface layer within a couple of years (Weaver et al. 2023).

The concept of "crack attenuating asphalt mixes" was originally developed by the Texas Department of Transportation (TxDOT) (FHWA, 2022). The major purpose was to install the crack attenuating layer, a 0.5inch to 1inch thick layer with fine-gradation (small size aggregates) and high asphalt binder content, to mitigate reflection cracking. This thin asphalt layer is constructed on top of the old asphalt layer after milling, and the new asphalt layer is constructed on top of it. By having the thin and highly flexible crack attenuating layer in between the old and the new pavement layers, the occurrence of reflection cracking is mitigated. The asphalt mixtures for the crack attenuating layers are designed to have high crack resistance by using finer gradation and high binder content. In addition, their crack resistance can be further increased by using polymer modification, crumb rubber recycled from vehicle tires, and fiber reinforcement in the asphalt mixture.

Although the crack attenuating layers are effective in reducing reflection cracking, they are more expensive than conventional asphalt mixtures. However, the long-term performance improvement that crack attenuating mixes can create reduces their life-cycle (long-term) cost by 20% to 30% (FHWA, 2022). In addition, crack-attenuating mixes can replace other interlayers that are used to avoid reflection cracking. Since those interlayers are generally more expensive than any asphalt mix, crack attenuating layers can be considered to be cost-effective strategies when implemented with the correct mix designs and construction processes.

Although crack attenuating mixes have been proven to reduce long-term paving costs and improve the longevity of pavements, their effectiveness with Oregon aggregates, binder types, and additives needs to be tested to incorporate that strategy into ODOT's processes and specifications. A field study must also be performed to test the practicality of the construction of this layer. Adhesion between the crack attenuating layer and the old and new pavement layers should also be checked and evaluated to ensure that this design would not result in any major delamination issues, which can be detrimental to the long-term performance of the pavements. For all those reasons, a laboratory and field-level research study should be conducted to find the best materials, design methods, and construction processes that can provide the highest level of performance with this promising technology. The long-term cost-effectiveness must also be evaluated by conducting a life-cycle cost analysis (LCCA) using the collected performance data.

2. What **final product or information** needs to be produced to enable this research to be implemented?

The major products from this proposed research project would be:

- Laboratory asphalt mix testing and designs with various additives, fibers, RAP contents, binder types, contents, and aggregates with different properties.
- New mix design, construction methods, and specifications to successfully implement crack attenuating mixes in Oregon.
- Cost and performance comparisons between the crack attenuating layers and other more expensive interlayer options.
- Long-term cost-effectiveness of crack attenuating layers.
- **Demonstrations:** Field implementation of mixture designs (pilot section constructions) that are most promising based on the laboratory results.
- Long-term performance monitoring of the constructed field pilot sections by Automated Pavement Condition Surveys (APCS) to validate the long-term performance effectiveness of the selected strategies.
- Based on the research findings, recommend a list of materials to be included in ODOT's Qualified Products List (QPL).
- A comprehensive research report with a literature review, all research components and results, and major conclusions.

3. (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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Chris Duman	Pavement Quality & Materials Eng.	Christopher.L.DUMAN@odot.oregon.gov	(503) 559-4994
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4. Decision making lenses

Please complete the following three sections. Your answers to these questions will be applied on a programmatic basis to support agency decisions. Answering yes to the questions below is not required. Resolving a narrowly focused technical research problem may meet agency needs without answering yes to any of the following questions. The ODOT Research Section will seek a balanced portfolio some projects will answer yes to one of the three categories below (e.g. climate, equity, and/ or safety) and other projects in a different category.

We are looking for an overall program balance and no one project is expected to balance all categories. Generally, a research problem statement is expected to be able to answer yes with clear and verifiable information in only one of the three categories below, some projects may be able to answer yes in two or even three categories. Some projects (i.e. needs focused on specific elements of infrastructure design), may have no yes answers but may still be high value research need.

Climate

Oregon recognizes the climate crisis and makes systemic changes to reduce emissions caused by travel. Every mile driven in Oregon is powered by a clean source of fuel. We seek research that supports construction and maintenance operations are carbon neutral and investments in mobility that support travel by low and no emission modes. While every research project may not result in a reduction in emissions, transportation investments overall support emission reductions to achieve state goals. Oregon envisions a transportation system that is resilient in the face of seismic and climate events and impacts to the degradation of the natural environment are reduced. Our vision includes a transportation infrastructure is built in a way that avoids impacts on key habitat and results in better environmental conditions for wildlife and native vegetation. For definitions and details please review the equity vision, goals, and objectives of the ODOT Strategic Action Plan and Oregon Transportation Plan.

4f. Will addressing the **transportation issue** identified as a need in Question 1 develop, or validate methods for the estimation, measurement, or monitoring of transportation generated greenhouse gasses (GHG)?

☐Yes ☒No ☐Unsure

4g. If climate or GHG is not the focus of this **transportation issue** identified in this problem statement, will the research apply a GHG analysis to transportation infrastructure, planning, operations, maintenance, or materials?

☒Yes ☐No ☐Unsure

4h. Will the addressing the **transportation issue** include development or testing of construction practices, methods, or materials to establish potential reductions in greenhouse gas emissions?

