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Freeze-thaw behavior of geocell-reinforced bases considering different fines contents

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Abstract: Freeze-thaw (F-T) cycles are a major cause of pavement distress in seasonal frost regions, and the presence of fines in bases can accelerate the pavement degradation induced by cyclic freeze and thaw. Among countermeasures used to mitigate the F-T induced damages in pavements, geocell-reinforced bases can be an effective solution in mitigating F-T damage to cold region roads. However, there is almost no research dedicated to understanding the potential benefit of geocells and the underlying mechanisms in this regard. This study employed a custom-made model test device to investigate the F-T performance of geocell-reinforced sands considering different fines contents. The experimental results showed that the increase in fines content substantially increased the peak heave and thaw settlement and decreased the stiffness and ultimate bearing pressure. The application of geocells reduced the peak heave and thaw settlement by 11–18% and 22–35%, respectively, but this benefit was negligible at high kaolin content (12%). The use of geocells increased the stiffness and ultimate bearing pressure by about 43–90% and 41–73%, respectively, after five F-T cycles. The findings of this study are relevant to the design of geocell-reinforced bases under F-T cycles and advance the understanding of the underlying mechanisms.
Keywords: Geosynthetics, Model tests, Geocell, Freeze and thaw, Fines

Performance of landfill low-permeability liners for minimizing groundwater contamination

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Abstract: Low-permeability liners are required at the base of municipal solid waste (MSW) landfills to minimize leachate leakage and contaminant migration into groundwater. This paper uses a two-dimensional coupled groundwater flow and contaminant transport model to examine the performance of three types of low-permeability liners specified by the current Chinese landfill standard: (1) a compacted clay liner (CCL), (2) a geomembrane (GMB) overlying a CCL, and (3) a GMB overlying a geosynthetic clay liner (GCL) on a CCL. The model simulates leachate leaking and contaminant migrating over the entire base of the landfill for the CCL and through the holed GMB wrinkles for the GMB composite liners. The performance of each type of low-permeability liners was evaluated and compared in terms of leakage rate and peak impact of chloride on the aquifer. Based on liner cases and conditions examined in this paper, the results show that the three types of low-permeability liners are not equivalent for minimizing the leakage rate and chloride impact on the aquifer. The GMB+GCL+CCL performs the best among the three low-permeability liners, and is effective for limiting the peak chloride impact on the aquifer below the acceptable level in drinking water.

Keywords: Geosynthetics, Landfills, Low-permeability liners, Groundwater contamination, UN SDG 6: Clean water and sanitation

Compressive and shear response of fibre-reinforced backfill: impact of field temperature

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Abstract: Fibre-reinforced cemented paste backfill (F-CPB; a mixture of tailings, fibre, cement, and water) is exposed to non-isothermal curing environments in the field. However, no investigations have been conducted on the impact of non-isothermal curing environments on F-CPB compressive strength, shear characteristics and stress–strain behaviour, although these are important design parameters for F-CPB structures. Therefore, a series of mechanical and microstructural tests were performed on samples with and without fibres exposed to isothermal and non-isothermal conditions. It was found that the non-isothermal curing condition substantially enhances the F-CPB compressive strength and strength gain ratio. The shear strength, cohesion and internal friction angle of the F-CPB samples cured under non-isothermal conditions were higher than those cured under isothermal conditions. These impacts of non-isothermal curing on the compressive and shear characteristics of F-CPBs are related to the temperature-induced change in the microstructure of these samples. The F-CPBs cured under non-isothermal conditions had more hydration products than those cured under isothermal conditions. Moreover, mercury instrusion porosimetry (MIP) tests showed that the F-CPBs subjected to non-isothermal conditions had a finer pore structure than those exposed to isothermal conditions, which contributed to an enhancement of the mechanical characteristics of the F-CPBs subjected to non-isothermal curing.

