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LONG-TERM BEHAVIOR OF GEOSYNTHETIC REINFORCED MECHANICALLY STABILIZED EARTH WALL SYSTEM

PROBLEM STATEMENT

Utilization of geosynthetic reinforced soil technology has grown dramatically in the past ten years due to its enhanced durability and corrosion resistance properties. A significant advantage of mechanically stabilized earth (MSE) walls is their flexibility and their capability to absorb deformations due to poor subsoil conditions in the foundations. Thus, MSE walls with geogrid reinforcement have gained substantial approval, both statewide and nationally, as an alternative to conventional reinforced concrete retaining structures for bridge abutments and wing walls. The cost savings are on the order of 25% to 50% when compared to conventional reinforced concrete retaining structures, and especially when supported by deep foundations.

Despite their widespread usage, the long-term behavior of geogrid-reinforced MSE walls remains uncertain. In particular, the tendency of polymeric geogrids to creep under sustained loading at high temperatures poses a potential risk to the performance of MSE walls in warmer climates, as in Florida.

OBJECTIVES

The objectives of this project are to experimentally and analytically investigate the geogrid-reinforced MSE walls and to develop a Windows-based computer program to assist design engineers and Florida Department of Transportation (FDOT) personnel with the design and analysis of MSE walls subjected to long-term degradation due to high temperatures and various corrosive environments.

FINDINGS AND CONCLUSIONS

Experimental and analytical investigations of geogrid-reinforced MSE walls were conducted in this study. Small and full-scale wall tests were supplemented with numerical and analytical methods to provide the FDOT with the necessary knowledge and tools to design and analyze geogrid-reinforced MSE walls for long-term performance.

An extensive literature review was carried out on a number of relevant topics covering the following areas: 1) design methodology for MSE walls, 2) analytical prediction of performance for MSE walls, 3) field evaluation (case studies) and factors that influence the long term performance-based design of MSE walls, 4) pullout strength, 5) durability and degradation, 6) environmental stress cracking resistance, 7) creep, and 8) connections and junctions between facings and geogrids.

The data utilized for creep analysis was based on creep tests, previously performed by the principal investigator, on HDPE (UX-1600 SB) and PET (Matrex-30) geogrids submerged in different chemical solutions. The purpose of this work was to model the mechanical characteristics of geogrids exposed to typical construction soils and environmental conditions in Florida. A general creep equation was formulated to predict the strain of a geogrid subjected to prolonged constant loading.

Four small-scale MSE walls were tested to simulate the prototype with a scale of approximately 1 to 5.5. Two walls were reinforced with UX-1400 HDPE geogrids, and two with Miragrid 3XT geogrids. The soil was an SP Class II [ASTM D2321 and D2487]. A load frame with the required dimensions to accommodate the small-scale MSE wall specimens was designed and fabricated. The main objective of the small-scale testing was to evaluate the failure and distress mechanisms in MSE walls, in preparation for construction of the full-scale wall. This testing enabled the verification and calibration of the FLAC (Fast Lagrangian Analysis of Continua) model and the constitutive properties, and it provided an assessment of the variability between two similar walls constructed using the same procedures.

A full-scale wall was constructed on the Florida Atlantic University campus in Boca Raton for long-term testing and planed for loading to failure. The wall was designed to a factor of safety of 1, according to the standard FHWA design methods, with the intent to expedite distress and to fail the wall. The purpose behind this design was also to verify whether or not the current design methods are overly conservative. The types of geogrids used in the construction of the wall were HDPE-1400 Uniaxial SB and PET Mirafi Miragrid 3XT. In order to compare the experimental values for the full-scale wall with the numerical data, the MSE wall was modeled with the corresponding geogrid modulus used in the experimental walls. A design tool for MSE walls, a stand-alone Windows application programmed in Visual Basic™ and compiled to run on any Windows platform, was developed.

One of the more significant observations resulting from the experimental evidence and model predictions was that, even when the structure was loaded to very high stress levels, only excessive deformations occurred—there were no incidences of catastrophic failure occur.

BENEFITS

The primary benefits of this research are that (1) it has resulted in software that can analyze and design geogrid-reinforced MSE walls for long-term durability, to withstand creep under high temperatures and in corrosive environments, and (2) it has demonstrated that the current design method is very conservative, which suggests the potential for future economically advantageous design modifications.

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