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Leakage of composite cutoff walls through geomembrane joint defects

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Abstract: Composite geomembrane-soil-bentonite (CGSB) cutoff walls are effective barriers to contain highly aggressive contaminated groundwater. Defects in the geomembrane (GM) joint are inevitable during the installation, inducing preferential flow paths. An experimental device is designed to measure the flow rate Q through the joint defects of CGSB walls. Experiments and numerical simulations are performed to investigate the leakage characteristics of CGSB walls. The results show that soil-bentonite (SB) enters the joint under pressure and has a sealing effect similar to a hydrophilic gasket, which effectively reduces the Q. As the hydraulic head h_w increases, the internal gap width of the joint increases, resulting in a significant increase in Q. When h_w increases from 1 to 2 m, the maximum increase in the measured Q exceeds 17.6 times. The fracture pore diameter d_f of the joint filled with SB decreases by an order of magnitude compared to the case without SB filling. When d_f is less than 0.1 mm, the leakage of the CGSB wall is mainly controlled by d_f while d_f is greater than 0.2 mm, the leakage is mainly affected by the interface transmissivity between the GM and SB.

Keywords: Composite cutoff wall, Geomembrane, Soil-bentonite, Joint defect, Leakage

Performance evaluation of geocell-reinforced pavements overlying black cotton soil

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Abstract: The study conducted full-scale field trials in Dholera to examine the performance of geocell-reinforced and unreinforced pavements on expansive subgrades. Three geocell-reinforced sections (S-2 on expansive subgrade, S-4 on lime-treated subgrade, and S-5 on lime-treated subgrade with reduced base) and two unreinforced sections (S-1 on expansive subgrade and S-3 on lime-treated subgrade) were constructed. Performance was evaluated using static plate load tests and falling weight deflectometer tests. Geocell reinforcement enhances pavement bearing capacity, reduces subgrade vertical stress, and offers potential reductions in life-cycle costs and annual greenhouse gas emissions. Section S-2 showed higher bearing capacity compared to those of section S-3, highlighting the efficacy of reinforced sections over traditional stabilization. The study found that solely relying on lime treatment for expansive soil is not very effective, but combining it with geocells significantly improves pavement performance. Section S-4 showed the highest improvement in pavement performance, with a bearing capacity improvement factor of 3.04, modulus improvement factor of 2.26, and service life ratio of 2.61. The comparable performance of sections S-4 and S-5 suggests that section S-5 offers a sustainable and cost-effective alternative with satisfactory performance. Additionally, numerical analysis confirms the reliability of the field results as a valuable resource for researchers.

Keywords: Geocell, Field study, Expansive subgrade, Plate load test, Falling weight eflectometer, Lime treatment

Mechanical properties and mechanisms of soil-geotextile interface under constant normal Stiffness: Effect of freezing conditions

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Abstract: A set of direct shear tests on the soil-geotextile interface (SGI) were conducted using a temperature-controlled constant normal stiffness (CNS) direct shear apparatus. This was done in order to evaluate the effects of normal stiffness, initial normal stress, soil water content, and temperature on SGI shear behavior and micro-deformation patterns. The observations indicate that all shear stress-shear displacement curves demonstrate strain-hardening characteristics, with SGI cohesion and friction angle increasing at higher normal stiffness and lower temperatures. At freezing conditions, water content significantly affects the interface friction angle, while this effect is minimal at positive temperatures. Normal stress increases with higher water content, lower temperatures, and higher normal stiffness. Shear stress initially rises with normal stress before decreases, with a more pronounced rise under sub-zero conditions. Normal stress shrinkage shows a positive correlation with normal stiffness. Micro-deformation analysis of soil particles at the interface indicates significant strain localization within the shear band, which is less pronounced under sub-zero temperatures compared to positive temperatures. These patterns of normal displacement vary across analysis points within the shear band, with the macroscopic normal displacement reflecting a cumulative effect of these microscopic variations.
Keywords: Frozen soil, Geotextile, Constant normal stiffness, Shear strength, Strain ocalization

Investigation on relationship of geogrid strain and settlement in the GRPS embankment under cyclic loading

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Abstract: Geosynthetic-reinforced pile-supported (GRPS) embankments provide an effective solution for mitigating subgrade settlement and enhancing service performance. This study presents a series of physical model tests aimed at gaining a comprehensive understanding of the mechanical behavior of geogrids in GRPS embankments. Effects of loading cycles, loading frequency, geogrid layer number, and pile type on geogrid strain and settlement were investigated. An empirical formula was introduced to evaluate the impact of these factors on the relationship between geogrid strain and settlement. The results demonstrate that both geogrid strain and settlement increase with loading cycles and loading frequency, while longer piles effectively reduce settlement. GRPS embankments with two geogrid layers exhibited smaller geogrid strain and settlement compared to those with a single layer. A power function incorporating the normalized geogrid strain increment ratio and settlement was developed to predict the geogrid strain variations under cyclic loading, with significant influence from the aforementioned factors. Furthermore, an application of the EBGEO method, modified to account for cyclic loadings, is proposed, which introduces a load parameter to account for the number of loading cycles. The results obtained using this modified method closely align with measured values, providing a more accurate estimation of geogrid strain development under cyclic loading.

