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摘要集

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目　录

The mechanical behaviour of compacted Lambeth-group clays with and without fibre reinforcement

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Abstract: This study investigated the effect of fibre reinforcement on the large strain behaviour of compacted clay samples tested using large triaxial test equipment. A novel specimen preparation method was proposed where peds of clay are compacted to closely simulate the in-situ compaction. A large number of 100 × 200 mm triaxial tests and one-dimensional compression tests were performed using reinforced and unreinforced samples. The behaviour of unreinforced samples was observed to be similar to highly fissured clays; ped compaction generated a random fissure pattern due to the contact between peds. The addition of fibres to the compacted samples created fissures with higher mobility at lower friction than those in the unreinforced samples; hence, the state boundary surface of reinforced clay was below that of the unreinforced clay. With the addition of fibres, the failure mechanism changed from the formation of a shear plane to barrelling, demonstrating that the fibres transferred stresses further away from the shear plane, producing a more homogeneous stress distribution. The preparation method proposed here produced a fissure pattern in the clay that introduced transitional behaviour, which was drastically reduced with addition of the fibres, allowing better normalisation and the definition of a unique boundary surface.
Keywords: Fabric; Structure; Laboratory tests; Reinforced soil; State boundary surface; Fissured clay

Interface pullout resistance of polymeric strips embedded in marginal tropical soils

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Abstract: This paper presents an experimental and analytical evaluation of factors affecting the interface pullout resistance of polymeric strips embedded in marginal soils, with a particular interest in supporting the partial replacement of natural sands by intensely weathered tropical soils in reinforced soil structures, which have often been considered marginal fills in design guidelines. Large-scale pullout tests were conducted to evaluate the soil-geosynthetic interface pullout resistance, which also provided quantitative insight into the local increases in vertical stresses acting on the reinforcements due to pullout. Based on the experiments, analytical models were developed and calibrated to establish the relationship between confinement and soil-geosynthetic interface pullout resistance. The relationship between actual and initial stresses could then be represented in terms of a linear model in which the angular coefficient corresponds to the ratio between the apparent and actual friction coefficients (f*/f). This analytical relationship was found to represent a useful design tool since it directly correlates with soil geotechnical properties. The use of lateritic soils to partially replace coarse-grained soils in reinforced soil structures was found to be feasible for mixtures involving up to 25% of lateritic soils, with higher fractions affecting the interface resistance significantly.

Keywords: Reinforced soil; Pullout resistance; Interface shear resistance; Polymeric strips; Tropical soils

Water exchange across a subgrade-GCL interface as impacted by polymers and environmental conditions

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Abstract: This paper examines the hydration behaviour of polymer enhanced geosynthetic clay liners (GCLs) under both isothermal conditions and diurnal cyclical temperatures as recorded at a Melbourne landfill site. The diurnal temperature cycles introduced thermal gradients, which induced water movement downwards into the subgrade. It was found that the bulk of the thermal and hydraulic effects occurred within the upper 50 mm of the subgrade layer. Compared to isothermal conditions, diurnal temperature cycling's main effect was to suppress GCL hydration. Thermal gradients induced capillary breaks, and GCL hydration was thus limited to vapour phase hydration from the subgrade, which restricted the gravimetric water content of the GCLs to <30%. The hydration process at the interface was observed to gradually return to isothermal condition hydration levels once the temperature cycle conditions were removed. While the polymer's presence ensures the adsorption of more water, it also renders GCLs more sensitive to the effects of temperature. This study provides insights on the hydration behaviour of uncovered GCLs in field applications and the impact that diurnal temperature cycles can have on GCL hydration in a Mediterranean type climate.

