Wisconsin Highway Research Program
Project 0092-18-07
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Mechanically Stabilized Earth (MSE) Wall Backfill Water Infiltration

Research Objectives

- Quantify how infiltration and drainage correspond with the stability of mechanically stabilized earth (MSE) walls subject to flooding and rapid drawdown

Research Benefits

- Produced generalized charts for estimating the extent and timing of infiltration or drainage from flooding and drawdown and corresponding impacts to wall stability

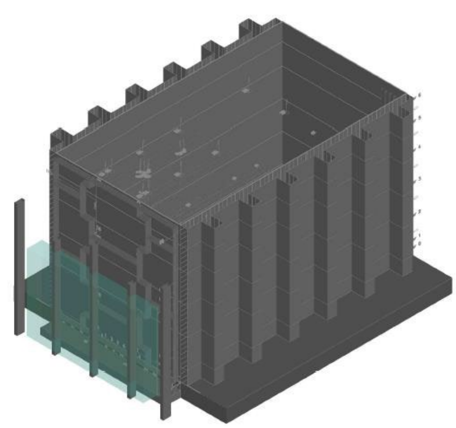
Background

Mechanically stabilized earth (MSE) walls are structures comprising layers of compacted backfill and soil reinforcement behind concrete facing. MSE walls can support heavy loads, like traffic, and prevent earth from shifting or spilling out onto roads or rights-of-way. The stability of MSE walls may be compromised in undrained conditions such as during heavy rain, flooding or rapid drawdown. For MSE walls subject to inundation, such as those located adjacent to rivers, canals, detention basins or retention basins, understanding pore pressure evolution during infiltration and drainage of the backfill soils and the corresponding implications to wall stability is essential. The objective of this research was to quantify how infiltration and drainage correspond with the stability of MSE walls subject to flooding and rapid drawdown.

Methodology

Two full-scale MSE walls were constructed at an indoor geostructure testing facility located at the Royal Military College of Canada. Both walls had the same dimensions, facing material, reinforcement (spacing and material) and boundary conditions; however, one wall had sand backfill, and the other wall had sand with gravel backfill. Instrumentation was installed to measure pore pressure distribution; moisture content distribution; strain in the reinforcement layers; connection loads; wall deflections; horizontal and vertical toe loads; and earth pressures during flooding and rapid drawdown.

The research team also conducted numerical simulations using model geometry and material properties calibrated to match the full-scale physical test results. Stability factor of safety during infiltration and drawdown was analyzed, and parametric studies were conducted to examine how backfill hydraulic conductivity, flood height and length of the backfill affect time to backfill saturation and wall stability during flooding and drawdown.



Full-scale MSE wall with water reservoir to simulate flooding and rapid drawdown. Model dimensions are 3.6m H X 3.4m W X 6m L.

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"This project provides an analysis method for evaluating MSE walls under flooding and drawdown conditions, which can be used in designing MSE walls near fluctuating bodies of water."

– Jeffery Horsfall, WisDOT

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Final report is available at: WisDOT Research website

Results

The stability factor of safety increased immediately after flooding and gradually decreased to the value before flooding as the backfill was saturated. However, it decreased immediately after rapid drawdown and gradually increased to the value before rapid drawdown as pore water pressure dissipated from the backfill. The relative increase and decrease in the stability factor of safety after flooding and rapid drawdown correlated with the water pressure head in front of the walls relative to the height of the walls. Results showed the stability factor of safety can increase by up to 105 percent immediately after flooding and decrease by up to 25 percent after rapid drawdown when the ratio of the pressure head to wall height increases to one.

The percent rise or drop in the stability factor of safety presented are extreme values that reflect sudden rise or drawdown of reservoir water levels. The gradual rise or drawdown that would allow some level of hydrostatic pressure balance during flooding or pore pressure dissipation during rapid drawdown in the backfill would result in less change in the stability factor of safety. Increasing the reinforcement tensile strength increased the stability factor of safety for both flooding and rapid drawdown. The increase of backfill friction angle from 30 to 35 degrees increased the stability factor of safety by about 20 percent for both flooding and rapid drawdown conditions.

Recommendations for implementation

The research team produced a series of generalized charts for estimating the extent and timing of infiltration or drainage from flooding and drawdown and corresponding impacts to wall stability. For the wall type examined in this research, the team recommended the following procedure:

1. Calculate the stability factor of safety during steady-state seepage based on the backfill strength properties, geometry and reinforcement layout and strength properties.

2. Select the appropriate graph for factor of safety at a given time for backfill hydraulic conductivity, applied pressure head ratio and hydraulic gradient.

3. In the selected graph, choose or interpolate the change in the factor of safety at a given time.

4. Compare the new factor of safety with the minimum design factor of safety.

Unique models should be developed for walls with different reinforcement layout, slope and backfill material types.

This brief summarizes Project 0092-18-07,
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