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摘要集

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Application of the digital image correlation technique in wide width tensile test of geogrids

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Abstract: This paper aims to explore the DIC technique for use in wide width tensile testing of geogrids, from specimen preparation to selection of DIC parameters required for analysis to provide a guide for a proper use. A series of monotonically loaded wide width tensile tests were conducted on a PET geogrid to investigate the effects of specimen surface preparation methods and the user-defined DIC parameters. An additional set of tests under cyclic loading was conducted to investigate the effect of the image sampling rate. The results indicate that the speckle pattern (image texture) has a significant effect on the DIC results such that the larger is the speckle size, the greater is the uncertainty level, eventually leading to increased nonuniformity in the calculated strains. Also, it was revealed that a subset size smaller than optimal, typically 20–30 pixels, results in highly localized strain distribution. A similar trend was observed in step size. In addition, the image sampling rate was found to have a significant effect on the DIC-calculated cyclic strains, such that the lower is the image sampling rate, the lower is the calculated cyclic strain.

Keywords: Geosynthetics, Geogrid, Digital image correlation, Wide width tensile test, Cyclic loading

Experimental evaluation on in-soil water migration reducing performance of restraining moisture geotextile (RMG)

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Abstract: Engineering materials such as geosynthetics clay liners (GCL) and gravel layers are effective to cut off the in-soil water migration and have been widely employed to stabilize the moisture content of subgrades. However, the moisture stabilizing performance of GCL or gravel layer is usually compromised due to the complexity of service condition. This paper introduces an engineering material named restraining moisture geotextiles (RMG), which is expected to show low permeability as GCL. With characterization of basic properties of RMG, moisture migration column test of silty soil and test cases with employments of RMG, GCL, and gravel layer are performed, respectively. The temperature and moisture fields of soil columns subjected to a freezing-thawing process are measured, and the capillarity and in-soil water migrating behavior are analyzed. Carbon footprints of GCL and RMG are compared and discussed. Test results show that RMG, GCL and gravel layer are effective to cut off the capillarity, but the gravel layer can result in higher moisture content in silty soil due to the vapor migration and capillary isolation. In conclusion, RMG can be an alternative method with low permeability on reducing the in-soil water migration, and is much lighter and more engery-efficient than GCL.

Keywords: Geosynthetics, Soil column, Water migration, GCL, Superabsorbent polymer

Evaluating the mechanisms and performance of Geosynthetic-Reinforced Load Transfer Platform of pile-supported embankments design methods

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Abstract: This study evaluates the existing design methods of Geosynthetic-Reinforced Load Transfer Platform for Pile-Supported Embankments (GLTP-PSE) through comprehensive 3D Finite Element (FE) analyses. It scrutinizes the assumed arching mechanisms, methodologies, design criteria (arching height, maximum strain, differential settlement, and T in geosynthetics), and overall performance of these methods. The 3D FE analysis results and measurements from two case studies were compared with six established GLTP-PSE design methods based on the four design criteria. Key findings include the identification of a progressive concentrated ellipsoid as the developed soil arching formation, with arching height dependent on the embankment equivalent height (including embankment and traffic load), pile spacing, maximum strain along the geosynthetics, and the number of geosynthetic layers. The load distribution on geosynthetic reinforcement was observed to align more closely with a non-linear inverse triangle. These insights led to recommendations for updating existing design methods, enhancing the accuracy and reliability of GLTP-PSE designs. The study's outcomes contribute significantly to advancing and refining GLTP-PSE design practices by providing a deeper understanding of soil arching mechanisms and the performance of geosynthetic reinforcements.

Keywords: Geosynthetic-reinforced load transfer platform(GLTP), Pile-supported embankment (PSE), Analytical design methods, Arching mechanism, 3D Finite Element (FE) analyses

Creep rupture behaviour of elastomeric bituminous geomembrane seams

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Abstract: The short-term and long-term performance of bituminous geomembrane (BGM) seams are examined using both small-scale and large-scale tests. Different BGM products, different sustained tensile loads, different weld qualities, and different overburden stresses are examined. The BGM seams are shown to be very susceptible to creep rupture under sustained tensile loads. Time to rupture and strain at rupture for acceptable welds are both exponentially correlated with the sustained load, for the different BGM products examined. With the increasing tensile load from 5%, 10%, 20%, 30%, 40% of sheet maximum tensile strength, the time to rupture decreased from 30–50 days (5%), 5 days (10%), 0.8 day (20%), 0.2 day (30%), to 0.03 day (40%) and, the strain at rupture increased from 5%, 7%, 13%, 17%, to 20–30%. In large-scale tests simulating field conditions, the BGM seam creep ruptured within 24 days when the overburden stress was 20 kPa, and within $\leqslant$0.2 day when the over-burden stress reached 50 kPa. The consequences of liquids or gases readily permeating through failed seam should be evaluated before using BGMs in an environment where tensile stresses can develop (e.g. due to differential settlement, subgrade irregularity, or downdrag).
Keywords: Geosynthetics, Bituminous geomembrane, Seams, Tensile strength, Creep rupture