Keywords: Geosynthetics, Tailings, Fibre reinforcement, Composite materials, Geotechnical engineering

Investigation of rubber content and size on dynamic properties of expansive soil–rubber

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Abstract: Waste rubber has been widely applied in geotechnical engineering, benefiting from its light weight, high elasticity, low density, good durability and high compressibility. In this paper, the effects of rubber content (RC) and rubber size (d_0) on the dynamic properties of expansive soil–rubber (ESR) were investigated by low-temperature dynamic triaxial tests. The results show that: (1) the shear stress of ESR decreases with the increase of RC with a particle size ratio of 1.3, but first decreases and then increases with a particle size ratio of 2.4; (2) the RC threshold between soil-like and rubber-like ESR is 10%; (3) the maximum shear modulus ratio of ESR occurs at RC=10% and d_0=0.25 mm, with the best dynamic performance; (4) the hysteretic curve of ESR was flat and elliptical, deviating upward to the right at freezing condition. In addition, different contact modes between rubber and expansive soil are proposed and the contact mechanism has been revealed.

Keywords: Geosynthetics, Waste rubber, Expansive soils, Dynamics, Damping ratio

Image-aided physical and compression characterisation of expanded polystyrene geofoam

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Abstract: The present study focuses on an advanced and accurate characterisation of the compressive behaviour of expanded polystyrene (EPS) geofoam with the aid of imaging techniques. To this end, four types of EPS geofoam with nominal densities varying from 15 kg/m^3 to 30 kg/m^3 are used. Initially, a detailed physical characterisation is carried out including image-based microstructural quantification (cell size, void fraction, population density), homogeneity using ultrasonic pulse velocity and apparent density. Insights into the compression behaviour of the geofoams, including true strains and failure patterns, are further gathered through full-field strain behaviour in the block using two-dimensional image correlation analysis. For the first time, the effect of nominal densities on the Poisson's ratio of geofoam is also studied through image analysis. The study reveals that compressive response is significantly influenced by homogeneity, which is manifested by the changes in microstructure and apparent density of the geofoam. Furthermore, the image analysis provides insights into the development of failure patterns and strain localisation and their dependency on density, comprehending the geofoam's complex behaviour. Predictions of compressive response based on apparent density and non-destructive tests are developed. The study further recommends safety factors for determining permissible and yield stresses based on statistical analysis.
Keywords: Geosynthetics, Morphology, Geofoam, Poisson’s ratio, Digital image correlation

Numerical simulation of the performance of GRS walls considering freeze-thaw cycles

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Abstract: In practice, little attention has been paid directly to freeze-thaw (FT) cycles during the design and analysis of geogrid-reinforced soil (GRS) walls due to a lack of relevant literature. This study investigates the pavement vertical deformation (s), panel lateral deformation (d), lateral earth pressure (σ_h), and geogrid strain (ε) of a field GRS wall using an ABAQUS-based numerical model considering variations of the recorded five-year ambient temperature (T_R). Numerical results show that the s distribution follows a convex shape instead of the initial concave shape after FT cycles and can be divided into high, transition, and stable deformation zones. FT action alters both location and amplitude of the maximum d within the first two cycles, making the d distribution evolve from a J-shaped curve into an S-shaped one. During freezing, the developments of s and d are coordinated and can be described using a unified model; σ_h is larger than the Rankine active earth pressure; ε state depends on the interplay of two factors resulting from d and frost heave force. Furthermore, the hysteresis of s, d, σ_h, and ε with T_R was discussed and several beneficial suggestions were proposed for GRS walls to avoid such FT destruction.

Keywords: Geosynthetics, GRS walls, Freeze-thaw cycles, Deformation, Hysteresis

Effect of a soluble subgrade on leakage through a geomembrane defect

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Abstract: Leakage and erosion of a soluble subgrade overlain by a geomembrane with a 70-mm-long slit defect is examined. The subgrade (gypsum) solubility and its rate of dissolution from a solid state in contact with various solutions are investigated. In the absence of flow, the rate of dissolution is negligible. However, when there is flow there is dissolution, and if the flow is high enough, erosion. Erosion greatly increases fluid migration. The presence of an interface between the subgrade and a dissimilar material (e.g. a geomembrane) facilitates flow, dissolution, and erosion as the interface becomes an ever increasing preferential flow path, leading to a much greater leakage and erosion feature. The findings from this study highlight the risk of having a soluble subgrade below a single geomembrane used alone and exposed for the containment of liquids.
Keywords: Geosynthetics, Geomembrane, Reservoir, Gypsum, Interface flow, Erosion

