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摘要集

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目　录

Using EPS geofoam blocks to protect buried pipes against strike-slip fault movement

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Abstract: This study evaluates the benefits of the adoption of geofoam blocks to improve the seismic performance of buried steel pipes for simulating the complex material-structure interaction under strike-slip fault rupture conditions. Comparison of the response of improved models with conventional ones considering the parameters as fault crossing angle, fault slip amount and pipeline wall thickness is evaluated. A set of limit states was defined based on the violation of the tensile strain limit: onset of local buckling, rate of cross-sectional distortion and crushing of the EPS Geofoam blocks are adopted as performance criteria. Obtained results indicate that in general, the use of both low- and high-density geofoam blocks significantly improved the seismic performance of pipelines. The critical fault displacement value (d_{cr}) leading to failure increases by more than 130% for high-density EPS. Moreover, use of geofoam blocks led to a more distributed damage pattern along the pipe, thus reducing localized strain accumulation and eventually pipeline failure. Additionally, increasing the fault crossing angle (β) from 10° to 30° and reducing the pipeline diameter-to-wall-thickness ratio (D/t) from 144 to 58 to enhance the beneficial effect of geofoam blocks in critical fault displacement value seemed to be achievable.

Keywords: Geosynthetics, Buried steel pipes, Strike-slip fault, EPS geofoam, Damage mitigation, UN SDG 9: Industry, innovation and infrastructure, UN SDG 13: Climate action, Geohazard mitigation

Airlift-assisted vacuum preloading: application of airlift via PVDs in vacuum preloading

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Abstract: To improve consolidation pressure along the prefabricated vertical drain (PVD), the presented study introduced a novel technique, airlift-assisted vacuum preloading, which incorporated the concept of airlift into traditional vacuum preloading. The innovative approach involves intermittent injections of pressurized air at the bottom of the PVD. A laboratory test captured direct observation of the fluid state in the PVD, and confirmed that water accumulated in the PVD could be efficiently expelled in a two-phase flow manner by the force of air. When the airlift was stopped, the air remaining in the PVD was quickly expelled, allowing the vacuum pressure to be transmitted without loss. Consequently, the distribution pattern of consolidation pressure was improved to trapezoidal-shaped that increased with depth. The efficacy of this method was validated against conventional vacuum preloading through a 4 m model test, revealing that water discharge rate improvement peaked at 74.2% after airlift, total water discharge increased 32.2% and vane shear strength of soil in the airlift-assisted method improved to over 20 kPa. The results demonstrate the superior performance of airlift-assisted vacuum preloading over the traditional method. Additionally, installation of airlift systems in engineering practice was discussed and related equipment was designed, which provided feasibility of the presented method in real projects.
Keywords: Geosynthetics, Vacuum preloading, Airlift, Vacuum loss, Consolidation pressure, Ground improvement, Consolidation, Ground improvement

Serviceability performance of piled embankments considering soil-reinforcement interface interaction

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Abstract: Geosynthetic reinforced and pile-supported (GRPS) embankment has been widely used to address the problem of insufficient bearing capacity in soft soil areas. A simplified method is proposed here to assess the serviceability performance of GRPS embankments where the evolution of soil arching and the development of subsoil consolidation have been synthetically considered. The main innovation is that the effect of the soil-reinforcement interface interaction is particularly focused. The proposed method is validated based on the field test results and thereafter a parametric study is performed. It shows that the soil-reinforcement interface interaction decelerates the subsoil consolidation and thus suppresses the subsoil settlement. The interface interaction roughly improves the load-transferring efficiency by imposing a lesser load on the subsoil and transferring more load on piles. Enhancing the soil-reinforcement interface interaction inhibits the development of load recovery, leading to the stress carried by the subsoil and the geogrid after maximum arching drops. The effects of the coefficient of consolidation, the pile spacing and the geogrid stiffness on the serviceability performance of the GRPS embankment are investigated when involving varied interface interactions. The beneficial effect of the interface interaction is more pronounced when a greater pile spacing and a lower geogrid stiffness are involved.

