Numerical Assessment of Shallow-Rooted Vetiver Reinforcement in Man-Made Slopes under Rainfall Infiltration

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Abstract:

Rainfall infiltration is one of the primary factors contributing to the instability of engineered slopes. Vegetation-based reinforcement offers a sustainable and cost-effective approach for improving slope performance under adverse environmental conditions. This study evaluates the effectiveness of a shallow-rooted vetiver grass (*Chrysopogon zizanioides*) system in enhancing the stability of a man-made slope subjected to prolonged rainfall infiltration. A finite element framework was employed to simulate transient seepage and slope responses under a prolonged variable-intensity rainfall event. To assess the contribution of root reinforcement, the performance of the vetiver-reinforced slope was compared with that of an unreinforced baseline slope under identical rainfall and loading conditions. The root system was represented using an equivalent truss-based network with mechanical properties derived from published experimental relationships. Hydromechanical responses, including pore-water pressure distribution, displacement characteristics, equivalent plastic strain (PEEQ), and the factor of safety, were evaluated for both cases. The shallow-rooted vetiver system increased the factor of safety by approximately 7.7%, from 1.3 to 1.4, under rainfall conditions. The PEEQ contours showed a modest widening of the plastic strain zone while maintaining a similar overall failure mechanism. The pore-water pressure distribution and displacement contours remained broadly similar to those of the baseline slope. The findings highlight the effectiveness of shallow-rooted vetiver reinforcement in improving the stability of man-made slopes subjected to prolonged rainfall infiltration.

Keywords:

Vetiver grass, rainfall infiltration, unsaturated soil, finite element analysis, slope stability, factor of safety.