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摘要集

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目　录

Upper bound seismic limit analysis of geosynthetic-reinforced unsaturated soil walls

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Abstract: The assessment of the internal stability of geosynthetic-reinforced earth retaining walls has historically been investigated in previous studies assuming dry backfills. However, the majority of the failures of these structures are caused by the water presence. The studies including the water presence in the backfill are scarce and often consider saturated backfills. In reality, most soils are unsaturated in nature and the matric suction plays an important role in the wall's stability. This paper investigates the internal seismic stability of geosynthetic-reinforced unsaturated earth retaining walls. The groundwater level can be located at any reinforced backfill depth. Several nonlinear equations relating the unsaturated soil shear strength to the matric suction and different backfill type of soils are considered in this study. The log -spiral failure mechanism generated by the point-to-point method is considered. The upper-bound theorem of the limit analysis is used to evaluate the strength required to maintain the reinforced soil walls stability and the seismic loading are represented by the pseudo-dynamic approach. A parametric study showed that the required reinforcement strength is influenced by several parameters such as the soil friction angle, the horizontal seismic coefficient, the water table level, the matric suction distribution as well as the soil types and the unsaturated soils shear strength.

Keywords: Geosynthetics; Unsaturated soil; Earth retaining wall; Limit analysis; Pseudo-dynamic; Discretization

Laboratory investigation of the behavior of a geosynthetic encased stone column in sand under cyclic loading

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Abstract: This paper presents the results of a laboratory investigation into the behavior of a geosynthetic encased stone column (GESC) installed in sand under cyclic loading using a reduced-scale model. A number of test variables were considered, such as the geosynthetic encasement stiffness and the cyclic loading characteristics, including loading frequency and amplitude. The results indicate among other things that the overall benefit of the encasement to the performance of the stone column is greater under cyclic loading than under static loading. It is shown that the degree of load transfer to the column becomes smaller when subjected to cyclic loading than under static loading, leading to a 25% decreased stress concentration ratio. The encasement is found to be more effective in improving the stone column performance when subjected to lower frequency and/or smaller amplitude loading. The lateral bulging zone of the GESC under cyclic loading tends to extend beyond the reported critical encasement length for an isolated static loading case, and therefore full encasement is recommended. Practical implications of the findings are discussed in detail.

Keywords: Geosynthetics; Stone column; Loose sand; Cyclic loading; Reduced-scale model test

Effect of aspect ratio of footing on behavior of two closely-spaced footings on geogrid-reinforced sand

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Abstract: This paper presents the results of laboratory model tests carried out on two closely-spaced interfering footings resting on the surface of geogrid-reinforced and unreinforced sand bed. The effect of aspect ratio (or shape) of the footing on interference behavior is studied by adopting three pairs of model footings of different sizes. The length (ID) to width (B) ratio (i.e., aspect ratio) of the footings is varied from 1.0 to 2.0. The effects of single layer of geogrid on footing interference and bearing capacity improvement are investigated. The optimum depth of the geogrid layer for both interfering and isolated footings is found to be one-third of the footing width and it is not dependent on the aspect ratio of the footing. The optimum spacing between the interfering footings is found to be 1.5 times the width of the footing. Lower efficiency factor is observed for interfering footings resting on the reinforced sand compared to the unreinforced sand. Higher bearing capacity ratio (BCR) is observed for isolated footing than that of interfering footings when BCR is measured based on ultimate bearing capacity values of reinforced and unreinforced cases and BCR value increases as the aspect ratio of the footing increases.
Keywords: Geosynthetics; Aspect ratio; Bearing capacity ratio; Efficiency factor; Footing interference; Sand

