Texas A&M Transportation Institute

PROJECT SUMMARY

Texas Department of Transportation

0-6716: Design Parameters and Methodology for Mechanically Stabilized Earth (MSE) Walls

Background

Since their appearance in the 1970s, mechanically stabilized earth (MSE) walls have become a majority among all types of retaining walls due to their economics and satisfactory performance. The Texas Department of Transportation (TxDOT) has primarily adopted the guidelines published by the Federal Highway Administration and the American Association of State Highway and Transportation (AASHTO) for design of MSE walls. However, TxDOT engineers have expressed concerns about both design assumptions and methodology, including soil parameter selection, to meet the required stability limits and possible failure modes. Validation of the assumptions and design methods is needed now since these uncertainties may lead to serviceability issues.

This project examined the assumptions and the analysis methods based on data collected from TxDOT and other projects, laboratory testing, statistical analyses, back analyses of the historical data, and numerical simulations. The main assumptions examined included material parameters used for TxDOT backfills, minimum reinforcement length, and the requirement for external stability. To validate the MSE walls design method, the bearing capacity analysis method was evaluated for its rationality and adequacy. The possible modes for compound failure were checked, and an improved method for compound failure analysis was recommended.

The basic methodology of the research included surveys to determine current practices, case history review, laboratory testing on typical backfill soils, finite difference modeling of MSE walls to investigate potential failure mechanisms, and comparison of finite difference model predictions to limit equilibrium models commonly used in design.

What the Researchers Did

The first research task was to assess current design practices for MSE walls based on a literature review of current design practices and on survey questionnaires sent to different state departments of transportation.

The second task performed case histories on MSE walls in Texas that were judged to have various degrees of unsatisfactory performance.

The third task involved laboratory testing on MSE backfill materials provided by TxDOT from different borrow pits within Texas for different classes of backfill materials. The researchers performed statistical analyses of the test results to support Monte Carlo simulations using different backfill material friction angles and unit weights to assess the effect of variability on the factor of safety against sliding and overturning. Statistical analyses were conducted using the laboratory test data to determine the minimum reinforcement lengths required for different types of backfill material and to compare them to current guidelines. Using a Fast Lagrangian Analysis of Continua (FLAC) program, possible failure modes were assessed for MSE walls for different wall geometries, for compound walls under various soil conditions, and for various combinations of retained and foundation soils to evaluate the effect of these soil parameters on failure mechanisms.

Finally, a parametric study was conducted to evaluate design guidelines on sliding analyses recommended by AASHTO, and to recommend modifications to these guidelines based on FLAC simulations for various wall configurations and soil conditions. Similar studies addressed AASHTO guidelines for the bearing capacity of MSE walls. The bearing capacity guidelines were compared to the German code of practice (EBGEO) for MSE walls.

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What They Found

The findings from this research are as follows:

- Laboratory test results on backfill materials show that there is variability on strength parameters based on the amount of fine particles present in the backfill material. The detailed explanation is provided in the final report.
- The FLAC analysis for minimum length shows that 0.7H length for reinforcement is appropriate for material properties obtained from laboratory tests performed on backfill material provided by TxDOT.
- The global stability of walls evaluated using the FLAC program shows that there is an active wedge behind the wall moving downward and increasing the lateral pressure on the wall. The area of active wedge increases with lower retaining soil friction values.
- The backfill friction angle has negligible influence on global stability.
- For weak foundations (ϕ found = 26° and 30°), the bearing capacity analysis significantly underestimates the actual factor of safety. This is a likely consequence of the conservative assumption that the full overburden stress due to the backfill acts on the foundation. In actuality, the shearing resistance in the backfill and retained soil will likely reduce the pressure acting on the foundation.
- The parametric study shows that forces from FLAC simulations are higher than forces calculated from Rankine's theory, especially for higher ϕ (retained) values. The higher lateral loads largely account for the lower FOS values predicted from the FLAC analyses.
- Meyerhof's equation, which is used in the AASHTO analysis, gives a lower estimate of FOS for bearing than Vesic's equation.
- The load inclination factor has a significant influence on both the embedment and cohesion contributions to bearing capacity predicted from Meyerhof's and Vesic's equations.

What This Means

The possible recommendations provided by the researchers are as follows:

- The laboratory test data for backfill materials such as Type A, B, and D show friction angle values higher than what is recommended by AASHTO (2002).
- The soil parameters for Type C backfill material should be quantified based on drainage condition at failure loading. The amount of fines for Type C recommended by TxDOT is between 0 and 30 percent, and this amount changes the behavior of backfill material from cohesionless to cohesive.
- The FLAC simulations performed for a minimum reinforcement length using Type A, B, and D show that the current AASHTO recommendation (i.e., 0.7H) is sufficient.
- A FLAC simulation performed using pure frictional soil parameters on retaining and foundation soils shows that there is an interaction effect on the base friction factor used in sliding analysis, and it should be considered in the design process.
- A FLAC simulation should be performed in cases of weak foundation and/or retained soils to assess the FOS before recommending any appropriate design guidelines.

For More Information

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