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CALTRANS DIVISION OF RESEARCH, INNOVATION AND SYSTEM INFORMATION

TRANSFORMING IDEAS INTO SOLUTIONS

Research Notes

Implementation of Advanced Sustainability and Performance-Based Practices for Concrete Infrastructure

Investigate state-of-the-art practices, methodologies, and the performance of novel materials for reducing the carbon footprint of concrete materials used in transportation infrastructure.

Geotechnical/ Structures

November 2025

Project Title:

Implementation of Advanced Sustainability and Performance-Based Practices for Concrete Infrastructure

Task Number: 4332

Start Date: December 04, 2024

Completion Date: September 30, 2027

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WHAT IS THE NEED?

It is estimated that cement production is responsible for 4% to 6% of the global emissions, with predictions for increasing trends in global cement consumptions for the years to come. Considering the impact of cement and concrete production on greenhouse gas (GHG) emissions in California, Senate Bill 596, which was passed into law in late 2021, demands strategies that lead to 40% reduction in GHGs from the cement sector of California by 2035, along with the final goal of net zero emissions by 2045.

Being a major consumer of cement and concrete materials in the State, it is necessary for Caltrans to investigate methodologies for reducing the carbon footprint of concrete materials used in transportation infrastructure. However, this is a multi-criteria problem to solve, which involves the state-of-the-art material science and technology, understanding and proper utilization of environmental product declarations (EPDs), and the use of computational platforms to conduct life-cycle analysis (LCA). This research project will help with improving the sustainability of concrete construction materials used in transportation infrastructure in California.

WHAT ARE WE DOING?

Proposed research tasks include:

- Literature review and selection of the current best practices relating to the development and use of novel materials and advanced technologies to improve the sustainability of concrete.

Caltrans

DRISI provides solutions and knowledge that improves California's transportation system.

- Field sampling and laboratory investigation to evaluate the effect of the potential technologies or products on concrete performance in fresh and hardened states when subjected to the California raw materials and exposure conditions. Provides the technology readiness levels (TRL) of the reviewed novel technologies.
- Review available computational platforms for incorporating the material properties and EPDs as an input for LCA, as relates to Caltrans' needs, and recommends an existing tool or develops a new one if needed. Perform the LCA analysis for the selected materials and compare it with the conventional concrete mixtures used in Caltrans.
- Develop a list of desired engineering characteristics, along with the measurement methods to be included as part of the acceptance criteria. These requirements need to be tailored to the needs of Caltrans specific raw materials and exposure conditions (e.g., Alkali-Silica Reaction, sulfate attack, reinforcement corrosion, de-icing salt scaling, freeze-thaw, etc.).
- Based on the findings, develop a performance-based evaluation and rating protocol for Caltrans to screen the novel concrete materials, and make informed decisions on adoption or rejection of future novel concrete technologies.

WHAT IS OUR GOAL?

The goal of this research is to improve the sustainability of transportation infrastructure in California by reviewing the current best practices related to the development and use of novel materials and technologies; and performing a risk-benefit analyses and performance evaluations to support adoption of innovative advanced alternative materials in concrete that could be incorporated in Caltrans projects.

WHAT IS THE BENEFIT?

It is expected this research will help improve the sustainability of transportation infrastructure in California by supporting the adoption of the state-of-the art in materials science, technology and best practices related to concrete infrastructure, and by enhancing our understanding of the following:

- Novel materials that could contribute to a resilient infrastructure, while reducing the carbon footprint of concrete construction
- Performance criteria to evaluate novel materials; such criteria should be street ready and attainable with reasonable training and equipment
- Environmental impacts of the novel materials and technologies using EPDs and LCA

WHAT IS THE PROGRESS TO DATE?

The contract was executed on December 04, 2024, and Kick-off meeting was held on December 19, 2024. The Oregon State University research team completed a comprehensive literature review on 1) partial or full replacement of OPC or PLC, 2) carbonation and CO2 mineralization, and 3) improving carbon efficiency has been reviewed. The field sampling and laboratory work of Task 2 has begun with discussions with companies providing materials for evaluation and some test samples have been cast.