0-5506: Design of MSE Retaining Walls Placed in Front of a Stable Face

Background

Widening of existing highways often results in new mechanically stabilized earth (MSE) walls being placed in front of existing stable walls or slopes. The design of these walls is unique because limited right-of-way often forces the length of the reinforcing strips to be shorter than those normally used. Furthermore, the presence of an existing stable face restricts the extent to which a potential slip surface can form and, thus, influences the overall, global stability of the wall. This study investigates the effect of walls being placed in a restricted space in front of an existing stable face and seeks to develop suitable guidelines for design of such walls.

What the Researchers Did

Available data for walls placed in front of stable faces and/or with restricted widths between the existing stable face and the face of a new MSE wall were compiled and reviewed. Data included both large-scale field tests and small-scale laboratory model tests performed in a geotechnical centrifuge.

Existing procedures for design of mechanically stabilized earth (MSE) retaining walls were also reviewed. Particular emphasis was placed on procedures that accounted for limited space between the face of the new wall and the existing ground or wall behind the new wall.

Finite element models were developed using the software Plaxis, and "calibrated" by comparisons of calculated stresses with measured values from field and laboratory tests as well as various theoretical solutions. The finite element models were then used to perform a series of parametric studies to examine the stresses behind walls placed in front of a stable face. Walls with aspect (width-to-height) ratios ranging from 0.1 to 0.7 were examined and the stresses were compared with those from available theoretical solutions. Based on the results of the parametric analyses, generalized representations of both the vertical and horizontal stresses behind walls were developed in the form of nondimensional graphs and charts.

Limit equilibrium analyses were also performed for walls with various aspect ratios. These analyses were performed to determine how the overall stability of a wall was influenced by the wall aspect ratio. Analyses were performed using both circular and noncircular slip surfaces; the results were compared for these two different shapes of slip surfaces.

Research Performed by:

Center for Transportation Research (CTR), The University of Texas at Austin

Research Supervisor:
Stephen G. Wright, CTR

Researchers:
Ken Kniss, CTR
Kuo-Hsin Yang, CTR
Jorge Zornberg, CTR

Project Completed:
8-31-07

What They Found

The finite element analyses performed with the Plaxis software provided excellent insight into the stresses behind an MSE wall placed in front of a stable face. Because most of the MSE walls constructed by TxDOT employ metallic reinforcement, studies focused on nondeformable reinforcement. By assuming nondeformable reinforcement, the maximum effects of wall aspect ratio and of walls being placed in a confined space are believed to have been realized and, thus, the effects of wall aspect ratio can be bounded.

The finite element analyses revealed that the vertical stresses in the backfill behind a retaining wall were reduced due to "arching" effects when the wall aspect ratio became less than the conventional 70 percent wall width to height ratio. The reduced vertical stresses reduce the pullout resistance of reinforcing elements and should be taken into account when determining the resistance that reinforcement can provide. The finite element analyses also revealed that horizontal (lateral) stresses behind a wall placed in a limited, confined space are also reduced, thus reducing the force that the reinforcement must provide.

The limit equilibrium analyses showed that noncircular slip surfaces yield lower factors of safety than circular slip surfaces, which may overestimate stability and lead to unconservative and possibly unsafe designs.

What This Means

When walls are placed in a confined space in front of an existing stable face, the vertical stresses in the back fill may be less than those behind walls with width-to-height ratios of 70 percent or greater. The reduced vertical stresses will reduce the (frictional) resistance of the reinforcement against pulling out from the backfill and can be accounted for using the information developed in this study. If the pullout resistance is found to be inadequate to withstand the lateral earth pressure forces, alternative schemes, including anchoring the reinforcement to the stable face, need to be considered but are not addressed in detail by this study.

When walls are placed in a confined space in front of a stable face, the lateral earth pressures may also be reduced. Neglecting the reduced lateral earth pressures should result in conservative designs; however, sometimes the economic benefits of designing for smaller lateral earth pressures are desired. In such cases, the results of this study can be used to estimate the reduced lateral earth pressures as a function of the wall aspect ratio.

Design of MSE walls placed in a confined space should include appropriate limit equilibrium stability analysis using a computer program suitable for analyses of reinforced earth structures. The analyses should be performed using both circular and noncircular slip surfaces to determine the most critical slip surface producing the minimum factor of safety. In most cases this slip surface will pass at least partially through the reinforcement and an appropriate distribution of forces along the reinforcement should be taken into account in the analyses. The project report illustrates the appropriate limit equilibrium analyses that should be performed.

For More Information:

Research Engineer - Tom Yarbrough, TxDOT, 512-465-7403
Project Director - Rachel Larcom, TxDOT, 512-997-2237
Research Supervisor - Stephen G. Wright, CTR, 512-232-3684

Technical reports when published are available at:
http://library.ctr.utexas.edu/index.html

www.txdot.gov
keyword: research

Texas Department of Transportation
Research and Technology Implementation Office
P.O. Box 5080
Austin, Texas 78763-5080
512-465-7403