SPR RESEARCH PROGRAM
SECOND-STAGE PROPOSAL SUMMARY

PROBLEM NUMBER AND TITLE

26-54 – Evaluation of Ultra-High Performance Concretes for Longevity and Climate

PROBLEM SUMMARY

Ultra-high performance concretes (UHPC) are emerging as a potentially transformative material for bridge construction, offering superior compressive and tensile strength, enhanced durability, and increased resistance to chloride ingress. These characteristics suggest UHPC could extend bridge service life well beyond 75 years and reduce maintenance costs and environmental impacts. However, prior to adoption in Oregon, research is needed to evaluate UHPC's long-term performance under regional conditions, including cyclic loading from truck traffic, environmental exposure to deicing and wind-born ocean salts, and seismic resilience during a Cascadia earthquake. This study will provide the necessary technical evaluations to ensure UHPC can meet Oregon Department of Transportation (ODOT) performance expectations.

ODOT OBJECTIVES

This research will deliver:

1. **Standardized testing and evaluation criteria** to assess UHPC's long-term durability under combined cyclic loading, freezing and thawing, chloride exposure, and seismic demands.
2. **Design specifications and structural details** to facilitate incorporating UHPC into bridge systems and ensuring their compliance with ODOT's Bridge Design Manual (BDM).
3. **Training materials and workshops** to educate ODOT engineers and consultants on UHPC’s capabilities and implementation.

BENEFITS

The proposed research provides the following benefits to ODOT:

- **Extended Bridge Service Life** – UHPC's superior physical properties could reduce deterioration, minimizing future repair and replacement costs and provide longer bridge lifespan.
- **Enhanced Seismic Performance** – Improved strength and ductility could significantly enhance Oregon’s bridge resilience in the event of a major earthquake.
- **Reduced Maintenance and Environmental Impact** – Less frequent repairs/replacements will lower lifecycle costs and minimize work-zone hazards, enhancing motorist and worker safety.
- **Standardized Implementation Pathways** – This research will establish clear guidelines for integrating UHPC into Oregon’s bridge design and maintenance practices.

SCHEDULE, BUDGET AND AGENCY SUPPORT

Estimated Project Length: 30 months.
Estimated Project Budget: $425,000
ODOT Support: Tanarat Potisuk, Ph.D., P.E., S.E.; Prestressed Concrete Standards Engineer; Tanarat.POTISUK@odot.oregon.gov; 971-283-5600.

FOR MORE INFORMATION

For additional detail, please see the complete STAGE 2 RESEARCH PROBLEM STATEMENT online at: https://www.oregon.gov/odot/Programs/ResearchDocuments/26-54.pdf

SPR RESEARCH PROGRAM
SECOND-STAGE PROBLEM STATEMENT
FY 2026

PROBLEM NUMBER AND TITLE

26-54 – Evaluation of Ultra-High Performance Concretes for Longevity and Climate

RESEARCH PROBLEM STATEMENT

Ultra-high performance concrete (UHPC) is recognized for its superior durability, high compressive and tensile strength, and resistance to environmental degradation. While widely researched globally (e.g. [1],[2],[3],[4],[5]), there is limited data on long-term performance under **Oregon-specific conditions**, particularly regarding **high-cycle fatigue truck loading combined with chloride and freeze-thaw exposures, with the need for seismic resilience after long-term exposure**. Given ODOT's interest in adopting UHPC for link slabs and bridge decks, this study will assess UHPC's long-term reliability in these applications and provide clear implementation guidelines.

RESEARCH OBJECTIVES

1. Establish **laboratory-based durability testing** for UHPC under simulated Oregon climate and traffic conditions.
2. Develop **full-scale structural tests** to assess UHPC behavior in bridge elements (link-slabs) subjected to seismic loading after long-term durability exposure tests.
3. Evaluate **different UHPC mix designs** to determine the most effective formulations for durability and seismic resilience.
4. Provide **recommendations** for implementing UHPC into new bridge systems for long service life.

WORK TASKS, COST ESTIMATE AND DURATION

Task 1: TAC Meeting #1

Project kick off meeting. The research team will meet with the TAC to review the research plans and develop specimen details that accurately reflect ODOT intended UHPC applications.
Time Frame: July 2025; **Responsible Party**: PI, ODOT Research Coordinator, TAC;
Deliverable: TAC meeting attendance, TAC meeting presentation, TAC Meeting Minutes
TAC Action: Review and understand project research problem statement, research question, the limits of the research, and the project schedule. Advise ODOT Research Coordinator regarding any critical issues with the project's scope or schedule. Advise PI's regarding related professional practices, standards, methods and context for the project.
ODOT Action or Decision: Review TAC advice, discuss with PI, and if necessary direct PI to make changes to project documents.

