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摘要集

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目　录

Experimental study on the vacuum consolidation of recycled fibre-improved soft soils assisted with prefabricated vertical drain

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Abstract: Billions of face masks were discarded daily, causing severe environmental concerns. Recycling waste face masks presents a significant challenge. Meanwhile, the traditional vacuum preloading shows limitations on the performance on soft soil ground. This paper investigates the potential benefits of reusing Face-Mask Fibres (FMF) as an admixture to enhance the treatment effects of vacuum preloading on soft soils. The performance of an environmentally biodegradable type of Prefabricated Vertical Drain (PVD) is also compared with that of conventional PVD through a series of laboratory physical model tests. The settlement, distributions of vacuum pressure, porewater pressure, and water content were monitored. In addition, after vacuum preloading, the undrained shear strength of treated soil was determined. Scanning electron microscope tests were also carried out to analyse the microscopic structure of treated soil. Results reveal that face-mask fibres significantly improved the performances of vacuum preloading in terms of vacuum dewatering and strengthening. Furthermore, the rate of vacuum consolidation was accelerated due to the additional drainage channels provided by recycled face-mask fibres. Notably, the final water content of the treated soil decreased to 41.8%, which is markedly lower than the liquid limit of 63.9%. The undrained shear strength exhibited considerable improvement, nearly doubling in value. The mechanism of how FMF works was also discussed.

Keywords: Soft soil, Consolidation, Vacuum preloading, Wasted face mask fibre, Biodegradable prefabricated vertical drain

Estimation of the carbon sequestration potential of ecological retaining structures: A comparative study

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Abstract: In the pursuit of sustainable development, the environmental impacts of geotechnical engineering are often neglected. The utilization of geosynthetic-reinforced soil (GRS) and ecological slope protection technology presents promising and eco-friendly alternatives, paving the way for a cleaner future. In this study, the temporal and spatial distribution of the carbon coefficient (CC) and embodied energy coefficient (EEC) are characterized through data analysis. Subsequently, the impact of spatial factors on the total embodied carbon (TEC) is considered. Finally, the carbon sequestration effect of vegetation through photosynthesis is quantified to examine the long-term environmental impact of the selected design options. The findings suggest that embodied carbon (EC) is preferable as an indicator for environmental impact assessment. The GRS technology can effectively mitigate approximately one-third of the environmental impacts compared to conventional methods. Furthermore, when combined with vegetation, GRS technology can achieve net-zero emissions approximately 30 years after the construction of the ecological retaining structure. Although many factors are not considered in this study, the results may inform initial decisions to realize more sustainable infrastructure.

Keywords: Geosynthetics, Retaining structures, Embodied carbon, Vegetation, Carbon neutrality

Mitigating frost heave of an expansive soil channel reinforced with soilbags: Insights from physical model tests

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Abstract: Frost heave significantly affects the normal operation and long-term performance of expansive soil channels, and the soilbag reinforcement method offers a potential solution for its mitigation and control. To confirm the effectiveness of the soilbag reinforcement method in frost heave mitigation of expansive soil channels, a middle-scale model test apparatus was developed to be equipped with temperature control and water supply functions, and then two groups of physical model tests were conducted. The evolution of water and heat distribution, frost heave deformation, and surface morphology in expansive soil channels with and without soilbag reinforcement during the freezing process were carefully compared. The experimental results demonstrate that: 1) The developed apparatus presents excellent performance, which can accurately capture the freezing behavior differences between an expansive soil channel and a soilbag-reinforced channel. 2) Utilizing soilbags in expansive soil channels not only provides thermal insulation but also mitigates the segregation frost heave. 3) Soilbags have the ability to decrease water evaporation from the bagged expansive soil, effectively preventing the soil from shrinking due to water loss while also reducing uneven deformation. Furthermore, the frost heave mitigation mechanism of the soilbag-reinforced expansive soil channel was well illustrated with two idealized schematic diagrams.