Improving clay-geogrid interaction: Enhancing pullout resistance with recycled concrete aggregate encapsulation

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Abstract: In this study, Recycled Concrete Aggregate (RCA) was employed as a sandwich technique around the geogrid to enhance the pullout resistance of the geogrid in clayey backfills. Large-scale pullout tests were conducted on three configurations: geogrid-reinforced clay, geogrid-reinforced RCA, and geogrid sandwiched between layers of RCA, aimed at investigating pullout resistance and deformation. The experiments encompassed two different geogrid types (designated as G1 and G2), varying normal pressures ranging from 10 to 50 kPa, and RCA layers with thicknesses of 40, 80, 160, and 320 mm. Results from the experiments revealed that the inclusion of RCA layers around the geogrid substantially enhanced pullout resistance, with improvements ranging from 1.5 to 3 times compared to clay specimens. Optimal RCA thicknesses were determined in order to enhance soil-geogrid bonding and pullout resistance. For G1 geogrid, a thickness of 160 mm (equivalent to replacing 25% of clay volume with RCA) was identified as optimal, while for G2 geogrid, an 80 mm thickness (equivalent to replacing 15% of clay volume with RCA) was found to be sufficient. These thicknesses were established to achieve over 80% of the pullout force compared to full RCA specimens.

Keywords: Recycled concrete aggregate, Geogrid, Sandwich technique, Pullout test, Reinforced clay

Investigation of soil arching in GRPS embankments under localized loading: Multi-span spring-based trapdoor model test

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Abstract: A novel multi-span spring-based trapdoor apparatus has been developed to simulate more realistically the coupling of piles, soft soil, and geosynthetics, as well as the intricate interactions between adjacent soil arches under localized loading within geo-reinforced pile-supported (GRPS) embankments. By employing movable blocks with varying spring stiffnesses, this study advances the understanding of the coupling effect between piles, soft soil, and geosynthetics. Utilizing digital image correlation (DIC) technology, the research captures the dynamic evolution of soil arch shapes, providing new insights into stabilization mechanisms within GRPS embankments. It is found that lateral geosynthetics can effectively reduce the overall settlement of the embankment and mitigate the influence of trapdoor stiffness on the soil arch height. The geo-reinforcement enhances the stability of soil arches under localized loading by providing essential support to the arch feet of multiple internal soil arches. Four distinct stages in soil arch evolution under localized loading have been identified. The relationship between geo-reinforcement stiffness and trapdoor stiffness in affecting soil arching is complex and varies with different loading scenarios. The membrane effect plays a pivotal role in inter-span load transfer.

Keywords: GRPS embankment, Soil arching, Membrane effect, Localized loading, Spring-based trapdoor

Laboratory evaluation of wicking geotextile for moisture reduction in silty sands at different fines contents

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Abstract: The effect of fines content on the performance of the wicking geotextile is not clear. This study developed a simple moisture reduction test method to quantify the effectiveness of the wicking geotextile in reducing moisture in silty sands at four different fines contents and four different waiting periods. The sand was prepared at an initial moist condition based on its average field moisture capacity. A wicking or non-wicking woven geotextile was placed in the middle of a soil column. The effect of a geotextile on the moisture content of the sand was evaluated by measuring their gravimetric moisture contents at different distances from the geotextile at different times. Test results show that the amount of moisture reduced by the wicking geotextile decreased with the content of fines in the silty sand. On the contrary, the non-wicking geotextile obstructed water flow, hence moisture accumulated on it. The moisture content profile in the soil column indicated the influence zone by the wicking geotextile in the silty sand, which depended on the fines content. The percent of soil moisture content reduction by the wicking geotextile identified the limit of the fines content for the effectiveness of the wicking geotextile.
Keywords: Moisture reduction tests, Silty sand, Fines content, Influence zone, Wicking geotextile

Parameters affecting performance of fully instrumented model testing of strip footings on geocell-reinforced soils

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Abstract: A thorough study was conducted to assess the performance of the strip footing reinforced with geocells in sand, focusing on understanding the enhancement effects and geocell reinforcement mechanisms. Critical factors such as geocell modulus, height, soil relative density and load eccentricity were examined through fully instrumented model tests. Measurements included surface displacement profiles, strains on the geocell layer, subsurface pressure distribution and other relevant parameters. Results revealed that the strip footing on geocell-reinforced sand beds exhibited better performance compared to those on unreinforced soil, characterized by increased load-carrying capacity and reduced settlements. Notably, stiffer geocells improved performance significantly, with a 40% higher modulus enhancing the bearing pressure by up to 25%, due to better confinement and anchorage effects. Conversely, geocells with a lower modulus demonstrated more effective vertical stress distribution. Furthermore, increased geocell height moderately enhanced footing performance by improving confinement, although wall buckling under eccentric loading limited major gains. Dense soils under centric loading exhibited up to a 20% better improvement in bearing pressure than loose soils due to higher strain mobilization within the geocell layer. These findings highlight the crucial role of geocell and soil properties, as well as loading conditions, in optimizing reinforcement effects for strip footings.