Geomembrane factory and field thermally welded seams comparison

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Abstract: This technical paper presents a unique comparison of geomembrane factory and field welded thermal seams for a large off-stream water reservoir project. The results of the comparison show that factory welded seams exhibit higher seam peel and shear strengths at yield, less variability, and more consistency than field welded thermal seams. In particular, the results show that factory seams are about 10% stronger than field seams in shear and about 9% stronger in peel strength at yield. More importantly, this resulted in 1 00% of the factory welded seams passing the project seam strength requirements even though the factory welding speed was 1.1-1 .6 times faster than the field welding speed. Conversely, about 25% of the field welded seams did not pass the initial specified field seam shear strength requirement, which caused significant delays, scheduling, and other construction issues. As a result, the field seam shear strength requirement was reduced from 9.6 kN/m to 8.2 kN/m to increase the number of field seams that achieved project requirements. Because the geomembrane was primarily factory fabricated, there were about 78% less field seams on this project than if the geomembrane was entirely field fabricated.
Keywords: Geosynthetics; Geomembranes; Thermal welding; Seam strength; Seam quality control; Factory welding; Polypropylene geomembrane

Geosynthetic-stabilized flexible pavements: Solution derivation and mechanistic-empirical analysis

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Abstract: Geosynthetics have been widely applied in flexible pavements for decades. However, the mechanistic-empirical analytical approach for geosynthetic-stabilized flexible pavements based on the elastic solution derived from the layered elastic theory has not been established. In this study, the solution for a typical three-layer geosynthetic-stabilized flexible pavement was derived according to the layered elastic theory. In the derivation, lateral restraint and tensioned membrane effect of geosynthetics quantified in terms of layer permanent deformations were considered at the interface as a continuity condition. The derived solution was then incorporated into the mechanistic-empirical approach for the calculation of pavement rutting and fatigue cracking. The result indicates that the solution derived in this study is capable of analyzing the geosynthetic-stabilized three-layer flexible pavement. The pavement elastic responses calculated using the solution obtained in this study are in line with those by the previously established solutions in the literature. The rut depths estimated using the proposed solution reasonably match those measured in the previous study. For rut reduction, the geosynthetic placed underneath the base layer is more effective. For the tensile strain relief at the bottom of the asphalt layer, the geosynthetic placed at the bottom of the asphalt shows more benefit.

Keywords: Geosynthetics; Flexible pavement; Mechanistic-empirical; Elastic solution; MEPDG

Oxidative lifetime prediction of a polypropylene woven geotextile by applying high temperature and moderately increased oxygen pressure

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Abstract: Resistance to oxidation of a polypropylene (PP) woven geotextile was determined by performing and evaluating various high-pressure autoclave tests (HPAT). Unlike that proposed in the corresponding ISO standard and the majority of HPAT studies published, tests were performed at slightly elevated oxygen pressures (Po2) of up to 500 kPa. Extrapolations were carried out with regard to temperature and oxygen (partial) pressure. The times-till-failure results obtained indicate an Arrhenius dependency with respect to temperature (T) and a reciprocal dependency with respect to oxygen pressure. The relationship found between time-till-failure/service life and the two acceleration factors (T and Po2) is not an empirical one but is based on chemical reactions according to the basic autoxidation scheme. Since the oxygen pressure was monitored in the autoclave during the tests it was possible to directly determine the oxygen consumption rate and not just indirectly as is common practice via the determination of mechanical/physical properties. Furthermore an accelerated oven test was performed and time-till-failure results from both methods were compared.
Keywords: Geosynthetics; Oxidation; HPAT; Autoclave; Service life

Effects of pressurizing timing on air booster vacuum consolidation of dredged slurry

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Abstract: Air booster vacuum preloading is a newly improved method applied in land reclamation projects. Highly pressurized air can provide an additional pressure difference between the prefabricated vertical drain (PVD) and injection point, thereby increasing the hydraulic gradient and generating small fractures that can improve the soil permeability and the transmission efficiency of the vacuum pressure. However, with a premature activation time, the pressurized air can create air channels connected to the PVD, which may drastically decrease the vacuum pressure. With a delayed activation time, the strength of the dredged clay may be too high to permit fractures, thus limiting the permeability improvement. In this study, soils with degrees of consolidation (DOCs) of 0%, 40%, 60%, and 80% were selected for testing the efficacy of initial booster activation times in four tests. The results show that the pressurizing groups were more effective in improving the consolidation of soils, and the best effect of the use of air booster is obtained when soil has been consolidated to a DOC of 60%. The lower soils of the pressurized groups showed greater increase rates than those demonstrated by conventional vacuum preloading.