Keywords: Geosynthetics, Soilbag reinforcement, Expansive soil channel, Model test, Frost heave mitigation

Investigation of geogrid-reinforced unbound granular material behavior using constant radial stiffness triaxial tests

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Abstract: A series of constant radial stiffness triaxial (CRST) tests were performed to investigate the long-term behavior of geogrid-reinforced unbound granular materials (UGMs). Two types of multi-stage cyclic loading tests were conducted with various vertical constant loads ($\sigma_{1,min}$). In the first type, $\sigma_{1,min}$ was maintained at 10% of the maximum axial stress at each loading stage to determine the resilient modulus. The results indicated that the inclusion of geogrid increased the resilient modulus by 21–25 MPa under various cyclic loads. In the second type of tests, three tests were performed with $\sigma_{1,min}$ of 5, 10, and 20 kPa, respectively, to investigate the effects of vertical constant loads on the contributions of geogrids to the confining stress and permanent deformation. The results showed that the inclusion of geogrid mitigated permanent deformation by enhancing the confining stress. However, an adverse effect of the geogrid on permanent deformation was observed when $\sigma_{1,min}$ was 5 kPa, which can be attributed to the loss of contact between the geogrid and aggregates. Furthermore, R-values and stress paths obtained in this study also demonstrated the capability of CRST tests in quantifying the effects of geogrids on UGMs under cyclic loadings.

Keywords: Unbound granular materials, Geogrid reinforcement, Constant radial stiffness triaxial test, Dynamic confining stress, Resilient modulus, Permanent deformation

Generation and prediction of defect in HDPE GMB serving as landfill base barrier

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Abstract: This study utilized electrical defects detection, correlation analysis, and regression analysis to conduct a prediction about the generation of defects in high-density polyethylene geomembranes (HDPE GMBs) in landfills. The findings revealed that the average defect density of 108 landfills was 15 defects/ha, and the average defect area was 122 cm^2/ha. Four out of the 11 potential indicators, namely construction unit qualification, HDPE GMB thickness, drainage media type, and drainage system structure, had a significant impact on the density of installation and total defects. Prediction models of installation and total defects, using the four key indicators as independent variables, could reasonably predict the occurrence of initial defects. The model supports the accurate prediction of landfill risk and the identification of high-risk sites, which is crucial for hierarchical classification management and risk control.

Keywords: Landfill, HDPE GMB, Initial defect, Prediction model

Optimal design and application of geogrid for ballasted track stabilization in high-speed railways

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Abstract: This study investigates the optimal design parameters and installation location for geogrid stabilization in ballasted tracks under high-speed train loads. By integrating discrete element simulations with full-scale model tests, the performance of ballasted tracks was evaluated across various geogrid aperture sizes, stiffnesses, and installation locations. Multiple ballast gradations and trackbed compaction levels were also analyzed to ensure the generality of the results. The discrete element simulations indicate that a geogrid with an aperture size-to-median ballast gravel size ratio of 0.83 and a stiffness of approximately 2.3 kN/m is most effective in minimizing trackbed settlement. Furthermore, installing the geogrid immediately above the subballast surface provides the greatest constraints on ballast displacement and rotation, while most effectively reducing trackbed settlement. Full-scale model tests involving millions of wheel-axle load cycles at moving speeds of up to 360 km/h and axle loads of up to 25 t corroborate these findings, confirming the reliability and practical applicability of the optimal geogrid parameters and installation locations identified through discrete element simulations. This research offers evidence-based guidelines for optimal design of geogrid-stabilized ballasted tracks under practical railway service conditions, thereby extending maintenance intervals and improving long-term performance.

Keywords: Ballasted track, Geogrid stabilization, Full-scale model tests, Discrete element simulations, Optimal design

Experimental and consolidation modeling of flowing mud during vacuum preloading considering transient clogging and vacuum pressure attenuation

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Abstract: The non-uniform dense soil column that forms around plastic drainage plates when using vacuum preloading to treat flowing mud exhibits varying clogging along the extension direction, which severely lowers both the consolidation effectiveness and rate of consolidation. A transient clogging model is established based on indoor tests conducted under varying vacuum pressure for analyzing the evolution and impact of soil column along the plastic drainage plate direction. The study reveals that the vacuum pressure attenuation alters soil water content, density, and permeability, resulting in the formation of a “carrot-shaped” clogging zone, which adversely affects the drainage rate and consolidation uniformity. Building on the transient clogging model, a vacuum consolidation analysis method is proposed taking into accounting for the nonlinear vacuum transfer and soil characteristics. The validity of the proposed method is confirmed through case studies, accompanied by a detailed parameter analysis and discussion.

