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摘要集

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目　录

Geosynthetic-reinforced soils above voids: Observation of soil and geosynthetic deformation mechanisms

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Abstract: Understanding how a geosynthetic-reinforced soil deforms in response to the formation of an underlying void is crucial to provide appropriate designs of these systems. Centrifuge models employing a trapdoor to simulate the void formation below a geosynthetic-reinforced sand were conducted to investigate the behaviour in a controlled environment at realistic stress levels. The plane-strain models allowed visual observations of the deformation mechanisms using Particle Image Velocimetry (PIV). These observations were used to validate assumptions about the geosynthetic behaviour made in current design recommendations, and address limitations related to the fill behaviour. Soil expansion was observed to be confined to a parabolic zone above the void related to the soil dilatancy, rather than with a single, unique coefficient of expansion. The zone of subsidence was characterised by an initial vertical prism with a funnel to the surface, with the surface settlement profile better described by a Gaussian distribution rather than the parabolic profile used historically. Detailed interpretation of the centrifuge tests has given new insight into the soil and geosynthetic behaviour relevant to how these systems deform in practice. This paves the way for more efficient design recommendations and consequently will facilitate better predictions of geosynthetic-reinforced soil behaviour above voids.
Keywords: Geosynthetic-reinforcement; Void spanning; Centrifuge; PIV

Experimental investigation of a reinforced soil retaining wall with a flexible geogrid-wrapped ecological bag facing

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Abstract: This paper presented a field study of the reinforced soil wall (RSW) with a geogrid wrap-around facing. In addition to the conventional monitoring content, the strain of the face-wrapping geogrid, which was neglected in most previous studies, was monitored during the construction process. The positional relationship between the maximum vertical earth pressure and horizontally laid geogrid strain was revealed by using the proposed oblique dragging effect. It was found that the strain on the face-wrapping geogrid occurred mainly in the early stage of construction. The oblique dragging effect existing in the flexible RSWs increased the vertical earth pressure and changed its distribution law, resulting in the position of the maximum vertical soil pressure appearing behind the position of the maximum horizontally laid geogrid strain. The horizontal earth pressure at different positions behind the wall was obviously lower than the theoretical result by using Rankine's theory. Also,a modified 0.3H method (where H refers to the wall height) was presented to account for the slope of the wall face,which could be used to determine the potential sliding surfaces for single-stage RSWs and two-tier RSWs with small offset.

Keywords: Geosynthetics; Retaining wall; Field study; Construction progress; Earth pressure; Reinforcement strain

Examining metal migration through geotextiles during dewatering

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Abstract: This paper presents a study conducted to assess the influence that a filter cake deposited on the surface of the geotextile has on the mobility of three metals (Cu, Pb, Zn) during filtration of a contaminated sediment. Two chemical additives (cationic coagulant and cationic polymer) were introduced to the sediment to increase the particle size and improve the filtration efficiency. Bench scale experimentation was conducted to identify contaminant reduction using a small volume of sediment. A field test was applied to observe what effect three dimensional filtration and a larger filter cake had on metal mobility. Analysis of the effluent was conducted to determine total and dissolved metal contaminants, as well as particulate matter. Effluent chemical properties (pH, Eh, and zeta potential) were analyzed to identify a possible rationale for variations in concentration during filtration. The results of the study show that as an increasing buildup of filter cake on the surface of a geotextile developed, filtrate quality was improved with respect to the metal and particulate contaminants considered. In addition, the metals detected in the effluent were primarily in the solid state, suggesting further reduction could be achieved through subsequent filtration (if desired).
Keywords: Geotextile; Filtration; Metal; Filter cake; Effluent; Contaminated sediment

