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摘要集

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Experimental study on seismic response of soilbags-built retaining wall

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Abstract: The seismic performance of soilbags-built retaining wall model was studied experimentally. A series of small-scale shaking table tests with the input of different amplitude sinusoidal waves and a large-scale shaking table test in a designed laminar shear box with the input of the Wenchuan earthquake wave were carried out on soilbags' retaining wall models. For comparison, the small-scale shaking table tests were also conducted on horizontally reinforced retaining wall models. The horizontal acceleration responses, the Fourier spectra, the dynamic earth pressure and the lateral displacements of soilbags' retaining wall models were investigated in shaking table tests. The results show that the seismic response of the soilbags' retaining wall is equivalent to or even slightly better than that of the horizontally reinforced retaining wall. The fundamental frequency and the Fourier spectral characteristics of the soilbags' retaining wall are similar to those of backfill sands. The dynamic earth pressure of the wall model fluctuates almost synchronously with the input Wenchuan wave and no residual earth pressure is induced by the seismic loading. The permanent lateral displacements are small when subjected to multiple shakings, providing a proof that the retaining wall of soilbags has a good seismic performance.

Keywords: Geosynthetics; Soilbags; Retaining wall; Seismic performance; Shaking table test

Experimental study on the clogging effect of dredged fill surrounding the PVD under vacuum preloading

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Abstract: Clogging effect surrounding prefabricated vertical drains (PVDs) is a typical problem when vacuum preloading is applied to a dredged fill foundation. A large-scale model test was designed to clarify the cause and mechanism of the clogging effect, and the basic physical and mechanical parameters of the soil in the clogging zone were tracked during the test. The results demonstrated that a clogging zone was formed around the PVD in the early stage of improvement with conventional vacuum preloading, and the boundary of the clogging zone was approximately 0.2–0.4 of the boundary radius. The clogging zone surrounding the PVD was formed because of the overall movement of the soil toward the PVD under the high vacuum pressure gradient, rather than fine particle migration. The soil in the clogging zone exhibited permeability anisotropy and equivalent 'smear' effect. The permeability ratio (k_h/k_v) was less than 1, and the ratio of horizontal permeability coefficients at the test distances of 45 cm and 10 cm were 9.6 at a depth of 20 cm and 8.9 at a depth of 80 cm. An analysis of the microstructure of the soil in the clogging zone demonstrated that the clay particles tended to be vertically oriented. The re-orientation of the clay particles reduced the horizontal permeability coefficient and led to the permeability anisotropy of the soil in the clogging zone. Thus, decrease in the horizontal permeability coefficient and equivalent 'smear' effect of the soil in the clogging zone affect the consolidation of dredged fill, which leads to the clogging effect. The permeability anisotropy also slightly affects consolidation.

Keywords: Geosynthetics; Vacuum preloading; Clogging effect; PVD; Dredged fill; Permeability anisotropy; Equivalent 'smear' effect

Interface shear strength properties of geogrid-reinforced steel slags using a large-scale direct shear testing apparatus

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Abstract: This research evaluates the shear strength properties of unreinforced and geogrid-reinforced ladle furnace slag (LFS), electric arc furnace slag (EAFS) and a blend comprising 50% LFS and 50% EAFS (LFS50+EAFS50) using the large direct shear testing apparatus (DST). The large DST results of unreinforced steel slags indicated that LFS had the lowest shear stress ratio at the peak shear strength among all samples, while LFS50+EAFS50 samples (both unreinforced and reinforced) demonstrated the highest shear stress ratio amongst the tested samples. A higher apparent cohesion value was achieved with the inclusion of biaxial geogrid in LFS and EAFS samples as compared to the triaxial geogrid interface. The observed behavior can be attributed to the larger aperture size of the biaxial geogrid compared to the triaxial geogrid leaving more void planar space for a direct interaction between slag particles. In contrast, the apparent cohesion of LFS50+EAFS50 without a geogrid interface was high and did not change significantly with the insertion of geogrid. Given, the range of internal friction angles for ordinary soils, studied slag by-products achieved internal friction angles in excess of 59° (with no geogrid interface) and these significant values proved highly beneficial application for these waste materials in pavement construction.