Keywords: Geosynthetics; Vacuum preloading; Dredged slurry; Air booster; Pressurizing timing; Prefabricated vertical drain

Experimental study on the sandbag isolator of buildings for subway-induced vertical vibration and secondary air-borne noise

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Abstract: This paper presents a new geosynthetics isolator composed of stacked sandbags for buildings' base-isolation method to improve human comfort under subway-induced environmental vibrations. The static and dynamic mechanical properties of the isolator are tested in a laboratory first. Then field experiments are performed with a full-scale building to investigate the effectiveness of the isolator. The results indicated that the bearing capacity is mainly influenced by the soft contact interfaces between different sandbags, and is sufficient for most low-rise and mid-rise buildings. Similar to some springs in a series, the soft contact interfaces make the vertical stiffness of the isolator low enough to isolate vibrations. The friction forces between sand particles are a benefit to dissipating energy, which increases the damping ratio to 14%. After the installation of geosynthetics isolators, the vertical vibration and secondary air-borne noise inside the building are effectively suppressed, and therefore the comfort for residents is enhanced. Further, there is no negative impact caused by automobile vibrations on the isolated building because the damping ratio of the isolator is high enough to resist resonant amplitudes. These results demonstrate that the isolator is feasible for buildings near subway transportation.

Keywords: Geosynthetics; Stacked sandbags; Field experiment; Subway-induced vibration; Secondary air-borne noise; Human comfort

Experimental research on employed expanded polystyrene (EPS) for lightened sulfate heave of subgrade by thermal insulation properties

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Abstract: In sulfate-rich soils with high sodium sulfate contents, sulfate heave can occur and then generate severe damages. to engineering facilities such as pavement, airplane runway due to the hydration of thenardite or crystallization of mirabilite when the temperature is below 32.4 ° C. Based on the significant effect of expanded polystyrene (EPS) geofoam in reducing the temperature variations, a comparative experimental investigation on the sulfate heave of subgrade generated by the artificial coarse-grained saline soil with and without EPS material is conducted. Parameters of swell displacement and temperature fluctuation obtained from this comparative experiment are further validated and analyzed. The X-Ray Diffraction (XRD) measurement result is used to demonstrate the performance of EPS in microstructure. Test results indicate that: (1) The presence of crystallized mirabilite is proved within subgrade with saline soil when the temperature drops below 32.4 ° C; (2) sulfate heave of subgrade is dependent on temperature fluctuation, but more specifically, on the temperature drop that occurs below 32.4 ° C; and (3) EPS thermal insulation can reduce sulfate heave in pavement subgrade by effectively reducing the temperature fluctuation within the subgrade.

Ce database subject headings: Heave; Hydration; Salinity; Subgrades; Sulfates; Temperature effects.

Keywords: Geosynthetics; Temperature fluctuation; Crystallization; Hydration; Sulfate heave; Expanded polystyrene thermal insulation

Apparent clogging effect in vacuum-induced consolidation of dredged soil with prefabricated vertical drains

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Abstract: The improvement efficiency of a dredged slurry by vacuum preloading is greatly affected by the apparent clogging effect arising during the consolidation process, where the apparent clogging effect refers to the combined impacts of filter clogging and particle blinding around the drain due to particle migration and non-uniform consolidation. Three laboratory model tests with different types of soils were performed to investigate the apparent clogging effect. First, the filter clogging effect was investigated by scanning electron microscopy and cross-plane permeability tests. Second, changes in the particle size distribution due to particle migration were analysed at the micro- and macro-levels, and the particle migration induced blinding effect was assessed through the results of the compressibility and permeability tests. The test results indicated negligible particle migration in pure clay and relatively higher blinding effect in mixture soils. Finally, the effects of blinding due to particle migration and non-uniform consolidation on the overall consolidation rate were theoretically quantified. Both the analytical and tests results implied that the apparent clogging effect is predominantly by non-uniform consolidation rather than the particle migration-induced blinding effect, especially for cohesive marine clay.