An analytical model for particle-geogrid aperture interaction

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Abstract: The shear strength of geogrid-reinforced ballast is often dependent on the aperture size of geogrids and the nominal size of ballast. This paper presents a theoretical analysis based on probabilistic mechanics of how aperture size affects the interaction between particles and geogrid. Unlike past literature, in this study, the properties of the particle size distribution is analysed using a Weibull distribution. The probability of grain interlock is proposed to describe the interactive mechanisms between particles and geogrids based on the relative particle size, which is defined as the ratio of particle size to aperture size. The mathematical model is calibrated by a set of large-scale direct shear tests with almost single-size (highly uniform) ballast aggregates, and then validated by independent set of data taken from both literature and current study. The study concludes that more uniform particle size distribution increases the probability of grain interlock at the optimum aperture size but decreases it at non-optimum aperture sizes.
Keywords: Ballast; Geogrids; Interlock; Theoretical analysis

Experimental study on the multi-impact resistance of a composite cushion composed of sand and geofoam

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Abstract: In the case of the rockfall hazards, multiple rockfall impacts usually occur. To improve the ductility and the multi-impact resistance ability of the rock-shed, geofoam is proposed to replace part of sand, forming a composite cushion. Two types of geofoam are selected in the paper, namely, expandable polyethylene (EPE) and expanded polystyrene (EPS). A systematic experimental study was conducted to compare the properties of EPE and EPS. The compression tests showed that EPE geofoam had better resilience than EPS geofoam. Under the laboratory multi-impact tests, the buffer performance of the sand-EPE composite cushion performed well under the multi-impacts. However, for the sand-EPS composite cushion, the buffer performance became poor with increased impact number. For the thicker geofoam, the buffer performance of the composite cushion changed slightly from the second impact to the fifth impact, especially for the EPE geofoam. Finally, large-scale rockfall experiments were carried out to further study the buffer performance of different cushions. Compared with EPS geofoam, EPE geofoam was more suitable for improving the capability of the composite cushion to resist multi impacts, as well as to protect the rock-shed under multiple rockfall impacts.

Keywords: Sand-geofoam composite cushion; Resilience; Buffer performance; Multi-impact resistance; Laboratory multi-impact test; Large-scale rockfall experiment

Modified Broms' method for formation of working platform on very soft soil

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Abstract: Construction over soft soil is a challenge as the ground can be too soft to work on it. To overcome this, a working platform has to be formed before any soil improvement work can be carried out. One of such methods was proposed by Broms (1987) which uses geotextile and sand berms. In this paper, a modified Broms' method is proposed to use geotextile tubes to confine the sand berms. A new analytical solution is also proposed to calculate the tensile strain and the profile of geotextile under the sand berms/tubes. Design charts for different design conditions are also developed. Parametric studies were conducted to identify the key parameters affecting the design. Finite element analyses (FEA) and a field trial were also carried out to verify the modified Broms' method and the proposed solution. The monitoring data agree reasonably well with the results obtained from proposed solution and FEA. A design procedure for modified Broms' method and Broms' method is proposed using the analytical solution.
Keywords: Geosynthetic; Geotextile; Sand berms; Sand tubes; Soil improvement; Soft soil

Full scale consolidation test on ultra-soft soil improved by prefabricated vertical drains in MAE MOH mine, Thailand

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Abstract: The reclamation of slurry pond with ultra-soft soil deposit using the prefabricated vertical drains (PVDs) with preloading technique in the Mae Moh mine, Lampang, Thailand is a challenging work and is illustrated in this paper. Geotextile reinforcement was used to strengthen bearing capacity of the soil foundation prior to the installation of sand platform. The delay of excess pore water pressure dissipation at the early loading stage occurred despite the occurrence of large settlements was a distinct behavior of the ultra-soft soil. Within the delayed time, the calculated average degree of consolidation based on measured settlements, Us increased while the calculated average degree of consolidation based on measured excess pore water pressures, Ue and the undrained shear strength, Su remained unchanged. Beyond the delayed time, both Ue and Su increased significantly with time and when Us > 90%, the difference between Ue and Us was observed to be small. It was suggested to use Us for approximation of Su when Us > 90% based on the SHANSEP's method. The successful installation and application of PVD to improve ultra-soft soil in this research is applicable for the ground improvement of similar problematic ultra-soft soils in international land reclamation projects.

