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Hybrid Geogrid–J-Pin Reinforcement for GeoBarrier System

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Abstract

The Geobarrier System (GBS) is a composite system for enhancing slope stability, integrating a capillary barrier, a structural retaining component, and vegetative protection. In conventional GBS configurations, slope reinforcement is primarily governed by geogrid elements. However, achieving the required embedment length for geogrids often necessitates extensive excavation, resulting in increased construction time and cost. To address this issue, this study focuses on minimizing geogrid embedment length while maintaining adequate slope performance. Although earth nailing is a well-established technique in slope stabilization, its combined application with geogrid reinforcement has not been fully explored within a unified design framework. To bridge this gap, J-pin anchors are introduced at the ends of geogrids to offset the reduction in tensile capacity caused by shorter embedment lengths. In this investigation, the conventional embedment length of 0.7 times the slope height (H) was reduced to 0.6H, 0.5H, and 0.4H. J-pin installation was progressively applied starting from the lowest reinforcement layer. The study employed two finite element software, PLAXIS 2D and ABAQUS. PLAXIS 2D was used to provide calibration parameters for ABAQUS. Subsequently, ABAQUS was utilized to evaluate the mechanical response of modified configurations incorporating J-pin anchors. The findings indicate that variations in geogrid embedment length have negligible effects on pore-water pressure distribution. From a mechanical perspective, J-pin reinforcement effectively compensates for reduced embedment lengths in the 0.6H and 0.5H cases, with an optimal configuration of five J-pins. However, increasing anchorage density alone cannot fully substitute for insufficient embedment. Additionally, J-pins were found to contribute up to 19.3% of the total reinforcement force, highlighting their role in enhancing the composite interaction with geogrid systems.

Keywords: Unsaturated soil; Finite Element Method; Slope stability; Capillary Barrier System; Geobarrier System