Keywords: Geocell, Geosynthetics, Model test, Strip footing, Strain gauge, Pressure cell

Dynamic response and damage of pile-geogrid composite reinforced high-speed railway subgrade under seismic actions

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Abstract: In this study, the dynamic response and damage mode of a pile-geogrid composite reinforced high-speed railway subgrade under seismic action were investigated based on a unidirectional shaking table test. Various seismic waves were applied to the subgrade, allowing for an analysis of acceleration, dynamic soil pressure, displacement, and strain responses. The displacement field of the subgrade was visualized using particle image velocimetry (PIV). The study shows that changes in peak ground acceleration (PGA) amplification factors become evident with height due to the presence of geogrid layers. The increase in peak ground motion causes a redistribution of dynamic soil pressures inside the subgrade. The transverse and longitudinal ribs of the geogrids provide an "anchoring effect". The peak strain of the piles in the center is greater than that of the piles on the sides. The direction of soil particle displacement is closely related to the damage patterns observed in the subgrade. Damage begins to occur once the peak ground motion exceeds 0.4 g, characterized by collapse at the bottom of the subgrade.

Keywords: High-speed railway, Subgrade, Pile, Geogrid, Dynamic response, PIV

Analytical model of three-dimensional concentric ellipsoidal soil arching in geosynthetic-reinforced pile-supported embankments

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Abstract: The geosynthetic-reinforced pile-supported (GRPS) embankment is an effective method for improving soft ground, widely adopted in engineering applications. In this paper, a concentric ellipsoidal soil arching model was proposed to describe the stress distribution within the GRPS embankment. An analytical solution for soil arching efficacy was derived by solving the loads acting on the pile caps and geosynthetics under piles arranged in a squared pattern. Subsequently, finite difference models were established to verify the accuracy of the derived analytical solution. Meanwhile, four field tests were introduced to validate the analytical model. Finally, parametric studies were conducted on the concentric ellipsoidal soil arching model, considering parameters such as the embankment height, the pile spacing, the pile cap width, the unit weight, and the friction angle of fill soil.

Keywords: Geosynthetic-reinforced pile-supported embankments, Soil arching effect, Analytical solution, Parametric analysis, Finite difference method

Research on the aging mechanism of polypropylene nonwoven geotextiles under simulated heavy metal aging scenarios

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Abstract: We conducted accelerated aging experiments on two types of polypropylene (PP) nonwoven geotextiles (filament geotextile and staple fiber geotextile), immersing them in five different simulated liquids at temperatures of 25 ◦C, 55 ◦C, and 85 ◦C for 200 days. At 85 ◦C and a pH of 1, the tensile strength and elongation at break of PP filament materials decreased by 95% and 86%, respectively. The presence of heavy metals(arsenic and cadmium), speeds up the aging process in both types of PP geotextiles. Under identical conditions, these heavy metals can increase the loss of tensile strength in geotextiles by more than 7% in 200 days. Increases in temperature, acidic environment, and heavy metal concentration all contribute to faster aging of these geotextiles. Although filament geotextiles exhibit higher tensile strength and elongation at break, staple fiber geotextiles show a lower rate of tensile strength loss during aging and better maintain their tensile strength in high-temperature acidic conditions. During the aging process, cross-linking and recrystallization occur, both of which control the aging rate and the formation of microplastics.

Keywords: Polypropylene (PP), Nonwoven geotextiles, Aging mechanism, Heavy metals, Microplastics

Tensile behavior of needle-punched nonwoven geotextiles based on in-situ X-ray computed tomography and numerical simulation

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Abstract: There are situations where geotextiles are subjected to uniaxial tensile strain, which may result in noticeable variations in their filtration performance. This study accordingly investigated the behaviors of needle-punched nonwoven geotextiles during tensile testing using in-situ X-ray computed tomography. Furthermore, a numerical analysis of the variation in pore size characteristics was performed by establishing a geotextile model based on the web formation and bonding manufacturing process. The pore size and fiber orientation distributions were subsequently investigated and a model for the changes in the pore characteristics was established and validated. With increasing tension strain in the machine direction, the pore throat size distribution curve exhibited an overall shift towards larger sizes, and the characteristic pore sizes ranging from 10% to 98% either initially decreased, then increased or consistently increased. Furthermore, the fiber distribution was predominantly within the geotextile plane along the machine direction, and as the strain increased, the fibers stretched and aligned along the direction of the tensile load along the machine direction. Finally, the experimental findings of this study and relevant test results from the literature were thoroughly interpreted. The numerical model align well with the actual changes in pore size characteristics observed under tensile strain.

Keywords: Nonwoven geotextiles, In-situ X-ray CT, Numerical modeling, Uniaxial tensile, Pore size characteristics