Keywords: Ground improvement; Prefabricated vertical drains; Geotextile; Consolidation ; Ultra-soft soil

Laboratory test and modelling of gas pressure under geomembrane subjected to the rise of groundwater in plain reservoirs

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Abstract: To investigate the development of pore pressures in the air-confined system with a rise of groundwater under a geomembrane, a laboratory test was conducted. Then, a numerical model with the consideration of the water gas-solid three-phase system was developed based on the hydro-mechanical coupling theory for unsaturated soils. The model was validated by the experimental result and then a numerical study was conducted on the Datun plain reservoir. The result confirms the fact that the rise of groundwater is one of primary driving force for gas pressure under the geomembrane. When there is no surcharge over the geomembrane, air bulge would be produced. As the groundwater under the geomembrane replenished by water infiltration from groundwater around the reservoir, the gas pressure increases from the edge to the center of the reservoir and reaches the same final value with time. The increment of the pore gas pressure is significant during the increase of reservoir water, especially for the soils with larger compression strain. Thus, the coupled deformation is necessary to be considered for the regulating reservoir that undergoes the fluctuation of reservoir water frequently.
Keywords: Air bulge; Geomembrane; Water-air flow; Finite element method; Unsaturated soils

Experimental study of the performance of geosynthetics-reinforced soil walls under differential settlements

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Abstract: The deformation performance and settlement failure mechanism of geosynthetics-reinforced soil (GRS) walls are the two key points of engineering design under the differential settlement. This paper presents model tests of deformation performance and failure mechanism of the GRS wall with and without lateral restriction under differential settlement conditions. The observation and measurement results, including force and vertical displacement of geosynthetics and lateral deformation of facing panels, indicate good settlement control performance of GRS wall during construction and under differential settlement. Results indicate that the influence of the stress state of facing panels on the settlement control performance of GRS wall cannot be ignored. And the differential settlement failure of GRS wall is likely to occur in the joint of facing panels and geosynthetics. For good illustrations, two analytical approaches about deformation and stress of geosynthetics were proposed based on elastic cable theory, in GRS wall with and without lateral restriction. The expressions exclude the necessity to carry out sophisticated numerical analyses to stress and deformation and may help to develop the design guidelines for such GRS wall.

Keywords: Geosynthetics; GRS wall; Differential settlement; Deformation performance; Failure mechanism

Experimental study on vacuum preloading consolidation of landfill sludge conditioned by Fenton's reagent under varying filter pore size

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Abstract: In view of the deep dewatering of landfill sludge (LS) that had been buried for more than ten years in Shanghai, Fenton's reagent combined with a vacuum preloading method was proposed. First, a vacuum filtration test was carried out to study the optimal amount of Fenton's reagent for LS. Then, four filter membranes with different pore sizes were used for a vacuum preloading model box test to study the influence of pore size on the consolidation behaviour of LS. Through particle analysis, SEM and MIP testing, the consolidation behaviour of sludge under different pore sizes was studied from the microscopic perspective. The results show the following: the optimal amount of Fenton's reagent for conditioning LS is Fe^{2+}4%, H_2O_2 12%; the water content of LS with different pore sizes is reduced from 73% to 56%-63%; the unconfined compressive strength is increased from 10 kPa to above 80 kPa; and the volume reduction ratio is approximately 50%, among which the filter pore size of 180- μ m has the best performance. The micro-test results show that the pore size of the filter membrane has an important influence on LS's consolidation. The research results can provide significant references for the in-situ treatment of LS.

