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摘要集

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目　录

Influence of pore water chemistry on GCL self-healing with hydration from silica sand

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Abstract: The self-healing of a GCL with a circular hole is examined in experiments where the GCL, overlain by geomembrane, is hydrated from a silica sand subgrade (SSS) having three different pore water chemistries. Factors considered included: hole size, subgrade initial moisture content w_{fdn}, GCL mass per unit area, and overburden stress (20–100 kPa). GCL self-healing is better for w_{fdn} = 16% than for w_{fdn} = 10%, which is better than for 5%, when the SSS pore water has negligible cations (ionic strength, I < 0.1 mM). However, only the 14.3 mm-diameter hole fully self-healed and only when w_{fdn} = 16%. In contrast, when the GCL is hydrated from SSS with pore water having an ionic strength, I, of 20 and 30 mM, the self-healing for w_{fdn} = 5% is better than for w_{fdn} = 10%, which is better than for w_{fdn} = 16%, although none of the holes self-healed. When a ~0.5 m hydraulic head was applied above the GCL under σ_v = 20–100 kPa, a 38.1 mm-diameter hole self-healed with water having I < 0.1 mM, a 25.4 mm-diameter hole self-healed with pore water with I = 20 mM and 30 mM, but none self-healed with simulated synthetic landfill leachate (SSL). Post-hydration hydraulic conductivity (k) tests with SSL suggest that a hole up to 14.3 mm-diameter would not pose a significant adverse impact on the k compared to an intact GCL; however, this is not the case for the larger holes tested.

Keywords: Geosynthetics; GCL; Hydration; Cation exchange; Self-healing; Hydraulic conductivity

Laboratory evaluation of interfacial mechanical properties in geogrid-reinforced bituminous layers

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Abstract: In this study, the mechanical properties of composite bituminous structures with geogrid products, used as an interlayer between different types of bituminous mixtures, at a constant temperature, were examined. A twofold experimental program based on new approaches was selected. A new configuration of the 3-Point Bending Test (3-PBT) was adopted to capture the J-integral and crack resistance property defined by crack resistance index (CRI) at the interface against bottom-up crack propagation. The bonding quality at the interface was also defined through a new index named coefficient of interface bonding (CIB), which was measured via a modified version of the slant shear device. The results derived from this research revealed that reinforcement of the interface, with varying degree of surface texture, by geogrid products significantly enhances the fracture toughness of the whole system in terms of the J-integral, which could be properly connected to the combined functions of bonding quality and crack resistance indices defined at the interface.

Keywords: Reinforced interface; J-integral; Crack resistance index; Coefficient of interface bonding; Bituminous layers

Shear strength characteristics of geosynthetic reinforced rubber-sand mixturesl

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Abstract: Shear strength characteristics of the geosynthetic-reinforced rubber-sand mixture (RSM) has been investigated by conducting Unconsolidated Undrained (UU) triaxial test. In the first part, a series of UU triaxial tests have been carried out to know the size effect of granulated rubber/tyre chips from seven different rubber sizes. RSM sample that provides higher strength, energy absorption capacity and stiffness is considered as the optimal size and has been used in the investigation on geosynthetic-reinforced RSM. In the second part, shear strength characteristics of geosynthetic-reinforced RSM has been investigated by varying proportions of rubber content (50% and 75% rubber by volume), type of geosynthetic (geotextile, geogrid and geonets), number of geosynthetics (1-4) layers, geosynthetic arrangement and confining pressure. The results demonstrate that RSM reinforced with geosynthetic has enhanced peak strength, failure strength and corresponding axial strain at failure. Fifty percent RSM reinforced by geotextile and 75% RSM reinforced by geonets with 4 layers of reinforcement, led to a maximum increase in shear strength. The strength and energy absorption capacity are doubled for the reinforced RSM's, and reduced the brittleness index values as close to zero, which depends on the type, number of layers and arrangement of geosynthetic.

