《Geotextiles and Geomembranes》

（土工织物与土工膜）

<双月刊>

2022年第50卷第2期

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中国土工合成材料工程协会秘书处

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Fate and transport of particle matter during geotextile tube dewatering of a dioxin and furan (PCDD/F) contaminated sediment

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Abstract: Geotextile tube dewatering is a pre-treatment method utilized in the remediation of high-water content materials (i.e. sediments and slurries). However, given the association some contaminants (e.g. dioxins and furans, (i.e. PCDD/F)) have with particulate matter in these contaminated sediments, understanding the fate and transport of this particle matter in the dewatered effluent is essential. In this paper, pressure filtration tests (PFTs) were conducted to investigate the effect of pressure and filter cake formation on both geotextile filtration efficiency and effluent quality. Transport tests were then performed to evaluate the particle transport through the developed filter cake, as well as the hydraulic characteristics of the medium during dewatering. HYDRUS, a one- dimensional model contaminant transport model was then employed to simulate the experimental particle transport test results. Three different mechanisms of particle transport (i.e. attachment only, detachment only, both attachment and detachment) through saturated porous media were examined to identify the possible mechanisms of observed effluent particle concentration. HYDRUS modeling outputs suggest that both attachment and detachment mechanisms are involved in a given particle's fate and transport during geotextile dewatering. In addition, parameters such as confining pressure and filter cake properties affect the particle concentration in the effluent.

Keywords: Geotextile tube dewatering; Colloid; Fate and transport mechanism; Dioxin and furans; HYDRU

Numerical study of strain development in high-density polyethylene geomembrane liner system in landfills using a new constitutive model for municipal solid waste

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Abstract: Tensile strain development in high-density polyethylene (HDPE) geomembrane (GMB) liner systems in landfills was numerically investigated. A new constitutive model for municipal solid waste (MSW) that incorporates both mechanical creep and biodegradation was employed in the analyses. The MSW constitutive model is a Cam-Clay type of plasticity model and was implemented in the finite difference computer program FLAC™. The influence of the friction angle of the liner system interfaces, the biodegradation of MSW, and the MSW filling rate on tensile strains were investigated. Several design alternatives to reduce the maximum tensile strain under both short- and long-term waste settlement were evaluated. Results of the analyses indicate that landfill geometry, interface friction angles, and short- and long-term waste settlement are key factors in the development of tensile strains. The results show that long-term waste settlement can induce additional tensile strains after waste placement is complete. Using a HDPE GMB with a friction angle on its upper interface that is lower than the friction angle on the underlying interface, increasing the number of benches, and reducing the slope inclination are shown to mitigate the maximum tensile strain caused by waste placement and waste settlement.

Keywords: Geosynthetics; Municipal solid waste; Settlement; Geomembrane liner; Tensile strain; Landfill; FLAC

Method for calculating horizontal drain induced non-linear and large strain degree of consolidation

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Abstract: Consolidating dredged clay slurries using a combination of vacuum pressure and prefabricated horizontal drains (PHDs) is widely used in practice. This is a large strain problem, but there is no existing large strain theory for PHD induced consolidation. A method with explicit equations has been proposed to consider both mechanical and geometrical non-linearities in analyzing PHD induced consolidation. The method considers stepwise variation of properties using imaginary time concept. An imaginary time is determined by the condition of continuity of degree of consolidation before and after changing the properties. Then the method was applied to analyze a large scale model test of vacuum consolidation with PHD. Two analyses were conducted. One considered both the mechanical and geometrical non-linearity (large strain), and another only considered mechanical non- linearity (small strain). The results of large strain analysis agree with the measured settlement curve and excess pore pressures well. While the small strain analysis under-estimated the rate of consolidation significantly. The results from this study indicate that for analyzing PHD induced consolidation of clay slurries considering the effect of large strain is important, and the proposed method can be a useful design tool.

