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摘要集

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目　录

The influence of geosynthetic properties on their shear behaviors at the interface with frozen soil

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Abstract: This paper investigates the shear properties of the interfaces between sand and short-staple nonwoven geotextile (GT1), long-staple nonwoven geotextile (GT2), and geomembrane (GM) under varying conditions of testing temperature, sand moisture content, and normal stress through temperature-controlled direct shear tests. The results reveal that the shear stress-shear displacement curves for the sand-GT1 and sand-GM interfaces can be broadly categorized into an elastic deformation stage, a nonlinear growth stage, and a stable stage. However, the sand-GT2 interface displays a continuously increasing trend throughout the experiment. The peak friction angles of the interfaces increase significantly as the temperature decreases, following the order GT1 > GT2 > GM. The average residual friction angle of sand with GT1, GT2, and GM decreased by 14.8%, 10.4%, and 31.1%, respectively, compared to the peak friction angle. The peak cohesion at the sand-GM interface is relatively weaker than that at the sand-GT1 and sand-GT2 interfaces. The shear mechanisms between frozen soil and geotextiles involve ice cementation, rolling, interlocking, and fiber tensioning, while the shear mechanisms between frozen soil and GM comprise ice cementation, rolling, indentation, and plowing.
Keywords: Frozen soil, Geosynthetics, Interface, Shear strength, Shear mechanisms

A novel two-layer composite geomembrane lining structure to mitigate frost damage in cold-region canals: Model test and numerical simulation

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Abstract: The canal is crucial for water diversion projects, but it is susceptible to frost damage. To address this, a two-layer composite geomembrane lining structure (TLCGLS) was proposed that regulates the interaction between canal lining and frozen soil. Model tests were conducted to investigate its anti-frost heave effectiveness. Considering the interaction among the lining, two-layer composite geomembranes (TLCGs), and frozen soil, a canal frost heave model with heat-water-mechanical coupling was developed. The influence of canal cross-section shapes and TLCGs arrangements on anti-frost heave performance and mechanism of TLCGLS were discussed. Results show that TLCGLS reduces uneven frost heave degree and compressive/tensile strains of the lining by 35%, 29%, and 28% respectively. During melting, it rapidly reduces frost heave, tangential deformation, and strain with minimal residual effects. TLCGLS demonstrates strong resetting ability and excellent anti-frost heave performance. It is particular suitable for arc-bottomed trapezoidal canals. However, excessive reduction in friction between TLCGs weakens arching effect of the bottom lining, increasing tensile stress and safety risks. TLCGLS with geomembrane-geotextile contact exhibits superior anti-frost heave performance, mitigating compressive stress by over 50% while meeting design requirements for tensile stress. These findings provide a theoretical basis and technical solution for mitigating frost damage in canals.

Keywords: Two-layer composite geomembranes, Anti-frost heave performance, Heat-water-mechanical coupling, Water conveyance canal, Model test, Numerical simulation

Field test of geosynthetic-reinforced floating pile-supported embankments on soft soil

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Abstract: This study conducted field tests on geosynthetic-reinforced floating pile-supported embankments to evaluate the load transfer mechanism and embankment deformation during embankment construction. Vertical pressures on pile caps and subsoils between piles, geosynthetic strains, settlement of pile caps and subsoils between piles, and settlement of the embankment at different elevations were measured throughout the embankment construction. Test results showed that the maximum settlement of the pile cap was approximately 66% of subsoils between the piles. Due to the large settlement of the floating piles, the soil arching was not significantly mobilized. The geosynthetic reinforcement exhibited a maximum tensile strain of 0.2% at the end of embankment construction, indicating a mobilization of low tensioned membrane effect. The predicted equal settlement heights at adjacent piles center and the diagonal pile center were close with an average value of approximately 1.23 times the pile net spacing. The measured vertical pressures on subsoil between piles were compared with calculated results using available analytical models from the literature. The analytical models underestimated the vertical pressures on the subsoils between piles, while the modified Terzaghi's model showed better agreement with the measured results than other analytical models.

