# Mechanically Stabilized Earth Walls with Intersecting Horizontal Obstructions

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**ABSTRACT**

Mechanically stabilized earth (MSE) walls are frequently constructed near drainage pipes, culverts, and other buried utilities located within the reinforced backfill or underlying foundation soil. The leakage, deterioration, or collapse of utilities can lead to the loss of backfill, differential settlement, deformation of the wall facing, and expensive repairs that may require excavation or partial reconstruction of the wall. Given these risks, guidance from federal and state transportation agencies regarding utilities located within or beneath Mechanically Stabilized Earth (MSE) walls is limited and inconsistent. This dissertation examines the mechanical interactions between MSE walls and intersecting horizontal utility pipes, and it offers mechanics-based recommendations for utility placement that ensure the stability and long-term performance of the walls.

The research combined a review of documented pipe leakages and current design practices with an extensive study of two- and three-dimensional finite-element analyses using PLAXIS. The numerical models were based on an actual 7.62-m-high MSE wall constructed by the Indiana Department of Transportation. A comprehensive parametric study was conducted to evaluate the effects of utility pipe diameter, burial depth, offset from the wall face, and orientation (parallel, perpendicular, or skewed) on the behavior of MSE walls. Pipe-collapse analyses were performed in sand, silty clay, and loam soils to establish minimum safe burial depths. The analyses were performed with either steel strips or geotextiles as reinforcement. Soil–geogrid interaction was investigated through laboratory pullout-test simulations, which demonstrated that a virtual soil-cluster interface model provided a more realistic representation of aggregate interlocking than the conventional interface reduction approach, and was therefore adopted throughout the geogrid analyses. Static and seismic loading conditions were considered, including a 1-Hz harmonic excitation and the scaled 2002 Darmstadt earthquake record, both with a peak ground acceleration of 0.29g.

The analyses showed that pipe orientation, diameter, burial depth, and reinforcement stiffness govern the interaction between utilities and MSE walls by redistributing stresses within the reinforced soil and modifying reinforcement response. In walls reinforced with steel strips, pipes

placed parallel to the wall face produced the greatest increases in reinforcement demand, with axial-force increases of up to 60% when the pipe diameter exceeded the reinforcement spacing. These effects were highly localized, generally extending no more than approximately 2–2.5 pipe diameters from the utility, and had little influence on the global stability of the wall. In contrast, pipes oriented perpendicular or skewed to the wall reduced reinforcement demand locally because friction mobilized around the pipe circumference provided additional resistance. A pipe underneath the wall and parallel to the facing primarily affected the lowest reinforcement layers.

For steel strip reinforced walls, the safe depth of a pipe during collapse has shown that, for the wall geometries and foundation soils investigated, collapse of pipes with diameters of 0.91 m or greater had a negligible effect on wall stability and performance when the burial depth was at least 10 times the pipe's radius for walls up to 7.62 m high and at least 11 times for walls between 7.62 and 12.2 m high.

Under both static and seismic loading, the presence of the pipe caused localized redistribution near the pipe of soil–reinforcement interface shear stresses, with greater effects at deeper pipe locations due to higher overburden stresses. Reinforcement stiffness significantly influenced this interaction. Geogrids permitted greater soil deformation and imposed higher thrust and bending-moment demands on the pipe. In contrast, steel strips provided greater soil confinement, reduced soil deformation, and produced a more favorable stress-transfer mechanism, particularly when the pipe diameter exceeded the reinforcement spacing. The harmonic excitation generated larger reinforcement forces, soil deformation, and pipe demand than the scaled earthquake record, demonstrating that loading history and frequency content influence wall response in addition to peak ground acceleration.

This research establishes a mechanics-based framework for evaluating utilities within and beneath MSE walls by integrating analytical solutions with idealized numerical models to explain the interaction between soil, reinforcement, and pipe. The findings provide practical guidance for utility placement and reinforcement selection while demonstrating that pipe orientation, burial depth, diameter, reinforcement type, and loading history should all be considered in design. Because the recommendations are based on the wall geometries, material properties, and loading conditions investigated, case-specific analyses remain necessary for applications outside the scope of this study.