☒Yes ☐No ☐Unsure

4i. Will the solving the **transportation issue** in question 1 study or support the reduction of vehicle miles traveled and single occupancy vehicle travel or support transition to electric vehicles (or other types of zero emission vehicles) or low-carbon alternative fuels?

☐Yes ☒No ☐Unsure

4j. Will the solving the **transportation issue** in question 1 lead to work that will support, measure, monitor, transportation system resilience in response to expected climate events, effects, or natural disasters in general?

☐Yes ☒No ☐Unsure

4k. Will the solving the **transportation issue** in question 1 lead to work that may result in better environmental conditions for wildlife and native vegetation ?

☐Yes ☒No ☐Unsure

4l. If you answered yes to any of the climate questions above or can provide alternative details related to climate, please provide additional information:

This proposed research study is expected to improve the longevity of pavements and result in less frequent construction and maintenance activities. This benefit will reduce greenhouse gas (GHG) emissions by reducing long-term material production, construction, and construction-related traffic delay emissions.

According to an ODOT/FHWA research study (FHWA Climate Challenge) recently completed by the OSU-Asphalt Materials and Pavements (AMaP) research group, the cost of fuel and tire wear that can be saved by reducing current pavement roughness levels by 20% is around $73 million/year for the road users. The associated annual emissions savings are around 193,000 MT CO_2/year, while ODOT's total annual emissions from all operations were calculated to be 182,592 MT CO_2/year (Proudfoot and Toneys 2022). This important result shows that strategies to improve the long-term durability of pavement structures are needed in this low paving budget environment to keep the roadway roughness and rolling resistance low to reduce GHG emissions and road user costs.

Equity

Equity can have many dimensions and impacts relating to communities, and transportation. It is important that problem statement proposals clearly explain in what capacities are equity dimensions or impacts being examined within problem statements. It is a goal of the OTP to "Improve access to safe and affordable transportation for all, recognizing the unmet mobility needs of people who have been systemically excluded and underserved. Create an equitable and transparent engagement and communications decision-making structure that builds public trust". Proposed research may have the intent of studying elements of this goal or apply analysis to specific transportation topics to ensure the resulting research recommendations is consistent with our equity goals. For definitions and details please review the equity vision, goals, and objectives of the ODOT Strategic Action Plan and Oregon Transportation Plan.

4a Is the **transportation issue** identified as a need in Question 1 specifically focused on transportation equity?

☐Yes ☒No ☐Unsure

4b If the **transportation issue** is not focused on transportation equity, will the primary topic be assessed for equity benefits or impacts within the research project?

☐Yes ☒No ☐Unsure

4c Is the implementation of potential findings from this research likely to directly involve participation from an identified group that would benefit from an equitable process or outcome?

☐Yes ☒No ☐Unsure

4d Is the intended final product or information expected to support ODOT's equity efforts (Including but not limited to supporting one of the equity related objectives of the ODOT's Strategic Action Plan or Oregon Transportation Plan) ?

☐Yes ☒No ☐Unsure

4e If you answered yes to any of the equity questions above or can provide alternative details related to equity, please provide additional information:

Safety

Research outcomes may include interventions and countermeasures to prevent or reduce the frequency of crashes or other causes of transportation-related injury or death; or may include measures to reduce severity of injury (including prevention of death) after a crash or other injurious event. For definitions and details please review the equity vision, goals, and objectives of the ODOT Strategic Action Plan, Oregon Transportation Safety Action Plan and Oregon Transportation Plan.

4m. Will solving the **transportation issue** in question 1 support improving **safety culture** for either transportation workers or the traveling public?

☐Yes ☒No ☐Unsure

4n. Will the solving the **transportation issue** support improving safety through **healthy and livable communities**?

☐Yes ☒No ☐Unsure

4o. Will solving the **transportation issue** support improving safety through using **best available technologies**?

☒Yes ☐No ☐Unsure

4p. Will solving the **transportation issue** support improving safety through **communication and collaboration**?

☐Yes ☒No ☐Unsure

4q. Will the solving the **transportation issue** support improving safety through **investing strategically**?

☒Yes ☐No ☐Unsure

4r. If you answered yes to any of the safety questions above or can provide alternative details related to safety, please provide additional information:

This proposed research study is expected to reduce reflection cracking, a major distress mode in Oregon, and improve the longevity of pavements. Improved performance will reduce the frequency of paving and improve worker and road user safety.

5. Other comments:

REFERENCES:

Estaji, M.; Coleri, E.; Harvey, J.T.; Butt, A.A. Predicting Excess Vehicle Fuel Use Due to Pavement Structural Response Using Field Test Results and Finite Element Modelling. Int. J. Pav. Eng. 2021, 22, 973–983.

FHWA. (2022). Targeted Overlay Pavement Solutions (TOPS). U.S. Department of Transportation. FHWA, FHWA-HIF-22-030.

Weaver, J., Coleri, E., & Chitnis, V. (2023). Centerline Rumble Strip Effects on Pavement Performance (Final Report FHWA-OR-RD-23-09; p. 170). Oregon Department of Transportation. https://www.oregon.gov/odot/Programs/ResearchDocuments/SPR838CLRSODOTFINAL.pdf

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