Keywords: Sludge's deep dewatering; Fenton's reagent; Filter pore size; Clogging; Consolidation behaviour

Performance of a 33m high geogrid reinforced soil embankment without concrete panel

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Abstract: Geosynthetic reinforced soil embankment are extensively applied in the construction of high-speed railway and highway in mountainous regions but limited field monitoring is conducted on high and steep cases. Aiming to acquire better understanding, a 33-m-high single-tiered wrapped-facing geogrid reinforced soil embankment with the slope of 1 V:0.5H in China was monitored for 2 years during and after construction. Vertical earth pressure, strain of geogrids, horizontal displacement and settlement per layer were recorded and analyzed. The results show that the geogrid tensile strains gradually increased during construction. And they were still developing after completion due to creep and subsequent vehicle surcharge load. The predictions of reinforcement loads by the FHWA methods were much higher than the estimated ones from measured strains. The vertical earth pressures linearly grew during construction and then stabilized fast. The horizontal displacement increases with height and the largest value achieved around the top of the slope two years after the construction is 0.14% the total height approximately. The settlement per layer is larger in the lower and middle portion of the embankment and no obvious change is observed over time. This study hopes to serve as a case reference for design and construction of similar reinforcement projects in the future.

Keywords: Geogrid reinforcement; Field monitoring; Embankment; Earth pressure; Deformation

Experimental investigation on the performance of multi-tiered geogrid mechanically stabilized earth (MSE) walls with wrap-around facing subjected to earthquake loading

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Abstract: Construction of mechanically stabilized earth (MSE) walls in multi-tiered configurations is a promising solution for increasing the height of such walls. The good performance of this type of walls after recent major earthquakes was reported in a number of technical studies. In the present study, an experimental approach was adopted to compare the seismic performance of single-tiered and multi-tiered MSE walls using physical modeling and through conducting a series of uniaxial shaking table tests. To do so, several geogrid-reinforced soil walls with wrap-around facing (i.e., three-, two-, and single-tiered) with a total height of 10 m were designed in the form of prototypes of 1-m-height wall models. The step-wise intensified sinusoidal waves were applied to the models in 14 typical forms. Comparing the shaking table test results confirmed the post-earthquake advantages of multitiered MSE walls. The results revealed that tiered walls exhibited better behaviors under earthquake loading in terms of the seismic stability of the wall, displacement of the wall crest, horizontal displacement of the wall facing, deformation mode and failure mechanism of the wall, settlement of backfill surface, and seismic acceleration responses.
Keywords: Physical modeling; Shaking table test; Multi-tiered MSE walls; Geogrid wrap-around facing; Earthquake loading; Seismic performance

Stress-dependent method for calculating the modulus improvement factor in geocell-reinforced soil layers

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Abstract: This paper presents an analytical method for determining the modulus improvement factor (MIF) in geocell reinforced soil layers. Using a modified version of the hyperbolic soil model as a constitutive model, the method is developed based on the soil-reinforcement interaction relating nonlinear elastic soil behavior to the linear elastic response of the reinforcement. The proposed method, in an original way, explicitly takes into account the geometry of the geocell pocket, effects of soil and geocell-reinforcement stiffness, compaction-induced stresses, soil strength and strain compatibility. The method can be used both analytically and using simple and presented non-dimensional charts. Parametric analyses show that the reinforcement, soil relation and the stresses induced during the compaction procedure are the major factors influencing MIF. An evaluation using data from several laboratory, full-scale and field experiments in works is presented showing good predictive capability of proposed method. An application procedure for calculating MIF is presented.
Keywords: Geosynthetics; Soil improvement; Modulus of elasticity; Pavement reinforcement

Design of geosynthetic reinforced column supported embankments using an interaction diagram

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Abstract: Geosynthetic reinforced column supported embankments predominantly utilise two mechanisms to transfer embankment loads towards column heads, soil arching and membrane actions. When undertaking the design of column supported embankments, it is common practice to perform a two-step design, whereby the arching actions are estimated independently of the subsoil deformation and membrane actions. This approach is unable to capture the deformation dependency exhibited by both arching and membrane actions. This paper presents deformation dependent arching and membrane action models and implements them within an interaction diagram. It is shown that an interaction diagram-based design approach is capable of performing an ultimate and serviceability limit state design of a geosynthetic reinforced column supported embankment. In contrast, most existing analytical design methods only consider the ultimate limit state. The proposed method is applied to a design example where the benefits of such a design approach are demonstrated.
Keywords: Geosynthetics; Piled embankments; Column supported embankments; Ground reaction curve; Design

