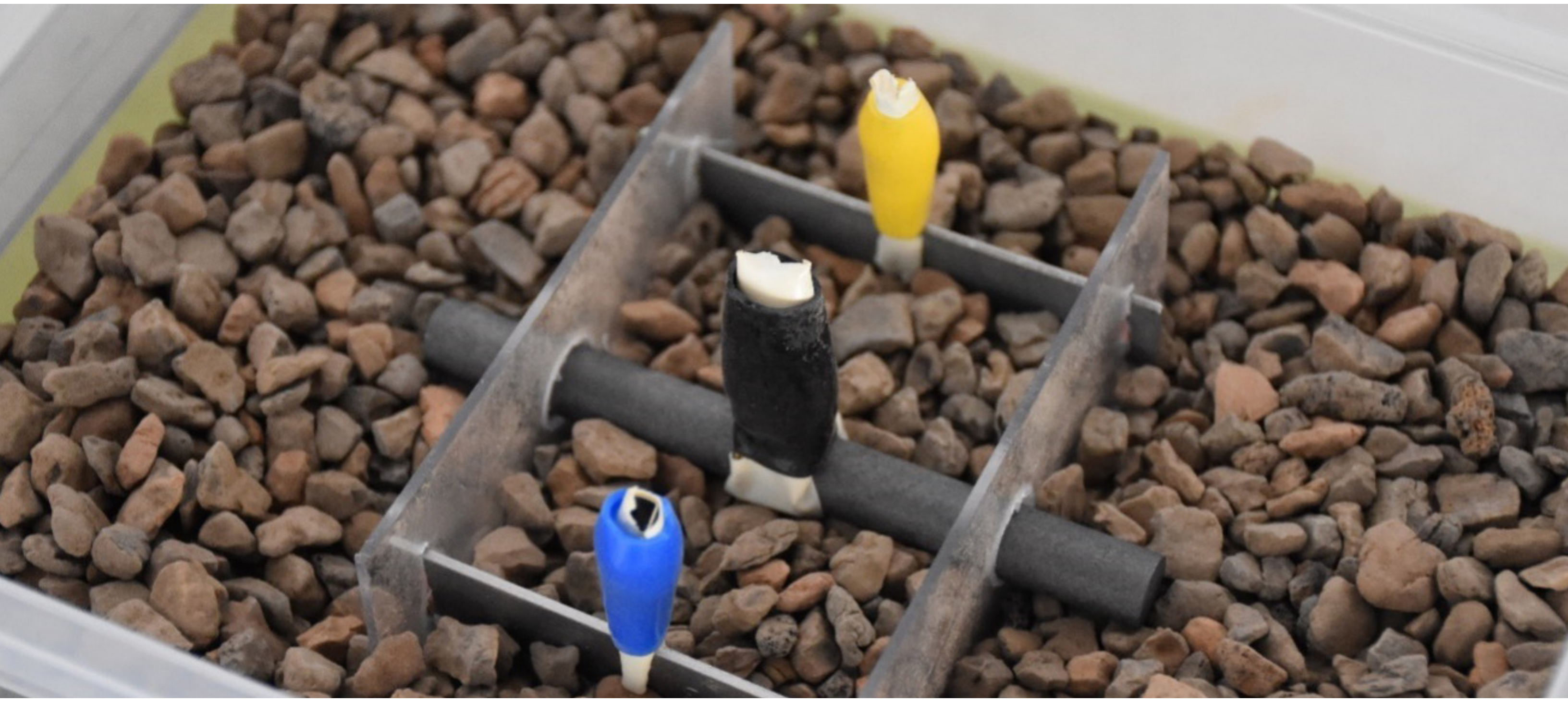
Extending the Service-Life of Bridges Using Sustainable and Resilient Abutment Systems: An Experimental Approach to the Electrochemical Characterization of Lightweight Mechanically Stabilized Earth

Project 2225
July 2023

Fariborz M. Tehrani Kenneth L. Fishman Farmehr M. Dehkordi



Introduction

This research addresses the need to extend the service life, reduce the life cycle cost, and improve the safety and reliability of bridge abutments, part of the nation's critical transportation infrastructure. Mechanically stabilized earth (MSE) abutments contribute to the constructability and economy of bridge infrastructure. The electrochemical properties of backfill materials influence the corrosion of embedded steel strips in MSE systems. The application of rotary kiln manufactured lightweight aggregates contributes to the sustainability of bridge abutments by addressing corrosion concerns, reducing structural loads and settlements, providing free drainage, and accelerating construction. This project investigates the properties and characteristics of expanded shale, clay, and slate aggregates compared with normal-weight aggregates concerning the corrosivity of steel reinforcement.