Keywords: Geosynthetics; GCLs; Polymers; Hydration; Temperatures

Effect of geotextile ageing and geomembrane surface roughness on the geomembrane-geotextile interfaces for heap leaching applications

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Abstract: A series of large scale direct shear experiments is used to investigate the effect of the geomembrane (GMB) surface roughness, geotextile (GTX) properties, and GTX ageing, on the GMB-GTX interface shear behaviour. Interfaces involving smooth, coextruded textured, and structured surface GMBs underlying four different nonwoven needle-punched staple fibres (GTXs) with mass per unit areas between 200 and 2400 g/m^2, and a geocomposite drain (GCD) are examined at normal stresses between 250 and 1000 kPa. The results showed that the interlocking between the GMB and GTX increased with increasing the GMB asperity height and/or decreasing the mass per unit area of the GTX. For the interfaces that involved GTXs preaged prior to the shear box experiments for up to 2 years at 85 ℃, it was found that the 2400 g/m2 heat bonded two-layered GTX exhibited internal shear failure at low shear displacements. However, all the highly aged single layered GTXs showed an increase in the peak interface friction angles with the increase in their ageing. For these single layered GTX, the results suggest that assessing the interface friction angles using unaged GTXs for the stability analysis is conservative as long as the GTX remains intact in the field.

Keywords: Geosynthetics; Direct shear test; Interface shear; Heap leach pad; Geomembranes; Textured geomembranes; Geotextiles; Chemical degradation

Liquefaction and post-liquefaction resistance of sand reinforced with recycled geofibre

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Abstract: The present study provides an insight into the effect of recycled carpet fibre on the mechanical response of clean sand as backfill material subjected to monotonic loading and cyclic loading as well as post-liquefaction resistance of both unreinforced and carpet fibre reinforced soils. To achieve these goals, a series of multi-stage soil element tests under cyclic loading event resulting in liquefaction followed by undrained monotonic shearing without excess pore water pressure dissipation as well as a series of monotonic undrained shear test is conducted. All the specimens are isotropically consolidated under a constant effective confining stress of 100 kPa by considering the effect of cyclic stress ratio and carpet fibre content ranging from 0.25% to 0.75%. The obtained results revealed the efficiency of carpet fibre inclusion in increasing the secant shear modulus and ductility of clean sand under monotonic shearing without previous loading history. The impact of carpet fibre inclusion on the trend of cyclic excess pore water pressure generation and cyclic stiffness degradation was minimal. However, adding carpet fibre significantly improved both liquefaction and post-liquefaction resistances of clean sand. The liquefaction resistance of clean sand, at a constant 15 loading cycles, improved by 26.3% when the soil was reinforced with 0.75% recycled carpet fibre. In addition, the initial shear modulus of the liquefied specimen significantly increased by adding recycled carpet fibre.

Keywords: Geosynthetic material; Recycled carpet fibre; Liquefaction; Post-liquefaction behaviour

Two-dimensional soil arching evolution in geosynthetic-reinforced pile-supported embankments over voids

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Abstract: Soil arching and tensioned membrane effects are two main load transfer mechanisms for geosynthetic-reinforced pile-supported (GRPS) embankments over soft soils or voids. Evidences show that the tensioned membrane effect interacts with the soil arching effect. To investigate the soil arching evolution under different geosynthetic reinforcement stiffness and embankment height, a series of discrete element method (DEM) simulations of GRPS embankments were carried out based on physical model tests. The results indicate that the deformation pattern in the GRPS embankments changed from a concentric ellipse arch pattern to an equal settlement pattern with the increase of the embankment height. High stiffness geosynthetic hindered the development of soil arching and required more subsoil settlement to enable the development of maximum soil arching. However, soil arching in the GRPS embankments with low stiffness reinforcement degraded after reaching maximum soil arching. Appropriate stiffness reinforcement ensured the development and stability of maximum soil arching. According to the stress states on the pile top, a concentric ellipse soil arch model is proposed in this paper to describe the soil arching behavior in the GRPS embankments over voids. The predicted heights of soil arches and load efficacies on the piles agreed well with the DEM simulations and the test results from the literature.

Keywords: Geosynthetics; Pile-supported embankments; Soil arching; Analytical model; Model test; Discrete element method

Analysis of cyclic shear characteristics of reinforced soil interfaces under cyclic loading and unloading