Keywords: Geosynthetics; Prefabricated horizontal drain; Vacuum consolidation; Non-linear consolidation; Slurry

The short-term and creep mechanical behaviour of clayey soil-geocomposite drainage layer interfaces subjected to environmental loadings

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Abstract: In this paper, to investigate the impact of environmental loadings on the short-term and creep mechanical characteristics of different types of clayey soil-Geocomposite Drainage Layers (GDL) interfaces, a series of rapid loading and creep shear tests were conducted on Mercia Mudstone Clay-GDL interfaces and Kaolin Clay-GDL interfaces subjected to drying-wetting cycles, thermal cycles and elevated temperature, etc, using a bespoke temperature and stress-controlled large direct shear apparatus. The experimental results indicate that, compared with the original specimens, the interfaces subjected to drying-wetting cycles, thermal cycles and elevated temperature, have lower peak shear strength and creep shear resistance. For example, under 25 kPa normal stress, the peak shear strength of original Mercia Mudstone Clay-GDL interfaces and Kaolin Clay-GDL interfaces falls by 11.91% and 10.11%, respectively, when subjected to 1 drying-wetting cycle. This can be ascribed to the weakening of interlocking effects and skin friction between soil and GDL caused by the softening of drainage core and geotextile fibres of GDL. The peak shear strength of clayey soil-GDL interfaces subjected to one drying- wetting cycle is lower than that subjected to one thermal cycle because of the reduction in the peak shear strength of clayey soil above GDL during drying-wetting cycles. The impact of drying alone on the decrease in the peak shear strength of clayey soil-GDL interfaces during drying cycles with heating is small, and the main influence factor is the elevated temperature.

Keywords: Geosynthetics; Geocomposite drainage layers; Interface shear strength; Creep; Drying-wetting cycles; Thermal cycle

Numerical analysis of a double layer rubber dam

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Abstract: A new rubber dam with two layers of dam bodies anchored closely into a rigid base is proposed to improve the water-retaining ability of the conventional rubber dam. Numerical studies using FLAC2D software are conducted to analyze the behavior of the proposed double layer rubber dam. Laboratory model tests are also carried out to verify the accuracy of the numerical model. It is found that the optimal internal water head in the upstream dam normalized by its cross-sectional perimeter ranges from 0.35 to 0.45, and that in the downstream dam ranges from 0.32 to 0.40. The double layer rubber dam has optimal perimeter ratio of 0.8 and optimal anchoring distance normalized by cross-sectional perimeter of upstream dam of 0.08. For same ultimate external water head, the cross-sectional perimeter of the double layer rubber dam increased by 25.7%–49.6% than that of conventional rubber dam in different design parameters. However, the requirements of the maximum circumferential tensile strength of the upstream and downstream dams decreased by 40.8%–62.9% and 51.9%–69.6%, respectively. Assuming the material cost is determined by length and maximum circumferential tensile strength of membrane materials, the total material costs of the proposed double layer rubber dam reduce at most 82.2% than those of the conventional rubber dam in different design parameters.

Keywords: Geosynthetics; Rubber dam; Geosynthetic tube; Geomembrane tube

Role of particle shape on the shear strength of sand-GCL interfaces under dry and wet conditions

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Abstract: Interface shear strength of geosynthetic clay liners (GCL) with the sand particles is predominantly influenced by the surface characteristics of the GCL, size and shape of the sand particles and their interaction mechanisms. This study brings out the quantitative effects of particle shape on the interaction mechanisms and shear strength of GCL-sand interfaces. Interface direct shear tests are conducted on GCL in contact with a natural sand and a manufactured sand of identical gradation, eliminating the particle size effects. Results showed that manufactured sand provides effective particle-fiber interlocking compared to river sand, due to the favorable shape of its grains. Further, the role of particle shape on the hydration of GCL is investigated through interface shear tests on GCL-sand interfaces at different water contents. Bentonite hydration is found to be less in tests with manufactured sand, leading to better interface shear strength. Grain shape parameters of sands, surface changes related to hydration and particle entrapment in GCL are quantified through image analysis on sands and tested GCL surfaces. It is observed that the manufactured sand provides higher interface shear strength and causes lesser hydration related damages to GCL, owing to its angular particles and low permeability.