Keywords: Geosynthetics; Filter clogging; Particle migration; Blinding effect; Non-uniform consolidation

Numerical- simulation of compaction-induced stress for the analysis of RS walls under surcharge loading

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Abstract: This study numerically investigates the behaviour of a geosynthetic-reinforced soil (GRS) wall under surcharge loading. Data from a full-scale GRS physical model wall was used to verify the numerical analysis. The modelling was carried out using the two-dimensional finite difference computer program FLAC to verify the post-construction performance of a full-scale GRS segmental wall under surcharge loading. The real value of compaction induced stress (CIS) specified for the vibrating plate compactor used in the physical model wall was employed in the analyses. Two procedures for modelling the CIS found in the literature were used in the analyses: uniform vertical stress applied to the surface of each layer (type I) and uniform vertical stress applied at the top and bottom of each layer (type II). The results clearly showed that the numerical analyses using compaction procedure type II accurately represent the measured values obtained from the full-scale wall under surcharge loading as well as during construction. The numerical analyses considering type I compaction modelling over-estimated the measurements during both construction and surcharge application.

Keywords: Geosynthetics; Compaction-induced stress; Numerical simulation; Surcharge loading; Reinforced soil walls

Shaking table tests on gravel slopes reinforced by concrete canvas

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Abstract: The behaviour and performance of different reinforced slopes during earthquake loading were investigated through a series of shaking table tests. Concrete-canvas and composite reinforcement (geogrid attached to concrete-canvas) were proposed for reinforcing slopes. By considering the effects of different reinforcement methods, the seismic responses of the reinforced slopes were analysed, along with the accelerations, crest settlements, and lateral displacements. The failure patterns of different model slopes were compared using white coral sand marks placed at designated elevations to monitor the internal slide of the reinforced slopes. Both the concrete-canvas and composite reinforcement could increase the safety distance, which ranged from the slide-out point to the back of the model box. The composite reinforcement decreased the volume of the landslide and increased the failure surface angle as a result of the larger global stiffness in the reinforced zone. These results indicate that the recently developed concrete canvas has a better effect on restricting the slope deformation during seismic loading than the nonwoven geotextile reinforcement, and that the use of composite reinforcement could improve the seismic resistance of slopes.
Keywords: Geosynthetics；Slope； Concrete canvas； Reinforcement； Shaking table

Performance monitoring and numerical assessment of a test embankment with preloading and vertical drains on Texcoco lacustrine soft clays

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Abstract: This paper presents the performance monitoring results and long-term numerical analyses of a 2.8 m-high test. embankment with vertical drains on soft highly compressible clays during a four years and two months observation period (1525 days). The peculiar study site is characterized by thick layers of lacustrine soft clay with water contents up to 300%, void ratios between 7 and 9 and ratios Ca/Cc range from 0.06 to 0.03. The loading applied by the test embankment was 43.4 kPa. The vertical drains installed were of two types: sand and prefabricated. The settlements that only take into account the effect of the preloading embankment at the end of the observation period were 2.62 m and 2.71 m, in the zones with sand and prefabricated vertical drains, respectively. The settlement measured by regional subsidence was 0. 47 m. The ultimate primary settlement was approximately 2.0 m and was estimated by two observational methods based on field settlement records. The settlement developed by secondary consolidation in the embankment ranged from 0.62 m to 0.71 m at the end of the observation period. The test embankment behavior was simulated by 2D and 3D numerical analyses. The 2D analyses used a theory to convert the axisymmetric drainage into plane drainage. The long-term numerical results and the field measurements were compared and discussed.

Keywords: Geosynthetics； Soft soil； Test embankment； Preloading-vertical drain system； Numerical modeling； Secondary consolidation

Consolidation behavior of dredged ultra-soft soil improved with prefabricated vertical drain at the Mae Moh mine, Thailand