Induced trench installation of the high-density polyethylene pipe using geofoam inclusion

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Abstract: The effects of induced trench configuration and stiffness of compressible inclusion on the high-density polyethylene (HDPE) pipe behavior were investigated through full-scale laboratory tests. Two pipe-compressible inclusion configurations ('compressible inclusion over the pipe crown' and 'the pipe covered with compressible inclusion') were tested and expanded polystyrene (EPS) Geofoam with 10 and 15 kg/m^3 nominal density was used as compressible inclusion. To simulate geostatic stresses imposed by high embankment fill, the surcharge stress up to 200 kPa was applied on the surface of the burial medium. Comprehensive instrumentation was implemented to measure the pipe deflections, soil stresses on the pipe, and soil settlements in the pipe zone. Considering the pipe behavior and cost-efficiency together, the configuration in which one EPS geofoam panel with 10 kg/m^3 nominal density is placed over the pipe crown arises as the optimal solution for the induced trench HDPE pipe. This solution provided a reduction in the vertical stress at the pipe crown of up to of 76% and in the horizontal stress at the pipe springline of up to 65%. The vertical and horizontal pipe deflections are reduced by 87% and 60%, respectively, under 200-kPa surcharge stress. – that is, overburden pressure imposed by a 10-m-high embankment fill.

Keywords: Geosynthetics, HDPE pipe, EPS geofoam, Full-scale test, Soil arching, Instrumentation

Particle shape effect on interfacial properties between granular materials and geotextile

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Abstract: This paper presents an experimental study investigating the effect of particle shape of granular soils on the shear strength characteristics via direct shear tests. Thirty direct shear tests were conducted on spherical and crushed sand mixtures with different proportions (i.e. 0%, 25%, 50%, 75% and 100%). The overall regularity (O_R) parameter of sand particles varies between 0.788 and 0.909, fairly reflecting the particle shape of sand mixture. A particular relation between O_R and maximum shear strength was found, namely that maximum shear strength increases with a decrease in O_R. Furthermore, a gradual increase was observed in the improvement factor (I_f) due to geotextile reinforcement with an increase in O_R except for S25C75, representing 25% spherical and 75% crushed sand, at high and low normal stress levels (i.e. 29 kPa and 116 kPa). The interfacial friction angle (ϕ) of sand mixtures is improved by geotextile reinforcement. Additionally, geotextile reinforcement caused an apparent increase in ϕ with decreasing O_R values.
Keywords: Geosynthetics, Geotextile, Particle shape effect, Direct shear test, Interface friction, Overall regularity

Contribution of geosynthetic to the shear strength of geosynthetic encased stone columns

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Abstract: This paper presents a numerical study to evaluate the contribution of geosynthetic to the shear strength of geosynthetic encased stone column (GESC) under direct shear loading conditions. The backfill soil was characterised using the linearly elastic–plastic Mohr–Coulomb model. The geosynthetic encasement was simulated using linearly elastic liner elements. The interaction between the geosynthetic encasement and soils on both sides was modelled through two interfaces. The three-dimensional numerical model was validated using experimental data from direct shear tests of GESC models. The shear stress–strain response and the development of longitudinal and circumferential strains of GESC during the shear process were first discussed, and then a parametric study was conducted to investigate the effects of various design parameters on the shear strength of GESC and the contribution of geosynthetic. Results indicate that the shear resistance provided by the geosynthetic encasement develops slowly, which depends on the mobilisation of tensile strains. At the failure condition, the longitudinal strains are larger than the circumferential strains, which indicates that the longitudinal tensile rupture is more critical for GESC under shear loading. The vertical stress, geosynthetic encasement stiffness and stone column diameter and spacing have the most important influences on the shear strength contribution of geosynthetic encasement.

Keywords: Geosynthetics, Stone column, Geosynthetic encased stone column, Shear strength, Direct shear, UN SDG 9: Industry, innovation and infrastructure