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摘要集

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目　录

Impact performance of unreinforced and geogrid-reinforced rockfall protection embankment

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Abstract: This study designs and analyzes a Rockfall Protection Embankment (RPE) for an unstable slope in the Indian state of Mizoram. Initially, an in-depth trajectory analysis of the site is conducted to determine impact velocity, bounce height, and kinetic energy of falling rocks. Subsequently, the dimensions of three RPE variants-unreinforced, primary geogrid-reinforced, and secondary geogrid-reinforced configurations are determined based on literature and guidelines. Dynamic analyses are performed on these RPE variants using three-dimensional Finite Element software, PLAXIS 3D. The assessments consider multiple direct impacts and rebound impacts involving the maximum evaluated kinetic energy. Performance is assessed by examining maximum and residual deformations, mobilized tensile forces within geogrid layers, and the number of impacts the RPEs can withstand before reaching a deformation threshold. The results show that the reinforced RPE configurations exhibit significantly enhanced performance, withstanding nearly 20–43 times more impacts than unreinforced ones under both direct and rebound impact conditions. The inclusion of reinforcement layers notably improves the RPEs' ability to mitigate deformations by providing a confining effect to the soil mass and dissipating a part of the impact energy through the geosynthetics' strain and frictional resistance, thus making them more effective for rockfall protection.

Keywords: Geosynthetics, Rockfall, Trajectory analysis, Rockfall protection embankment, Impact absorption capacity, Finite element modelling, UN SDG 11: Sustainable cities and communities

Simplified methods for the design of landfill double composite liners using neural network

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Abstract: Double composite liners (DCLs) have been widely used in landfills to protect the surrounding environment. This study aims to develop simplified empirical equations for calculating breakthrough times of DCLs based on analytical equations or experimental data. An artificial intelligence neural network called group method of data handling (GMDH)-type neural network was used to perform equation simplification. New empirical equations in polynomial formats were obtained by a layer-summation method and a series of numerical experiments based on analytical solutions for contaminant transport in double composite liners. The accuracy of empirical equations is demonstrated by comparing them with the existing solutions and numerical results. The performance of four types of DCLs were then investigated. The mean absolute percentage errors (MAPEs) for each type of DCL with different leachate heads and soil liner thicknesses were all lower than 10%. Additionally, a trend for the improvement of the GMDH equation accuracy with the increase of head loss of the upper composite liner (Δh_1) was observed. The presented equations can perform well in high leachate head conditions (e.g. >5 m) where DCLs are required.
Keywords: Geosynthetics, Composite materials, Breakthrough time, Landfill, GMDH-type neural networks, Empirical equations

Modelling the ultimate pullout resistance of geogrids

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Abstract: This paper provides a review of the modelling of geogrid ultimate pullout resistance. Several analytical models were found to disregard the effect of the geogrid stiffness as well as the particle size distribution of the soil. A sensitivity analysis was done on 289 pullout tests to evaluate the significance of these omitted variables as well as other key variables contributing to pullout resistance. It was found that ultimate pullout resistance was the most sensitive to normal stress followed by geogrid length, geogrid stiffness and the friction angle of the soil. By considering geogrid geometry, stiffness and soil grading descriptors, in addition to the standard variables of length, stress and friction angle, regression models of ultimate pullout capacity improved by 15%. In addition, an alternative model to the simplified linear models of FHWA and EBGEO which maintains dimensional consistency while incorporating geogrid stiffness and non-linearity in the model, was proposed. This alternative model performed 32% better than the simplified linear models.

Keywords: Geosynthetics, Geosynthetic-reinforced soils walls & slopes, Soil-geosynthetic interaction, Regression analysis, Sensitivity analysis

Antioxidant depletion from a 2 mm high-density polyethylene geomembrane used in brine containment