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Abstract: The effectiveness of the prefabricated vertical drains (PVDs) in the consolidation of ultra- soft dredged soil with various soil water contents (W) in Mae Moh mine, Lampang, Thailand was researched via a series of large-scale model tests and numerical analysis. Large settlements with the delay of excess pore pressures is a distinct behavior of ultra-soft soil. The PVD dimensions were found to have a significant effect on the rate of consolidation and the delay of excess pore pressure at low total vertical stress (w). The smaller PVD dimension resulted in the smaller rate of consolidation and longer delay of excess pore pressure. The undrained shear strength (Sw) of ultrasoft clay at various degrees of consolidation could be approximated by the vertical effective stress (σ v) based on the SHANSEP where the o'v was determined from the Asaoka's observational method. The finite element analysis with axisymmetric and plane strain models showed that the axisymmetric model produced an excellent settlement prediction. However, the excess pore pressures were not well predicted by the axisymmetric model, due to the delay of excess pore pressures at the early stages of consolidation. In practice, the plane strain models proposed by Chai et al. and Indraratna and Redana's methods are suggested to predict the consolidation settlement of the Mae Moh dredged soil improved with PVD. The outcome of this research will facilitate the geotechnical design of reclamation of ultra-soft dredged soil in Mae Moh mine and other similar soils.

Keywords: Ultra-soft soil; Large-scale model test; Prefabricated vertical drains; Consolidation; Ground improvement

Effect of soil-reinforcement interaction coefficient on reinforcement tension distribution of reinforced slopes

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Abstract: This paper examines the effect of the mobilized reinforcement tension within reinforced soil slope at a different level of soil-geosynthetic interaction. The mobilized reinforcement tension is assumed, in most design methods for the internal stability of reinforced slopes, to be equal to mobilized soil forces computed using a limit equilibrium method. However, comparison with the reinforcement tension force measured in the field has shown that this approach is conservative. This paper examines the effects of the soil-reinforcement interaction coefficient on the tensile redistribution of geosynthetics. The modified process of Bishop Method of slope stability analysis is used to locate the critical slip surface and to calculate the mobilized reinforcement tensile force. The reinforcement forces obtained from field data and on centrifuge model test results for a reinforced slope problem are used to examine the relationship between mobilized reinforcement tensile force and mobilized soil shear strength.
Keywords: Geosynthetics; Reinforced slope; Soil-reinforcement interaction coefficient; Limit equilibrium method

Effects of freeze-thaw cycles on the unconfined compressive strength of straw fiber-reinforced soil

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Abstract: Although natural fibers can improve the strength behavior of frozen-thawed soil, the reinforcing mechanism is still not fully understood. To investigate the effects of freeze-thaw cycles on the strength of natural fiber-reinforced soil, unconfined compression tests, single-fiber pull-out tests and scanning electron microscopy (SEM) tests under 0, 3, 5, 10, 15, and 20 freeze-thaw cycles were conducted on cotton straw fiber-reinforced soil. It was found that the unconfined compressive strength (UCS) of fiber. reinforced soil decreases exponentially with the soil under unconfined states. The UCS reduction in fiber-reinforced soil under freeze-thaw conditions is smaller than the strength reduction at the fiber-soil interface because fiber reinforcement is mainly governed not only by the fiber-soil interface but also by the spatial stress network established by discrete fibers. The complex spatial stress network, which improves the reinforcement of the fibers, is monitored by SEM after freeze-thaw cycles.

Keywords: Freeze-thaw cycles; Straw fiber-reinforced soil; Compressive strength; Interfacial strength

Numerical investigation of the behaviour of hydraulically dredged finegrained soils during and after filling of the containment facility of the port of Gaeta

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Abstract: Fine- grained dredged sediments can be efficiently and sustainably handled by hydraulically filling containment facilities, which can then be reclaimed. This study presents two numerical modelling strategies, characterized by markedly different levels of complexity, that simulate the gradual filling and subsequent consolidation process. Both numerical models employ hydro-mechanical constitutive relations apt to cover wide state ranges, starting from very low effective stresses. Class A predictions of a well-documented case study, where an articulated construction sequence was implemented, are reported and the effectiveness of the two proposed strategies is compared. After updating the numerical predictions according to the recorded construction timeline, the numerical results are validated against field data, specifically versus the monitored height of dredged mud. Finally, the monitoring data are back-analysed, emphasizing the influence of the hydro-mechanical behaviour at high void ratios. The results show that both modelling strategies are sufficiently accurate and can provide substantial benefits to the design of the filling works and to the evaluation of the actual storage capacity of the impoundments, especially if the available volume is limited or if complex construction procedures are implemented.
Keywords: Hydraulic dredging; Containment facility; Monitoring data; Numerical modelling; Large-strain consolidation; Geocomposite drains