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# Mechanically Stabilized Earth Walls on the Interstate Highway System

## *Thirty Years of Experience*

DANIEL ALZAMORA AND RICHARD J. BARROWS

*The authors are with the Federal Highway Administration: Alzamora is Geotechnical Engineer, Lakewood, Colorado; and Barrows is Geotechnical Team Leader, Western Federal Lands Highway Division, Vancouver, Washington.*

Mechanically stabilized earth (MSE) is a construction technique that alternates layers of compacted soil and reinforcing elements to build retaining walls and embankments. The reinforcing elements, which can be either steel or synthetic, interact with the soil by friction and confinement and provide tensile capacity. The combination of soil and reinforcement behaves as a gravity mass that retains lateral earth pressures.

The Interstate Highway System, which celebrated its 50th anniversary in 2006, has used MSE techniques for approximately 34 years. One of the earliest MSE walls in the United States was constructed on California State Highway 39, northeast of Los Angeles, in 1972. Since then, MSE walls have gained popularity and are accepted by most transportation departments as a standard retaining wall for fill or for embankment support.

## Problem

Retaining walls previously were rigid structural elements constructed from traditional materials such as concrete and steel; this approach had an exemplary track record. The MSE concept was a radical departure from the status quo. The argument that the change would produce cost savings, however, could not persuade decision makers to take on the risk of the new, unproven structures. Many technical questions remained—particularly about the soil-reinforcement interaction, the face deformation, and the durability of the reinforcing elements of MSE walls.

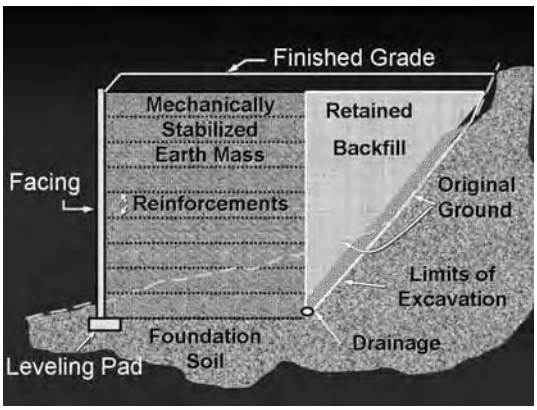
The early design methods mostly applied to proprietary MSE wall systems and often were difficult to verify. Each design method offered a different way to calculate the system's internal stability. The approaches differed not only in how to calculate the vertical stress but in how the stiffness of the reinforcement elements affected the calculations. Stiffness became increasingly significant as more types of reinforcement were developed and began competing with each other.

## Solution

The National Cooperative Highway Research Program's *NCHRP Report 290: Reinforcement of Earth Slopes and Embankments* assembled a comprehensive literature review of MSE systems (*1*). The report reviewed earth reinforcement systems, as well as reinforcement mechanisms, behavior, applications, designs, and durability. This was the first step in bringing MSE wall design out of the commercial realm and into the domain of practicing engineers and researchers.

The guidelines for the internal stability of MSE walls have involved several design methods and have undergone significant changes through research and practical experience. The Federal Highway Administration (FHWA) produced a research document, *Behavior of Reinforced Soil*, that examined MSE walls and slope systems and evaluated bar mats, strips, geosynthetic sheets, soil nails, and anchored systems.

This research was the foundation for FHWA's design and construction guidelines, which set out to develop a procedure for any type of reinforcement (*2*). The simplified coherent gravity method was the result of this work, an effort to merge and clarify the preferred design approach. The American Association of




Cross section of a typical MSE wall.

State Highway and Transportation Officials' technical committee on substructures and walls calibrated the new procedure with full-scale case history data for MSE walls and adopted the procedure.

*NCHRP Report 290* and the FHWA report referenced all of the MSE-related research that had been performed as of 1990. Since then, significant research has included the following:

- *Mechanically Stabilized Earth Walls and Reinforced Soil Slopes Design and Construction Guidelines*, from FHWA (FHWA-SA-96-071); and
- *Development of the Simplified Method for Internal Stability Design of Mechanically Stabilized Earth (MSE) Walls*, from the Washington State Department of Transportation (Research Report WA-RD 513.1).

Ongoing research activities include the MSE Wall Pooled Fund Study and its extension, which is addressing the design of MSE walls using marginal backfill soils; and NCHRP Project 24-22, Selecting Backfill Materials for MSE Retaining Walls, which also is addressing the use of marginal backfill soils.

## Application

U.S. highways now have more than 60,000 MSE walls commonly constructed to heights that exceed 35 feet. The highest transportation-related wall is an impressive 140 feet, along the third runway at Seattle–Tacoma International Airport. Today more than 9 million square feet of MSE walls are built for transportation applications each year.

## Benefits

Gravity walls or cantilever cast-in-place (CIP) concrete walls have worked well and are economical for some situations but in most cases cannot compete with MSE walls. The construction of MSE walls has become easier, faster, and more economical, particularly for fill projects, because the backfill material sometimes is available onsite. In addition, MSE walls can be built quickly from prefabricated materials such as precast concrete panels or modular blocks.

*Transportation Research Record 1414: Segmental Concrete MSE Walls, Geogrid Reinforcements, and Soil Nailing* provided case histories of the use and of the construction performance of MSE walls made of segmental concrete units (3). The construction of MSE walls generally costs 30 to 50 percent less than that of CIP concrete walls, depending on the wall height. The current estimated annual cost savings from the construction of MSE walls instead of CIP walls on the Interstate system is $180 million.

MSE walls also have greater flexibility and can tolerate significantly more total and differential settlement than can CIP concrete walls. MSE walls therefore offer viability to some design schemes that otherwise could not be possible.

The 140-ft high MSE wall at Seattle–Tacoma International Airport allowed for a critically needed third runway.

The introduction of MSE walls more than 30 years ago has changed the design and construction of highways. The benefits of MSE walls will be realized for another 30 years; more changes are to come. Two pioneers of this technology should be acknowledged: the French architect–engineer, Henri Vidal, who developed metallic-reinforced MSE; and Dick Bell of Oregon State University, who introduced geosynthetic MSE. Also noteworthy are the many research and development efforts by academia, industry, and public agencies.

## References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2. Christopher, B. R., S. A. Gill, J.-P. Giroud, I. Juran, J. K. Mitchell, F. Schlosser, and J. Dunnicliff. *Reinforced Soil Structures, Volume 1: Design and Construction Guidelines*. FHWA-RD-89-043, Federal Highway Administration, November 1990.
3. *Transportation Research Record 1414: Segmental Concrete MSE Walls, Geogrid Reinforcements, and Soil Nailing*. TRB, National Research Council, Washington, D.C., 1993.



*For more information contact Daniel Alzamora, Geotechnical Engineer, Federal Highway Administration, Resource Center, 12300 West Dakota Avenue, Suite 340, Lakewood, CO 80228, 720-963-3214, fax 720-963-3232, daniel.alzamora@dot.gov; and Richard J. Barrows, Geotechnical Team Leader, Federal Highway Administration, Western Federal Lands Highway Division, 610 East 5th Street, Vancouver, WA 98661, 360-619-7704, fax 360-696-7945, rich.barrows@fhwa. dot.gov.*



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Suggestions for "Research Pays Off" topics are welcome. Contact G. P. Jayaprakash, Transportation Research Board, Keck 488, 500 Fifth Street, NW, Washington, DC 20001 (phone 202-334-2952, e-mail gjayaprakash @nas.edu).