Keywords: Geosynthetics; Steel slag aggregates; Industrial waste; Large direct shear; Geogrid; Shear stress ratio

Geosynthetic liner integrity and stability analysis for a waste containment facility with a preferential slip plane within the liner system

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Abstract: The paper examines the effects of settlement-induced downdrag on geosynthetic liner systems for a waste containment facility with steep side slopes for different design scenarios, and conducts the stability analysis of the waste mass during waste filling operations. Without the presence of a reinforcing layer above a geomembrane (GMB) liner, the liner experiences unacceptable tensile strains under both short- and long-term downdrag waste settlements. It is shown that an anchored high strength/stiffness geotextile (HS-GTX) reinforcement over the GMB can reduce the GMB tensile strains to less than 3%, but the HS-GTX itself may be overloaded. A geosynthetic slip layer over the full or partial HS-GTX reinforcement overlying the GMB can reduce the tensile strains of the GMB to less than 3% and of the HS-GTX to less than 5% by providing a preferential slip plane between the geosynthetic slip layer and the HS-GTX. A rupture of the geosynthetic slip layer is likely to occur resulting in the exposure of the HS-GTX to the waste, but the protection of the GMB by the HS-GTX is still expected. The results from the stability analysis show that, during waste filling operations under a given factor of safety, there is a critical relationship between the width of the top of the waste pile and the total waste thickness.

Keywords: Geosynthetics; Waste containment liner systems; Landfill; Downdrag; Tensile strains; Stability analysis; Factor of safety; Integrity analysis

Experimental study on the behavior of eccentrically loaded circular footing model resting on reinforced sand

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Abstract: In this study, an experimental investigation has been conducted on a circular footing model subjected to eccentric load resting on the geonet-reinforced sand. To this end, five series of tests were carried out in order to evaluate the effect of reinforcement dimension and eccentricity on the bearing capacity, settlement, and rotation of the footing. Results show that the bearing capacity ratio (BCR) is in direct relationship with eccentricity and the impact of soil reinforcement at low settlements is much more significant in the case of eccentric loading. Additionally, the bearing capacity interaction diagram and variation in the position of rotation line at different load levels for reinforced and unreinforced conditions are presented.
Keywords: Geosynthetics; Reinforced sand; Eccentric loading; Bearing capacity; Footing rotation

TCE and PCE diffusion through five geomembranes including two coextruded with an EVOH layer

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Abstract: Aqueous diffusion of trichloroethylene (TCE) and tetrachloroethylene (PCE) is examined for high density polyethylene (HDPE), linear low density polyethylene (LLDPE), polyurethane/urea, and two polyethylene (PE) geomembranes coextruded with ethylene vinyl alcohol (EVOH). Additionally, the diffusion of benzene, toluene, ethylbenzene, and xylenes through polyurethane/urea geomembrane is examined. Permeation coefficients for HDPE, LLDPE, and polyurethane/urea range from 0.4-1.2 × 10^{-10} m^2/s for TCE and 1.0-2.5 × 10^{-10} m^2/s and for PCE. Experiments using the coextruded geomembranes have not reached equilibrium at 500 days, however parameters for the EVOH layer are deduced using data from these experiments. Using the parameters of the individual layers, single layer parameters were calculated. These single layer parameters range from 0.37-2.2 × 10^{-12} m^2/s for TCE to 0.28-0.93 × 10^{-12} m^2/s for PCE. Two hypothetical vapors intrusion cases are modelled using the parameters developed for the five geomembranes, and the calculated airspace concentrations decrease depending on the choice of vapors barrier in the following order: no barrier > 0.75 mm LLDPE > 1.5 mm polyurethane/urea > 1.5 mm HDPE > 0.75 mm LLDPE/EVOH/LLDPE > 1.5 mm HDPE/EVOH/HDPE.

Keywords: Geosynthetics; Vapor intrusion; VOCs; Diffusion; Brownfield sites; HDPE; LLDPE; Polyurethane/urea; Coextruded geomembranes with ethylene vinyl alcohol

Self-healing of circular and slit defects in GCLs upon hydration from silty sand under applied stress