Keywords: Interface shear; Hydration; Image analysis; Particle shape; Manufactured sand

Mitigation of track buckling in transition zones of steel bridges by geotextile reinforcement of the ballast layer

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Abstract: Track thermal buckling is one of the primary safety issues of continuously welded rail tracks. It has been shown that transition zones of open deck steel bridges are more prone to track buckling, as the thermal loads from the bridge and lower track lateral resistance in this region can destabilize the track in the lateral plane. The aim of this paper is to assess the possibility of reinforcing the ballast layer with geotextiles to mitigate the track buckling problem in the transition zones. To do so, a number of laboratory experiments are performed using one and two layers of geogrids and various depths of ballast layer. Single tie push tests are performed on the track and force- displacement curves are derived for the sleepers. It is shown that adding the geotextile layer to the ballast layer can increase its lateral resistance by up to 41%. The results are then introduced in the numerical model of a track developed in Abaqus finite element software for track buckling analysis. It is shown that adding the geogrid layer can increase the track buckling temperature by up to 11.33 ºC, an increase of almost 21%, compared to that of an unreinforced track.

Keywords: Ballasted track lateral; resistance Single tie push test (STPT); Geogrid reinforced ballast; Continuously welded rails (CWR) tracks; CWR track buckling temperature; Transition zones of bridges

Filtration performance of non- woven geotextiles with internally-stable and -unstable soils under dynamic loading

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Abstract: In many applications, geotextiles are subjected to dynamic loading conditions, for example, below roads and railways, for which a Gradient Ratio (GR) test is often used to assess filtration compatibility of soil-geotextile systems. This paper presents results from GR filtration tests with internally-stable and -unstable soils under dynamic loading conditions. In the tests, four non-woven geotextiles were used with varying types of soils under a hydraulic gradient of 5. Test results were interpreted in terms of GR values, permeability values, and mass and gradation characteristics of the soil before/after testing as well as the particles passing through the geotextiles. The test results show that the dynamic loading resulted in an increase of soil migration within the soil as well as an increase in the quantity of soil passing through the geotextiles. The available criteria for evaluating the internal stability of soils are evaluated based on the experimental data. Based on the test results, improvements to filter retention design criteria are suggested which take into account the internal stability of soils under dynamic loading.

Keywords: Geosynthetics; Soil/geotextile system; Gradient ratio test; Filtration Dynamic conditions; Soil retention; Blinding; Clogging

Characterisation of geomembrane and geotextile interface short-term creep behaviour in a dry condition

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Abstract: This study aims to characterise the interface creep behaviour between geomembrane and geotextile (i.e. GM-GT) in the liner system. Two types of GM (i.e. smooth SGM and textured TGM) and two types of GT (i.e. nonwoven NWGT and woven WGT) were investigated using the conventional direct shear apparatus for four combinations of GM-GT. The interface friction angles (φ_{in}) between GM-GT were firstly determined at the normal stresses (σ_n) of 25, 50, 100 and 200 kPa. The results show that TGM-NWGT has a much larger ϕ_{in} (23.9º) than the other three combinations which ranged from 9.5º to 11.1º. Subsequently, creep tests were conducted at three shear stress (τ) levels (i.e., 30, 50 and 70% of the peak stress (τ_p) under each normal stress). The creep test results of the four combinations were analysed and a power equation of time was used to estimate creep displacement (δ_{cp}). The coefficients A and B in the power equation were found to be functions of Young's modulus of the composite material (E_c), time, σ_n, τ, τ_p, and φ_{in}. The tertiary creep stage was not observed in the test and it is recommended that longer duration GM-GT interface creep tests should be conducted for in-depth understanding of the interface creep mechanism.

Keywords: Geosynthetics; Geotextiles; Geomembranes; Interface creep; Landfill

Working mechanism of a new wicking geotextile in roadway applications: A numerical study

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Abstract: Woven geotextiles are often to be used in roadways for reinforcement purposes due to their higher tensile strengths. In the design of a woven geotextile for practical applications, the focus is mainly put on its reinforcing effect, while its hydraulic behaviors are not major design parameters and the influence of hydraulic properties on the reinforcing effect is often ignored. However, woven geotextiles are predominantly made of polypropylene and polyester, which are hydrophobic. This characteristic can result in a capillary break effect which it is equivalent to raise the ground water table to the location where the geotextile is installed. Numerous researchers have reported that the moisture storage from a capillary break effect can be detrimental to the long-term performance of a pavement structure. Until now, no method is available to effectively resolve this issue.

Recently a new type of wicking geotextile is produced which has the capability to laterally drain excess water in a roadway under both saturated and unsaturated conditions. Several field applications demonstrated its potential in improving pavement performance. This paper attempted to investigate the working mechanism of the wicking geotextile through numerical studies and quantify the benefits of the wicking geotextile in term of drainage performance in a pavement structure. A numerical model was developed and validated using column test results from existing literature. After that the drainage performance of the wicking geotextile under different working conditions was simulated and evaluated.

