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目 录

Response of pavement foundations incorporating both geocells and expanded polystyrene (EPS) geofoam

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Abstract: The suitability of geocell reinforcement in reducing rut depth, surface settlements and/or pavement cracks during service life of the pavements supported on expanded polystyrene (EPS) geofoam blocks is studied using a series of large-scale cyclic plate load tests plus a number of simplified numerical simulations. It was found that the improvement due to provision of geocell constantly increases as the load cycles increase. The rut depths atthe pavement surface significantly decrease due to the increased lateral resistance provided by the geocell in the overlying soil layer, and this compensates the lower competency of the underlying EPS geofoam blocks. The efficiency of geocell reinforcement depends on the amplitude of applied pressure: increasing the amplitude of cyclic pressure increasingly exploits the benefits of the geocell reinforcement. During cyclic loading application, geocells can reduce settlement of the pavement surface by up to 41% compared to an unreinforced case - with even greater reduction as the load cycles increase. Employment of geocell reinforcement substantially decreases. the rate of increase in the surface settlement during load repetitions. When very low density EPS geofoam (EPS 10) is used, even though accompanied with overlying reinforced soil of 600 mm thickness, the pavement is incapable of tolerating large cyclic pressures (e.g. 550 kPa). In comparison with the unreinforced case, the resilient modulus is increased by geocell reinforcement by 25%, 34% and 53% for overlying soil thicknesses of 600, 500 and 400 mm, respectively. The improvement due to geocell reinforcement was most pronounced when thinner soil layer was used. The verified three- dimensional numerical modelings assisted in further insight regarding the mechanisms involved. The improvement factors obtained in this study allow a designer to choose appropriate values for a geocell reinforced pavement foundation on EPS geofoam.

Keywords: Geosynthetics; EPS geofoam; Geocell reinforcement; Cyclic plate load tests; Pavements

Wind-induced uplift of exposed geomembrane covers: A proposed revision to conventional design approaches

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Abstract: Conventional approach for exposed geomembrane design assumes that the geomembrane is subjected to an uplift pressure induced by wind above the geomembrane, and the pressure below the geomembrane is kept constant at atmospheric pressure by default. In reality, the exposed geomembrane is typically anchored into subgrade, which limits the exchange of air above and below the geomembrane. Therefore, when the geomembrane is being uplifted, suction will be generated temporarily below the geomembrane. This temporary suction provides significant resistance to uplift during short-duration wind gust. This paper recommended revisions to the current design approach. An average wind velocity within a selected period, instead of the 3-s gust speed, is recommended to be used for design. This period can be selected based on evaluation of how fast air can enter the voids below the geomembrane.

Keywords: Geosynthetics; Exposed geomembrane; Design wind speed; Wind uplift

Predicting deformation of PVD improved deposit under vacuum and surcharge loads

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Abstract: A series of modified triaxial tests was conducted to investigate the deformation characteristics of mini-prefabricated vertical drain (PVD) unit cells. The factors considered are the (1) magnitudes of surcharge load (p3) and vacuum pressure (Pvac); (2) pre-vacuum consolidation period (tra) before applying surcharge load; (3) surcharge loading rate (SLR); and (4) initial effective stress state in the specimens. Based on the test results, relationships between the coefficient of earth pressure (Kes) at the end of surcharge load application and the normalized horizontal and vertical specimen strains are esta blished. Further, a method is proposed for estimating the value of Kes and therefore the horizontal and vertical strains of the PVD improved soil layer subjected to combined vacuum pressure and surcharge load using loading conditions and basic soil properties. Finally, the proposed method was applied to a case history reported in the literature and good agreement between the field-measured and calculated lateral displacement and settlement was obtained, which suggesting that the proposed method can be a useful tool for designing preloading projects involving combined vacuum and surcharge loads.

