DRISI

Caltrans Division of Research, Innovation and System Information

Research Results

Transformation of Engineering Tools to Increase Material Efficiency of Concrete

Developing tools to inform selection of desirable concrete mixtures for transportation systems to reduce greenhouse gas emissions

Pavement

MAY 2022

Project Title:
Transformation of Engineering Tools to Increase Material Efficiency of Concrete

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WHAT WAS THE NEED?

Reducing greenhouse gas emissions from energy demand and material production is of great concern in California and around the world. Concrete, the second most used material after water globally, is responsible for 8% of all greenhouse gas emissions worldwide. The primary binder in concrete is cement, which is among the most difficult materials to decarbonize, a function of how the material is made. However, it is not a material that is easily replaced. For modern infrastructure, cement is a critical component, and to meet the needs of growing populations, California is the second largest producer of cement in the United States.

Due to large transportation infrastructure demands in California, Caltrans is the largest single consumer of cement in the state. The state-of-practice focuses on the use of cement and other individual constituents of concrete at single points in time, but overlooks how multiple components interact and how material longevity can affect environmental and monetary costs. This convention can lead to inefficient use of materials in transportation systems. As such, there is an urgent need to improve design and selection tools to facilitate efficient use of cement and concrete. By reducing the demand of these materials through informed design, reductions in burdens on the environment can be achieved.

WHAT WAS OUR GOAL?

The goal of this task was to develop robust datasets and decision-making tools to better quantify the environmental impacts and costs associated with green concrete infrastructure decisions as well as permit comparisons of most efficient improvements.

Caltrans

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

WHAT DID WE DO?

Researchers at the University of California, Davis developed an initial methodology to evaluate implications of design decisions on the environmental impacts of concrete systems using a multi-criteria selection process to assist decision-makers. Firstly, methods to compare concrete mixtures proportioning as they relate to environmental impacts, comparison indices based on common performance characteristics were used. This work was then built out to explore the role of steel reinforcement on reinforced concrete member environmental impacts to elucidate mechanisms to drive emissions reduction for these multi-material members. Finally, work was extended to understand how the longevity of concrete systems could influence environmental impacts associated with concrete production.

WHAT WAS THE OUTCOME?

The delivered report of this project demonstrates how considerations across infrastructure design, material design, environmental impact, and costs can be used together for the selection of appropriate materials for infrastructure systems to reduce environmental impacts. Tools were developed for quantitative environmental impact analysis of concrete composites and multi-criteria selection indices for comparing infrastructure material. These tools are demonstrated in the report through evaluation of mixtures in literature as well as a case study on an existing pavement overlay and potential alternative designs.

WHAT IS THE BENEFIT?

This work shows that the efficient use of concrete is a critical lever to mitigate GHG emissions. Findings suggest notable GHG emissions reduction is achievable as a result of design-stage decisions. These include that higher compressive strength can be more beneficial in certain loading conditions and approximately 30% lower emissions can be achieved through performance-based design methods by decreasing the over-use of material compared to prescriptive design standards.

LEARN MORE

Here is a report published for this project:
https://escholarship.org/uc/item/2zn128b 8

IMAGES

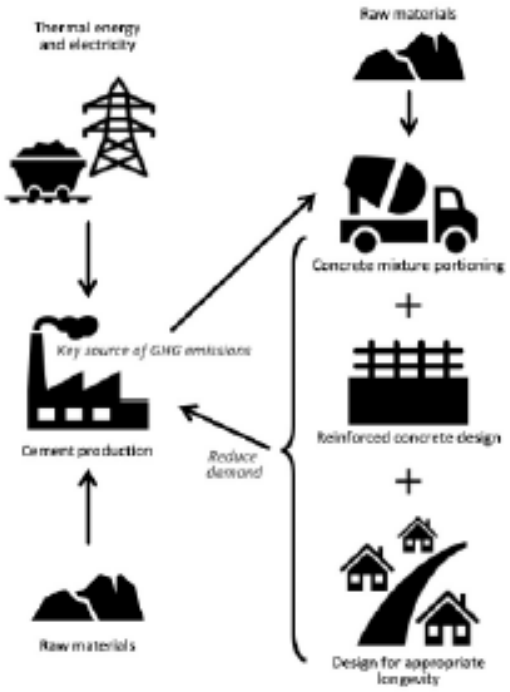

Image 1: Methods considered to more efficiently use cement and concrete, thus leading to lower emissions from material production