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Project Title: Implementation of Advanced Technology and Materials Recycling Techniques for Use of Alternative Materials in Concrete as Plain or Reinforced Materials

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Implementation of Advanced Technology and Materials Recycling Techniques for Use of Alternative Materials in Concrete as Plain or Reinforced Materials

Risk-benefit analysis and performance evaluation of alternative supplementary cementitious materials in concrete applications.

WHAT WAS THE NEED?

The production of ordinary Portland cement contributes to 4–8% of global greenhouse gas (GHG) emissions. The California Department of Transportation (Caltrans) uses over a million cubic yards of concrete annually in structural and pavement applications. Recent updates to Caltrans specifications include Portland Limestone Cement (PLC), which reduces the carbon footprint by about 10%.

Caltrans uses various cementitious materials in concrete mixtures. Alternative supplementary cementitious materials (SCMs), used to partially replace cement, can reduce GHG emissions by 20-40%, depending on replacement volume and type of SCM. While fly ash and blast furnace slag have been used for decades, their availability is declining. Natural pozzolans (NPs), once widely used, became less common due to the abundance of fly ash and slag. As traditional SCM supplies shrink and demand for low-carbon alternatives grows, revisiting older sources or identifying new SCMs has become a priority. Caltrans is actively seeking alternatives to the SCMs currently on the Department's Authorized Materials List (AML).

WHAT WAS OUR GOAL?

This research aimed to identify and add more SCM resources to Caltrans' AML by providing data on their availability, usage, testing, and specifications of alternative SCMs.

Caltrans

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WHAT DID WE DO?

This project focused on reducing carbon content through alternative SCMs. The research team conducted both experimental and computational analyses to assess their impact on concrete workability, mechanical performance, and durability. The study began with physical and chemical property evaluations of raw materials, followed by computational simulations to predict mixture performance. Results were compared to experimental data from existing SCMs. The project was carried out in three phases: Phase I involved a literature review, resource identification, and refinement of the experimental plan; Phase II focused on computational and experimental assessment of SCM properties; and Phase III focused on reporting and disseminating the results.

WHAT WAS THE OUTCOME?

Key findings included:

- Alternative SCMs varied in performance based on reactivity.
- NPs had lower admixture adsorption than fly ashes.
- Water absorption ranged from 3.25% to17.25% for NPs and from 5.55% to 9.25% for blended pozzolans; specific gravity ranged from 2.02 to 2.76.
- The base PLC mixture and mixtures that accounted for cement by volume and SCM absorption had similar water requirements.
- NPs accelerated initial setting, while fly ash delayed it; both reduced hydration peak and total heat.
- NPs increased resistivity and reduced porosity, suggesting improved durability.
- Alternative SCMs effectively controlled alkali–silica reaction (ASR) expansion, similar to fly ash.
- PLC+SCM mortars demonstrated satisfactory mechanical performance.
- All SCMs increased chloride binding, with NPs slightly outperforming fly ashes.
- PLC+SCM mixtures showed greater resistance to chloride ingress than pure PLC, with NPs performing best.

WHAT IS THE BENEFIT?

Expanding the SCM resources listed on the AML offers potential environmental and economic benefits, including:

- **Reduced energy consumption and GHG emissions:** Alternative SCMs lower construction impacts and energy consumption, supporting legislative mandates.
- **Cost reduction:** Expanding SCM options enhances supply flexibility and reduces concrete costs.

LEARN MORE

To view the complete report: https://ir.library.oregonstate.edu/downloads/st74d064b

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