Oregon Department of Transportation

Research Stage 1 Problem Statement

Number 26-17 – "Adjusting RAP and Asphalt Binder Content to Reduce Material Production Emissions While Achieving the Long-Term Performance Goals"

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

Recycling highway construction materials and reducing the reliance on virgin materials can lower pavement life cycle costs, enhance highway network conditions, conserve natural resources, and benefit the environment. While incorporating recycled asphalt pavement (RAP) offers many advantages, the main challenge with high RAP content mixes is the potential reduction in the long-term durability of the asphalt. The aged binder in RAP is less flexible than the virgin binder, which increases the risk of failure under repeated high axle loads and thermal stresses. Consequently, in Oregon, RAP usage in asphalt mixes is currently restricted to approximately 30% by weight for medium to high-traffic areas (Level 3 asphalt mixtures) and 20% for locations with heavy truck traffic (Level 4 asphalt mixtures).

For asphalt mixtures with a higher percentage of RAP (higher than the current limit), the common strategies for improving the resistance to cracking are using warm-mix additives, rejuvenators, increasing binder content, using softer binders, polymer modification, or improving the aggregate properties (aggregate shape, texture, angularity, and gradation). Rejuvenators and warm-mix additives restore the physical and chemical properties of the aged binder and make the mix softer by reducing the viscosity of the mix (Haddadi and Coleri, 2019; Coleri et al., 2018). Since adding rejuvenator or warm-mix additives to the mixture containing RAP has some uncertainties, including unknown rejuvenator or warm-mix additive uniformity and quality, amount of rejuvenator and other additives to be used for mixes with different RAP and binder contents, inadequate blending between rejuvenator and recycled binder, and the required reaction time, it is not widely used.

In addition, using softer binder grades, increasing binder content, and using more cubically-shaped aggregates (also called equidimensional aggregates) with high angularity are other potential methods to increase the performance of high RAP asphalt mixtures. However, selecting the most effective rejuvenators, warm-mix additives, aggregates, and binder properties for Oregon, developing methods and guidelines for mix design, ensuring appropriate mixing, and allowing the required reaction time for additives can offset these uncertainties and improve the crack resistance of high RAP asphalt mixtures (more than 30% RAP which is the upper limit currently allowed in Oregon).

According to a recently published ODOT research report from the climate office, about 60% of ODOT's annual emissions are from the production of construction materials. Since 95% of the pavements in Oregon are asphalt surfaced, the highest percentage of ODOT's GHG emissions are from asphalt mixture production. According to the research conducted by OSU-AMaP as a part of the FHWA Climate Challenge project, increasing RAP content from 20% to 40% can decrease plant emissions by 16%. Using warm-mix additives can also reduce the production temperatures (35°F to 100°F reduction in production temperatures) and create additional significant greenhouse gas (GHG) emission savings. In addition, using higher binder content, softer binder grades, and better aggregate geometries can also help reduce asphalt binder content and/or increase RAP content without sacrificing performance. The use of liquid anti-

stripping agents to replace hydrated lime (commonly used in Oregon to combat moisture-related premature asphalt failures) in asphalt mixtures will also be investigated in this proposed research project. According to a recent National Asphalt Pavement Association (NAPA) report, hydrated lime significantly impacts the overall A1-A3 GHG emissions (significantly more than aggregate production emissions and close to virgin binder production emissions). All these strategies can significantly reduce A1-A3 emissions for the asphalt concrete materials that are commonly used in Oregon. Increased use of RAP and reduced binder content also have the potential to reduce paving costs, which will ultimately allow for more annual lane-mile paving with a limited budget. Increased paving will improve the roadway network conditions in Oregon, ultimately reducing the emissions from road roughness-related excess fuel consumption and tire wear.

Balanced mix design (BMD) efforts have been ongoing in Oregon since 2015. There are two Oregon DOT research projects previously completed (SPR797 and SPR801) on this topic. There is also an ongoing project, SPR852, where OSU-AMaP provided BMDs for 9 construction projects, and 5 of the BMD segments were constructed along with the Volumetric mix design sections (current mix design method) across Oregon in the summer of 2023. The project also has LCA and LCCA components. The details of the SPR852 project are available under this link, SPR852.

Using the methods, test processes, software packages, and other tools to expand this process into implementing low-carbon construction materials for the asphalt side is critical. The test processes and the cracking and deformation thresholds developed in all the above-mentioned projects open up opportunities to increase RAP content, and/or reduce asphalt binder content of the Oregon asphalt mixtures. However, the performance of all those new low-carbon asphalt mix designs requires laboratory and field validations through the construction of additional pilot sections across different climate regions and traffic levels in Oregon.

OSU-AMaP also recently developed an accelerated pavement test (APT) system for conducting rapid full-scale performance tests that provide more accurate information than laboratory tests. High RAP mixes and mixes with different recycled material components are more likely to crack than deform (rut) in the field. For this reason, several years of field performance monitoring may be required to determine their in-situ effectiveness. The APT system can provide 10-15 years of performance data in about 4-6 months. This important testing capability and its use for in-situ material performance assessment is vital for achieving low-carbon construction materials that do not sacrifice long-term pavement performance.

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

- A preliminary investigation will be conducted using past ODOT asphalt mix designs and test results and conducting preliminary local LCAs to develop potential mix design strategies that will create the most impact on A1-A3 production emissions.
- Laboratory asphalt mix testing and designs with various additives, RAP contents, binder types, and contents, and aggregates with different properties.
- APT testing of the most promising options determined by laboratory testing.
- ***Demonstrations:*** Field implementation of mixture designs (pilot section constructions) that are most promising based on the APT and 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.
- Life-cycle assessment (LCA) and LCCA for all proposed asphalt mix designs to quantify their impact on cost and emission reduction.
- Provide a comprehensive list of asphalt mix designs and processes for ODOT to reduce A1-A3 emissions, increase RAP content, reduce the cost of paving, and improve the overall condition of the Oregon roadway network.
- Based on the research findings, recommend a list of materials to be included in ODOT's Qualified Products List (QPL).
- Quantify the impact of using renewable fuels for asphalt mix production on plant emissions for all selected strategies to determine the long-term impact. **The results of the pavement LCA conducted in the ODOT/FHWA Climate Challenge research project showed that a 26% reduction in plant emissions is possible by using renewable fuels.**
- Provide 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 reduce ODOT's A1-A3 GHG emissions for material production. All the strategies stated in Section 1 of this problem statement can significantly reduce A1-A3 emissions

for the asphalt concrete materials that are commonly used in Oregon (responsible for more than 50% of ODOT's annual emissions). Increased use of RAP and reduced binder content also have the potential to reduce paving costs, which will ultimately allow for more annual lane-mile paving with a limited budget. Assessment and adaptation of low-carbon alternative fuels (renewable propane for asphalt production) have the potential to create about 26% reduction in plant emissions, which is expected to have a significant impact on the overall ODOT's emissions (based on the results from FHWA Climate Challenge project). Increased paving will improve the roadway network conditions in Oregon, ultimately reducing the emissions from road roughness-related excess fuel consumption and tire wear.

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 CO2/year, while ODOT's total annual emissions from all operations were calculated to be 182,592 MT CO2/year (Proudfoot and Toneys 2022). This important result shows that lowering the cost of paving materials, which is one of the major objectives of this proposed research study, is crucial 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:

5. Other comments:

6. Corresponding Submitter's Contact Information:

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