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摘要集

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目　录

Effect of prehydration, permeant, and desiccation on GCL/Geomembrane interface transmissivity

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Abstract: A laboratory investigation was conducted on two different conventional GCLs (one with fine granular and another one with powdered bentonite) to explore the effect of prehydration and permeant fluid; GCL desiccation on the interface transmissivity, θ, between the interfaces of a 1.5 mm-thick high-density polyethylene (HDPE) geomembrane (GMB) and a GCL. The study also aimed to assess the self-healing capacity of desiccated GCLs for three different permeant solutions under a range of applied stresses (10–150 kPa). It was found that at stresses less than 70 kPa, θ was dominated by variability in the initial contact condition between the GMB-GCL interfaces. The effect of other factors was largely masked by the contact variability. At 100–150 kPa, the effects of initial variability were largely eliminated, but there was no notable effect of other factors on θ in the absence of desiccation. GCL desiccation increased θ by up to three orders of magnitude than an intact specimen at 10–100 kPa. Even at 150 kPa, desiccated specimens had a $\theta \leq 8.0 \times 10{-}9$ m^2/s for all specimens tested. The chemical composition of the permeant solutions, crack width, and nature of bentonite could play an important role in healing the cracks of desiccated GCLs.

Keywords: Geosynthetics; Conventional GCL; Desiccation; Interface transmissivity; Composite liner

Effect of polypropylene fiber and nano-zeolite on stabilized soft soil under wet-dry cycles

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Abstract: Nano-zeolite was used in the present study as a substitute for a part of lime and then inclusion polypropylene fiber in stabilized soil matrix to develop the soil stabilization method with lime and to improve the efficiency of this technique. In so doing, specimens of soft soil with 5, 10 and 15% of modifier L (lime), LZ (lime-nano-zeolite) and LZF (lime-nano-zeolite-fiber) were prepared, and were subjected to 1–7 wet-dry cycles. Then, microstructure and macrostructure tests were performed on the specimens. The results of the analyses, indicated that the optimal replacement of lime with nano-zeolite would be 40%, and the optimal amount of polypropylene fibers inclusion would be 1% in the stabilized soil matrix. Major reduction in lime consumption would yield a 40% increase in compressive strength and a 21% improvement in durability. The results also showed that the specimen containing 15% LZF would have excellent durability against environmental conditions and very good performance in terms of unconfined compressive strength (UCS), tensile strength and weight loss. Before and after applying 7 wet-dry cycles, the UCS increased by 39% and 16%, respectively. The results of this study indicate that LZF modifier is a suitable option for lime-based stabilization in areas under wet-dry cycles.

Keywords: Soft soil; Nano-zeolite; Lime; Wet-dry cycle; Fiber

Shaking table tests on wall-type gravel and rubber drains as a liquefaction countermeasure in silty sand

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Abstract: In this paper, the seismic performance of wall-type gravel and rubber drains as a liquefaction countermeasure in silty sand has been addressed using a series of 1 g shaking table tests. In these tests, the liquefaction resistance of silty sand was studied by changing soil relative density, silt content, number of walls, and materials of drainage walls. In order to evaluate shear wave propagation, the generation and dissipation of pore water pressure (PWP), and the ground surface settlement, various accelerometers, displacement and PWP transducers were placed. The obtained results indicated that an increase in the relative density and the number of wall-type gravel and rubber drains in liquefiable silty sand reduces the settlement, liquefaction-induced deformations, as well as the excess PWP and eventually improves the liquefaction resistance. Totally, it can be noted that the reinforced silty sand with wall-type gravel drains revealed less excess PWP and settlement than that with wall-type rubber drains.
Keywords: Liquefaction; Wall-type drains; Pore water pressure; Shaking table; Settlement

Experimental investigation on electro-osmotic treatment combined with vacuum preloading for marine clay

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Abstract: An electro-osmotic consolidation (EO) combined with vacuum preloading (VP) was investigated on marine clay using laboratory tests. To improve consolidation efficiency and reduce the settlement difference, a new prefabricated device was designed to combine EO and VP for the tests. The results indicated that the vacuum preloading with intermittent electro-osmotic consolidation (VP–I-ECM) provided more water discharge with higher discharge rate and produced larger soil settlement compared to traditional vacuum preloading and electro-osmotic consolidation. For the combined method, the VP effectively removed water from the soil for the first 12 h, and its efficiency decreased with the time. After 12 h, the intermittent EO was used to further consolidate the soil and maintain a high level of drainage rate. Test results also showed that the combined method of VP-I-ECM significantly improved the shear strength and bearing capacity of the marine clay to satisfy the construction requirements with a significant reduction in the anode erosion and the energy consumption. This research study provides useful information for the design guide and practical application of the combined technique for improving marine clay.