Study on filtration process of geotextile with LBM-DEM-DLVO coupling method

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Abstract: The method of filtering and dewatering waste slurry using geotextiles has been widely used in recent years. It is important to adopt suitable geotextiles to get a high dewatering rate and a high retention performance. In view of the unclear influence of the geotextile properties on the cake and the unclear soil particle retention mechanism in geotextiles, this paper uses the Lattice Boltzmann method-Discrete Element method-DLVO (LBM-DEM-DLVO) coupling method to simulate the mesoscopic process of slurry filtration process using geotextiles. The numerical results show that the nature of the geotextile does not affect the hydraulic conductivity of the cake. And the retention mechanism for soil particles being trapped inside geotextile was proposed. The mechanism is related to the relative relationship between the interaction force between the geotextile fiber and the soil particle Finter and the drag force of the soil particle F^{y}_{d} in the geotextile. The dimensionless ratio α_{sl}= Finter/(F^{y}_{d} +G) was proposed to quantify this retention mechanism; the smaller αsl is, the greater the probability that the geotextile will lose particles. When $\alpha_{sl} \geq 1.04$, the geotextile does not lose particles. According to these results, some suggestions of geotextiles for dewatering slurry were proposed.

Keywords: Geotextile; Filtration; Retention; Dewater; Soil loss

Influence of geosynthetic reinforcement on the stability of an embankment with rigid columns embedded in an inclined underlying stratum

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Abstract: Incompressible dipping substrata are commonly encountered in engineering practice. Compared to horizontal underlying strata, the inclined underlying stratum increase the risk of collapse of embankments reinforced with columns because it weakens the restraint of the column base. The objective of this study is to investigate the effectiveness of geosynthetics on improving the embankment stability when the underlying stratum is inclined. The influence of geosynthetic tensile stiffness on the ultimate surcharge and failure mechanism is studied. A deep-seated failure with column tilting occurs when the geosynthetic tensile stiffness is low, whereas a lateral sliding occurs when the geosynthetic tensile stiffness is high. To illustrate the contribution of geosynthetics, the distribution of the lateral pressures acting on the columns is analyzed.
Keywords: Geosynthetics; Deep-seated failure; Embankment; Lateral sliding; Rigid columns; Stability

Shear behavior of geocell-geofoam composite

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Abstract: In design, internal stability of EPS lightweight fills are provided either by applying load distributing mechanisms (thick pavements or concrete slabs) or using more strong lightweight material through denser EPS geofoam blocks. However, unit weight of the EPS geofoam is a limited parameter. As an attempt to improve the mechanical properties of EPS geofoam, geocell-geofoam composite (GGC) is introduced in this study. Geocell mattresses were infilled with solidified geofoam beads in the factory to fabricate GGC. The EPS geofoam and GGC samples were tested using a large-scale shear test apparatus of size measuring 1 m^3. Results indicate that inclusion of the geocell leads to a considerable increase in the shear strength and a great decline in the compressibility of the geofoam. In comparison with EPS blocks, up to 72% rise in the shear strength and 67% decline in the vertical displacement were observed in GGC samples at the normal stress of 35 kPa. In addition, incorporation of the geocell was found to change the resisting mechanism of the EPS geofoam from cohesive to cohesive-frictional. While there was only 4.5% decline in the cohesion, the internal friction angle of the tested geofoam increased six-fold due to the involvement of the geocell.