Keywords: Geosynthetics; Woven geotextile; Unsaturated soil; Capillary barrier; Reinforcement; Subsurface drainage; Pavement performance

Effect of coating optimization on performances of glass fiber geogrid for semi-rigid base asphalt pavement

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Abstract: Glass fiber geogrid (GFG) is one of the most commonly used materials to mitigate reflective cracks in semi-rigid base asphalt pavement, but there are still some defects in the application of GFG at present. Therefore, GFG was optimized from the perspective of coating treatment. In this paper, the coating materials were firstly optimized from a variety of compounded emulsions (CE) composed of polymer and emulsified asphalt (EA). Then, the properties of the CE and the effect of CE on performances of GFG were studied. The results show that the weighted average particle size, contact angle, viscosity and coating uniformity of polyacrylate compound emulsion (PA-CE) are smaller, higher, higher and better than those of styrene-butadiene compound emulsion (SB-CE), respectively. The GFG impregnated by PA-CE (PA-GFG) has better strength, folding resistance and durability than the GFG impregnated by SB-CE (SB-GFG) and GFG impregnated by EA (EA-GFG). The interlaminar bonding performances and resistance to reflective cracks from flexural-tensile loading of PA-GFG and SB- GFG are not significantly different, while the resistance to reflective cracks from shear loading of PA-GFG is higher than that of SB-GFG.

Keywords: Glass fiber geogrid; Coating material; Compound emulsion; Asphalt pavement; Reflective crack

Uni and bi-directional dewatering behaviour of open geotextile containers used for filtration of waste slurries

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Abstract: The simultaneous analysis of filtration mechanisms under vertical, horizontal, and bi-directional flow conditions has not yet been clarified for geotextile-dewatering involving different grain-sized slurries, therefore it is still not obvious which condition is dominant as particle sizes vary. In this paper, the differences associated to horizontal versus vertical filtration are investigated based on solids retention and effluent volume through the geotextiles. Three geotextile materials (two woven and a nonwoven) are separately employed for the filtration of three slurries with d_{50} ranging from 55 μm to 410 μm using an open dewatering unit. To facilitate the formation of a permeable filter cake on the inside of the geotextile surface, a range of particles with grain size distribution indicating internal stability was chosen for the slurries. The geotextile/slurry combinations targeted possible unfavorable retention conditions wherein only the particles of approximately the same size as the largest opening size of the filter could be retained ($O_{90}/d_{85} \geq 1.0$). A probabilistic model based on the geotextile pore size distribution curve and number of constrictions is added to the laboratory investigation to assess the geotextile retention reliability and confirms that for most cases slurry particles of all sizes can pass through the filters. Nonetheless, filtration efficiencies greater than 90% and control of particle loss are reached relatively fast for almost all experiments. In other words, it is a range of particles retained at the beginning of filtration tests that stimulates filter cake formation and governs further retention.

Keywords: Geotextiles; Slurries; Multidirectional flow; Filtration mechanisms; Filter cake; Probabilistic model; Retention prediction

Analytical solution for calculation of pullout force-deformation of geosynthetics reinforcing unsaturated soils

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Abstract: Performing tests on geosynthetic-reinforced soils under pullout conditions gives a comprehensive understanding of soil-geosynthetic interaction. However, they may be expensive and time-consuming. Therefore, the development of theoretical solutions may be beneficial to recognize characteristics of geosynthetic-reinforced soils under pullout conditions. This paper proposes an analytical solution for the determination of pullout force-deformation variation of planar geosynthetics reinforcing unsaturated cohesive-frictional soils. The solution predictions were validated with experimental results, demonstrating the capability of the presented solution. The solution can extend limited results obtained from experiments to a wider range of conditions. It has been demonstrated that under 20 kPa overburden stress, with decreasing the soil suction from 1153 to 312 kPa, corresponding to increasing the moisture content from 16% to 20%, the peak pullout force decreases by about 28%. The results also illustrate that by increasing the value of matric suction, the amount of U^* (relative soil-reinforcement displacement corresponding to the total mobilization of friction) decreases.

Keywords: Geosynthetics; Pullout; Analytical solution; Unsaturated soils; *c*-φ soils; Nonlinear force-deformation