Keywords: Geosynthetic, Deformation, Floating pile-supported embankment, Field test, Soil arching, Tensioned membrane

Influence of geogrid reinforcement on the cracking characteristics of expansive soils: A laboratory study

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Abstract: Expansive soils are susceptible to cracking due to significant moisture fluctuations, which can potentially lead to structural instability. Although geogrid reinforcement is widely used to control soil swelling and shrinkage, its effects on cracking behavior are not fully understood. This study investigates the influence of geogrid reinforcement on the cracking behavior of expansive soils by comparing soil samples reinforced with two layers of geogrid to unreinforced samples under evaporation conditions. Crack development was monitored using high-resolution imaging and fluorescence tracing to measure crack depth and calculate surface crack ratio. Additionally, moisture content distribution and evaporation rates were assessed. The results show that geogrid reinforcement reduced the total crack ratio by 1.34% and decreased average crack depth by 43.5%, leading to a more uniform crack distribution with smaller openings. Both internal and external cracks facilitated moisture exchange between the soil and atmosphere. The frictional and interlocking effects at the soil-geogrid interface effectively inhibited cracking and reduced moisture migration. The uniaxial geogrid also induced anisotropy crack restraint, with environmental exposure and geogrid orientation playing critical roles in crack control. Overall, these findings demonstrate the effectiveness of geogrids in enhancing the stability of expansive soils and limiting atmospheric influence through crack suppression.

Keywords: Geosynthetics, Expansive soils, Geogrid reinforcement, Cracking behavior, Moisture migration, Evaporation test

Probabilistic analyses of geosynthetic-reinforced pile-supported embankments using design methods and 3D finite element models considering soil variability

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Abstract: Geosynthetic-Reinforced Pile-Supported Embankments (GRPSE) are effective composite structures to support highway infrastructures on weak soils. Numerous design methods have been developed in practice to facilitate the use of this technology. However, it is well known that as the design methods adopt different theoretical assumptions, the performance indexes given by the design methods vary significantly. Furthermore, the effect of soil variability on the design outcomes given by the design methods is unknown. These uncertainties present great challenges to design engineers to select the proper design method and consider soil variability. To fill this knowledge gap, we conducted comprehensive probabilistic analyses using typical design methods (BS8006 and CUR226) and 3D finite element models (unit-cell and full-scale) considering soil variability. A well-established case study in the literature was used as a benchmark. Algorithms for the design methods and the 3D finite element models were developed, calibrated and tested in both deterministic and probabilistic scenarios. A detailed probabilistic comparison between the design methods and the 3D finite element models was also carried out. Results show that 1) soil variability affects the performance indexes of GRPSE, including stress reduction ratio, stress concentration ratio, differential settlement, and tensile force of geosynthetics; 2) model uncertainties of design methods can be as high as 46%, due to the assumptions and simplifications made to formulate the solutions; 3) the probabilistic 3D full-scale finite element method is the most robust approach to consider soil variability.

Keywords: Geosynthetic-reinforced pile-supported, embankment, Probabilistic analysis, Design method, 3D finite element analysis, BS8006, CUR226

Interface shear creep behavior between the nonwoven geotextile and the geomembrane pre/post peak strength

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Abstract: In landfills, shear creep of the liner interface occurs after some shear displacements under the influence of a sustained load from waste. In this paper, an apparatus was developed to conduct shear creep tests on interfaces after different initial shear displacements, and experimental investigations were performed on the shear creep behavior of the geotextile and geomembrane interfaces pre/post peak strength. The results demonstrated that the initial instantaneous displacement and the steady displacement rate at the interface increased with increasing shear stress. The initial instantaneous displacement at the geomembrane–geotextile interface in the post-peak tests was reduced compared with that in the pre-peak tests, whereas the displacement rate at elevated shear stress levels was greater in the post-peak tests than in the pre-peak tests. The creep behavior of the interface was influenced by both the initial shear displacement and the material interaction. An analysis of the Nishihara model revealed that the shear modulus of the Hooke body at the interface increased with increasing shear stress in the pre-peak test, whereas it decreased in the post-peak test as the shear stress increased. The difference in calculated creep time from the 30-day test results and from 3-day creep test results was approximately 8.9%.