Keywords: Geosynthetics; PVD; Ground improvement; Deformation; Laboratory test

Viscoplastic modelling of HDPE geomembrane local stresses and strains

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Abstract: The formulation, validation and application of a viscoplastic constitutive model for numerical analysis of HDPE geomembrane stresses and strains induced by overlying coarse gravel is presented. Model parameters were obtained from uniaxial tensile experiments conducted over a range of displacement rates. The model was implemented in geometrically-nonlinear finite- element-analysis and was able to match the force, displacement and strain measured from wide-width strip tensile experiments. The analysis also matched the geomembrane response measured from axisymmetric force- displacement experiments, where a 60-mm-diam. specimen, clamped around its perimeter, was subjected to loading normal to its plane from a steel probe machined to mimic the shape of a coarse gravel particle. The analysis matched: i) probe forces when loaded at a constant rate of displacement, i) displacements when loaded with step function increments of probe force, ii) creep displacements under a constant probe force for 1000 h, and iv) decreases in probe force from stress relaxation when held at a constant displacement for 1000 h. The analysis was used to further validate the applicability of thin plate theory to calculate geomembrane strains from measured deformations and provide first estimates of stress that develop beneath a gravel particle.

Keywords: Geosynthetics; Geomembrane; Viscoplastic; Wide-width strip; Local stress; Local strain

Geosynthetic-reinforced pile-supported embankments with caps in a triangular pattern over soft clay

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Abstract: Given the limit studies on the behavior of GRPS embankments with different numbers of geosynthetic layers and pile caps in a triangular pattern, this paper conducted a series of three-dimensional (3-D) numerical analyses. The numerical model was verified based on a well-instrumented large-scale test. A 3-D soil arch model was. proposed for pile caps in a triangular pattern, in which the crown of the upper boundary was approximately 1.4 times the clear spacing of pile caps. Inclusion of geosynthetic reinforcement reduced the soil arching effect but increased the total load carried by the piles. For the case with three geosynthetic layers, the lower layer had a significant effect on load transfer than the middle and upper layers, but each layer had an almost proportional effect on mitigating the differential settlement on the top of the gravel cushion. The maximum strains in the reinforcement concentrated on the geosynthetic strips bridging over two adjacent square cap corners.

Keywords: Geosynthetics; Pile-supported embankment; Load transfer; Soil arching;; Triangular pattern; Numerical analysiss

Visualisation and quantification of geogrid reinforcing effects under strip footing loads using discrete element method

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Abstract: Geogrids have been commonly used in reinforced soil structures to improve their performance. To investigate the geogrid reinforcement mechanisms, discrete element modelling of unreinforced and geogrid reinforced soil foundations and slopes was conducted under surface strip footing loads in this study. For unreinforced and reinforced soil foundations, the numerically obtained footing pressure-settlement relationships were validated by experimental results from the literature. In the numerical modelling of unreinforced and reinforced soil slopes, identical models and micro input parameters to those used in the numerical modelling of unreinforced and reinforced soil foundations were used. The geogrid reinforcing effects under strip footing loads were visualised by the qua litative contact force distributions in the soil structures, as well as the qualitative and quantitative tensile force distributions along the geogrids. In addition, the qualitative displacement distributions of soil particles in the soil structures and the quantitative vertical displacement distributions along soil layers/ geogrids also indicated the geogrid reinforcing effects in such practical reinforced soil structures. The discrete element modelling results visualise and quantify the load transfer and spreading behavior in geogrid reinforced soil structures, and it provides researchers with an improved understanding of geogrid reinforcing effects at microscopic scale under strip footing loads.

Keywords: Geosynthetics; Reinforcing effect; Strip footing; Visualisation; Quantification; Discrete element modelling

Pullout behavior of geocell reinforcement in cohesionless soils

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Abstract: Large-scale laboratory equipment was developed to assess interaction between soil and 3-D honeycomb shaped geocell reinforcement under normal and interface shear stress. An understanding of this interaction is vital in assessing mechanical behavior of geocell-reinforced soil mass. Specifically, the equipment allows evaluation of the load transfer mechanism with the measurements of strains, displacements and loads, including friction and passive resistance on the side surfaces and inside the cells of geocell reinforcement. Additionally, the device visually presents sequence of movement response of each reinforcing cell in the direction of the pulling force, thereby showing the contribution of each cell to the total capacity. Overall, it is concluded that the pullout capacity of geocell reinforcement in cohesionless soils is limited to the seam peel strength at junctions of longitudinal and transverse of geocell strips, which creates the cells in layout of geocell reinforcement. Finally, a theoretical approach was established to predict the pullout capacity of geocell-reinforced soil mass.
Keywords: Geosynthetics; Geocell; Pullout; Theoretical analysis

