SPR RESEARCH PROGRAM
SECOND-STAGE PROPOSAL SUMMARY

PROBLEM NUMBER AND TITLE

26-52 Practical Blended Cementitious Mixtures Using Local Materials to Extend Clinker Use

PROBLEM SUMMARY

Amount of Portland cement used in traditional cement mixes can be reduced by as much as 50% or more by using the following strategies in combination: adding supplementary cementitious materials, optimizing mixture proportioning, use of early strength gain accelerators, and use of limestone calcine clay cement systems. While the use of each of these strategies is well understood, research work is necessary to develop successful mix designs that employ these strategies simultaneously and use locally sourced materials to the extent possible.

ODOT OBJECTIVES

- Identify local and regionally available SCMs that are available or near-market available that can be produced in sufficient quantity to meet ODOT construction needs.
- Demonstrate readiness of these SCMs to produce blended cementitious mixtures, along with finely ground limestone, that reduce clinker usage and meet performance requirements.
- Develop draft specifications for ODOT to direct SCM replacement levels depending on the intended application that account for strength gain, constructability and long-term performance.

BENEFITS

- Increased use of locally available materials
- Financial benefit to the State and region for work force development, and industry job sector to produce a reliable supply of alternative SCMs for use in highway construction
- Extension of clinker by overall reduction of cementitious contents through replacement of SCMs. A financial benefit for importing/using less portland limestone cement and/or portland cement may also be realized.
- Specification language to allow the use of a broader class of SCMs to replace portland cement across a range of highway infrastructure.

SCHEDULE, BUDGET AND AGENCY SUPPORT

Estimated Project Length: 36 months.
Estimated Project Budget: $350,000
ODOT Support:
Austin Johnson – Concrete Quality Coordinator Austin.L.JOHNSON@odot.oregon.gov (503) 510-1384
David Dobson – Structural Materials Engineer David.DOBSON@odot.oregon.gov (971) 900-7118
Scott Nelson – Structure Services Engineer Scott.D.NELSON@odot.oregon.gov (503) 986-3056

FOR MORE INFORMATION

For additional detail, please see the complete STAGE 2 RESEARCH PROBLEM STATEMENT online at:
https://www.oregon.gov/odot/Programs/ResearchDocuments/26-52

SPR RESEARCH PROGRAM
SECOND-STAGE PROBLEM STATEMENT
FY 2026

PROBLEM NUMBER AND TITLE

26-52 Practical Blended Cementitious Mixtures Using Local Materials to Extend Clinker Use

RESEARCH PROBLEM STATEMENT

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), clinker (e.g. portland cement) can be reduced by as much as 50% or more depending on the application. While later-age strength is retained, or even exceeded compared to 100% OPC systems, the early-age strength (e.g., prior to ~7-14 days) can be reduced when compared with systems using 100% OPC. Despite this, there are several ways available to overcome this including proper mixture proportioning (particle packing optimization), use of accelerators including both chemical and cementitious accelerators, and use in precast systems. LC3 (limestone calcined clay cement) systems are gaining popularity and the first commercial production of the material in the U.S. was completed by Ash Grove Cement in 2024. Utilizing, locally available SCMs, particularly natural pozzolans, can be used in place of the calcined clay portion of a typical LC3 system where kaolinitic/reactive clays are not available (e.g. limited availability in Oregon, Washington, North California). Such blended cements must be carefully designed to maximize the synergistic benefits including extending clinker use, while obtaining desired mechanical and durability properties. This research will identify local materials that can be potentially used in these blended systems and will assess the fresh and hardened characteristics of these systems, particularly early-age strength gain. Revisions to ODOT specifications for these new practical blended systems will be included.

RESEARCH OBJECTIVES

The objectives of this research project include:

1. Identify local and regionally available SCMs that are available or near-market available that can be produced in sufficient quantity to meet ODOT construction needs.
2. Once these SCMs in objective 1 are identified, demonstrate that these SCMs can be used to produce blended cementitious mixtures, along with finely ground limestone, that reduce clinker usage and meet performance requirements.
3. Develop a draft specification for ODOT to direct SCM replacement levels depending on the intended application that account for strength gain, constructability and long-term performance.