Keywords: Electro-osmotic consolidation; Vacuum preloading; Marine clay; Bearing capacity; Prefabricated electrokinetic system

Effect of geomembrane hole geometry on leakage overlain by saturated tailings

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Abstract: Experiments are conducted to quantify leakage through holes in a geomembrane (GMB) overlain by tailings with 30% fines and underlain by a well-graded gravel. Analytical and empirical equations for predicting leakage through a circular hole are used to analyze the data. Test results show that changing the hole shape from circular to noncircular increases the leakage. Leakage through 2000 mm2 triangular, diamond, and square holes are all 15% higher than the 2000 mm2 circular hole. An increase by up to 33% is observed for a rectangular hole. The analytical equations for predicting leakage and head loss through a hole given by the modified Rowe-Booker equation are experimentally verified. The spatial distribution of fines content within about five diameters of the hole is shown to have a notable impact on leakage. Up to a 100% increase in leakage is detected due to 3% reduction in the fines content around the hole. For homogeneous tailings, the ratio of head loss within the hole and above the hole to total head loss are independent of consolidation stress and water head and primarily depend on the hole geometry (i.e., shape and size). Finally, the combined effect of tailings thickness and water head on leakage is discussed.

Keywords: Geosynthetics; Geomembrane; Leakage; Tailings; Noncircular hole

A new apparatus for the study of pullout behaviour of soil-geosynthetic interfaces under sustained load over time

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Abstract: At present, the design of geosynthetic-reinforced soil structures is executed with reference to the tensile strength of the reinforcement obtained from in-air short-term tensile tests, decreasing this value by means of several factors. Among these, the creep effect resulting from in-air tensile creep tests reduces tensile strength the most. Consequently, this procedure does not take into account the effects of soil confinement and interaction on the tensile response of the reinforcements. This paper illustrates a new large-scale pullout prototype apparatus, with the capacity to investigate the behaviour of a geosynthetic reinforcement embedded in a compacted soil and subject to a tensile load kept constant over time. The apparatus allows the verification of how the soil can modify the prediction of the long-term behaviour of geosynthetics. Results in terms of confined tensile strains were analysed, and the comparison of those values with the strains obtained by in-air tensile creep tests has led to the conclusion that the creep reduction factor might be conservative. Moreover, the confined tensile strains were related to the apparent coefficients of friction to propose a new procedure capable of determining the design interaction parameter under long-term pullout load as a function of the allowable reinforcement strains.

Keywords: Geosynthetics; Geogrid; Creep; Long-term behaviour; Pullout; Total strains; Design parameters; Apparent coefficient of friction; Viscous properties

Clogging effect of prefabricated horizontal drains in dredged soil by air booster vacuum consolidation

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Abstract: The typical problem that occurs when the conventional vacuum preloading (CVP) method is applied to dredged soil is that the drainage is impeded, permeability is progressively reduced, and clogging occurs in prefabricated horizontal drains (PHDs). This paper proposes a method in which air booster through PHDs under vacuum preloading to reinforce newly dredged soil, and thereby solve the clogging problem. To evaluate the proposed method, several experiments were conducted using soils with variable degrees of consolidation and the effect on clogging determined. Furthermore, the proposed method was compared to the CVP method considering several variables monitored during consolidation and after consolidation. The results indicate that the proposed method is superior to the CVP as it more effectively alleviates the clogging problem. These findings could provide design criteria for dredged soil consolidation in similar projects and for scientific research and engineering practice.

Keywords: Prefabricated horizontal drain; Air booster; Dredged soil; Consolidation; Clogging

A theoretical strain transfer model between optical fiber sensors and monitored substrates

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Abstract: This study proposed an analytical model to investigate strain transfer mechanism between FBG sensor and measured geogrid. Both geometric and mechanical parameters (bonding length, bonding thickness, bonding width, and Young's modulus) of interaction interface can be taken into account in this model. Both laboratory tensile tests of geogrid and experimental data in published literatures were used to verify the developed model. Validation study shows that the maximum relative error between experimental values and theoretical values is 8.2%, indicating that this theoretical model can be used to reflect geogrid deformation. Parametric study indicates that bonding length, bonding thickness, bonding width, Young's modulus of adhesive layer, and substrate layer have significant influence on strain transfer coefficient. Grey Relational Analysis (GRA) method was used to analyze influencing sensitivity of different parameters. GRA parameter values of bonding width and length are higher than 0.72, indicating that bonding width and bonding length are relatively dominant factors affecting average strain transfer coefficient in comparison with bonding thickness, Young's moduli of substrate and adhesive layers (their related GRA values are all lower than 0.692).

