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摘要集

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目 录

Use of soilbags to protect flexible pipes against repeated load effects

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Abstract: An investigation was made of the over-trench bridging effect provided by soilbags to reduce the pressure on, and vertical and horizontal diametral change (*VDC* and *HDC*) of, buried flexible pipes, along with reductions in trench surface settlement (*TSS*). Full-scale tests examined the effects of burial depth, soilbag width, number of soilbag layers and distance between layers in trenches with 250-mm diameter pipes subjected to 150 surface loading cycles that simulated vehicular traffic. TSS reduced most when a soilbag was nearest the surface, while positioning a soilbag over the pipe's crown best protected the pipe. The soilbag's width must exceed 1.2 times the loading surface diameter/width to prevent unhelpful downward (punching) movement of soilbags into the trench backfill. Increasing soilbag width beyond 1.6–2 times that diameter/width or using more than two (sometimes three) soilbag layers, delivers diminishing returns. Using one to four soilbag layers, *TSS*, *VDC* and pipe pressure reduce to 45-15%, 70-15% and 75-25% of the unreinforced values, respectively, though the improvement rates diminish with increasing layers. Overall, TSS and pipe protection are similarly sensitive to the positioning of two layers of soilbags, while the spacing between the layers has the opposite effect.
Keywords: Geosynthetics, Soilbag, Buried pipe, Pipe deformation, Trench surface settlement

Influence of rainfall and drying periods on the performance of a large-scale segmental GRS wall model built with poorly draining local soil

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Abstract: The use of poorly draining local soils as backfill material in geosynthetic reinforced soil walls has become a common practice despite the known risks. With climate change effects, it is crucial to understand how these structures will perform under such extreme conditions. In this study, the performance of a large-scale model of a modular block geogrid-reinforced soil wall, using fine-grained backfill material, is evaluated under varying simulated rainfall intensities and drying periods. The model was constructed in a laboratory environment, enabling the implementation of an extensive instrumentation program designed to monitor soil suction, volumetric water content, and the resulting deformation and reinforcement strains. Tensile loads mobilized by the geogrid within the backfill soil and at the connection with block wall facing are discussed in the paper. The study demonstrates the satisfactory performance of a poorly draining reinforced soil wall even after prolonged and intense simulated rainfall. The low hydraulic conductivity of the well-compacted backfill soil, combined with significant surface runoff, helped maintain low levels of soil suction which reflects in apparent cohesion. Drying periods led to varying but significant rates of suction recovery influenced by rainfall-drying patterns. The findings indicate that rainfall intensities of 10 mm/h (240 mm/day) for over 7 days were insufficient to fully eliminate suction in a poorly draining geogrid-reinforced wall.

Keywords: Geosynthetic, Climate change, Large-scale, Soil suction, Rainfall,Cohesion

Shear behavior of saline soil-geotextile interfaces under freeze-thaw cycles

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Abstract: Volume changes in soil caused by freeze-thaw cycles can affect the shear performance of the saline soil-geotextile interface. To investigate this issue, the study examined changes in shear strength, deformation characteristics, and failure modes of the saline soil-geotextile interface under different numbers of freeze-thaw cycles. The experimental results indicate that with the increase in freeze-thaw cycles, the shear stiffness of the interface initially increases and then decreases, demonstrating the reduction in elasticity and resistance to deformation caused by freeze-thaw cycles. And the enhancement of normal stress can effectively increase the density of the soil and the adhesion at the interface, thereby improving shear stiffness. Meanwhile, the salt content in the soil also significantly impacts the mechanical properties, with notable changes in the dynamic characteristics of the interface as the salt content varies. Furthermore, after freeze-thaw actions, the soil becomes loose, reduces in integrity, features uneven surfaces, and sees increased internal porosity leading to slip surfaces. Trend analysis from this study provides new insights into the failure mechanisms at the saline soil-geotextile interface.
Keywords: Saline soil-geotextile interface, Freeze-thaw cycles, Dynamic shear haracteristics, Cyclic shear, Failure mechanisms

The effect of a bench on leakage through a cover: A field and numerical assessment

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Abstract: Field experiments are conducted to quantify the leakage through an 11-mm-diameter hole in the liner on slopes with and without a bench under waste cover conditions. Over 14 months, with a total precipitation of 947 mm, a 0.68 m bench on a 4H: 1V slope results in a 43-fold increase in leakage (from 6.5 L to 282 L) compared to the reference section without a bench. Substantial leakage is attributed to snowmelt occurring at low temperatures. 3D numerical modelling is conducted and shows good agreement with the measured leakage induced by both rainfall and snowmelt. Parametric studies are conducted to further analyze the impact of hole locations, slope length, and slope gradient on leakage. The validated numerical model is used to predict potential leakage in a real case scenario, which features benches formed by differential settlement observed after 3-year service as a landfill cover. This paper contributes to enhancing leakage prediction so as to optimize the design of slope and bench configurations in waste covers.