Keywords: GRPS embankment, Geosynthetic reinforcement, Geogrid strain, Settlement, Cyclic loading

Response of isolated footing on a geogrid reinforced fill and undisturbed peat subgrade soil system

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Abstract: The geotechnical behavior of undisturbed peat subgrade within geogrid-reinforced foundation systems remains inadequately understood, despite its high compressibility and engineering complexities. This study conducts a systematic investigation into the bearing capacity and settlement characteristics of an isolated footing on geogrid-reinforced fill over undisturbed peat, utilizing laboratory-scale model tests. Unlike previous studies that rely on disturbed peat samples, this research preserves natural stratification and in-situ response mechanisms, providing a more accurate representation of reinforcement performance. The results demonstrate that geogrid reinforcement enhances bearing capacity by up to 149.7 % and mitigates settlement by 79 %, with optimal reinforcement efficiency achieved at h/B = 0.3. These findings underscore the critical role of geogrid embedment depth, fill thickness, and relative density in optimizing foundation stability. By integrating undisturbed peat in physical modeling, this study bridges the gap between controlled laboratory experiments and real-world geotechnical applications, providing a framework for optimizing geosynthetic reinforcement strategies in highly compressible subgrades and paving the way for more reliable foundation designs in challenging ground conditions.
Keywords: Geogrids, Model tests, Bearing capacity, Peat soil, Isolated footing

Load-induced strain analysis in geocell reinforced footing systems

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Abstract: In performance-based design, it is crucial to understand deformation characteristics of geocell layers in soil under footing loads. To explore this, a series of laboratory loading tests were carried out to investigate the influence of varying parameters on the strain levels within the geocell layer in a sandy soil under axial strip footing loading. The results were analyzed in terms of maximum strain levels, strain variation along the geocell layer and the correlation between horizontal and vertical strains. In this study, the maximum observed strain levels for geocell-reinforced strip footing systems reached 2.3 % for horizontal (tensile) strain and 1.4 % for vertical (compressive) strain. Furthermore, most strain levels were concentrated within a distance of 1.5 times the footing width from the axis of strip footing. In geocell-reinforced footing systems, the interaction between horizontal and vertical strains becomes a key factor, with the ratio of horizontal to vertical cell wall strains ranging approximately from 1 to 2.5. The outcomes of this study are expected to contribute to the practical applications of geocell-reinforced footing systems.

Keywords: Geosynthetics, Geocell, Strain gauge, Strain distribution, Shallow foundation, Bearing capacity, Footing settlement

Experimental investigation of the capillary drainage performance of multilayer wicking fabric

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Abstract: Excessive moisture within subgrade layers significantly diminishes subgrade stiffness and induces pavement deformation. A multilayer wicking fabric (WF) composed of deeply grooved fibers was developed to regulate moisture in unsaturated fine-grained soils. This study introduces a novel methodology for determining the water retention curve (WRC) over the full suction range. At the same time, an efficient method for predicting WF's WRC via NMR technology was pointed, and clarifying the material's microscopic drainage mechanisms. Building on this foundation, soil column drying experiments were conducted to verify WF's moisture regulation capacity in unsaturated fine-grained soils. The results demonstrate that WF exhibits its highest water retention under conditions of elevated matric suction. Additionally, soil column drying experiments reveal that WF incorporation significantly reduces average soil water content and accelerates drying rates. WF's drainage efficiency shows high sensitivity to initial water contents (w_i) and evaporation segment length (L), with drainage performance increasing proportionally to these parameters. Moreover, soil water profiles are influenced by water retention capacity, capillary migration rate, and hydraulic gradient. These findings underscore the potential of multilayer wicking fabrics in managing moisture within fine-grained subgrades, presenting a novel and effective strategy for maintaining subgrade dryness and enhancing long-term stability.

Keywords: Wicking fabric, Water retention curve, Nuclear magnetic resonance, Capillary drainage, Evaporation, Water content

Consolidation solution of ground improved with artificial solidified crust–vertical drain

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Abstract: For artificial solidified crust (ASC)–vertical drain ground, an analytical consolidation solution (IB solution: regarding ASC as an impervious boundary) is proposed, which considers both the radial and vertical seepage. The orthogonal relation is proven and the computing efficiency is greatly improved. Then, consolidation solutions applicable to ASC–vertical drain ground, include IB solution, RDL solution (radial consolidation solution of double-layered ground) by Li et al. (2025), the quasi-rigorous solution by Tang and Onitsuka (2001), are compared and discussed. Compared to the quasi-rigorous solution, IB solution slightly overestimates the consolidation rate, but it can be promoted in engineering according to the following reasons: a) the convergence is easier to be achieved; b) its accuracy is not affected by the ratio of the vertical time factor to the radial time factor; c) common major parameters of ASC (i.e., thickness and permeability) have little effect on the applicability. By ignoring the vertical seepage in soil, IB solution degenerates to the simplified solution. Consolidation rate calculated by the simplified solution is slower than that of IB solution, and the solution can be a simple method for estimating the consolidation behavior of ASC–vertical drain ground.

Keywords: Consolidation, Vertical drain, Solidified soil, Analytical solution, Computing method