Keywords: Vacuum preloading, Flowing mud, Transient clogging, Vacuum attenuation, Consolidation model

Numerical investigation of ground reinforced embankments: Structural geometry design

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Abstract: Ground reinforced embankment (GRE) is a common and efficient rockfall mitigation measure. However, due to the diversity of geometric dimensions and composite components of the embankments worldwide, the design methods have not yet been unified. This article proposes a DEM-based framework for modeling the GREs impacted by rockfalls, and to optimize the structural design by comparing the block-intercepting performance. The numerical model based on MatDEM is validated by restoring the Peila's field tests, and the simulated materials are calibrated by comparing the laboratory test results. The design elements can be determined through simulated impact tests, with the site topography and rockfall trajectory as prerequisite information. The simulation test results show that the structural positions and cross-sectional shapes alter the interaction between rockfalls and embankments, thereby affecting the block-intercepting capacity. Under the impact of high-energy blocks, the characteristic of structural failure is that the extrusion of the downhill face is greater than the displacement of the uphill face, which can be used as a criteria to determine the reasonable design elements. The proposed framework can be applied to an actual site and maximize the cost-benefit performance of design depending on the site space and budget conditions.

Keywords: MatDEM, Geosynthetics, Ground reinforced embankment, Rockfall, Design framework

Evaluation of two-layered soils reinforced with 3D printed geogrid models under axisymmetric loading conditions

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Abstract: A series of drained triaxial tests was carried out on homogeneous and two-layered soil (TLS) samples under low confining pressure. A granite aggregate was selected as the base layer, and sand was used to simulate the subgrade. Geogrids with varying aperture sizes and stiffness values were designed using CAD software and manufactured using 3D printing technology. A method for correcting the cross-sectional area during triaxial TLS testing was developed. The load transfer at the aggregate-geogrid interface was also evaluated. The strength of the TLS samples increased as the relation between the aperture size of the geogrid and the median particle diameter was closer to unity. Consistent results were found for the polylactic acid (PLA), photopolymer (RGD 8560), and polypropylene (PP) geogrids, but better mechanical behavior was observed for the RGD 8560 geogrid. Higher tensile forces at the interface were mobilized in geogrids with greater stiffness. However, the best interface behavior is not solely governed by the geogrid stiffness.
Keywords: Geosynthetics, Soil-geogrid interaction, Triaxial test, Two-layered soils, 3D printing

Deformation and load transfer of pile-supported foundation reinforced with soilbags raft cushion

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Abstract: This study proposes a new pile-supported soilbags raft cushion for foundation treatment. A series of two-dimensional model tests were conducted on the reinforced foundation to investigate its deformation and load transfer characteristics. An analytical method was established to determine the surface pressure between the piles. The tests demonstrated that the soilbags raft cushion can reduce the differential settlement of the foundation by improving the uniformity of the load transfer. The deformation patterns and load transfer efficiency of the soilbags raft cushion reinforced foundation were found to be related to the pile spacing, the embedded depth of the pile top, the thickness of the soilbags raft cushion, and the external pressure applied to the foundation surface. The performance of soilbags raft cushion is more effective when the ratio of the embedded depth of the pile top to the pile spacing is at least one and the ratio of the thickness of the cushion to the embedded depth of the pile top is at least 0.2. The analytical method considers the relative pile-soil settlement and the elastic modulus of the soilbags raft cushion reinforced foundation, allowing for a reasonable evaluation of the surface pressure between the piles and the load transfer efficiency.

Keywords: Soilbags raft cushion, Model test, Analytical method, Deformation pattern, Load transfer