Keywords: Fiber bragg grating sensor; Strain transfer coefficient; Parametric study; Grey relational analysis

Experimental evaluation of wicking geotextile-stabilized aggregate bases over subgrade under rainfall simulation and cyclic loading

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Abstract: Wicking geotextile has been increasingly utilized in field projects to mitigate water-related roadway problems. The previous studies showed that the wicking geotextile could provide mechanical stabilization, serve as capillary barrier, and enhance lateral drainage. The wicking geotextile differentiates itself from non-wicking geotextiles by providing capillary or wicking drainage in unsaturated conditions, whereas non-wicking geotextiles only provide gravitational drainage under saturated or near-saturated conditions. Although the previous studies have demonstrated the benefits of soil water content reduction by the wicking drainage, it is not well understood how the wicking geotextile stabilization improves overall performance of aggregate bases over subgrade under traffic or cyclic loading. This paper presents an experimental study where large-scale cyclic plate loading tests were conducted under different conditions: (1) non-stabilized base, (2) non-wicking geotextile-stabilized base, and (3) wicking geotextile-stabilized base, over soft and moderate subgrades. Rainfall simulation was carried out for each test section. After each rainfall simulation, a drainage period was designed to allow water to drain from the section. The amounts of water applied and exiting from the test section were recorded and are compared. Cyclic loading was applied after each drainage period. The test results show that the combined hydraulic and mechanical stabilization effect by the wicking geotextile reduced the permanent deformation of the aggregate base over the subgrade as compared with the non-stabilized and non-wicking geotextile-stabilized sections.

Keywords: Geosynthetic; Geotextile; Drainage; Road; Deformation; Unsaturated soil; Wicking

Probabilistic stability analysis of geosynthetic-reinforced slopes under pseudo-static and modified pseudo-dynamic conditions

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Abstract: An efficient and accurate reliability-based design of the geosynthetic-reinforced slopes (GRS) using the pseudo-static and modified pseudo-dynamic framework is proposed in the present study. Deterministic formulation used in the present study is made robust with the help of nonlinear constrained optimization. The collocation based stochastic response surface method (CSRSM) is used to probabilistically analyze the GRS. The critical modes of failure pertaining to the internal and external stability of the GRS are considered in the formation of the performance functions. The horizontal seismic acceleration coefficient (k_h), internal friction angle of soil (φ), soil unit weight (γ), shear wave velocity (V_s), and friction angle at the interface between soil and reinforcement (φ_b) are chosen as the random variables, owing to their high influence on the stability of the GRS. The influence of correlation on the stability of the reinforced slope is illustrated considering the internal and external stability. System reliability analysis considering the internal and external modes of failure is also performed. An illustrative example is presented showing the steps to design a GRS using the proposed formulation. The results confirm the necessity of performing the system reliability analysis to estimate an accurate value of probability of failure of GRS.

Keywords: Geosynthetic-reinforced slope; Stochastic response surface; Internal stability; External stability; System reliability; Probabilistic analysis

Case history on failure of geosynthetics-reinforced soil bridge approach retaining walls

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Abstract: Six geosynthetic-reinforced soil (GRS) retaining walls supporting bridge approach roads of an overpass bridge in China exhibited a series of structural problems after 18 years of service. Field investigations demonstrated that the major structural problems consist of excessive lateral facing displacement, settlement and damage of facing panels, and pavement cracks above the GRS retaining walls. The structural problems were mainly caused by inadequate backfill compaction behind the facing, rain water infiltration, the settlement of foundation soil, and reinforcement ageing. Among the six GRS walls, a 22-m-long section collapsed after mild rain in July 2016, and the failure surface in the collapsed zone was mainly located 0.5 – 0.9 m away from the back of facing panels along the wall height. The field investigation found that external water filtration into the backfill behind the facing panels, and the breakage of connection between reinforcement and facing panels were the main causes of the failure. The connection breakage resulted from the ageing of PP reinforcement strips, and the critical issue of PP reinforcement ageing in complex backfill environment was pinpointed. Remedial measures of the failed section and reinforcing techniques of the remaining GRS walls were briefly presented in the end.

Keywords: Geosynthetics; GRS retaining Walls; Structural problem; Reinforcement ageing; Collapse of facing panels

Development and mechanical properties of HDPE/PA6 blends: Polymer-blend geocells

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Abstract: Geocells are three-dimensional expandable panels composed of polymers such as polyolefin polymers. Currently, geocells are being extensively used in various geotechnical engineering applications; however, its applications are limited because of the sizeable long-term deformation under constant loading and poor tensile strength. Owing to the rapid growth rate of geocells, it has become necessary to develop a polymer material with excellent creep resistance and tensile strength. To this end, a polymer-blend geocell (PBG) is developed in this study using a twin-screw extruder with high-density polyethylene (HDPE), polyamide 6, and compatibilizer. The polymer formula is determined by the tear fracture surface and scanning electron microscopy. The tensile properties of the blends with different formulas are studied in terms of yield strength, tensile strength, and elongation at break. Finally, three types of PBG and HDPE geocells are selected to study the long-term creep behavior using accelerated creep tests. The analysis results of raw creep data, master creep curve, and isochronous creep curves indicated that the PBG had a better creep resistance than the HDPE geocells.

Keywords: Geosynthetics; Geocell; Polymer development; Blends; Accelerated creep test; Stepped isothermal method (SIM)