Study Methods

The experimental methodology of this project involves a series of tests using current standards and proposals to measure electrical resistivity, pH, sulfate, chloride, and corrosion of expanded shale, clay, and slate aggregates with various gradations, moisture conditions, dilution ratios, and curing conditions. Specimens represented samples produced by the Expanded Shale, Clay and Slate Institute (ESCSI) members.

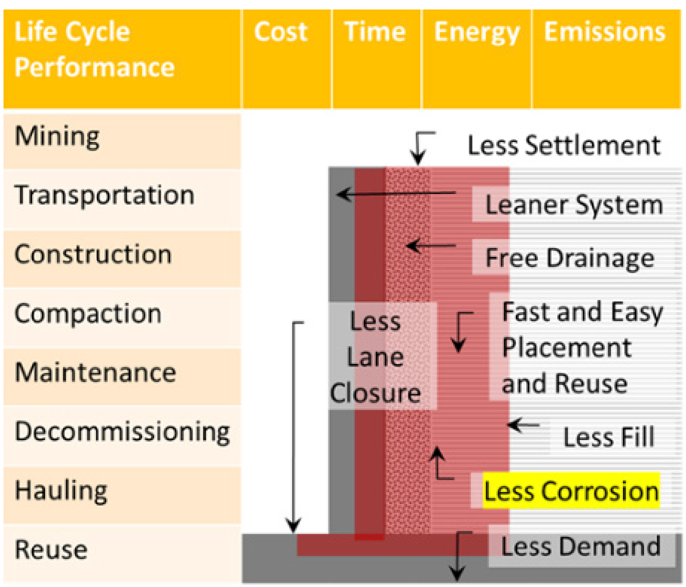
Findings

Assessing the corrosion measures and its correlation with electrochemical properties of expanded shale, clay, and slate aggregates indicate that the corrosion of galvanized and carbon steel coupons embedded in lightweight aggregates is equal to or less than those of normal weight aggregates having higher resistivity and lower sulfate ion contents. Hence, existing guidelines for the expected levels of corrosion of steel reinforcement in normal-weight aggregates require adjustment for the application of rotary-kiln-manufactured lightweight aggregates. These adjustments shall tolerate one-sixth lower resistivity, 2.5 times higher sulfate, and 1.5 times higher chloride ion contents as threshold values for ESCS for the same expected level of corrosion.

Application of expanded shale, clay, and slate aggregates contributes to the sustainability of bridge infrastructure, as ESCSs are suitable backfill materials for mechanically stabilized earth bridge abutments, whereby corrosion is a design consideration.

Policy/Practice Recommendations

Outcomes of this project include recommendations for performance-based guidelines for categorizing ESCS aggregates for corrosivity using characteristics such as gradation, electrical resistivity, pH, sulfate, and chloride ion contents. These guidelines can help optimize the design and reduce the need to maintain and rehabilitate bridges, abutments, and approach and departure slabs on roadways to keep transportation systems safe and cost-efficient.



About the Authors

Dr. Fariborz M. Tehrani, PhD, PE, ENV SP, PMP, SAP, F.ASCE, is a Professor at CSU and the Director of ESCSI with expertise in SR-SEMM and 33 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 Sharif University of Technology; an MSc from Amirkabir University of Technology; an MS and a PhD from UCLA.

Dr. Kenneth L. Fishman, PhD, PE, M.ASCE, is a geotechnical engineer and principal at McMahon & Mann Consulting Engineering and Geology, P.C., where he leads the Earth Reinforcement Testing Division. For the past 25 years, he has been involved in the research and application of corrosion testing and corrosion mitigation for buried steel performed on behalf of NCHRP, TRB, NASEM, FHWA, private industry, state DOTs, and municipalities.

Mr. Farmehr M. Dehkordi, MSc, M.RILEM, is a PhD student at Politecnico di Torino and a visiting research assistant at California State University, Fresno. He received his BSc from Isfahan University of Technology and his MSc from Politecnico di Torino.

To Learn More

For more details about the study, download the full report at transweb.sjsu.edu/research/2225

MINETA TRANSPORTATION INSTITUTE

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.