WORK TASKS, COST ESTIMATE AND DURATION

Task 1: Literature Review, Detailed Work Plan, Materials Survey and Procurement

In Task 1 a literature review and detailed work plan will be completed. Commensurate with this task a survey will be done to identify a range of locally available alternative supplementary cementitious materials (SCMs) with a focus on natural pozzolans. This will include sources in Oregon, Washington, and North California. Other neighboring states may also be surveyed upon consultation with the Technical Advisory Committee and Research Project Coordinator.

Task 2: Materials Characterization

After procurement of candidate materials in Task 1 the research team will fully characterize the material properties of the cementitious materials and SCMs chosen for the project. This will include x-ray fluorescence for oxide composition, x-ray diffraction for phase quantification, reactivity testing, particle size analysis, water absorption, and specific gravity. From these investigations, and the results of Task 1, the research team and TAC may down select materials for more detailed analysis in Tasks 3 and 4.

Task 3: Fresh and Hardened Properties
In Task 3 the fresh and hardened properties of cementitious systems produced with the candidate materials from Task 2 will be evaluated. Fresh property evaluation will include air entrainment, rheology, and unit weight. Hardened property evaluation will include strength gain and early-age volume change (e.g. cracking risk) evaluation.

Task 4: Transport Properties
In Task 4 the research team will evaluate the transport properties of the cementitious systems to determine the formation factor of these systems. This will involve bulk resistivity measurements and pore solution resistivity determination. The information gained in this task will provide insight about the durability and long-term performance of these materials.

Task 5: Final Report and Draft Specifications
The research team will produce a final report and draft specifications for review by ODOT and for potential inclusion into ODOT Standard Specifications. The final report will include a decision-making tool that can be used by ODOT to select SCMs and replacement levels for different ODOT concrete applications (e.g. pavements, bridge decks, other structural concrete, non-structural concrete).

Key Deliverables:

The key deliverables from this project will include the following:

1. Literature Review, Workplan, and compilation of available sources of alternative SCMs including market readiness level, approximate availability (tons/year), location, and transportation modes.
2. Quarterly Reports submitted through the established ODOT Research Process
3. Final Report
4. Draft Specifications and/or modifications to existing specifications for ODOT review and implementation.
5. ODOT Technical Memo to rapidly convey key research findings.

Estimated Project Length: 36 months.
Estimated Project Budget: $350,000

IMPLEMENTATION

Primary method for implementation is through the adoption of draft specifications resulting from this research. These specifications will reflect research findings and will include practical guidance for the design of blended cement mixes.

POTENTIAL BENEFITS

Benefits to ODOT include the following:

- Increased use of locally available materials
- Financial benefit to the State and region for work force development, and industry job sector to produce a reliable supply of alternative SCMs for use in highway construction
- Extension of clinker by overall reduction of cementitious contents through replacement of SCMs. A financial benefit for importing/using less portland limestone cement and/or portland cement may also be realized.
- Specification language to allow the use of a broader class of SCMs to replace portland cement across a range of highway infrastructure.

PEOPLE

ODOT champion(s):
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Problem Statement Contributors:

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REFERENCES

None

STAFF REVIEW PAGE

LITERATURE CHECK

TRID&RIP

☒ A review of TRID & RIP databases found no existing research that answers the research question

ODOT DECISION LENSES

Climate:

The blended cementitious mixtures developed through this research project will reduce the CO_{2eq} footprint of normal and high strength concrete mixtures by 30-50%. This will be quantified using an open-source greenhouse gas emission calculation tool recently utilized by the research team on a CalTrans project.

Equity:

None

Safety:

Reducing the CO_{2eq} footprint of our most used building material, concrete, will result in improved health and livability for Oregon. Further the increased use of regional resources will be an economic benefit for the state and keep more state dollars within the state rather than importing materials from other states and/or countries. The dollar value of this could be quantified using an appropriate life cycle costing, or up front costing tool/database in conjunction with appropriate ODOT staff and personnel.

TECHNOLOGY & DATA ASSESSMENT

☒ No Identified T&D output

☒ At the end of this project, the implementing unit(s) within ODOT will need to coordinate the adoption of new technology or data in order to realize the full potential of this research.

CROSS-AGENCY IMPACTS

- List ODOT partners or impacted units: **Structure Services, Construction Section**
- Identify any issues of concern raised by an ODOT partners. Note expected mitigation that addresses these concerns: **None**