



## 0-6493: Pullout Resistance of Mechanically Stabilized Earth Reinforcements in Backfills Typically Used in Texas

### Background

Current design practice for evaluating the internal stability of Texas Department of Transportation (TxDOT) mechanically stabilized earth (MSE) wall systems relies on equations published by the American Association of State Highway and Transportation Officials (AASHTO) to determine the pullout resistance factors for earth reinforcements. However, these equations were developed based on data collected from testing performed many decades ago on reinforcement-backfill combinations that are not representative of materials used in TxDOT wall construction today. Since pullout often governs the internal stability of wall systems that utilize metallic reinforcements, it is important to determine pullout resistance factors for the specific reinforcement-backfill combinations used in Texas. A second important reinforcement pullout resistance question involves the use of alternative reinforcement layouts to resolve conflicts that arise in the field in relation to obstructions located within the reinforced fill. Such alternative reinforcement layouts have the potential to impact the internal stability of the wall system. TxDOT initiated this three-year research study with the primary objective of addressing these questions.

### What the Researchers Did

In Project 0-6493, the researchers completed an extensive laboratory test program that included a total of 650 pullout tests. These tests were conducted using a large-scale pullout test system that was specially designed and constructed as part of this study. This system consisted of a test

box with dimensions of 12 ft × 12 ft × 4 ft that could accommodate three layers of reinforcement in a single filling. The system also had the capability to simulate overburden pressures equivalent to 40 ft of fill. Tests were conducted on ribbed strip reinforcements, welded steel grid reinforcements, and a limited number of smooth bars embedded in two types of backfill, designated as Type A (gravelly) and Type B (sandy) select backfill as per TxDOT specifications. A subset of strip and grid reinforcements in each backfill type was instrumented with strain gages to provide further insight into mechanisms that control pullout resistance. The research design evaluated pullout resistance factors for both strip and grid reinforcements for a variety of independent variables including overburden pressure, reinforcement length, skew or splay angle, grid wire size, and grid geometry including both transverse and longitudinal wire spacing. Appropriate statistical analyses were used to interpret the data within the context of published AASHTO design guidance for inextensible MSE reinforcements.

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Texas Tech University Multidisciplinary  
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## What They Found

Detailed analyses of data collected from the pullout tests completed for this research support the following conclusions:

- Pullout resistance factors determined for ribbed strip and welded steel grid reinforcements embedded in TxDOT Type B (sandy) backfill are significantly higher than those predicted by the AASHTO equations. The pullout resistance factors determined for reinforcements embedded in Type A (gravelly) backfill are even higher. Improvement in the pullout resistance factor is most evident at depths less than 20 ft.
- Limited data on pullout performance of ribbed strip reinforcements embedded in under-compacted, Type B backfill show that even slight under-compaction (relative compaction 4 percent below specification) can have a significant adverse impact on the pullout resistance capacity (reduction of 34 percent).
- Statistical analyses conducted on pullout data for skewed strip reinforcements reveal that skew angles up to 15-deg do not significantly impact the pullout resistance. Furthermore, statistical analyses of test data for cut and splayed grid reinforcements show that splay angles up to 30-deg can be allowed. However, in the case of grids, it is important that appropriate adjustment is made in the grid length based on the cosine projection.
- Data obtained for welded steel grid reinforcements in both Type B and Type A

backfills show that narrower longitudinal bar spacing provides higher pullout resistance per unit width of grid. This effect is not reflected in the current AASHTO equation. Data also show that pullout resistance does not decrease inversely with transverse bar spacing as predicted by the AASHTO equation.

## What This Means

The research findings clearly demonstrate that when backfill material is selected and compacted according to TxDOT specifications, the actual factor of safety against pullout failure will be much larger than safety factors typically assumed in design. At the same time, data from limited testing indicate that failure to comply with construction specifications may lead to significant reduction in pullout resistance capacity. Accordingly, this research study emphasizes the need for good construction quality control associated with MSE retaining walls. The data support improved pullout resistance predictive models for strips and grids that can be used to achieve more cost-effective wall designs. The new predictive models for grids facilitate optimization of MSE wall design through informed selection of longitudinal and transverse bar spacings. The research also yielded improved guidelines for skewing strips or cutting-and-splaying grids to avoid obstructions encountered in the field.

### For More Information

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