Keywords: Geosynthetics, GRPS embankment, Serviceability performance, soil-reinforcement interface interaction, Soil arching, Subsoil consolidation, Roads & highways, Service life

3D-printed AD-EKG for reinforcement and remediation of heavy metal-contaminated soils

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Abstract: Metal electrode corrosion and soil shrinkage in electrokinetic remediation and reinforcement may lead to poor electrode-soil contact and increased interfacial resistance during the mid-to-late stages of electro-osmosis. In this study, two plain-woven electrokinetic geotextiles using carbon fiber and polyester were fabricated to avoid the corrosion of electrodes, and a deformable support (DS) was developed using 3D printing technology to adapt to soil shrinkage. Comparative experiments were conducted to evaluate the performance of different electrode materials and DS in electrokinetic remediation and reinforcement. The results demonstrated that electrokinetic geotextiles with higher carbon fiber content could slow the increase of anodic interfacial resistance and exhibit better electro-osmotic drainage performance. The incorporation of DS could effectively improve the contact between electrode and soil, thereby further enhancing electro-osmotic drainage efficiency. Based on a soil resistivity model and monitoring results of the voltage at both ends of the soil, electric current and cumulative drainage volume, the copper ion content in the soil initially declined and then leveled off in the mid-to-late stages, as validated by both measured and predicted results. Compared to traditional metal electrodes, the adaptive deformable electrokinetic geosynthetics (AD-EKG) achieved more effective performance of electrokinetic remediation and reinforcement.

Keywords: Geosynthetics, Ground improvement, Deformable support, Interfacial resistance, Copper-contaminated soil, AD-EKG

Perfluoroalkyl substances (PFAS) partitioning into a high-density polyethylene geomembrane

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Abstract: This paper investigates how five PFAS congeners, namely, perfluorooctanoic acid (PFOA), perfluorooctanesulfonic acid (PFOS), perfluorohexanoic acid (PFHxA), perfluorobutane sulfonate (PFBS) and trifluoromethanesulfonic acid (TFMS), interact with a high density polyethylene (HDPE) geomembrane, through equilibrium batch sorption tests, to assess its ability to minimise the migration of these contaminants. The sorption experiments show that the HDPE geomembrane exhibits varying degrees of uptake for different pollutants, in the following order: PFBS = TFMS < PFHxA < PFOA < PFOS. Additionally, minimal partitioning of PFAS congeners to the HDPE geomembrane was observed, with longer-chain PFAS exhibiting higher partitioning coefficients. This indicates that an intact HDPE geomembrane can potentially slow down the migration of these pollutants. PFOS exhibited a slightly stronger affinity than PFOA, likely due to its stronger hydrophobicity and/or higher electronegativity.
Keywords: Geosynthetics, Geomembranes, PFAS, Sorption, UN SDG 12: Responsible consumption and production, Adsorption, Waste Containment & disposal system, Contaminants

DEM–FDM analysis in stereoscopic geogrid-reinforced interface under cyclic loading

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Abstract: Stereoscopic geogrids with thickened transverse ribs present a promising approach to improving interface strength in reinforced soil systems. To investigate particle mobilization and energy dissipation under dynamic loading, cyclic shear tests and 3D discrete–continuous coupled numerical simulations were conducted on coarse particle interfaces reinforced with 3D-printed stereoscopic geogrids. This study examines the influence of thickened transverse ribs on the hysteretic response and interface strength from both macroscopic and mesoscopic perspectives. Results indicate that during cyclic loading, the shear strength and energy dissipation ratio of the geogrid-reinforced interface remained stable, with no notable fluctuation. The nonlinear hysteretic behavior observed in cyclic shear tests is closely linked to energy dissipation mechanisms at the particle scale. Compared to planar geogrids, stereoscopic geogrids increase particle interlocking, reduced frictional slip, and facilitated greater storage of periodic strain energy, leading to lower energy dissipation ratios. The average force chain strength was higher in stereoscopic geogrid-reinforced interfaces, with more vertically aligned force chains that enhanced load transfer across a broader shear band. Stereoscopic geogrids also mobilize bearing resistance more effectively, particularly in low-contribution areas, thereby enhancing overall interface performance. Overall, stereoscopic geogrids demonstrated superior strength mobilization and dynamic performance compared to their planar counterparts.