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Abstract: The cyclic properties of geosynthetic soil interface are crucial for reinforced soil structures subject to seismic loading. A series of cyclic direct tests under cyclic normal loading was conducted on geogrid-gravel interface. The relationship among the amplitudes of cyclic normal loading and shear displacement and frequencies in the horizontal and vertical directions with interface shear strength and volume change was investigated. Test results showed that the relative time shift, shear stiffness, and enhance coefficient increased with increasing amplitude of cyclic normal loading. The interface exhibited shear hardening and softening with increasing amplitude of shear displacement. The vertical displacement decreased with increasing amplitude of cyclic normal loading but increased with increasing amplitude of shear displacement. Furthermore, three patterns were analysed for different frequencies in two loading directions. The value of vertical displacement was largest when the normal loading impact frequency was larger than the cyclic horizontal shear frequency, and smallest at equal frequencies in two loading directions. The shear stiffness was positively correlated with the amplitude of cyclic normal loading. However, it was negatively correlated with the amplitude of shear displacement. The value of the damping ratio was smallest under constant normal loading at a shear displacement amplitude of 0.5 mm.
Keywords: Geosynthetic; Cyclic normal loading; Cyclic direct shear tests; Shear stiffness; Damping ratio

Shaking table study on seismic behavior of MSE wall with inclined backfill soils reinforced by polymeric geostrips

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Abstract: In this study, the seismic behavior of a mechanically stabilized earth (MSE) wall with inclined backfill is investigated under sinusoidal acceleration excitations using a series of 1-g shaking table tests performed on the MSE model of 150 cm in height reinforced with polymeric geostrips. The effects of the stiffness of the reinforcement and slope angles of the backfill soil on the acceleration amplification factor (RMSA), the lateral displacement of the wall, the surface displacement of the backfill, the distribution of dynamic earth pressure along the height of reinforced wall and the strain distributions on the surfaces of the polymeric geostrips in three planes of the wall are investigated. The experimental results show that the dynamic earth pressure determined by traditional pseudo-static approaches leads to overestimated values. In addition, increasing the inclination angle of backfill soil results in the increase of surface settlement, lateral wall displacements, soil dynamic earth pressures, acceleration amplification factors and strains on the polymeric geostrip materials. The stiffness of the polymeric geostrip material has a negligible effect on the displacement, dynamic earth pressures and failure surface geometry.

Keywords: Geosynthetics; Polymeric geostrip; Shaking table; MSE Wall; Seismic response; Failure surface

Case study and numerical simulation of PVD improved soft Bangkok clay with surcharge and vacuum preloading using a modified air-water separation system

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Abstract: This manuscript presents the case study of soft Bangkok clay improvement and simulations using combined vacuum pressures with pre-existing surcharge embankment preloading, including installations of air-tight membranes and horizontal prefabricated drains connected to the top of the PVDs as well as to the vacuum system with a modified air-water separation system. The 17-m-long PVDs were installed from the top of the embankment in a triangular pattern at a spacing of 0.9 m. Monitoring instruments were installed to measure surface settlements, lateral movements, and pore water pressures in the soft clay layer. The subsequent analyses included settlement calculations, settlement predictions using observational methods, flow parameter back-calculations, soil property comparisons before and after improvement, and FEM simulations. The very soft to soft clay was transformed to medium-stiff clay because its undrained shear strengths and maximum past pressures increased, and its water contents, void ratios, and compression indices decreased. The analyses of the degree of consolidation utilized one-dimensional and observational methods as well as a numerical simulation for the prediction of consolidation settlements and comparison to the field data. The results illustrated the effectiveness of the modified vacuum-PVD system. The findings could be used for guidance of similar soft clay improvement projects.

Keywords: Geosynthetics; Ground improvement; Preloading; Simulation; Soft clay; Vacuum- PVD

Interlayer bonding characterization of interfaces reinforced with geocomposites in field applications

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Abstract: Geocomposites are extensively used in asphalt pavements as they provide significant long-term pavement benefits. Indeed, when correctly installed, geocomposites enhance road pavement performance thanks to their waterproofing properties, stress absorbing membrane interlayer (SAMI) action and improved mechanical strength of the pavement. Nevertheless, the presence of an interlayer causes de-bonding effects that negatively influence the overall pavement characteristics. This paper presents an experimental investigation aimed at comparing the interlayer bonding characteristics of four different geocomposites with an unreinforced reference configuration, laid on an Italian motorway section, in which the reinforcement depth and the lower layer surface condition (milled or new) were also varied. Interlayer shear strength (ISS) was measured, on both cores and laboratory produced specimens, through Leutner and Ancona Shear Testing Research and Analysis (ASTRA) equipment. The ISS results showed that geocomposites can be successfully applied directly on milled surfaces. Moreover, the application of a normal stress, as in the ASTRA device, tends to mitigate any difference related to the specimen heterogeneity. Finally, existing laws, which correlate the results obtained with different shear equipment on unreinforced interfaces, were generalized by considering the presence of geocomposites and the corresponding ISS specification limits were proposed for both ASTRA and Leutner test.