Keywords: Geosynthetics; Brittleness index, Energy absorption; Triaxial test; Shear strength

Geosynthetic reinforcement stiffness for analytical and numerical modelling of reinforced soil structures

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Abstract: Many analytical and numerical analysis and design methods for geosynthetic-reinforced soil structures require a single-value (constant) estimate of reinforcement stiffness. However, geosynthetic reinforcement products are rate-dependent polymeric materials meaning that they exhibit time and strain-dependent behaviour under load. Hence, the appropriate selection of a constant (elastic) stiffness value requires careful consideration. A simple hyperbolic stiffness model is shown to be a useful approximation to the constant-load isochronous creep-strain behaviour of these materials at low load levels applicable to operational (serviceability) conditions of geosynthetic-reinforced soil structures. A large database of 606 creep tests on 89 different geosynthetic reinforcement products falling within seven different product categories was collected. From these data, isochronous stiffness values were determined for different combinations of duration of loading and strain level. Data from products falling within the same category were collected together to provide approximations linking the isochronous load-strain (creep) stiffness to the ultimate tensile strength of the material. These approximations are useful for analytical and numerical modelling particularly when parametric studies are undertaken to identify the sensitivity of model outcomes to reinforcement stiffness. Finally, three different geosynthetic-reinforced soil application examples are provided to demonstrate the important role of tensile stiffness on analysis and design outcomes.

Keywords: Geosynthetic reinforcement; Isochronous load-strain behaviour; Tensile stiffness; Creep; Hyperbolic stiffness model; Mechanically stabilized earth (MSE)

Effects of chemical precipitation on the permeability of geotextile envelopes for subsurface drainage systems in arid areas

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Abstract: This paper focuses on the effects of chemical precipitation on the permeability of geotextile envelopes for a subsurface drainage system in arid areas by conducting precipitation experiments of the geotextile in static or flowing solution. The results show that the precipitation process is not significantly promoted or inhibited by the network structure of geotextile. The precipitates in the form of rhombus wrap around the fiber surface. The number of geotextile pores with the smaller diameters decreases significantly after precipitation experiments. As the increase of the area density of precipitates (ΔR), the variation of the pore area (ΔS) and the variation of permeability coefficient (ΔK) of the geotextile decrease rapidly at first and then slowly. The ΔK and ΔS VS ΔR data were best fitted with logarithmic trend line. This study provides a preliminary reference for quantifying the chemical clogging process of geotextile envelopes in arid areas.
Keywords: Geosynthetics; Chemical precipitation; Pore size characteristic; Permeability

A fast and precise methodology of creep master curve construction for geosynthetics based on stepped isothermal method (SIM)

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Abstract: The variability of the virtual time of stepped isothermal method (SIM) was observed during the creep master curves construction of a new high-performance geosynthetics material, which led to the significant errors in predicting the long-term creep. After analyzing the process of construction, the difference in selecting the beginning and end segments is the reason causing the errors. Therefore, a set of computer-based routine was programmed to eliminate the errors. Based on the amount of data of SIM and conventional creep tests, the virtual time of each corresponding step, the curves of scaled creep data, and the comparison between these two creep data were obtained in the present study by the routine. They were used to study the influence of different beginning segments and end segments on the master creep curve. Overall, the 5% of elevated temperature step and 50% of the previous step is suggested to regard as the beginning segment and end segment respectively to obtain the more well-founded virtual time and more accurate creep curve. This study not only provides a reference for research focusing on accelerated creep tests but proposed a fast and accurate methodology to construct the creep master of SIM tests.

