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Development of Physics-Based Deterioration Models for Reinforced Soil Retaining Structures

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Introduction

Since its introduction in the 1960s, soil reinforcement has become essential for earth retention in transportation projects worldwide. Reinforced soil retaining walls (also known as Mechanically Stabilized Earth walls or MSE walls) are known for being cost-effective, time-efficient, eco-friendly, and resilient to earthquakes. Today, they dominate retaining wall construction in transportation infrastructure. However, none have yet reached their expected 75-year lifespan. The first U.S. wall, built in 1972, is still 23 years short. Early walls were built with outdated design guidelines, and some have recently failed due to deterioration over time.

Reinforced soil retaining walls, like all infrastructure assets, have limited lifespans. Their unexpected, sudden failure can result in severe and costly consequences, including disruption to the mobility of users, goods, and services. The service life of reinforced soil walls is affected by multiple deterioration processes that may start at different times and eventually lead to failure. As a result, the lifespan of these walls is often unknown, leading to costly risk mitigation measures and inefficient use of resources. The outdated specifications used in the design and construction of the early generations of reinforced soil walls add uncertainty to their remaining service life.

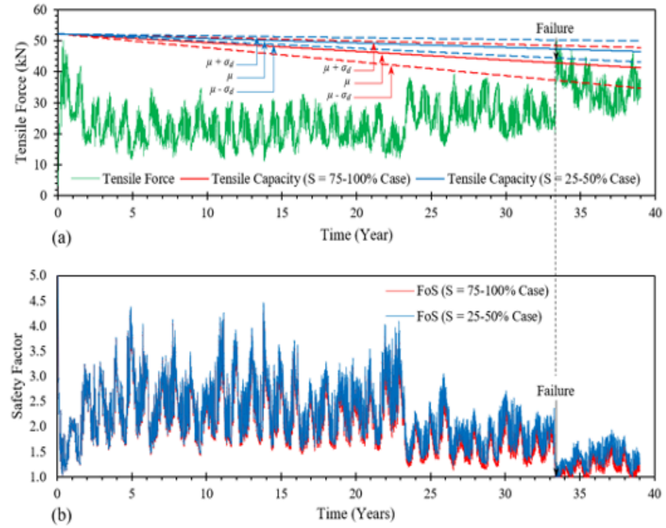
Study Methods

This study used advanced numerical modeling approaches to offer valuable insights into the behavior and long-term performance of early-generation reinforced soil walls constructed in the 1970s for asset management purposes. An asset-scale, hydromechanical numerical model was developed for a reinforced soil wall constructed with metallic reinforcement and subject to weather conditions. A material-scale reinforcement model was added to the asset-scale model to account for moisture-driven corrosion, enabling reinforcements to corrode over time at varying rates based on moisture levels in the fill at each reinforcement location. Such a numerical model can predict long-term performance indicators necessary for vulnerability assessment of old, aging reinforced soil walls.

An asset-scale performance model based on performance-requirement failure framework was developed using the outputs of the asset-scale numerical model, with reinforcement tensile strength as a performance indicator. Such performance models can serve as decision support tools by providing quantitative data for informed decisions about maintenance, repair, or replacement strategies, and optimizing resource allocation.

Findings

As expected, the results of this study indicate that fill moisture may have a considerable effect on the rate of corrosion. Unlike newer wall generations constructed with strict specifications that limit fill corrosivity and promote fill drainability, early wall generations may maintain high levels of moisture for prolonged periods that can significantly increase corrosion rates. The results show that while corrosion rates fluctuate with changes in fill moisture, the overall increase in cumulative thickness loss over time is relatively constant, supporting the use of linear models to predict cumulative corrosion. The results also indicate that 25% fluctuation in fill moisture has little to no effect on cumulative corrosion and that the average fill moisture can be used to predict long-term cumulative corrosion.



Example of the performance-requirement failure model: (a) tensile force vs. tensile capacity; and (b) factor of safety against reinforcement rupture.

> Predicting deterioration, especially through visual inspections, can leave the service life of reinforced soil walls uncertain, leading to costly risk mitigation strategies and inefficient resource use. Numerical modeling offers critical insights into the long-term performance of reinforced soil walls, improving asset management.

Policy Recommendations

Findings indicate that fill moisture monitoring be added to asset management protocols of early-generation reinforced soil walls that could have been constructed with highly corrosive or poorly drainable fills. Such data can be useful to make proper predictions based on field conditions. Average annual climate records for a specific location can provide the yearly variation in fill moisture needed to predict corrosion of wall reinforcements, which can then be multiplied by the number of service years to estimate long-term cumulative corrosion.

About the Authors

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Dr. Morsy is an Assistant Professor in the Department of Civil Engineering and Construction Engineering Management at California State University, Long Beach. His research focuses on geotechnical infrastructure deterioration and asset management, climate change impacts on geotechnical and geoenvironmental infrastructure, geosynthetics applications in geotechnical engineering, and engineering solutions for sustainable built environment.

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To Learn More

For more details about the study, download the full report at transweb.sjsu.edu/research/2360

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