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Abstract: The depletion of antioxidants from a 2 mm high-density polyethylene geomembrane immersed in brine at seven temperatures (95, 85, 75, 65, 55, 40, and 25°C) for 28 months is reported. An Arrhenius model is used to predict the performance of the geomembrane at low site-specific temperatures. The antioxidant depletion times are reported for temperatures between 20 and 95°C. The solubility of the antioxidant and stabilizer packages, the oxidation by-products, and their susceptibility to hydrolysis are discussed. After 28 months of incubation, no oxidative degradation was observed for samples in the full brine solution even at 95°C. Morphological changes reduced the stress-crack resistance to a stable representative value without a reduction in the tensile elongation at break. The effect of the brine solution concentration on the depletion of antioxidants and stabilizers was investigated at 85°C. It was found that the depletion rate decreases with the increasing brine concentration.
Keywords: Geosynthetics, HDPE, Antioxidant depletion, Brine

Pullout capacity at the bamboo reinforcement-compacted earth interface

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Abstract: Compacted earth materials are still popularly used to construct wall structures in rural areas. To address the drawbacks of poor ductility and low shear resistance in compacted earth walls, bamboo, with excellent tensile properties, is introduced as a reinforcement material. Pullout tests on bamboo-reinforced compacted earth were conducted in this study, in which the effects of four parameters of normal stress, bamboo reinforcement form (without node, with node, and with curved anchor head), bamboo reinforcement width, and embedment length were investigated. Results demonstrated that the presence of chemical bonding force, frictional resistance, and end resistance at the interface between bamboo reinforcement and compacted earth could contribute to the mobilized pullout capacity. The parameter impact on pullout resistance can be ranked as follows: embedment length>bamboo reinforcement width>normal stress>bamboo reinforcement structure. Based on the Mohr strength theory, a model for estimating the ultimate tensile capacity of bamboo-reinforced compacted earth was derived. The pullout capacities obtained from theoretical calculations and experimental measurements differed from 0.73% to 14.60%, mostly failing below 10%. The proposed calculation model enabled the estimation of load-bearing capacity at the bamboo reinforcement-compacted earth interface, providing valuable guidance for wall design.

Keywords: Geosynthetics, compacted earth, bamboo reinforcement, pullout test, interface performance, load-bearing capacity model

Complementary use of analytical equations and numerical models for composite liner designs

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Abstract: The finite element (FE) method is used to identify limitations and extend the applicability of an analytical solution for leakage through holed wrinkles in composite liners. The limiting assumption in the analytical model is relaxed based on FE results, providing a means of obtaining good agreement through the two methods over a wide spectrum of cases. Despite the flexibility of the FE, the analytical model has the advantage of readily accommodating a wide range of dimensions and material properties that, even with a very large mesh, may be difficult to analyze using FE. In addition, the analytical equation is well-suited for Monte Carlo simulation. This is illustrated by the use of the modified analytical equation and the Monte Carlo simulations to compare the performance of two types of composite liners currently approved for use in Chinese landfills with a generic design in Canada and other parts of the world. It is shown that even with a relatively small number of holed wrinkles leakage through the geomembrane composite liner can differ by up to two orders of magnitude between composite liners considered to be equivalent. The paper also notes the need to revise regulations to reflect the evolution of knowledge.

Keywords: Geosynthetics,Geomembranecompositeliners, Holed wrinkles, Leakage rates, Analytical equations, Numerical models

Monitoring performance of a new smart geosynthetic under drawing test

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Abstract: Geosynthetics are widely used in civil engineering reinforcements owing to their high strength, acceptable toughness, and ease of transportation. However, traditional geosynthetics do not have the capability to monitor damage inside the soil. Therefore, in this paper, a new sensor-enabled piezoelectric geobelt (SPGB) is developed to measure the deformation of reinforced-soil structures. In-soil drawing tests are conducted to investigate the sensing performance of the SPGB. Variations in the voltage and impedance signals of the SPGB with the drawing displacement under different damage conditions are investigated. The results show that with the increase of drawing displacement, SPGB undergoes tensile deformation followed by pullout damage. In tensile deformation, the signal response of SPGB is related to strain. As the strain increases, the output voltage first increases and then decreases, and the impedance gradually decreases. In the pullout damage phase, the signal response of SPGB is related to the contact area between SPGB and soil. As the drawing displacement increases, the contact area between SPGB and soil gradually decreases, the output voltage gradually decreases, and the impedance gradually increases. Therefore, the SPGB, as a sensor-enabled geosynthetic, provides a reinforcing function to the soil body and simultaneously performs in-soil catastrophe identification.