Keywords: Geosynthetics; Creep test; Accelerated creep test; Stepped isothermal method (SIM)

Three-dimensional numerical analysis of geocell reinforced shell foundations

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Abstract: The effects of geocell reinforcement on the behavior of shell foundations were studied using PLAXIS 3D finite element software. For this purpose, conical and pyramidal geometries were adopted as shell foundations. The real honeycomb shape of geocell and rigid body behavior of shells were simulated in PLAXIS 3D. The numerical models for shell foundations and geocell reinforced foundations were separately validated using several laboratory studies in the literature. The validated models were extended to the shell foundations resting on geocell reinforced sandy beds. The inclusion of geocell-reinforcement provided more than 70% reduction in the settlement of pyramidal and conical shell foundations. The stress transferred to the sand beds were reduced and distributed a wider area compared to the unreinforced cases. The maximum improvement in the bearing capacity and the settlement were observed in the case of conical shell foundation. The effect of adopted geocell and shell configuration on the foundation behavior was also analyzed for realistic prototype foundation size.

Keywords: Geocell; Shell foundations; Reinforced soil; Numerical modelling; PLAXIS 3D

Verification of unified effective stress theory based on the effect of moisture on mechanical properties of fiber reinforced unsaturated soil

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Abstract: The unified effective stress theory based on suction stress (SSCC theory) enables the characterization of soils under both saturated and unsaturated conditions with one closed-form relationship. This study provides experimental verification of this theory through the unconfined compressive strength test (UCS) and indirect tensile test strength (ITS) on silty clay soil stabilized with fiber. A series of matric suction, ITS, and UCS tests were conducted to validate the SSCC theory through the representation of the results of ITS and UCS tests in terms of mean total stress (p) versus deviatoric stress (q) and mean effective stress (p`) versus deviatoric stress (q). The results of the validation procedures showed that the SSCC theory is applicable and valid at a range of 6%–16% of water content on the silty clay and the silty clay fiber-reinforced soils. There is a small fluctuation in the increase of ITS and UCS values with increasing fiber content due to randomly oriented distribution of the fiber. The addition of glass fiber does not significantly affect the capacity of water retention of the soil. It improves the condition of the mechanical soil properties at the end of construction more than of the effective stress condition.
Keywords: Unified effective stress theory; Soil suction; Shear strength; Discrete fiber

Particle shape effects on the cyclic shear behaviour of the soil – geogrid interface

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Abstract: The accurate determination of the interface shear strength is essential in the design of geosynthetic-reinforced soil structures. The particle geometries of three types of soil materials and a spherical granular medium are imaged and quantified using binary image-based methods and described in terms of regularity. Cyclic direct shear tests are conducted to investigate the effects of particle regularity on the interface shear strength, stress–displacement relationship, shear stiffness, and damping ratio. The results reveal that the interface shear strength and deformation strongly depend on particle regularity. The vertical displacement ratio is found to increase with particle regularity under the same cycle number. The interface stiffness is observed to increase with the cycle number for particle regularities of 0.453, 0.565, and 0.672 but decreases with the cycle number for a particle regularity of 0.971. For a given regularity, the trend of damping ratio with the increasing cycle number is contrary to the that of shear stiffness. Finally, it is observed that the cyclic friction angle decreases with increasing particle regularity, the relationship of which is determined using linear regression. Thus, the systematic quantification of particle shape characteristics can lead to a better understanding of soil–geogrid interface behaviour.

Keywords: Geosynthetics; Cyclic direct shear tests; Shear stiffness; Damping ratio; Cyclic friction angle; Soil-geogrid interface

Investigating factors influencing polymer elution and the mechanism controlling the chemical compatibility of GCLs containing linear polymers