Keywords: Geosynthetics, Geomembrane, Leakage, Waste cover, Bench

Consolidation of slurry treated by PHDs-VP incorporating development process of clogged zone

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Abstract: The prefabricated horizontal drains combined with vacuum preloading (PHDs-VP) method exhibits significant benefits in dredged slurry treatment. This study introduces an analytical model of slurry consolidation treated by PHDs-VP. In this model, the PHD is treated as a permeable boundary with a vacuum pressure. The governing equations are established by dividing the analytical unit into normal zone and clogged zone, and by incorporating the development process of the clogged zone. Numerical solutions are obtained utilizing the finite difference method. The accuracy and reliability of the solutions are validated through both degradation analysis and experimental verification. Furthermore, a parametrical analysis is conducted to investigate the influence of several key parameters on consolidation behavior. The results indicate that the clogging effect significantly retards the consolidation process, with a lower permeability coefficient or a greater thickness of the clogged zone resulting in a more pronounced reduction in the consolidation rate. Additionally, the consolidation rate decreases with the accelerated development of the clogged zone, and this effect becomes more pronounced with denser PHDs layout.
Keywords: Consolidation, Prefabricated horizontal drains, Vacuum preloading, Development process of clogged zone, Clogging effect, Dredged slurry treatment

Critical state mechanics-based arching model for pile-supported embankments

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Abstract: The study and application of soil arching theory in geosynthetic-reinforced pile-supported (GRPS) embankments have gained increasing attention, as accurate arching estimation significantly influences load-deflection behavior of structures. While most existing models rely on Rankine's earth pressure theory, which applies primarily to granular soils and neglects cohesion effects. This paper employs three-dimensional numerical simulations to examine the impact of soil cohesion on soil arching mechanisms in pile-supported embankments. Results indicate that cohesion enhances load transfer to piles, with arching efficacy increasing nonlinearly before stabilizing at higher cohesion values. Building on these findings, the ground reaction curve (GRC) model is proposed to predict arching behavior in both cohesive and non-cohesive embankments at various deformation stages. By integrating critical state soil mechanics with the concentric arch model, the transition between maximum and critical arching states is captured through changes in the mobilized friction angle with relative displacement. Model validation against two well-instrumented case studies demonstrates its accuracy, particularly in accounting for soil cohesion. Moreover, the maximum arching model better predicts GRPS embankments under small deformations (relative displacement <4 %), while the critical arching model is more suitable for large deformations (relative displacement >6 %). The proposed model effectively captures arching behavior improvements in both cohesive and non-cohesive soils.

Keywords: Pile-supported embankment, Soil arching, Critical state mechanics, Concentric arches model, Cohesive soils, Ground reaction curve

Model tests on wicking geosynthetic composite reinforced bases over weak subgrade

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Abstract: Road performance is significantly enhanced by incorporating geosynthetics through their reinforcement and drainage functions. This study introduces a novel geosynthetic that integrates these functions. It is made of biaxial polypropylene geogrids heat-bonded to wicking nonwoven geotextiles (WNWGs). WNWGs are chemically treated to be hydrophilic and thus possess rapid wetting and wicking properties while preserving the large lateral drainage functionality of conventional nonwoven geotextiles. To assess the combined reinforcement and drainage performance of this material, a series of model tests including rainfall simulation and plate loading tests were performed on the WNWG-geogrid composite reinforced bases over weak subgrade using a customized model test apparatus. The results confirmed that the inclusion of wicking geosynthetic composite significantly enhanced drainage, stiffness, and bearing capacity of road bases compared to the conventional nonwoven geotextile-geogrid reinforcement and the unreinforced condition. The modulus improvement factor (MIF) for this wicking composite was 2.74 as compared to 1.46 for the conventional nonwoven geotextile-geogrid reinforcement. The findings from this study demonstrate the promising performance of this new composite and provide a valuable reference for full-scale tests and applications on roads.