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Abstract: The self-healing of a GCL with artificial defects (circular holes and rectangular slits, both with and without the carrier geotextile preserved below the holes) upon hydration on a Godfrey silty sand (GSS) subgrade with w_{fdn} = 5, 10 and 16% under 2–100 kPa is examined. Circular holes with the carrier geotextile missing below holes with diameters up to 25.4 mm self-healed on the w_{fdn} = 5% and 10% GSS but not on 16% GSS, while none self-healed when carrier geotextile was preserved below the holes. When DI water was introduced to the surface under 100 kPa, circular holes with diameter up to 38.1 mm self-healed. Neither the single 15 mm-wide slit nor double 15 mm-wide parallel slits with 20 mm-wide strip of undamaged GCL between them resting on w_{fdn} = 10% GSS under 20 kPa fully self-healed. The introduction of simulated synthetic landfill leachate (SSL) to the GCL surface under 70 kPa did not result in self-healing. Post-hydration *k* tests found that GCL without a carrier geotextile below a hole up to 25.4 mm in diameter would not have a significant adverse effect on the hydraulic conductivity compared with an intact GCL provided the permeant was tap water rather than SSL.

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

Study of lateral earth pressures on nonyielding retaining walls with deformable geofoam inclusions

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Abstract: This paper proposes a method to predict the lateral earth pressures on nonyielding retaining walls with geofoam inclusions. The previous study of the lateral stress-strain relation of the backfill was extended, and the solution was derived by the iterative method. The proposed solution could be applied without the known value of the compression of the geofoam inclusions. Model tests for nonyielding retaining walls with expanded polystyrene (EPS) geofoam were also conducted to investigate lateral earth pressures. The accuracy of the proposed solution was verified by comparison to test data in the absence of surface loading. The proposed solution was also validated by a previous study of laboratory-scale model tests with surface loading as well as numerical simulations for field-scale applications with a vehicle load. Furthermore, the effect of the density and thickness of EPS on the reduction of lateral earth pressures was discussed, and appropriate design parameters of EPS were suggested for nonyielding retaining walls with EPS geofoam.
Keywords: Geosynthetics; Deformable geofoam inclusion; Lateral earth pressure; Nonyielding retaining wall; Iterative method

Seismic analysis of 3D geosynthetic-reinforced soil structures in cohesive backfills with cracks

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Abstract: This study proposes a procedure for predicting the required tensile strength of geosynthetics for three-dimensional (3D) geosynthetic-reinforced soil structures (GRSSs) comprised of cohesive backfills subjected to earthquake loadings. This procedure is undertaken using the kinematic approach of limit analysis together with a pseudo-dynamic approach. The influence of cracks is incorporated into the analysis by using a 3D horn-like failure mechanism that includes a vertical crack to characterize the collapse of GRSSs. Two different forms of cracks are considered: cracks forming prior to the collapse of GRSSs (open cracks) and cracks forming simultaneously with the collapse (formation cracks). Based on the work-energy balance equation, the amount of reinforcements needed to maintain the stability of GRSSs is determined. The results of this paper show that the required reinforcements significantly decrease when soil cohesion and 3D effects are considered, whereas accounting for the existence of cracks and seismic forces has an opposite effect.

Keywords: Geosynthetics; 3D geosynthetic-reinforced soil structure; Cohesive backfill; Cracks; Pseudo-dynamic approach

Geobag stability for riverbank erosion protection structures: Numerical model study

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Abstract: Flexible, sand-filled, geotextile bags (geobags) have been used in both India and Bangladesh along the banks of the Brahmaputra for protection against riverbank erosion. Geotextile containers have been researched extensively for their use in coastal structures; however, there is a gap in knowledge of the application of smaller geobags used in riverbank protection structures. In 2018, flume experiments (scaled 1:7) were performed to study the incipient motion of geobags and the methodology for sizing geobags. Building on the data collected from the flume experiments, numerical models have been employed to gain further insight into the hydraulic forces acting on the bags. The numerical models have been created using ANSYS CFX. While there is not enough data to obtain a Shields parameter which can be used for design purposes, initial estimates find the Shields value for geobags lies around 0.09, which is much larger than the value for rocks, around 0.045. The results from this study suggest that the Shields parameter varies with fill percentage of the bags. This paper also presents first results on the roughness of underwater geobag aprons.