Keywords: Geosynthetics, Dynamics, Interfaces, Soil–geosynthetic interaction, DEM–FDM, Transverse-rib thickness

Rheological properties and viscoelastic model of sensor-enabled piezoelectric geocable

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Abstract: Sensor-enabled piezoelectric geocables (SPGC) have attracted widespread attention as an emerging technology due to their effective strain and vibration monitoring effects. However, the mechanical and electrical properties of SPGC during long-term rheological processing remain unclear. In this study, the stepped isothermal method (SIM) was used to perform creep tests under different constant loads, and stress relaxation tests were conducted under different initial strains and strain rates. The creep test results show that SPGCs exhibit a decaying creep curve and are a typical viscoelastic-plastic material. The time-strain and the time-normalized impedance change value curves of SPGC conform to the logarithmic creep empirical model and viscoelastic constitutive model. The normalized impedance change value of SPGC increased with the increase of initial stress level and creep strain. At initial stress levels of 30%, 50%, and 60%σT, the creep strains of SPGC after 51.3 years were expected to reach 1.08%, 3.29%, and 5.31%, and the corresponding normalized impedance change values would reach 0.0771, 0.1704, and 0.2246. The results of the stress relaxation test showed that the normalized impedance change value of SPGC decreased with stress relaxation. The normalized impedance change value had a linear functional relationship with both the initial strain and the strain rate. The tensile strain and strain rate of SPGC caused by the sliding surface of the soil can be determined by monitoring the rate of growth of the normalized impedance change value. The research results fill a gap in the long-term rheological properties of SPGC and provide support for further practical applications of SPGC.

Keywords: Geosynthetics, Sensor-enabled piezoelectric geocable, Distributed monitoring, Creep, Stress relaxation, Land surveying, Non-destructive testing, Service life

Drainage performance of wicking geotextiles under rainfall and capillary rise conditions

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Abstract: Wicking geotextiles have been developed to overcome the limitations of conventional geotextiles in unsaturated soil conditions. Over the past decade, research has demonstrated the effectiveness of woven wicking geotextiles in draining capillary water and improving lateral drainage. However, the performance of nonwoven wicking geotextiles under different drainage conditions remains largely unexplored. This study assesses the effectiveness of nonwoven wicking geotextiles in various unsaturated soils using soil column and soil box tests to simulate capillary rise and rainfall, respectively. In the column test, clayey sand was used to evaluate capillary rise, while the box test examined two subgrade materials: Ottawa sand (well-draining) and clayey sand (poorly draining). Volumetric water content was monitored under three conditions: wicking geotextile, non-wicking geotextile, and a control with no geotextile. Results indicate that the wicking geotextile significantly restricts capillary rise, reducing it by around 100 mm in clayey sand columns. After rainfall, wicking geotextile prevents water accumulation above the geotextile and enhances drainage efficiency in both sand types, with superior performance in Ottawa sand. By limiting upward water movement and promoting effective drainage, the wicking geotextile mitigates moisture-induced instability risks in embankments, offering substantial advantages over conventional geotextiles for geotechnical drainage applications.
Keywords: Geosynthetics, Wicking geotextile, Water content, Rainfall, Capillary rise, Unsaturated soils

Freeze-thaw durability of fiber-lime-soil based on mechanical damage and crack features

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Abstract: :Freeze-thaw cycling damages soil structure, leading to degradation of mechanical properties. A series of tests—including freeze-thaw cycling test, unconfined compressive strength (UCS), splitting tensile, computer tomography (CT), and scanning electron microscopy (SEM) tests—were conducted on lime-soil and fiber-lime-soil to investigate the degradation laws of mechanical properties and microstructural damage characteristics. Results demonstrated that the UCS, tensile strength, and peak strain of both lime-soil and fiber-lime-soil decreased in three distinct stages: a high-decline-rate stage, a low-decline-rate stage, and a stable-strength stage. Fiber-lime-soil exhibited superior mechanical performance compared to lime-soil. As the number of freeze-thaw cycles increased, the mean crack length, crack width and crack ratio of both soils increased. However, fiber-lime-soil showed fewer cracks and lower crack connectivity than lime-soil, indicating that fiber reinforcement enhanced crack resistance. Lime significantly improved soil strength, while fibers improved deformation resistance through interfacial forces and spatial-constraint effects between fibers and soil particles. The findings contribute to understanding the freeze-thaw resistance mechanisms of fiber reinforced soil, elucidating the relationship between strength deterioration and microstructural damage, and evaluating the freeze-thaw durability of such soils in seasonally frozen regions.
Keywords: Geosynthetics, Fiber reinforced soil, Freeze-thaw cycling, Compression strength, Tensile strength, Crack characteristic, Reinforced soil, Polypropylene, Crack feature

