SJSU SAN JOSÉ STATE UNIVERSITY
FRESNO STATE
Discovery. Diversity. Distinction.

Strategized Reduction of Greenhouse Gas Emissions Through Predicting and Extending the Service Life of Concrete Pavements and Bridges

Project 2450
May 2025

Fariborz M. Tehrani, PhD, PE, ENV SP, PMP, SAP, F. ASCE

Introduction

This research investigates the performance and longevity of concrete by examining how different materials and techniques influence its resistance properties. Understanding these factors is vital, as the presence of chloride ions from external factors can cause the corrosion of reinforcing steel, which may jeopardize structural integrity and shorten the lifespan of concrete infrastructure. Therefore, it is crucial to grasp the factors affecting chloride diffusion and electrical resistivity in concrete to support the creation of resilient and durable infrastructure.

This research identifies and evaluates methods for predicting and enhancing the durability of concrete used in transportation. Specific objectives included examining lightweight aggregates and concrete mixtures composed of expanded shale, clay, and slate. The research also involved conducting experiments to determine indicators of concrete durability. Additionally, comprehensive data analysis was performed to forecast the lifespan of the concrete and to assess lifecycle performance measures.

Study Methods

The research methodology adopted a blend of experimental and analytical techniques to conduct the study. The project explored various types of lightweight concrete, including all lightweight, sand lightweight, internally cured, and high-strength sand-lightweight concrete, compared to their counterpart normal-weight concrete. The samples used for this research were collected from six expanded shale, clay, and slate plants across the country.

The experimental investigations evaluated the physical, mechanical, and transport properties of concrete. Initial assessments included measurements of density, workability, compressive strength, and splitting tensile strength. Furthermore, the study investigated transport properties, encompassing the water absorption rate, surface and bulk electrical resistance, and chloride penetration. Furthermore, analyses utilized established models and simulations to assess the durability of concrete mixtures and lifecycle performance across diverse environments.

Analyses included costs and greenhouse gas emissions to evaluate their economic and environmental impacts.

Expanded shale, clay, and slate lightweight aggregates are game changers in the pursuit of sustainable and resilient concrete applications for safe, reliable infrastructure.

Findings

Using lightweight aggregates significantly enhances the ability of concrete to resist chloride ion penetration while also maintaining or improving its physical and mechanical properties. These aggregates contribute positively to the hydration process and strengthen the bond between the aggregates and the cementitious paste, resulting in reduced permeability and minimized cracking, ultimately improving durability. Concrete formulated with expanded shale, clay, and slate (ESCS) exhibits a substantial reduction in both permeability and diffusion rates, coupled with enhanced electrical resistance, thereby providing greater protection against chloride ion ingress. All types of ESCS concrete are associated with a longer service life and lower lifecycle costs and emissions than traditional normal-weight concrete. The impacts of a reduced lifecycle significantly outweigh the initial insignificant increases in costs and emissions severalfold.

Policy/Practice Recommendations

This project provides crucial insights into the future of sustainable civil engineering. It outlines how the transportation industry can incorporate expanded shale, clay, and slate alongside adopting techniques such as internal curing. This information can help establish best practices that improve concrete structures while addressing the urgent need for sustainable infrastructure in light of climate change. To further this initiative, it is crucial to pinpoint transportation projects that can effectively integrate lightweight aggregates and concrete materials.

About the Authors

Dr. Fariborz M. Tehrani, PhD, PE, ENV SP, PMP, SAP, F.ASCE, is a Professor at California State University, Fresno and the Director of the Expanded Shale Clay Slate Institute (ESCSI) with expertise in SR-SEMM and 35 years of experience. Fariborz is a voting member of ACI, ASTM, and TRB; EMI ORC Vice Chair; and EMI's Liaison in ASCE STC. Fariborz has a BSc from Shariff University of Technology; an MSc from Amirkabir University of Technology; an MS, a degree of engineer, and a PhD from the University of California, Los Angeles.

To Learn More

For more details about the study, download the full report at transweb.sjsu.edu/research/2447

MTI is a University Transportation Center sponsored by the U.S. Department of Transportation's Office of the Assistant Secretary for Research and Technology and by Caltrans. The Institute is located within San José State University's Lucas Graduate School of Business.