Keywords: Geofoam; Geocell; Composite; Shear behavior

Hydration/dehydration behaviour of geosynthetic clay liners in the Antarctic environment

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Abstract: This paper examines the hydration/dehydration behaviour of geosynthetic clay liner (GCL) under polar conditions for four simulated conditions experienced at Australia’s Casey Station in Antarctica: (a) hydration during summer, (b) dehydration during a winter-summer cycle, (c) hydration through a fine Antarctic soil, and (d) hydration through a coarse Antarctic soil. Hydration during the summer is found to occur if there is direct contact with the water table. In contrast, the low relative humidity of the environment tends to dehydrate the GCL along a path that depends on the field conditions the GCL is exposed to. Hydration from either fine or coarse Antarctica soil is function of the original gravimetric water content of the subgrade soil and its grain size distribution as well as the low relative humidity prevailing in Antarctica.

Keywords: Geosynthetics; Geosynthetic clay liner; Antarctica; Unsaturated behaviour; Cold regions engineering

Centrifuge modeling of geosynthetic-encased stone column-supported embankment over soft clay

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Abstract: Geosynthetic-encased stone column (GESC) has been proven as an effective alternative to reinforcing soft soils. In this paper, a series of centrifuge model tests were conducted to investigate the performance of GESC-supported embankment over soft clay by varying the stiffness of encasement material. The enhancement in the performance of stone columns encased with geosynthetic materials was quantified by comparing the test with ordinary stone columns (OSCs) under identical test conditions. The test results reveal that by encasing stone columns with geosynthetic material, a significant reduction in the ground settlement, relatively faster dissipation of excess pore pressure and enhanced stress concentration ratio was noticed. Moreover, with the increase in the encasement stiffness from 450 kN/m to 3300 kN/m, the stress concentration ratio increased from 4 to 6.5, which signifies the importance of encasement stiffness. In addition, a relatively lower value of soil arching ratio observed for GESCs compared to OSCs indicate the formation of a relatively strong soil arch in the GESC-supported embankment. Interestingly, under embankment loading, GESCs fail by bending while OSCs fail by bulging. The stress reduction method can be used to calculate the settlement of GESC-supported embankment with larger stress reduction factor than that in the OSC-supported embankment. Finally, the limitation of the construction of the embankment at 1 g was addressed.

Keywords: Geosynthetics; Encased stone column; Embankment; Soft soil; Centrifuge; Load transfer

Performance of polypropylene textile encased stone columns

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Abstract: This paper explores the potential use of a woven polypropylene textile for encapsulating stone columns and improving performance of a local soft soil in Warangal city of India. A series of axial load tests were performed on stone columns of various diameters and under various encapsulation conditions that include single and double layers and other combinations. Load carrying capacity of stone column increased twice its original capacity when encapsulated with different geofabric materials. Performance enhancement strongly correlated to the tensile strength of encasement material and encapsulation condition. In addition, the influence of lateral thrust on group of stone columns arranged in square and triangular patterns were investigated. Irrespective of the material used, lateral displacement reduced by half for encased stone columns. Apart from tensile strength of encasing material, the amount of material used for encasement in the form of additional encasement layer was found to be crucial. The cost of using the polypropylene encasing material is only a third of the commercial geotextiles; however, the performance is inferior to woven geotextiles but far superior to non-woven geotextiles.
Keywords: Stone columns; Geotextiles; Encasement; Woven polypropylene textile; Axial loading; Lateral thrust

Geo synthetic reinforced piled embankment modeling using discrete and continuum approaches

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Abstract: Understanding the load transfer mechanism can support engineers having more economical design of geosynthetic reinforced piled embankments. This study aims to investigate the load transfer mechanisms by two different numerical methods including the Discrete Element Method (DEM) and the Finite Difference Method (FDM). The DEM model adopts (a) discrete particles to simulate the micro-structure of the granular materials and (b) coupled discrete element - finite element method (DEM-FEM) to capture the interaction between granular materials and geotextiles. On the other hand, the FDM model uses an advanced constitutive soil model considering the hardening and softening behaviour of the granular materials. The numerical results show that the geotextiles can only contribute to the vertical loading resistance in cases where the soils between piles are soft enough. In terms of design, an optimum value of the geotextile tensile stiffness can be found considering the load, the soft soil stiffness and the thickness of the embankment. Both the DEM and the FDM show that a high geotextile tensile stiffness is not required since an extra stiffness will slightly contribute to the efficiency of the geosynthetic reinforced piled embankments. Nevertheless, both models are useful to optimize the design of geosynthetic reinforced piled embankments.