Keywords: Asphalt pavements; Interlayer bonding; Geocomposites; Reinforcements; Interface shear strength; Field performance

Stress-strain behavior of geotextile: A proposed new indirect calculation using the static puncture test (CBR test)

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Abstract: Some of the main applications of geosynthetics include use as a hydraulic barrier in sanitary landfills, as a reinforcement element and in pavement engineering. In most cases, these materials are subject to the overlapping effects of tensile strength and puncture. This paper presents a review of indirect methods for calculation of stress and strain averages by means of the California Bearing Ratio (CBR) puncture strength test. In addition, a new calculation method is proposed based on the Kirchhoff plate theory, which interprets the behavior of thin circular plates subjected to a uniform normal loading. This new method enables analysis of the stress-strain in each stretch of the geosynthetic. The methodology is applied to four woven geotextiles of different weights. The results of the new calculation method yielded a better stress-strain correlation with direct tensile strength tests, presenting the smallest relative errors compared to the other indirect calculations reviewed. With the aid of a disk and pins, vertical displacement values at different points in the geotextiles were measured and showed good agreement with analytical predictions. Therefore, the static puncture test combined with the new proposed calculation method is a good alternative for determining the stress-strain parameters of geotextile.

Keywords: Geosynthetics; Geotextiles; Static puncture test; Stress-strain; Indirect tensile strength

Combined influence of subsoil water content and mass per unit area on cation exchange behavior of geosynthetic clay liners

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Abstract: Hydration tests were performed on geosynthetic clay liners (GCL) to examine the influence of subsoil water content ($w_{subsoil}$) and mass per unit area (MPUA) on the cation exchange occurred during hydration. Increase in the $w_{subsoil}$ increased the final water content of GCL (w_{final}). At MPUA of 4.0 kg/m^2, w_{final} increased from 70 to 109%. Such increase was less pronounced when MPUA was considered. Also, an inverse relation between MPUA and w_{final} existed where w_{final} increased as the MPUA decreased. The greatest w_{final} was determined when $w_{subsoil}$ was ~17% and MPUA of GCL was ~3.0 kg/m^2 (112%). The exchange reaction was the most favorable when $w_{subsoil}$ was ~8% and MPUA of GCL was ~3.0 kg/m2 (mole fractions of monovalent cations, XM, decreased from 0.81 to 0.65) and the least favorable when $w_{subsoil}$ was ~17% and MPUA of GCL was ~3.0 kg/m^2 (XM decreased from 0.81 to 0.80). Combined influence of MPUA and $w_{subsoil}$ showed that although cation exchange depends on both factors, $w_{subsoil}$ had significant role in this reaction more than MPUA. The findings of cation exchange analyses were supported with swell index tests. The hydrated GCLs had lower swell indices than the virgin GCL (17.5 – 19.0 mL/2g vs. 21.5 mL/2g), indicating cation exchange.

Keywords: Cation exchange; GCL; Hydration; Mass per unit area (MPUA); Subsoil water content; Swell index

Piping of silty sand tailings through a circular geomembrane hole

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Abstract: Experiments are conducted to study leakage and piping through circular geomembrane holes from the overlying silty sand tailings. Three subgrades, a poorly graded gravel, a well-graded gravel, and a poorly graded sand are studied. Test results show that leakage through the geomembrane hole is not proportional to the surface area of the hole. A 5-fold increase in hole diameter from 10 to 50 mm results in an approximately 6-fold increase in leakage. With the filter incompatible subgrade, piping is prone to occur at small consolidation stress and/or with a larger hole. Open voids within soil skeleton induced by piping result in a 2- to 4.5-fold higher leakage than in the no-piping cases. The extent of silty sand piping and internal erosion depends on the filter compatibility and surface regularity of the subgrade, which could be significantly improved by increasing its fine particle component or placing a layer of nonwoven needle-punched geotextile beneath the geomembrane.

Keywords: Geosynthetics; Geomembrane; Hole; Leakage ;Piping; Silty sand