Influence of foundation soil conditions on the service performance of GRS abutments

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Abstract: This paper presents a numerical investigation of the influence of foundation soil conditions on the performance of geosynthetic reinforced soil (GRS) abutments under service load conditions. The backfill soil was considered as a dense sand, and the foundation soils were simulated with four different granular soils representing different density states ranging from loose to very dense sand. The backfill soil and foundation soils were simulated using a nonlinear elastoplastic constitutive model. Results indicate that as foundation soil density decreases, facing displacements and bridge seat settlements increase, and the effect becomes more pronounced for higher vertical stress. The maximum tensile forces in the bottom layer are much larger when constructed on loose foundation soil due to the lower stiffness and strength. A parametric study was conducted to evaluate the influence of reinforced soil foundation (RSF) on the performance of GRS abutments constructed on loose granular foundations. The implementation of RSF could effectively reduce abutment deformations and reinforcement tensile forces, and the GRS abutment would show good performance similar to that constructed on a competent foundation.
Keywords: Geosynthetics, Geosynthetic reinforced soil, Bridge abutment, GRS abutment, Foundation soil, Reinforced soil foundation, Ground improvement

Direct relaxation method to calculate stresses induced by gravel particles in a geomembrane

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Abstract: A new method, direct stress relaxation, was developed, verified and applied to calculate local geomembrane stress from local strain induced by gravel particles. The method utilizes the fading memory concept whereby the deformation path is taken to have a minor effect on stress if strains remain constant for some time before calculating stress. The method requires a geomembrane time-dependent material model, test time and final local strain to calculate stress. The method was tested against, and was in good agreement with, stresses from finite element models simulating physical tests. The new method was applied to analyse the deformed shape of a geomembrane from a physical test with coarse gravel above a geomembrane to examine new insights into local stresses gained from protection layer testing. Local strains were deduced from the deformed shape using thin plate theory and strains were converted to local stress by the direct stress relaxation method. The local stress results showed that different major tensile strain can develop under different major and minor local stresses. The new direct stress relaxation method now provides the ability to calculate local stress in addition to just strain, which may be used to unlock new insights into local stress rupture.
Keywords: Geosynthetics, Geomembrane, Viscoplastic, Local stress, Local strain

Experimental evaluation of a newly developed nanocoating for EPS

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Abstract: Expanded Polystyrene (EPS) is widely used in geotechnical applications, where its durability depends on geomembrane protection. The aim of this study was to develop a new eco-friendly nanocoating for EPS, that can resist hydrocarbons, made of polyurethane and nanocellulose extracted from sugarcane waste. The nanocoating is proposed as an alternative in certain cases when it is impractical or uneconomic to use geomembrane. Experimental testing showed full resistance of the nanocoated EPS against diesel, in addition to a water absorption percentage below 2.7% by weight. The static and dynamic properties were also measured, as well as the interface properties of the nanocoated EPS samples with sand and concrete. Results showed that the compressive and flexural strength of the nanocoated samples significantly improved by 38% and 110%, respectively, compared with uncoated samples. The interface and dynamic properties showed great enhancement. Additionally, an economic feasibility study was performed to compare the use of nanocoating and geomembrane across the manufacturing, transportation, and construction stages to evaluate their economy, whereas results indicated that nanocoating is about 7.1% lower in cost. In general, the outcomes indicate that the newly developed nanocoating is a promising option that can be used to protect EPS and enhance its performance.

Keywords: Geosynthetics, EPS, Protection, Geomembrane, Eco-friendly, Nanocellulose, Nanocoating, Polyurethane, Compressive strength, Interfaces, Damping, UN SDG 9: Industry, innovation and infrastructure, UN SDG 11: Sustainable cities and communities