Oregon Department of Transportation

Research Stage 1 Problem Statement

Number 26-48 – "Identification and Specification of Alternative Supplementary Cementitious Materials for Making Lower Clinker Content Concrete with a Low GWP"

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

The adoption of lower-carbon concrete is resulting in a shift from cements that are predominately clinker-based to systems with high clinker replacements with alternative supplementary cement (ASCMs). This can reduce the GWP for concrete mixtures as quantified in EPDs. Historically, the industry has relied on fly ash and slag as the primary SCMs; Oregon may have an abundance of ASCM (i.e., natural pozzolans). This project will aide ODOT in both update its specifications and approved material list. In doing so it will provide ODOT and state with mixtures that can greatly reduce the GWP of concrete.

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

This will enable ODOT to specify low GWP concrete using these local materials and ensure that adequate strength and durability performance. Local industry will also be engaged. This work will develop the processes to:

1) outline the SCMs that the state needs to specify/accommodate;
2) identify the testing needed to qualify these materials;
3) purchase ODOT equipment for performing the test;
4) train state personnel and consultants in testing;
5) outline how performance criteria can be established;
6) outline a proportioning procedure and typical resulting EPDs,
7) outline a quality assurance (QA) approach;
8) help contractors establish a quality control procedure;
9) develop and implement training materials; and
10) demonstrate the value of using these materials. In the end, the state will have state-of-the-art specification language, trained personnel, SCM benchmarks, performance-based SCM criteria, and a QC/QA program with the levers that control the performance of the SCM.

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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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

The project asses GHG/GWP associated with testing more durable concrete materials and seeks methods to keep this low and reduce it further. This proposal outlines reactivity testing to quantify the use of ASCM materials to replace clinker. This can reduce GHG/GWP.

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

The project asses GHG/GWP associated with testing more durable concrete materials and seeks methods to keep this low and reduce it further. This proposal outlines reactivity testing to quantify the use of ASCM materials to replace clinker. This can reduce GHG/GWP.

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

The project asses GHG/GWP associated with testing more durable concrete materials and seeks methods to keep this low and reduce it further. This proposal outlines reactivity testing to quantify the use of ASCM materials to replace clinker. This can reduce GHG/GWP.

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

The project asses GHG/GWP associated with testing more durable concrete materials and seeks methods to keep this low and reduce it further. This proposal outlines reactivity testing to quantify the use of ASCM materials to replace clinker. This can reduce GHG/GWP.

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:

See responses above

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:

While the project is not focused on equity the process can be used by all and provides a level platform for evaluating material solutions.

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

Establishing practices for quantifying and specifying long-term durability reduces the number of construction cycles removing construction workers from dangerous situations. This also reduces traffic at construction sites which have been known to result in a substantial increase in accidents and fatalities.

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:

These results are provided in the sections above.

5. Other comments:

Title: Identification and Specification of Alternative Supplementary Cementitious Materials for making Lower Clinker Content Concrete with a Low GWP

Category: Process for Substantially Lower Embodied Carbon

The adoption of lower-carbon concrete is resulting in a shift from cements that are predominately clinker-based to systems with high clinker replacements of supplementary cementiitious materials (SCMs). This can reduce the GWP for concrete EPDs. Historically, the industry has relied on fly ash and slag as the primary SCMs; however, recently many fillers, natural pozzolans, ground glasses, ground shale/slate/clays, and other alternative cements have emerged/reemerged into the market. And Oregon may have an abundance of natural materials. ASTM has tests for supplementary materials (ASTM C618), strength activity index (SAI, ASTM C311), and water demand (WD, ASTM C311). The historical specifications are changing and ODOT will need to update its specifications and approved material list. Further, OSU research has shown that tests like SAI (Suraneni et al. 2017, Bharadwaj et al. 2022, Choudary et al. 2022) and WD are flawed (Chopperla et al. 2024). The SAI can be greatly improved by performing the pozzolanic reactivity test (developed at OSU) to quantify the performance of a pozzolan in terms of its reactivity or the ASTM C1867. The WD test has been improved accounting for several factors as demonstrated in recent work for Caltrans (Chopperla et al. 2024). This can be coupled with previously developed approaches (for EPRI, CALTRANS, and DOE) that evaluate the proportions of these materials. This project would gather natural pozzolanic materials (as well as other pozzolans) currently being evaluated by the industrial groups in Oregon (working in conjunction with OCAPA).

Work is needed to develop a listing of all the pozzolanic materials that are likely to be used in the Pacific Northwest (Oregon), quantify the performance of these materials and ensure that the specifications are ready for these materials similar to that done for Caltrans (Weiss et al. 2022). This can include historic materials like fly ash, slag, natural pozzolans, and ground glass as well as emerging materials like steel slag, mine tailings, biochar, carbonated products, ground expanded slate/shale/clay, zeolites, etc. This will enable ODOT to specify and ensure that adequate strength and durability performance is provided while providing low GWP for concrete made using these local materials. Local industry will also be engaged. This work will develop the processes to 1) outline the SCMs that the state needs to specify/accommodate; 2) identify the testing needed to qualify these materials, 3) purchase ODOT equipment for performing the test; 4) train state personnel and consultants in testing; 5) outline how performance criteria can be established; 6) outline a proportioning procedure and typical resulting EPDs, 7) outline a quality assurance (QA) approach; 8) help contractors establish a quality control procedure; 9) develop and implement training materials; and 10) demonstrate the value of using these materials. In the end, the state will have state-of-the-art specification language, trained personnel, SCM benchmarks, performance-based SCM criteria, and a QC/QA program with the levers that control the performance of the SCM.

6. Corresponding Submitter's Contact Information:

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