Keywords: Initial shear displacement, Instantaneous displacement, Displacement rate, Shear modulus, Creep time

Study on the hydraulic properties of internally unstable soil-nonwoven geotextile systems: Boundary values and preliminary estimates

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Abstract: Internally unstable soils can pose severe conditions to granular and geotextile filters in geotechnical engineering works. Regarding the latter, several researchers have investigated the behaviour of such filters in contact with internally unstable soils and severe clogging and flow rate reductions of soil-geotextile filter systems have been observed in several cases. This paper presents a study on the prediction of boundary values for hydraulic properties of nonwoven geotextile filters in cohesionless internally unstable soils. A broad survey on results of filtration tests present in the literature was carried out for the development of a database for the study. The results obtained show that significant reductions in soil-geotextile system permeability coefficient and flow rate may occur independent on the type of test carried out, quite often as a consequence of poor hydraulic behaviour of the soil rather than geotextile filter clogging. The study has identified the level of importance of relevant parameters to assess potential malfunction of the soil-geotextile system and equations were developed to predict lower bound values and estimates of soil-geotextile system permeability coefficient for preliminary analyses.

Keywords: Geosynthetics, Nonwoven geotextiles, Filtration, Internally unstable soils, Clogging

Characteristic pore size of nonwoven geotextiles based on low-field nuclear magnetic resonance technology

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Abstract: Conventional methods for assessing the pore characteristics of nonwoven geotextiles are plagued by several limitations such as low accuracy and lengthy processing time. Consequently, this paper proposed low-field nuclear magnetic resonance (NMR) technology to acquire the pore size distribution (PSD) curves, porosity, and characteristic pore size (CPS) of nonwoven geotextiles. The T_2 characteristic spectrum of vacuum-saturated specimens was obtained from low-field NMR tests, while the pore shape coefficient and surface relaxation rates were determined via scanning electron microscopy (SEM) and X-ray computed tomography (CT) three-dimensional (3D) reconstruction technology. The PSD curves and CPS (O_{90}) values were acquired and compared with results from the wet sieving, dry sieving, and CT digital image methods. The results demonstrate that low-field NMR technology can accurately and efficiently determine the CPS of nonwoven geotextiles.

Keywords: Geosynthetics, Nonwoven geotextiles, Low-field NMR, Pore size distribution (PSD), Porosity, Characteristic pore size (CPS) O_{90}

A model for predicting permeability of geotextile envelope for subsurface drainage after combined clogging in arid areas

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Abstract: This study develops a coupled model for the combined clogging and permeability coefficient of a geotextile envelope. Based on the characteristics of pore size distribution and its impact on permeability coefficient after clogging, a permeability coefficient model assuming the geotextile is composed of multiple layers of planar mesh is developed. Then, based on the range of pore size after clogging, hypotheses for large-pore clogging area and small-pore permeable area are proposed to simulate the process of decreasing the theoretical maximum pore size of the geotextile and the increasing area of large-pore clogging area. The physical and chemical clogging models are coupled and field sampling was used to confirm the availability of the model. Results indicate that the model effectively simulates the impact of clogging on the permeability coefficient. Additionally, sensitivity analysis and trend simulations show that permeability reduction coefficient (β_1), area density (μ_{g0}), and saturation index (SI) are the main factors affecting combined clogging and permeability, with β_1 and μ_{g0} having significant early impacts, while SI has a greater impact in the later stages. When β_1 is equal to 0.3 and SI is greater than 1.0, the geotextile envelope for subsurface drainage faces a high risk of combined clogging.

Keywords: Subsurface drainage, Geosynthetic envelope, Combined clogging, Arid area

Field behavior of a GRS bridge approach retaining wall on highly compressible foundation soils

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Abstract: To reveal the behavior of geosynthetic-reinforced soil (GRS) bridge approach retaining walls on highly compressible foundation soils, in this study, a GRS bridge approach adjacent to the Yangtze River was monitored for approximately 3 years during construction and post-construction. The settlement of the GRS bridge approach, the vertical earth pressure at the base of the backfill soil, and the reinforcement deformation were monitored. The monitoring points were arranged on the left and right sides of a cross-section and a longitudinal section at the mid-span. The results showed that the settlement of the GRS bridge approach was large and uneven, and the settlement rates were influenced by the water level of the Yangtze River. Due to the large and differential settlement, the distributions of the vertical earth pressure and geogrid reinforcement strain for a retaining wall constructed on highly compressible foundation soils were different from those for a retaining wall constructed on stable foundation soils. The overall GRS bridge approach performed well with large settlements, with only some minor structural problems in the facing of the retaining wall. This indicated that the flexible GRS bridge approach was a good choice when the retaining wall was constructed on highly compressible foundation soils.

