

Evaluation of Interaction Properties of Geosynthetics in Cohesive Soils: LTRC Reinforced Soil Test Wall

Introduction

Design specifications of Mechanically Stabilized Earth (MSE) walls have focused on the use of high quality granular soil as a backfill material. This is primarily due to its higher frictional resistance and stable mechanical properties. Sandy-silt and silty-clay soils of medium plasticity ($PI < 15$) have been used in reinforced steep slopes and may be suitable as backfill in reinforced walls. Using available low quality silty-clay soil as a backfill material may present an economical and practical solution for the construction of MSE walls where high quality backfill is not readily available.

To investigate the interaction mechanism and long-term performance of reinforced silty-clays, the Louisiana Transportation Research Center (LTRC) has constructed a full-scale reinforced test wall. The test wall was constructed in 1998. The wall was monitored for lateral and vertical deformations, internal soil pressures, and strains in the reinforcement for four years.

Objectives

The test wall was constructed to evaluate the behavior of MSE walls constructed with silty-clay soils through comparison between predicted and field measurements. The primary objectives of the construction of the LTRC reinforced test wall were to monitor the performance of the reinforced-soil wall and to evaluate the effect of reinforcement type, strength, geometry, and vertical spacing on the distribution of the stresses along the height of the wall. Other secondary objectives addressed in the design, construction, and instrumentation of the test wall

included investigating the effect of vertical settlement on wall deformation and monitoring the performance of steep slopes reinforced with woven and non-woven geotextiles.

Research Approach

A full-scale, fully instrumented test wall was constructed using a silty-clay soil backfill material with a Plasticity Index of 15. The test embankment was 20 feet high and consisted of a vertical wall on the front side and a one-to-one slope at the back. The wall was constructed with a modular block facing and consisted of three test sections reinforced with various geogrid types. The strength, geometry, and vertical spacing of the geogrids varied in each section to evaluate the effect of these design parameters on the wall performance. The embankment was constructed over a soft soil subgrade. Bearing capacity failure was mitigated with a heavily reinforced base pad. The long-term settlement was monitored to determine its effect on the wall performance.

Principal Investigator:
Khalid Farrag, Ph.D., P.E., LTRC
Mark Morvant, P.E., LTRC

LTRC Contact: Mark Morvant, P.E.
Phone 225-767-9124

Louisiana Transportation Research Center

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4101 Gourrier Avenue
Baton Rouge, LA 70808-4443
www.ltrc.lsu.edu

Section 1 of the wall was constructed using low strength geogrids placed at a vertical spacing of 16 inches. Section 2 was constructed using higher strength geogrids placed at a vertical spacing of 40 inches. The vertical spacing of section 3 was varied to obtain relatively uniform stresses in the reinforcement layers along most of the wall height. The end of the embankment was constructed using Geoweb cells to investigate the construction procedures with low-quality soils and the performance of such systems around culverts. The backside of the embankment contained two 1:1 slope sections reinforced with woven and non-woven geotextiles.

The design criteria of the wall used low factors of safety to obtain measurable deformations in the test sections. The instrumentation program monitored the deformations of the silty-clay backfill, the mobilized strains in the reinforcement, vertical and horizontal earth pressures, and the settlement of the embankment.

Conclusions

The LTRC test wall was designed to produce measurable deformations in the test sections. Consequently, the results of the instrumentation program showed relatively higher deformations as compared to conventionally designed walls. The high deformations were mainly due to the low factors of safety employed and high settlement. The maximum settlement occurred below the vertical wall and linearly decreased below the slope section. However, the measurements of the horizontal inclinometers showed that the settlement below the reinforced section of the wall was approximately uniform. Thus, strain measurements of the reinforcement were not affected by the settlement of the wall.

Strain measurements were used to estimate the state of stresses in the reinforcement. The results showed that the distribution of reinforcement strength in the layers varied with the change in the reinforcement stiffness modulus and its density in the wall sections. The results showed that the Rankine's failure surface, usually employed for extensible reinforcement, did not accurately represent the critical failure surface in the three wall sections. The measurements of earth pressures near the wall facing were less than the theoretical values calculated from soil weight, and they decreased after the completion of construc-

tion due to wall settlement. The low values of vertical soil pressures near the facing are possibly due to the facing boundary effect as a portion of the vertical load is carried by the frictional resistance of the modular blocks at the facing. The normalized reinforcement strength in the term ($K = T_{max} / h S_h S_v$) was used to define the relative "rigidity" of the wall and to determine the horizontal earth pressure coefficient of the wall (K). The results showed that the value of coefficient K was less than the theoretical K_a value in the three wall sections. The values of K from this study give a more appropriate estimation of the lateral earth pressure coefficients for the three configurations of the test sections. The results suggest a bilinear stress distribution in the weak geogrid-minimum spacing section and a trapezoidal distribution in the strong-geogrid-maximum spacing section. The stress distribution in variable spacing section was closer to the surface than the Rankine's failure surface.

The test wall demonstrates that both woven and non-woven geotextiles were effective in reinforcing steep 1:1 slopes. There were no results that determine an advantage of using one type of geotextile over the other.

Recommendations

Current design specifications of reinforced-soil walls require the use of high quality granular soil as a backfill material. The performance of the LTRC wall demonstrated the effectiveness of using marginal silty-clay soil as a backfill material. The use of the marginal silty-clay soil with a PI of up to 15 presents an economical and practical solution for the construction of reinforced walls. The use of these materials requires the proper control of soil moisture content during construction and a proper drainage system behind the wall facing. Until the long-term performance of these walls can be evaluated, implementation should be limited to non-critical wall structures. The performance of the reinforced slopes indicated the effectiveness of using woven and non-woven geotextiles in reinforcing steep slopes with marginal soils.

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