Oregon Department of Transportation

Stage 1 Research Problem Statement

Number*: 25-42*

Proposed Title: Low Carbon Concrete for ODOT

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

The concrete industry is pushing toward lower carbon footprint systems. However, research is needed to elucidate the local materials in Oregon (and surrounding areas) that can be used to produce low carbon concrete while still achieving the desired mechanical and durability properties necessary for implementation. CO_{2eq} emissions from cement production account for approximately 8% of the world's CO_{2eq} contribution. In mid-2022 most U.S. cement suppliers made a significant change by increasing the substitution of finely ground limestone from less than 5% to 10-15%. In combination with replacements by supplementary cementitious materials (SCMs), CO_{2eq} emissions can be lowered by as much as 50% or more. A recent approach that is gaining significant traction in the U.S. are LC^3 systems (limestone calcined clay cement). These cementitious blends have been proven to reduce CO_2 emissions without compromising design strength and durability. Several challenges exist for full-scale implementation. First, the availability and the quality of kaolinite calcined clay can play a significant role in the performance of LC^3. Second, locally available SCMs may be able to be used in place of the calcined clay portion of LC^3 where kaolinitic clays are not available. Finally, while later age strength is retained, or even exceeded compared to 100% OPC systems, the early-age strength (e.g., prior to 7 days) can be reduced when compared with systems with high cement replacements. Such blended cements must be carefully designed to maximize the synergistic benefits while obtaining desired mechanical and durability properties. Several different acceleration techniques to overcome the early-age strength impacts are possible, and merit investigation in this proposed project.

2. Document how this **transportation issue** is important to Oregon and will meet the Oregon Research Advisory Committee Priorities

Developing low-carbon blended cement (with 50% clinker or lower) can improve long-term performance and reduce CO2eq emissions by as much as 50% compared to OPC for ODOT concrete assets. In addition, developing new low-carbon blended cement will meet ODOT's mission by addressing ODOT's current strategic action plan to further enable a modern transportation system with lower maintenance costs and carbon emissions. The implementing actions covered in this research problem statement will be identifying the alternative lower-carbon materials for developing blended cements for use in ODOT construction practices.

The major advantages of developing low-carbon blended cement are that: (1) the performance of the concrete members under the mechanical, thermal, and environmental loading (e.g., alkali-aggregate reactivity, shrinkage, chloride exposure, etc.) can be specifically designed based on their requirements compared with the current approaches; (2) highway structures built with low-carbon blended cement will have lower carbon footprint, maintenance and repair costs compared with conventional concrete.

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

The objective of this research plan will be to develop low-carbon blended cement with using local Oregon material that can be readily produced in Oregon per ODOT requirements. This will involve replacing up to 20% of the portland cement with finely ground limestone and another 20-40% with a supplementary cementitious material such as calcined clay, natural pozzolan, slag, or others to be identified. The performance of the locally available kaolin clays, nature pozzolans, slag, etc., will be evaluated to target a clinker factor of 50% (or lower) and optimized for producing concrete for ODOT applications. Since low cement content concrete can have reduced early age (e.g., prior to 7 day) strength, accelerating approaches to offset this lower initial strength gain will be investigated.

Low-carbon blended concrete optimized using locally available materials will help ODOT to meet one goal of the ODOT Strategic plan to reduce carbon emissions. Any updates to current materials specifications will need

to be made based on the outcome of this research project. The eventual result is anticipated to be the commoditization of low-carbon concrete using local Oregon materials.

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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Dean Chess	Product Evaluation Coordinator	Dean.M.CHESS@odot.oregon.gov	503-986-3059
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5. Other comments:
Overall, the objective of this research project is to identify in-state materials and concrete mixture designs that result in concrete with similar strengths, workability, and durability characteristics as traditional mixes which do not employ low carbon, in-state materials. In addition to changing the cementitious materials, SPR-823 reported that the cementitious materials content can be reduced by almost 20% if the aggregate is first characterized. However, the research noted the need for better dimensional stability (e.g., shrinkage) and abrasion testing. The goal of this research is to develop low-carbon blended cements using local Oregon materials that are durable and can be readily produced in Oregon per ODOT requirements. This will involve replacing up to 20% of the portland cement with finely ground limestone and another 20-40% with a supplementary cementitious material such as calcined clay, natural pozzolan, slag, or others to be identified, all after minimizing the cementitious materials content following the method proposed in SPR-823. The performance of the locally available kaolin clays, nature pozzolans, slag, etc., will be evaluated to target a clinker factor of 50% (or lower) and optimized for producing long-lasting concrete for ODOT applications. Since low cement content concrete can have reduced early age (e.g., prior to 7 day) strength, accelerating approaches to offset this lower initial strength gain will be investigated.

6. Corresponding Submitter's Contact Information:

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