Keywords: Geogrids, Retaining wall, Bridge approach, Highly compressible foundation soils, Field instrumentation

Long-term performance of polyethylene geomembranes to contain brine

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Abstract: The degradation of five fortified polyethylene geomembranes (three HDPE, one LLDPE, and one blended) with high initial properties compared to minimum requirements in GRI-GM13 is investigated when immersed in brine at three concentrations (100%, 50%, and 10% brine) and deionized water at temperatures ranging from 25 to 95°C for 8 years. The performance of the geomembranes in different incubation fluids is compared to explore the effect of salt concentration on the durability of geomembranes. The results indicate that the high initial properties of a GMB may not be indicative of its long-term performance due to the effect of other factors like GMB resin, stabilizers, thickness, exposure conditions, and manufacturing process on GMB degradation. Increasing salt concentration decreases the rate of antioxidant depletion, with a depletion rate in 10% brine 1.5 times faster than that in 100% brine. Thus, any assessment of the likely service life of a polyethylene geomembrane in a brine pond with variable salt concentration requires investigating their performance over the expected range of brine concentrations. Temperature and choice of geomembrane (especially antioxidant package) are shown to have a significant (e.g., by a factor of 4 at 55°C in brine) effect on liner longevity.

Keywords: Geomembranes, HDPE, LLDPE, Antioxidant depletion, Stress crack resistance, Degradation

An approximate solution of consolidation for double-layered ground withdifferent smear radii by vertical drains

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Abstract: An analytical solution for consolidation of double-layered ground by vertical drains is proposed, in which only the radial seepage is taken into consideration and the smear radius varies with soil layers. To improve the computing efficiency, a simplified method for selecting serious solutions is presented. The approximate solution is illustrated by Tang's solution (Tang and Onitsuka, 2001) and a large radial consolidation test. The error caused by the forbiddance of vertical drainage can be ignored when the ratio of vertical time factor to radial time factor is small enough, for example, 1/200; and which is easy to satisfy in the field. Through adjusting the control precision of series solutions, the consolidation behavior at any soil layer can be calculated. Horizontal permeability coefficient and smear radius affect the consolidation rate, especially when changing them in the layer which has smaller consolidation coefficient. Moreover, the orthogonal relation for the double-layered and muti-layered system is demonstrated. Using the proposed method, analytical solution for consolidation of double-layered ground by vertical drains can be more acceptable to engineers.

Keywords: Double-layered ground, Vertical drain, Consolidation, Smear radius, Analytical solution

Influence of perforation characteristics and geotextile envelopes on the drain pipe

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Abstract: Preventing clogging effectively and ensuring stable drainage performance are crucial for the efficacy of subsurface drainage systems. This paper presents the results of a laboratory study on the drainage performance of drain pipes using soil samples from the Yinbei Irrigation District in Ningxia Hui Autonomous Region, China. The perforation characteristics and geotextile envelopes were investigated. Results demonstrated that a drain pipe with a six-row staggered perforation layout performed exceptionally well in drainage. Increasing the number and reducing the size of perforations while maintaining a constant perforation ratio can enhance drainage performance. A higher degree of clogging was observed in the geotextile envelope at the bottom of the drain pipe, and this issue can be mitigated by increasing the perforation ratio of the pipe wall. Findings from this study can provide theoretical support and practical guidance for optimizing the design of drain pipe perforations and the selection of geotextile envelopes in subsurface drainage.

Keywords: Subsurface drainage, Drain pipe, Perforation ratio, Perforation layout, Geotextile clogging, Permeability