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Abstract: A study was conducted to investigate (1) physicochemical factors that influence polymer elution from GCLs containing a blend of bentonite and linear (water-soluble) polymer (LPB GCLs) and (2) the mechanism that controls the chemical compatibility of LPB GCLs when polymer elutes. A series of hydraulic conductivity (k), free swell and viscosity tests were performed on a commercial LPB GCL using DI water, varying concentrations of NaCl and $CaCl_2$. Comparable tests were also performed on a conventional bentonite (CB) GCL containing the same untreated bentonite and the same physical properties as the LPB GCL. The LPB GCL showed improved swelling and hydraulic performance compared to the CB GCL when permeated with salt solutions. Total organic carbon analysis of the effluents showed that polymer eluted from the LPB GCL regardless of the permeant solution. However, the rate at which polymer eluted increased as the concentration and valence of the dominant cation increased. The rate at which polymer eluted also increased with hydraulic gradient. The mass of polymer retained inside the GCL matrix did not correlate with the k of the LPB GCL. Free swell tests coupled with chemical analysis suggest that, the improved chemical compatibility of the LPB GCL was due to the ability of the polymer to scavenge cations from the solution which allows the bentonite to undergo adequate swelling during the initial hydration period. Analogous to water-prehydrated CB GCLs, the dispersed structure of the bentonite fabric and increased adsorbed water molecules attained during initial swelling controls the k of the LPB GCL when polymer elutes.

Keywords: Geosynthetic clay liners; Hydraulic conductivity; Polymer-modified bentonite; Bentonite-polymer composite; Bentonite; Water-soluble polymer

Responses of single and group piles within MSE walls under static and cyclic lateral loads

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Abstract: To investigate the behavior of piles and the performance of the mechanically stabilized earth (MSE) walls under static and cyclic lateral loading, six reduced-scale model tests of single and group piles within the MSE walls were conducted inside a test box. In the single pile tests, a hollow aluminum tube as a pile was placed at a distance of 2D or 4D (D is pile diameter) behind the wall facing, while in the group pile tests, the piles were only placed at the distance of 2D with a spacing of 3.3D between the piles. The piles were subjected to static lateral loading only and cyclic lateral loading followed by static loading until failure. The test results showed that the lateral load capacity of each pile in the group pile test was approximately 60% that of the single pile, while the wall facing displacements and the geogrid strains in the group pile test were larger than those in the single pile test. The lateral pile capacity, the wall facing displacement, the strain in the geogrid, and the lateral earth pressure behind the wall facing in the static and cyclic loading tests were evaluated at the pile head displacement equal to 20%D.

Keywords: Geosynthetic; Cyclic loading; Lateral capacity; Model test; Pile; Pressure distribution; Tensile strain; Wall

Design of soilbag-protected slopes in expansive soils

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Abstract: Slope failures and slope slides of expansive soils are usually characterized by shallow sliding along the surface crack. Soilbag is an effective method to prevent and control slope failures and slope slides of expansive soil. Currently, soilbag protection for expansive soil slopes has been commonly designed using empirical methods, which led to many failures of soilbag-protected slopes, or high-cost. In this paper, a new design method of the soilbag-protected slopes in expansive soils is proposed based on the balance between the soilbag friction and the active lateral earth pressure induced by the swelling pressure of expansive soils. Specifically, the friction between the soilbags is assumed to be in direct proportion to the soilbag heap-up height. The active lateral earth pressure acted on a layer of soilbag is calculated along with the total height of the slope. Moreover, the width of soilbag layers is calculated from the balance of the sum of soilbag friction and the total active lateral earth pressure along with the soilbag height and expressed by the height of slopes. For the convenience of soilbag construction, the heap-up unit of soilbags is proposed for different slope heights of expansive soils.
Keywords: Expansive soil; Soilbag; Swelling pressure; Swelling stress; Cutting slope

Experimental study on the L-shaped anchorage capacity of the geogrid by the pullout test

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Abstract: The soil reinforcement by geosynthetics has been extensively applied in covers and liners of landfills. The stability of this structure is especially dependent on the effectiveness of the anchorages holding the geosynthetic sheets. The simple run-out and L-shaped anchorages are the two most commonly used approaches. For increasing the available knowledge of the anchorage system behavior, experimental studies have been conducted. This paper shows the results of the experimental analysis that are based on the results of large-scale pullout apparatus on geogrid embedded in simple run-out and L-shaped anchorage in two modes (fixed length and fixed space). The influence of different geometric parameters of the trench on the behavior of the geogrid is also examined. Based on the results, the values of pullout force were approximately 69% and 196% higher in the case of the fixed length mode and the fixed space mode, in the respective order, compared to the simple run-out anchorage. In the L-shaped anchorage, it is observed that for the initial length (L) constant, the mode is optimized with a small value of the geogrid rear heel length (B) and a greater value of the depth of the buried geogrid (D) when D+B is constant.