Study on seismic stability and performance of reinforced soil walls using shaking table tests

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Abstract: The paper reports a 1 g shaking table test that was carried out on a reinforced soil wall with an objective to study the acceleration amplification in the backfill, and phase differences between dynamic responses of the reinforced and retained zones. Results of the study show that including the observed larger acceleration amplification in the upper half of the wall, and the phase difference between maximum lateral earth pressure and inertial load in the backfill in the analysis would lead to more accurate predictions of: (1) the wall response relative to predicted reinforcement load, (2) elevations of line of action for both the inertial and lateral earth forces in the backfill, and (3) wall deformations, as compared to pseudo-static methods of analysis.

Keywords: Geosynthetics; Reinforced soil retaining walls; Seismic design; Shaking table; Phase difference; Acceleration amplification

Numerical evaluation of secondary reinforcement effect on geosyntheticreinforced retaining walls

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Abstract: A finite difference method was employed to evaluate the effect of secondary reinforcement on the performance of Geosynthetic-Reinforced Retaining (GRR) walls. The two-dimensional numerical models used a Cap-Yield soil constitutive model to represent the behavior of backill. The numerical model was first calibrated and verified by the measured results from a full-scale field test. A parametric study was then performed to investigate the effects of secondary reinforcement length, secondary reinforcement stiffness, secondary reinforcement connection, and secondary reinforcement layout. The numerical results show that an increase in secondary reinforcement length and stiffness can reduce the deflection of the GRR wall and the maximum tensile stress of primary reinforcement. The mechanical connection of secondary reinforcement can also reduce the wall facing deflection and result in relatively small maximum tensile stress and connection stress in the primary reinforcement as compared with no connection to the secondary reinforcement. In addition, a wall with fewer but longer secondary reinforcement layers at certain elevations had relatively smaller wall facing deflections than the baseline case. This comparison demonstrates that more optimal layout of secondary reinforcement exists that could further reduce the maximum wall facing deflections and create a better performing wall while the same or less amount of geosynthetic reinforcement material is used.

Keywords: Geosynthetics; Deformation; Geosynthetic-reinforced retaining wall; Numerical simulation; Secondary reinforcement; Tensile stress

Geobag stability for riverbank erosion protection structures: Physical model study

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Abstract: Geotextile, sand filled bags (geobags) are successfully being used to protect riverbanks against repeated erosion attacks. Large scale physical hydraulic model tests have been used to shed light on the incipient motion of the flexible geobags and enabled the review of the design methodology for sizing geobags against current loading. This study finds that the flling percentage has a large influence on the stability of the geobags, and consequently they should have a degree of filling of at least 80%. Additionally, this study found that the stability formula used for geobags should use the thickness as the characteristic diameter rather than the cube root of the volume.

Keywords: Geosynthetics; Geobag revetments; Incipient motion; Sizing formula; Physical model

Centrifuge tests to investigate global performance of geosynthetic-reinforced pile-supported embankments with side slopes

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Abstract: Three centrifuge model tests were conducted to investigate the influence of the number of geosynthetic layers and the pile clear spacing on the global performance of Geosynthetic-Reinforced Pile- Supported (GRPS) embankments with side slopes constructed on soft soil foundations. This study found that the change of the geogrid number from one to two did not significantly affect the foundation settlement, the geogrid deflection, and the vertical stress at the embankment base. For the GRPS embankment with a single geogrid layer, the geogrid strain distribution at the em bankment base showed an “M” shape along the transverse direction with the maximum strain near the embankment shoulder. When two geogrid layers with sand in between were used, the upper and lower layers showed different strain distributions with the maximum strains happening near the em bankment shoulder and at the center of the embankment for the upper and lower layers respectively. The strains of the upper geogrid were smaller than those of the lower geogrid. Smaller pile clear spacing reduced the geogrid deflection and the foundation settlement. Despite the change of the pile clear spacing, the progressive development of soil arching with the normalized displacement at the embankment base followed a similar trend without an obvious stress recovery stage.

Keywords: Geosynthetics; Centrifuge test; Embankment; Pile; Settlement; Soil arching; Strain