Keywords: Discrete element method; Finite difference method; Soil arching; Load transfer; Reinforced piled embankment; Granular embankment; Softening behaviour

The characterisation of geosynthetic interface friction by means of the inclined plane test

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Abstract: The paper focuses on the evaluation of the shear strength in conditions of low normal stress of various geosynthetic-geosynthetic interfaces, which are typical of landfill cover systems, by means of the inclined plane test, with the aim of studying the friction mobilisation in relation to various kinematic behaviours. The results of three different methods to evaluate the angle of friction were analyzed, together with the sensitivity of the interfaces in relation to the wear effect and the influence of the state of hydration. The results showed very different responses of the interfaces to the shear stress, which involved three main types of sliding mechanisms, referred to as sudden, gradual and uneven sliding. Another outcome observed was that the shear strength of geosynthetic-geosynthetic interfaces cannot always be properly characterised following the procedure proposed by the European standard for soil-geosynthetic interfaces (EN ISO 12957-2), since the actual mobilised kinematic behaviour should be taken into consideration. In this regard, the paper provides some hints on the choice of the more representative parameter of friction for each type of sliding. A particular focus was given to the case of gradual sliding interfaces, for which the static friction is difficult to detect due to the very slow movements; for practical purposes, the design friction of these interfaces should be evaluated by using an adequate safety factor with respect to the friction evaluated at 1 mm of displacement.
Keywords: Geosynthetics; Interface; Shear strength; Friction; Inclined plane

Microanalysis of smooth Geomembrane-Sand interface using FDM-DEM coupling simulation

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Abstract: Very limited attention was paid on the micro-response of sand as it interacts with geomembrane and the effect of surface hardness on the interaction at the microscopic level. In this study, a coupled finite difference-discrete model was adopted with which to analyze the shear behavior of sand-smooth geomembrane interface. The model was validated using published experimental data. The numerical results show that the effects of normal stress and surface hardness on the interface strength depend on the shear mechanism (sliding or plowing) at the interface. There exists a critical normal stress at which the mechanism transforms from predominant sliding to predominant plowing. There is a high level of coupling effect between normal stress and surface hardness on the interface strength. Micro-topographical analysis of geomembrane provides clear insights into the shear mechanism at the interface, supporting the results obtained from interface shear tests. No shear band is formed during shearing for a sand-smooth geomembrane interface. The shear resistance of sand-smooth geomembrane interface relies on interface indentations and characteristics rather than on the formation of shear band.

Keywords: Geosynthetics; Sand-smooth geomembrane interface; Coupled finite difference-discrete element; Shear mechanism; Microscopic analysis

Numerical parametric study of geosynthetic reinforced soil integrated bridge system (GRS-IBS)

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Abstract: A 2-D finite element model was developed in this study to conduct a FE parametric study on the effects of some variables in the performance of geosynthetic reinforced soil integrated bridge system (GRS-IBS). The variables investigated in this study include the effect of internal friction angle of backfill material, width of reinforced soil foundation (RSF), secondary reinforcement within bearing bed, setback distance, bearing width and length of reinforcement. Other important parameters such as reinforcement stiffness and spacing were previously investigated by the authors. The performance of GRS-IBS were investigated in terms of lateral facing displacement, strain distribution along reinforcement, and location of potential failure zone. The results showed that the internal friction angle of backfill material has a significant impact on the performance of GRS-IBS. The secondary reinforcement, setback distance, and bearing width have low impact on the performance of GRS-IBS. However, it was found that the width of RSF and length of reinforcement have negligible effect on the performance of GRSIBS. Finally, the potential failure envelope of the GRS-IBS abutment was found to be a combination of punching shear failure envelope (top) that starts under the inner edge of strip footing and extends vertically downward to intersect with Rankine active failure envelope (bottom).
Keywords: Geosynthetics; Finite element analysis; Parametric study; Geosynthetic reinforced soil (GRS); Integrated bridge system (IBS); Bridge abutment