Keywords: Geosynthetics; Experimental study; Pullout test; L-shaped anchorage; Low confinement stresses

Performance of AC overlays using geogrids on PCC contraction joints

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Abstract: It is widely known that vertical displacements and strains occur on the joints and these cause defects on the asphalt concrete (AC) overlays on existing Portland cement concrete (PCC) pavements. Various approaches were introduced to minimize these defects. In this study, the effect of joint support formed using the geogrid material with grout mortar on the vertical displacement of PCC and the strain at the bottom of the AC layer. Produced layers were exposed to 1,186,000 Equivalent Single Axle Load (ESAL) in an APT (Accelerated Pavement Test) facility and the results were monitored. According to the obtained results, the use of AC overlay reduces vertical displacement in the PCC by 75%. When geogrid reinforced AC overlay was used, an additional reduction in displacement by 41.2% was achieved. Geogrid reinforcement reduced strain values formed at the bottom of the AC layer from 29.5% to 92.5%. The use of geogrid at joints instead of increasing the thickness of the AC layer from 50 to 80 mm resulted a more significant reduction in both strain and displacement. Besides, the usage of a geogrid interlayer instead of increasing the thickness of the AC layer also provided a significant cost reduction of 57.9% in overall cost.

Keywords: Geogrid reinforcement; Accelerated pavement test; AC overlay; Contraction joints; Strain; Vertical displacement

Experimental study on a geosynthetics isolator for the base vibration isolation of buildings neighboring metro transportation

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Abstract: By replacing the polyethylene terephthalate (PET) package of stacked sandbags by polyethylene naphthalate (PEN) textile capsule from air springs, a new geosynthetics isolator is developed to improve the mechanical properties of stacked sandbags. Sand and rubber particles were mixed and used to fill the isolator as a soil skeleton. The mechanical testing results showed that the vertical stiffness and damping performance could be easily adjusted by changing the particle mixture ratio. The horizontal stiffness is approximately a quarter of the vertical value, and the horizontal damping ratio is as high as 25%. The ultimate shear strain and compressive stress are 15% and 40 MPa, respectively. Both of these values are much greater than that of stacked sandbags and are appropriate for most buildings near metro transportation. The feasibility of the isolator is verified via field experiments with a full-scale building. After installing the new isolators, the vibration comfort of occupants in the vertical and horizontal directions is significantly improved, as is the secondary air-borne noise comfort. Moreover, the resonant influences caused by vertical and horizontal low-frequency road vibrations are suppressed by the isolator's high-damping performance. Therefore, this geosynthetics isolator is feasible for the base isolation of buildings neighboring metro transportation.

Keywords: Metro vibration; Geosynthetics isolator; Particle mixture ratio; High-damping performance; Field experiments; Occupant comfort

Hysteresis of the water retention curves of geosynthetic clay liners in the high suction range

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Abstract: This paper examines two needle-punched geosynthetic clay liners' water retention behaviour at high suction ranges using the vapour equilibrium technique where super-saturated salt solutions controlled the relative humidity. This study shows that the bentonite form and its mineralogy affect the absorption/desorption of GCLs and their corresponding water retention curves. In particular, a granular bentonite-based GCL was found to absorb more and release less water than a powdered bentonite-based GCL due to its higher montmorillonite content and larger pores. The water retention curves of both GCLs exhibited very little hysteretic behaviour at high suction. Repeated wetting-drying cycles shifted the WRCs of both GCLs slightly downward with minimal impact on their degree of hysteresis.

Keywords: Geosynthetics; Geosynthetic clay liners; Wet-dry cycles; High suction; Hysteresis; Unsaturated