Keywords: Geosynthetics; Geobag revetments; Incipient motion; Shear stresses; Computational fluid dynamics; Shields parameter

Shear strength of landfill liner interface in the case of varying normal stress

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Abstract: Landfills are sequentially filled by solid waste lifts, thus normal stress on the liner interface changes in different shear stages, which may affect selection of interface strength in landfill slope stability analysis. Shear tests were conducted at the liner interfaces of geomembrane/geotextile (GM/GT) and geomembrane/geocomposite/sand (GM/GC/Sand), and the normal stress changed in different shear stages. Values of friction angles on both the GM/GT and GM/GC/Sand interfaces obtained by direct and simple shear tests under increasing normal stress in the hardening, softening, and large-displacement stages were lower than those obtained by the traditional direct shear test. The reduction was greater for peak friction angles. Since the peak liner interface strength obtained by staged loading is lower than the peak interface strength by using the traditional shear test method, using the peak shear strength obtained from the traditional direct shear test for the base floor liner to conduct slope stability analysis may cause an un-conservative result. It is necessary to consider the effects of normal stress changes on the liner interface strength in landfill slope stability analysis.
Keywords: Geosynthetics; Landfill liner interface; Varying normal stress; Shear tests; Peak strength; Large displacement

Prediction of pore size characteristics of woven slit-film geotextiles subjected to unequal biaxial tensile strains

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Abstract: The basic pore unit model is extended to predict the strained pore size characteristics of woven slit-film geotextiles subjected to unequal biaxial tensile strains. The strained percent open area (POA) and analytical pore size are expressed as functions of the weft strain and the warp strain to weft strain ratio. The influence of the biaxial tensile strain on pore size characteristics is evaluated in three woven slit-film polypropylene geotextile samples using image analysis under the warp strain to weft strain ratios of 1, 2, 3 and 4. It is shown that the experimental POA and O95 increased significantly with increasing strain at different warp strain to weft strain ratios, and the PSD curves moved toward the direction of large open sizes. The analytical models of POA and pore size can accurately predict the increasing trend of POA and O95. Moreover, unequal biaxial tensile strains can significantly change the shape of the pores, which may influence the results of the pore size obtained by indirect methods. A larger warp strain to weft strain ratio can lead to a larger change in the pore shape when the length to width ratios of initial pores are close to 1.

Keywords: Geosynthetics; Pore size characteristic; Unequal biaxial tensile strain; Analytical model; Pore shape; Image analysis

Influence of clogging substances on pore characteristics and permeability of geotextile envelopes of subsurface drainage pipes in arid areas

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Abstract: This study investigates the influence of clogging substances on pore characteristics and permeability of geotextile envelopes that were used for 3, 7 and 15 years in irrigated farmlands in Xinjiang region, which is arid and suffers from the soil salinity problem. Results show that the macropores (above 125 μm) of envelopes are evidently clogged, whereas the smaller pores less than 100 μm are still unblocked after operation. The permeability coefficients of geotextile envelopes after serving for 3 and 15 years are smaller than the minimum required permeability coefficients after clogging. The main chemical components of clogging substances in the geotextile envelope are silicon dioxide and calcium carbonate. Calcium carbonate content of the geotextile envelope is consistent with calcium carbonate content of soil. Chemical clogging susceptibility increases with the operation time of the subsurface drainage pipes. The ratio of O90 size of envelope material over d90 of soils (O90/d90) and saturation index (SI) can be used to assess the susceptibility of physical and chemical clogging respectively. This study provides a preliminary reference for estimating the clogging susceptibility of geotextile envelopes in arid areas.

Keywords: Geosynthetics; Geotextile envelope; Clogging substances; Pore size characteristic; Permeability coefficient; Potential susceptibility

Laboratory investigation of boundary effect on pressure-settlement behavior of foundation soil with limited thickness involving geosynthetics

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Abstract: Plate loading tests were conducted to investigate the effect of a bottom boundary condition on the pressure settlement behavior of a footing on sand with a limited thickness involving geosynthetics. Seven boundary materials including geosynthetics were used to create different boundary conditions at the bottom of the sand. Interface direct shear tests were conducted first to determine the interface friction angles between these boundary materials and sand, followed by plate loading tests to determine their pressure-settlement curves. Test results show that the sand with a limited thickness by a rigid bottom boundary had a higher bearing capacity than that with a larger thickness. The ultimate bearing capacity of the footing on the sand with a limited thickness generally increased with the increase of the interface friction angle. Geosynthetics provided better lateral restraint than other materials. An equation was developed to describe the relationship of the bearing capacity ratio of the sand with a limited thickness to that with a large thickness versus the soil thickness and the interface interaction coefficient. The effect of the boundary material on the back-calculated modulus of the sand was also evaluated.
Keywords: Geosynthetics; Bearing capacity; Boundary; Interface; Modulus; Thickness