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Experimental and Predictive Study on Deformation Characteristics of Geogrid-Reinforced High-Liquid-Limit Clay Considering Additional Equivalent Stress: Postprint

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Abstract

Most areas in southern China are characterized by a hot and humid climate. High liquid limit clay, when employed as subgrade fill material, exhibits relatively low bearing capacity and shear strength, necessitating reinforcement and improvement during construction, among which geogrid reinforcement technology represents a common physical stabilization method for subgrades. To accurately characterize the resilient and permanent deformation characteristics of geogrid-reinforced high liquid limit clay, this paper establishes a prediction model for the resilient modulus and permanent deformation of such materials that incorporates the relative displacement between geogrid and soil, lateral confinement effects of geogrid, and the influence of compaction process, thereby quantifying the impact of geogrid lateral confinement on soil resilient modulus and permanent deformation. Experimental investigations were conducted on the resilient modulus and permanent deformation of geogrid-reinforced subgrade soil under various conditions encompassing different geogrid types, reinforcement configurations, confining pressure levels, and deviatoric stress levels, analyzing the influence of each factor on the deformation characteristics of reinforced subgrade soil. The experimental results demonstrate that geogrid reinforcement increases both the cohesion and internal friction angle of the soil, with double-layer reinforcement proving superior to single-layer reinforcement, and biaxial geogrid reinforcement outperforming triaxial geogrid reinforcement. Furthermore, the reinforcement effectiveness exhibits positive correlation with geogrid tensile strength. Geogrid reinforcement enhances the soil's resilient modulus, though the improvement rate decreases with increasing deviatoric stress level. Conversely, geogrid reinforcement reduces permanent deformation under cyclic loading, with the reduction rate increasing with deviatoric stress and decreasing with confining pressure. The prediction accuracy of the newly developed resilient modulus and permanent deformation model for geogrid-reinforced subgrade soil, based on additional equivalent stress, was validated through experimental testing. The proposed model can accurately predict the resilient modulus and permanent deformation of subgrade soil across different geogrid types, reinforcement configurations, stress levels, and loading cycles, providing valuable guidance for the design and engineering practice of geogrid-reinforced subgrades.

Full Text

Characterization and Prediction of Deformation Characteristics of Geogrid-Reinforced High Liquid Limit Clay Subgrade Based on Equivalent Additional Stress Principle

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Abstract

In most regions of southern China, the hot and humid climate results in high liquid limit clay subgrade materials exhibiting low bearing capacity and shear strength, necessitating reinforcement during construction. Geogrid reinforcement represents a common physical stabilization method for such subgrades. To accurately characterize the resilient and permanent deformation behavior of geogrid-reinforced high liquid limit clay, this study develops a predictive model for resilient modulus and permanent deformation that incorporates the effects of geogrid-soil relative displacement, geogrid lateral confinement, and compaction processes, thereby quantifying the influence of geogrid confinement on soil deformation properties.

Comprehensive laboratory testing was performed to investigate the resilient modulus and permanent deformation of geogrid-reinforced subgrade soil under various conditions, including different geogrid types, reinforcement configurations, confining pressures, and deviatoric stress levels. The experimental results demonstrate that geogrid reinforcement significantly enhances soil cohesion and internal friction angle, with double-layer reinforcement outperforming single-layer configurations and biaxial geogrids proving more effective than triaxial geogrids. Furthermore, the reinforcement efficacy exhibits positive correlation with geogrid tensile strength. Geogrid reinforcement increases soil resilient modulus, though the improvement rate diminishes with increasing deviatoric stress. Conversely, geogrid reinforcement reduces permanent deformation under cyclic loading, with the reduction rate increasing under higher deviatoric stress but decreasing under higher confining pressure.

The proposed model based on the equivalent additional stress principle was validated through experimental data, demonstrating its capability to accurately predict the resilient modulus and permanent deformation of reinforced subgrade soil across various geogrid types, reinforcement methods, stress levels, and load cycles. This model provides a valuable reference for the design and engineering implementation of geogrid-reinforced subgrades.

Keywords: roadbed engineering; geogrid; dynamic triaxial test; resilient modulus; permanent deformation; equivalent additional stress

Note: Figure translations are in progress. See original paper for figures.

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