A simple solution for prefabricated vertical drain with surcharge preloading combined with vacuum consolidation

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Abstract: Prefabricated vertical drains (PVDs) with the surcharge preloading and vacuum consolidation has become considerably popular for ground improvement projects. A simple solution that incorporates the fundamental embankment features, such as the average degree of consolidation and excess pore pressure, are essential for the design of soft ground improvements by PVDs with vacuum preloading. However, most of the solutions for vertical drains with vacuum consolidation require numerical simulations, whose implementation tends to be laborious. In contrast, a simple solution for vacuum consolidation under time-dependent loading has not yet been proposed. In this study, a simple solution that can be easily incorporated into a conventional spreadsheet is derived for PVDs with vacuum preloading by applying the Laplace transform technique. The proposed solution accounts for several actual construction conditions, such as initial surcharge load, vacuum pump trial period, variations of radial permeability, and time-dependent loading. The results obtained from this proposed approach were validated with those from the finite element method and field data from the case study of the Cai Mep International Terminal project in southern Vietnam. The derived solutions, including the excess pore pressures and average degrees of consolidation, were in good agreement with the predicted and observed data.

Keywords: Vertical drains; Surcharge preloading; Vacuum; Time-dependent loading; Drainage patterns

Soil-reinforcement interaction: Stress regime evolution in geosynthetic-reinforced soils

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Abstract: Understanding the stress regime that develops in the vicinity of reinforcements in reinforced soil masses may prove crucial to understanding, quantifying, and modeling the behavior of a reinforced soil structures. This paper presents analyses conducted to describe the evolution of stress and strain fields in a reinforced soil unit cell, which occur as shear stresses are induced at the soil-reinforcement interface. The analyses were carried out based on thorough measurements obtained when conducting soil-reinforcement interaction tests using a new large scale device developed to specifically assess geosynthetic-reinforced soil behavior considering varying reinforcement vertical spacings. These experiments involved testing a geosynthetic-reinforced mass with three reinforcement layers: an actively tensioned layer and two passively tensioned neighboring layers. Shear stresses from the actively tensioned reinforcement were conveyed to the passively tensioned reinforcement layers through the intermediate soil medium. The experimental measurements considered in the analyses presented herein include tensile strains developed in the reinforcement layers and the displacement field of soil particles adjacent to the reinforcement layers. The analyses provided insights into the lateral confining effect of geosynthetic reinforcements on reinforced soils. It was concluded that the change in the lateral earth pressure increases with increasing reinforcement tensile strain and reinforcement vertical spacing, and it decreases with increasing vertical stress.
Keywords: Soil reinforcement; Soil-structure interaction; Reinforced soil; Geosynthetic reinforcements; Lateral earth pressure

One-step analytical method for required reinforcement stiffness of vertical reinforced soil wall with given factor of safety on backfill soil

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Abstract: The selection of geosynthetic reinforcements in the design of geosynthetic-reinforced soil (GRS) retaining walls has been based on the requirement on the long-term strength. However, the mobilized loads in the reinforcements are related to both the reinforcement stiffness and soil deformation, and the desired factor of safety may not exist in the earth structure if they are not properly considered. Therefore, it is also important to take into account the long-term reinforcement stiffness when designing GRS retaining walls. In this study, a simplistic analytical method is proposed to determine the required reinforcement stiffness with given factor of safety on the backfill soil. The method takes into account soil-reinforcement interaction, nonlinear stress-strain behavior of soil, and soil dilatancy. The reinforcement strains predicted by the proposed method were compared to those analyzed by validated nonlinear Finite Element analyses, and close agreement was obtained.
Keywords: Geosynthetics; Geosynthetic-reinforced soil wall; Reinforcement stiffness; Analytical method; Factor of safety