Keywords: Geosynthetics,Reinforced-soil structures, Sensor-enabled piezoelectric geobelt, Drawing test

Filtration compatibility of clay-nonwoven geotextiles under normal stress

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Abstract: Nonwoven geotextiles are commonly utilized as filter materials in drainage and filtration engineering. This study focuses on the clogging phenomenon of the nonwoven geotextile filter wrapping the blind drain in the active anti-floating technology of underground structures. In this paper, the filtration compatibility of clay-nonwoven geotextiles was evaluated using a newly developed gradient ratio test device that can apply normal stress. Two fabrication technics and four specifications of nonwoven geotextiles were used to filter clay, and the geotextiles' clogging degree was assessed after the test. The influences of normal stresses, hydraulic gradients, and fabrication technics on nonwoven geotextile filtration performance were discussed based on results from a series of gradient ratio tests. Relevant assessment parameters (clogging coefficient, soil retention, and equivalent porosity) were also presented to quantify the clogging degree of nonwoven geotextiles after the test. Furthermore, the clogging process of nonwoven geotextiles filtering clay was initially explored, and the filtration effect of the needle-punched and heat-bonded nonwoven geotextiles was evaluated. The results showed that normal stress had a significant effect on nonwoven geotextile filtration, with needle-punched nonwoven geotextiles having better soil filtration and water permeability. Discussions on nonwoven geotextile applications in specific environments or conditions are also presented.

Keywords: Geosynthetics,NonwovenGeotextiles, Filtration Compatibility, Normal Stress, Clogging Degree

Effect of UV radiation on shear behaviour between geotextile and geomembrane interface

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Abstract: Geotextile/textured geomembrane (GTX/GMBT) liner at the bottom of the landfill will be exposed to ultraviolet (UV) radiation after installation and before being put into use, but the interface shear behaviour has not yet been studied. In this paper, based on laboratory UV accelerated weathering tests, the tensile behaviour of GTX and GMBT and the shear behaviour between the GTX/GMBT interface were studied. The experiment results showed that the Std-OIT value of aged GMBT was kept for a period of time and then dropped down due to the obstruction of the overlying GTX; the tensile strengths of GMBT exposed to UV radiation decreased, the GTX stiffness increased while both the tensile strength and elongation at break decreased. The peak and large displacement shear strengths between the GTX/GMBT interface both increased with the aging process. The compression behaviour between the aged GTX/GMBT interface decreased and the dilation phenomenon became obvious with the aging process during direct shear tests. The variation of shear-induced vertical displacement between virgin and aged GTX/GMBT systems based on the disturbance model was also established. This paper helps evaluate the variation of shear behaviour, compression, and shear-induced vertical deformation of GTX/GMBT exposed to solar radiation.
Keywords: Geosynthetics,UVRadiation,Geotextile, Geomembrane, Direct Shear, Strength Parameters

Geotextile filtration characteristics in piping rescue under extreme soil-retained state

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Abstract: Geotextiles have significant potential in rescuing backward erosion piping (BEP) occurring in levees. To investigate the filtration characteristics of woven geotextile for BEP prevention under the extreme soil-retention state, laboratory experiments were conducted using woven geotextiles with different pore sizes. The extreme soil-retention characteristics of the geotextile were analyzed, and the optimal relationship between filter pore size and particle size of the protected soil was explored. Additionally, the impact of fine particle content of the protected soil on the filter's filtration performance was studied. The results indicated that, for the medium sand and silty sand tested, the filter still met soil retention requirements when the ratio of the geotextile's equivalent pore size (O_{95}) to the protected soil's characteristic particle size (d_{85}) was 5.2 and 4.3, respectively. With the increase of filter pore size, the clogging degree of the filter showed a trend of rapid decrease followed by an increase, indicating that there was an optimal matching relationship between the filter aperture and the particle size of protected soil. When woven geotextiles are used for preventing BEP, to ensure optimal filtration performance of the filter, the recommended values for O_{95}/d_{85} in medium sand and silty sand are 5.2 and 3.3, respectively.

Keywords: BackwardErosionPiping,Geosynthetics, Geosynthetic Applications, Filters & Drains, Filtration Characteristics, Limit Soil-Retained State