Task 2: Draft Literature Review

Review of prior UHPC research and global best practices will be performed. Data gaps specific to Oregon conditions will be identified. The review will summarize the state of knowledge, gaps, and ensure that new work advances the field. The results of this review will provide the following:

- Clearly define the problem and research question(s), including related issues
- Provide a theoretic context

- Identify research methods that may be used to answer the research question (include brief discussion of commonly applied methods that may not be appropriate for use on this project)
- Identify data resources, including their availability and quality

Time Frame: 4 months following notice to proceed; **Responsible Party**: PI;
Deliverable: Draft Literature Review
TAC Action: Read Draft Literature Review and advise ODOT Research Coordinator regarding any gaps in the literature.
ODOT Action or Decision: Review TAC advice, discuss with PI, and if necessary direct PI to make changes to project documents.

<u>Task 3: Material Testing & Durability Assessment</u>
Based on Tasks 1 and 2, laboratory scale specimens will be designed and fabricated to assess durability under long-term service level exposure conditions. Different commercially-available UHPC formulations will be considered. Durability will be evaluated under freeze-thaw, chloride exposure with accelerated corrosion, and high-cycle service-level fatigue. Uncracked and pre-cracked specimens will be tested. Each exposure condition will be applied separately and then all will be combined. No prior work has combined mechanical loading with environmental exposures, and it is anticipated that the combined effects may produce more deleterious outcomes.
Time Frame: 10 months; **Responsible Party**: PI ;
Deliverable: Brief report detailing the member characteristics and laboratory specimen details.
TAC Action: Review report and provide advice on parameter selection and study focus.
ODOT Action or Decision: Review report.

<u>Task 4: Full-Scale Structural Testing</u>
Based on prior tasks, full-scale UHPC bridge elements will be designed and fabricated to assess seismic performance after long-term service level exposure conditions. It is expected that these elements will be link-slabs in this phase of testing. The worst observed exposures will be used based on Task 3. Performance relative to unexposed specimens will be compared.
Time Frame: 6 months; **Responsible Party**: PI ;
Deliverable: Brief report detailing the member characteristics and laboratory specimen details.
TAC Action: Review report and provide advice on loading and support conditions.
ODOT Action or Decision: Review report.

<u>Task 5: Analytical Modeling</u>
Nonlinear finite element models of the Task 4 UHPC bridge elements will be developed and calibrated to the observed responses. Parametric studies will be performed to evaluate untested alternatives and to facilitate simplified design methods.
Time Frame: 4 months; **Responsible Party**: PI ;
Deliverable: Brief report detailing the analytical models and methods.
TAC Action: Review report and provide advice on models.
ODOT Action or Decision: Review report.

<u>Task 6: Design Guidelines & Implementation Strategies</u>
Based on prior tasks, draft specification and design recommendations will be developed with detailed examples.
Time Frame: 2 months; **Responsible Party**: PI ;
Deliverable: UHPC design guidelines and ODOT BDM updates.
TAC Action: Review report and provide feedback.
ODOT Action or Decision: Review report.

<u>Task 7: Draft Final Report</u>
Publication ready Draft Final Report in the prescribed ODOT report format. (Formatting includes correct fonts, spacing, citations and graphics) Contents include: an updated abstract, acknowledgement, disclaimer, introduction, Updated Lit Review (Task 2), Final Research Methodology (Tasks 3, 4, 5, and 6), discussion of results, conclusions, and potential for future research, application, or technology transfer, and other sections as appropriate.
Time Frame: 6 months concurrent with Task 7. **Responsible Party**: PI;
Deliverable: Draft Final Report using ODOT's report template

TAC Action: TAC review and feedback to the ODOT Research Coordinator
ODOT Action or Decision: Review and counsel prior to TAC meeting

Task 8: Draft ODOT Research Note
Write 1000 to 1500 word summary of the research project. The summary will concisely document the research findings, value of the research to the agency, science, and society, and any limitations on the use of the findings.
Time Frame: 1 month concurrent with Task 7. **Responsible Party**: PI ;
Deliverable: Draft ODOT Research Note using ODOT's report template
TAC Action: None
ODOT Action or Decision: Review and advise.

Task 9: TAC Meeting #2
This TAC meeting will include a review of the Draft Final Report, and Draft Research Note prior to the TAC meeting. The TAC will offer advice on the content and clarity of these work products. The TAC will also advise on post research implementation.
Time **Frame**: 29 months after notice. **Responsible Party**: PI, assisted by the ODOT Research Coordinator, TAC;
Deliverable: TAC meeting attendance, TAC meeting presentation, TAC Meeting Minutes
TAC Action: TAC review of Draft Final Report, and Draft Research Note. Advise ODOT Research Coordinator regarding any critical issues with the project's research design. Advise ODOT Research Coordinator regarding any required final edits to the Draft Final Report, and Draft Research Note.
ODOT Action or Decision: Review TAC advice. If necessary direct PI to make changes to project documents.