Keywords: Wicking nonwoven geotextile-geogrid composite, Rainfall simulation, Plate loading test, Bearing capacity

Comparative numerical analysis of anti-liquefaction in sandy soil reinforced with OSC and GESC under sinusoidal loading

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Abstract: Three-dimensional numerical models are developed to investigate the anti-liquefaction of ordinary (OSCs) and geosynthetic-encased (GESCs) stone columns in sandy soil under sinusoidal loading using the fluid-solid coupling method. The validated models capture and compare the vertical and radial deformation, excess pore water pressure (EPWP), and vertical effective stress of OSC, GESC, and sandy soil. Furthermore, ten essential factors are selected to conduct the parametric study. Numerical results reveal that GESC is more suitable for improving sandy soil and resisting dynamic load considering the deformation and EPWP. The bulging deformation is no longer the primary reason for failure. The partial encasement (e.g., 1-2D, D = column diameter) and short floating and end-bearing GESCs (e.g., 1-2.5D) are not recommended for reinforcing the sandy soil. GESC is more sensitive to low-frequency and high-amplitude loads, with shear and bending, whereas displays a block movement under higher frequency and lower amplitude loading. The change in loading amplitude is more disadvantageous to GESC than loading frequency. GESC with a large diameter cannot effectively resist the dynamic loads.

Keywords: Geosynthetic, Anti-liquefaction, Ordinary and encased stone column, Sandy soil, Fluid-solid coupling method

Connection failure between reinforcement and facing in geosynthetic reinforced soil bridge abutments: A case study

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Abstract: Geosynthetic-reinforced soil (GRS) bridge abutments are increasingly used in transportation engineering. However, limited research has been conducted on the failure mechanisms of GRS bridge abutments, particularly the connection failures between reinforcement and facing. In this study, large-scale model tests were carried out to investigate the impact of connection failure between reinforcement and facing on the overall stability of GRS bridge abutments. The tests focused on a weaker connection configuration using low-strength cable ties subjected to high vertical loads. Photographic analysis was employed to document deformation and failure processes, while additional data were collected via sensors to monitor settlement, lateral displacement, and strain behavior during loading. The results indicated that inadequate connections between reinforcement and facing could result in progressive deformation, panel detachment, backfill leakage, and collapse under high loads. These findings underscore the importance of a strong connection between reinforcement and facing for maintaining structural stability. To address these issues, improved measures were proposed and validated, demonstrating significant enhancements in load-bearing performance and resilience.

Keywords: Geosynthetic-reinforced soil, Bridge abutments, Large-scale model test, Failure mechanism, Load-bearing performance

Study on the dynamic performance of heavy-load railway reinforced subgrade under flood condition

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Abstract: To mitigate the subgrade deterioration induced by water infiltration, geosynthetics are employed to reinforce overloaded railway subgrades. Indoor model experiments were conducted to simulate dynamic loads under different axle weights, investigating the impacts of immersion on the dynamic characteristics of reinforced subgrades. Results demonstrated that immersion significantly increased the subgrade's stress, settlement, and acceleration. Compared to submerged unreinforced subgrades after immersion, the geocell-reinforced subgrade exhibited a 33 % reduction in additional stress, while the composite-reinforced subgrade, comprising geocell and geotextile, exhibited a 35 % decrease. The geotextile was placed beneath the ballast layer, with the geocell positioned below the geotextile. Additionally, settlement at the middle sleeper was reduced by 29 % for the geocell-reinforced subgrade under 30 t load and 38 % for the composite-reinforced subgrade, demonstrating that reinforcement enhanced subgrade strength, stabilized the upper structure, and mitigated subgrade acceleration. After immersion, geotextiles play a crucial role in maintaining the integrity of the ballast layer and minimizing ballast contamination. A modified model for the additional stress distribution within the ballast layer has been proposed, whereby the additional stress at any point outside the projected surface of the ballast layer can be calculated based on the distances from both the side and front of the sleeper.

Keywords: Immersion, Overloaded railway, Reinforced subgrade, Acceleration, Settlement, Pore water pressure

Development and application of a nonlinear stress dilatancy model for geocell-reinforced soil via the FEM

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Abstract: To address the ambiguities in current ontological models of geocell-reinforced soil and the limitations inherent in finite element analysis methods, a nonlinear stress dilatancy model (NSDM) encompassing geocell-reinforced soil was successfully formulated. This model is based on the interaction between the geocell and the infilled soil, which can consider the confining pressures provided by the geocells and the stress dilatancy model of the soil. A finite element method (FEM) implementation of the model was achieved via the User-defined Material (UMAT) subroutine interface provided by ABAQUS software. Validation of the model was achieved via triaxial tests on geocell-reinforced sand with varying relative densities, as well as reinforced foundation and retaining wall model tests. Concurrently, the model calculation results were compared and analyzed with those obtained from a conventional separated model, and an in-depth exploration of the sensitivity of the model's key parameters was carried out. The findings demonstrate that the UMAT subroutine of the model can accurately predict the reinforced sand triaxial test, the reinforced foundation model test and the retaining wall model test results. Compared with the reinforced soil-separated model, the model delineated in this paper is easier to construct and has markedly improved computational efficiency. Additionally, the model can capture failure within the geocell fill, thereby affording a more precise depiction in the near-failure stage. This research offers an efficient and practical novel methodology for numerical analysis within the domain of geocell-reinforced soil.

