ODOT RESEARCH

HIGHLIGHTER

PROJECT TITLE
PROTOTYPE REINFORCED SOIL EMBANKMENT FOR RECONSTRUCTION OF US ROUTE 62 SLOPE FAILURE IN CHICKASHA, OK

FINAL REPORT ~
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PROTOTYPE REINFORCED SOIL EMBANKMENT FOR RECONSTRUCTION OF US ROUTE 62 SLOPE FAILURE

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OVERVIEW Oklahoma Department of Transportation (ODOT) and other departments of transportation in the U.S. are continually faced with the persistent problem of landslides and slope failures along highways, such as the failure shown in **Figure 1**. Repairs and maintenance work associated with these failures cost these agencies millions of dollars annually. Reinforced soil technology using locally available materials can provide viable and economical solutions to stabilize or reconstruct highway slopes and embankments. However, in order to reinforce embankment structures that are built with marginal soils, which are common in Oklahoma, it is important to obtain satisfactory soil-reinforcement interface performance.

Figure 1 Failed slope of a highway embankment in Chickasha, Oklahoma

Current design guidelines and test protocols for reinforced soil slopes (RSS) in North America do not include provisions to account for the reduction in the interface shear strength due to increased gravimetric water content (GWC) in the soil. Marginal soils may exhibit internal stability or serviceability issues related to soil-reinforcement interface strength properties when the soil GWC increases significantly, which can occur during construction or prolonged precipitation periods. Wetting-induced reduction in matric suction and loss of shear strength in the soil and soil-reinforcement interface could lead to excessive deformation or complete failure of reinforced soil structures. This study investigated the influence of the as-compacted GWC value to evaluate *moisture reduction factors* for reinforced embankment design.

RESULTS & IMPLEMENTATION This study was part of a long-term research project sponsored by ODOT and the Oklahoma Transportation Center, which aimed to improve the design guidelines for reinforced soil slopes (RSS) that are constructed with locally available soils in unsaturated conditions and subjected to climatic factors in Oklahoma. The primary objective of this study was to determine moisture reduction factors [MRF or $\mu(\omega)$] for the interface shear strength of geotextile reinforcement for the design of reinforced soil structures with marginal soils using multi-scale laboratory embankment tests. Model embankments were constructed with a mixture of lean clay (CL), sand and a small percentage of commercially available sodium bentonite at the GWC values ranging between OMC-2% and OMC+2% (OMC: Optimum Moisture Content). The embankments, which were subjected to strip footing loading in plane-strain condition, were instrumented to measure footing load, earth pressure, reinforcement strains and the soil GWC and matric suction values (**Figures 2 & 3**). Results from six reduced-scale and two large-scale models indicated that regardless of the size of the model examined, the embankment model constructed at OMC-2% resulted in the largest failure load when subjected to a line surcharge load simulating loading from bridge abutments.

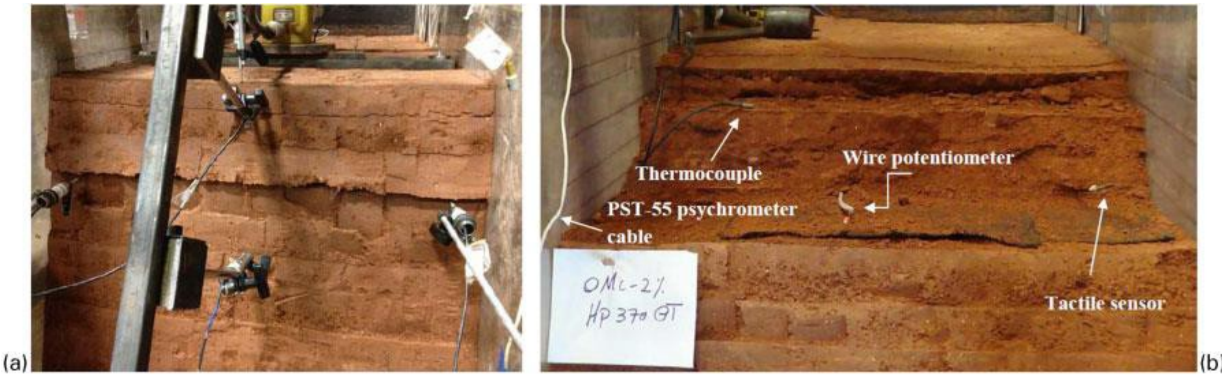

Figure 2 Reduced-scale indoor model embankments after surcharge load testing and excavation

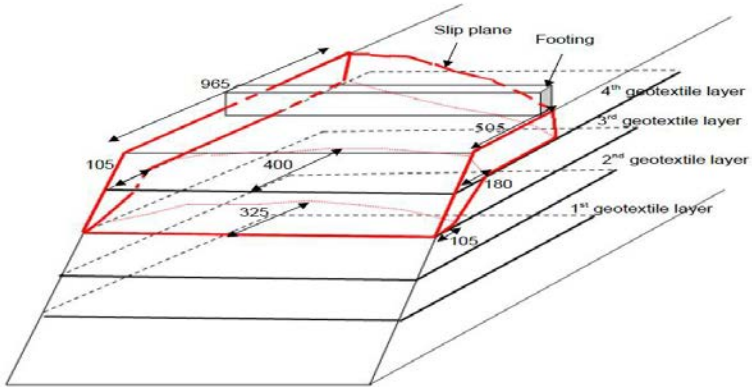

Figure 3 Failure plane geometry of OMC-2% outdoor model embankment (all dimensions are in mm)

The failure loads of reduced-scale indoor embankment models that were built and tested at OMC+2% were as much as 40% smaller than that of the model compacted and tested at OMC-2%. The results of stability analysis using GSTABL also indicated that the bearing capacity of outdoor embankment model constructed at OMC-2% was 40% larger compared to the model at OMC+2%. The MRF values for the case of OMC+2% (using the OMC-2% case as baseline) for the embankment models constructed with HP370 and HP570 geotextiles were 74% and 79%, respectively. Based on the results of this study, current FHWA equations for the shear resistance of soil-geotextile reinforcement interface could be modified to explicitly account for the influence of moisture content in the internal stability calculations of reinforced soil structures that are constructed with fine-grained or marginal soils. Internal stability and performance of such structures can be negatively impacted by the reduction in the shear strength of the soil-reinforcement interface when the soil GWC increases.

BENEFITS The MRF values can help design engineers estimate the magnitude of reduction that could be expected in the soil-reinforcement interface shear strength as a result of wetting during construction or service life of mechanically stabilized earth (MSE) and reinforced soil slopes (RSS) with significant fines content and thereby, make their design methodologies more accurate and reliable.