Task 10: Final Report
Edit Draft Final Report to incorporate edits identified by the ODOT research Coordinator after the last TAC meeting
Time Frame: Within 1 month after Task 10. **Responsible Party:** PI ;
Deliverable: Final Report
TAC Action: None
ODOT Action or Decision: Review. Provide formal acceptance of Final Report. Publish Final Report on ODOT's research website

Task 11: Final Research Note
Edit Draft Research Note to incorporate edits identified by the ODOT research Coordinator after the last TAC meeting
Time Frame: 3 months after Task 8. **Responsible Party**: PI ;
Deliverable: Final Research Note
TAC Action: None
ODOT Action or Decision: Review. Provide formal acceptance of Research Note. Publish Final Report on ODOT's research website

Task 12 : Conference or External Meetings Travel
Travel and attendance at meetings and conferences is planned to allow dissemination of project specific technical information or where travel and attendance at meetings and conferences would benefit performance of the study
Time Frame: Over duration of the study; **Responsible Party**: PI ;
Deliverable: Meeting or conference presentation materials produced by the PI or project (e.g. PowerPoint) and conference agenda with the project specific technical presentation documented) or a written summary of technical information that benefits performance of the study for inclusion in the revised literature review section of the Final Report.
TAC Action: None
ODOT Action or Decision: Review and accept Deliverables

Key Deliverables:

Standard methods that can be used to evaluate the long-term performance of UHPC for bridge applications.

Relative durability comparisons of different UHPC mixes for selection of most appropriate to design.

Design and detailing recommendations that can facilitate the transition to UHPC in bridge practices.

Training workshops and supporting documentation for implementation of UHPC into endurable and seismically resilient designs.

Estimated Project Length: 30 months.
Estimated Project Budget: $425,000

IMPLEMENTATION

Research will produce design specification language that will directly inform the ODOT BDM design specifications for the UHPC applications investigated.

Sample designs will be provided with detailed examples in reports.

Training workshops and documentation will ensure ODOT engineers and consultants can effectively integrate UHPC into future projects.

POTENTIAL BENEFITS

The outcomes of this research provide the following potential benefits:

Cost Savings: If proven, the increased durability of UHPC will reduce maintenance needs and extend bridge lifespan thereby producing significant long-term cost reductions.

Enhanced Safety: If proven, UHPC will improve seismic resilience and lower maintenance frequency thereby enhancing safety for both motorists and construction workers.

Sustainability: If proven, the increased durability of UHPC will reduce environmental impacts by lowering the frequency of major rehabilitation and replacement projects.

https://www.oregon.gov/odot/Programs/ResearchDocuments/RAC-Priorities_2023.pdf

PEOPLE

ODOT champion(s):

Tanarat Potisuk, Ph.D., P.E., S.E.; Prestressed Concrete Standards Engr; Tanarat.POTISUK@odot.oregon.gov

Ray Bottenberg; Bridge Engineer; Raymond.D.BOTTENBERG@odot.oregon.gov

Problem Statement Contributors: Christopher Higgins, PhD, PE, Professor, Oregon State University

REFERENCES

[1] Graybeal, M. A. (2006). "Assessing Durability Properties of Ultra-High Performance Concrete," Transportation Research Record: Journal of the Transportation Research Board, 1979(1), 19–23.

[2] Graybeal, B. A., & Tanesi, J. (2007). "Durability of an Ultra-High Performance Concrete," Journal of Materials in Civil Engineering, 19(10), 848–854.

[3] Abbas, S., Soliman, A. M., & Nehdi, M. L. (2016). "Ultra-High-Performance Concrete: Mechanical Performance, Durability, Sustainability, and Implementation Challenges," Cement and Concrete Composites, 71, 1–13.

[4] Rawat, A., Bhardwaj, A., & Kumar, M. (2020). "Ultra-High Performance Concrete: A Review," Materials Today: Proceedings, 32, 563–566.

[5] Islam, M. S., Jamil, M., & Rahman, M. K. (2023). "A Comprehensive Review of the Advances, Manufacturing, and Performance of Ultra-High-Performance Concrete," Journal of Building Engineering, 57, 104969.

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:

While climate is not the focus of this research, the research outcomes have direct impacts on climate. Concrete materials contribute significantly to greenhouse gas (GHG) emissions. Present materials have shorter design lives and thus will require more frequent replacements and maintenance than those purportedly available with UHPCs. The impacts on GHG emissions can be comparatively assessed for different UHPC and conventional materials, operational lives, and hazard resilience estimates. This study seeks to assess whether the expected long life and corresponding benefits can be achieved in Oregon considering our environmental exposure conditions and seismic hazards.

Equity:

None

Safety:

The proposed research essentially evaluates the safety of transportation structures constructed with UHPC. Safety of the motoring public who make use of it daily, and the safety and security of all Oregonians who will necessarily rely on transportation systems, of which bridges serve as critical links, to perform as intended during the most critical of moments, such as during and after an earthquake. Choosing to bring to service the best available material technology, UHPC, if it can achieve longer life with reduced maintenance needs, will reduce ODOT crew exposures to hazardous working conditions and reduce motorist exposure to construction zones. Selection of one material over another in design is making a strategic investment decision with the expectation that it will safely serve as intended.

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: **Bridge Engineering, Structure Services**
- Identify any issues of concern raised by an ODOT partners. Note expected mitigation that addresses these concerns: **None**