Keywords: Geocells, UMAT subroutine, Jacobian stiffness matrix, Triaxial test, Foundation/retaining wall model test

Prediction method for lateral deformation of PVD-improved ground under vacuum preloading

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Abstract: A series of finite element analyses, conducted on the basis of modified triaxial tests incorporating radial drainage, were carried out to investigate the lateral deformation and stress state characteristics of prefabricated vertical drain (PVD) unit cells under vacuum preloading. The analyses revealed that the inward horizontal strain of the unit cell increases approximately linearly with the vacuum pressure (P_v) but decreases non-linearly with an increase in the initial vertical effective stress (σ'_{v0}). The variations in the effective stress ratio, corresponding to the median excess pore water pressure during vacuum preloading of the PVD unit cell, were elucidated in relation to the P_v and σ'_{v0} using the simulation data. Relationships were established between the normalized horizontal strain and normalized effective stress ratio, as well as between the normalized stress ratio and a composite index parameter that quantitatively captures the effects of vacuum pressure, initial effective stress, and subsoil consolidation characteristics. These relationships facilitate the prediction of lateral deformation in PVD-improved grounds subjected to vacuum preloading, utilizing fundamental preloading conditions and soil properties. Finally, the proposed methodology was applied to analyze two field case histories, and its validity was confirmed by the close correspondence between the predicted and measured lateral deformation.

Keywords: Geosynthetics, Prefabricated vertical drain, Vacuum preloading, Lateral deformation, Prediction method

Ensemble-based approach for automatic prediction of pullout resistance of geogrids in different soil types

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Abstract: Determination of the pullout resistance of geogrid, an essential parameter in MSE wall design, is time-consuming and expensive. The present study applies ensemble methods, namely, random forest, gradient boosting, extreme gradient boosting (XGB), and light gradient boosting to predict the pullout resistance factor *(F^**) of geogrid. An extensive review resulting in a large pullout test dataset of 759 data points encompassing various influencing features such as normal stress, relative compaction, fines content, average particle size of fill material, embedment length, ultimate tensile strength, and longitudinal and transverse spacing of ribs of the geogrid, and pullout displacement rate is used to evaluate models. Results showed that the XGB (R^2 = 0.91 and RMSE = 0.18) outperformed the other ensemble approaches. Based on the feature importance analysis on the best-performing XGB model, normal stress, reinforcement embedment length, and relative compaction are found to be the most influencing parameters affecting F^* . A simplistic model to predict F^* as a function of only these three influencing parameters is proposed considering the ensemble model. Furthermore, limited laboratory pullout experiments are performed to evaluate these models. The proposed machine learning models fitted very well with the laboratory F^* values with an error within ±3 %.

Keywords: Ensemble methods, Pullout resistance factor, Geogrid, Sensitivity analysis

Tensile failure mechanism and stress-strain behavior of scratched HDPE geomembranes

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Abstract: In the application of geomembranes (GMBs) for anti-seepage purposes, damage and defects are almost inevitable and can lead to premature failure during their service life. This study conducted a series of indoor tensile tests on defective GMBs to evaluate the effects of various defect types, locations, and geometric characteristics on their failure behavior. The results were validated through orthogonal tests to determine the influence of defect quantity and combination patterns on GMB performance. Furthermore, the performance at different stages was assessed under the condition of varying scratch geometric characteristics. The findings indicate that scratches pose a greater threat to GMB performance compared to other defect types. At the same angle, variations in scratch position have a negligible effect on mechanical properties. Among scratch geometric characteristics, length and angle are the primary factors affecting performance. For practical engineering applications, the allowable tensile stress range for scratched GMBs should be maintained between 2.97 and 3.50 MPa, while the allowable tensile strain range should be confined to 1.78–3.30 %. The evaluation and prediction of each stage of scratched GMBs can provide references for design engineers and the repair of scratched GMBs.
Keywords: Geomembrane, Scratch, Stress, Strain