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摘要集

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Assessing tensile performance and damage in glass fibre mesh reinforcements using image-based characterization

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Abstract: The study investigates the tensile behavior of three different glass fibre meshes (having different geometrical, physical, and mechanical properties) using the digital image correlation (DIC) technique by carrying out single-yarn, strip, and wide-width tensile tests. Single-yarn tests exhibited the highest tensile strength per meter width, while wide-width tests showed reductions of up to 34% for a glass fibre mesh having a mass density of 205 g/m² compared to the strength obtained from single yarn tests. DIC analysis revealed that the reduction in tensile strength of glass fibre meshes under multi-rib testing is primarily attributed to variations in aperture size, yarn geometry, and multiple microscopic flaws in the yarns of the glass fibre mesh. Furthermore, the effects of installation damage on the tensile strength of the glass fibre meshes were examined using aggregates of various sizes. Percentage strength reduction (*PSR*) increased with larger aggregates and the glass fibre mesh with smaller apertures, showing a maximum reduction of 38% observed for the glass fibre mesh having a mass density of 405 g/m². Moreover, DIC analysis of the damaged glass fibre meshes under tensile loading revealed that failure is primarily governed by localized damages induced during cyclic loading. Localized damages in the longitudinal and transverse yarns leads to relative displacement between them under tensile loading, causing a non-uniform stress distribution across the glass fibre mesh. Finally, a predictive model for calculating *PSR*, incorporating aggregate size, grid aperture dimension, applied normal pressure, and number of cycles, was developed and validated against the experimental results obtained from the existing literature. The model predictions showed close agreement with the existing results, validating its suitability for quantifying strength reduction during the installation of grids.

Keywords: Glass fibre mesh, Geosynthetic reinforcement, Tensile behaviour, Damage characterization, Digital image correlation, Full-field measurement

Progressive failure mechanisms and stability assessment of geotextile bag tailings dams using upper-bound analysis

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Abstract: Geotextile bag dam technology is widely adopted in tailings management owing to its material synergy and environmental sustainability. However, the stability evaluation of such dams remains constrained by the limitations of conventional homogenisation assumptions. To address this issue, this study investigates failure mechanisms under loading through reduced-scale model tests on unreinforced and reinforced dams with varying slope ratios. Based on the experimentally observed failure modes and the upper-bound theorem, a kinematically admissible failure velocity field is developed to propose a composite slip-surface limit analysis method, explicitly incorporating interface shearing. Results demonstrate that the inclusion of geotextile bags increases the ultimate bearing capacity by 62.6% compared with the unreinforced dam. Crucially, the failure mode is identified as a composite pattern of “circular shear within tailings coupled with interface sliding along geotextile bags,” with flexible confinement effects being more pronounced under gentler slopes. Analytically, predicted slip surfaces align closely with experimental observations. Furthermore, the calculated safety factors exhibit a relative error of only 5.3%, demonstrating significantly superior accuracy than that obtained using Bishop's method, which yields an error of 13.3%. Overall, this study elucidates interface-dominated failure mechanisms and establishes a high-precision framework for the stability assessment of geotextile bag dams.

Keywords: Geotextile bag, Tailings dam, Stability analysis, Upper-bound limit analysis, Composite slip surface, Interfacial shear strength

Leakage through waste covers with small geomembrane wrinkles

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Abstract: Large-scale field experiments are conducted to quantify the effect of geomembrane wrinkles on leakage through a waste cover system exposed to natural rainfall and temperature. The waste cover consists of a geomembrane layer with an 11-mm diameter hole overlain by 0.3-m thick sand on a 4H:1V slope. From March 1 to August 21, 2022, 486 mm of precipitation yielded <0.1 L of leakage in Section A without wrinkles, and 4 L in Section W with crossed wrinkles (2 m long, 0.05 m high). A subsequent single rainstorm on August 22-23, with the annual peak precipitation of 115 mm, generated leakage that accounted for nearly 100% of the total leakage in Section A and 60% in Section W. This demonstrates that leakage through waste covers is dominated by extreme rainfall events rather than by cumulative precipitation. Three-dimensional transient numerical seepage models are validated using the field data and then used to extend the leakage prediction beyond the period of measurement. The mechanism of wrinkle-induced leakage is that the small 50 mm high wrinkles act as hydraulic “dams”, increasing water retention upslope and both the magnitude and duration of the positive hydraulic head above the hole.

Keywords: Geosynthetics, Geomembrane, Waste cover, Wrinkle, Leakage, Hydraulic conductivity

A generalized SR-to-CP framework for predicting long-term creep behavior of geogrids from temperature-accelerated stress relaxation tests

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Abstract: This study presents a generalized framework for predicting the long-term creep behavior of polypropylene (PP) and high-density polyethylene (HDPE) geogrids by integrating temperature-accelerated creep (CP-TTS) and stress relaxation (SR-TTS) testing with an irreversible strain-rate-based SR-to-CP conversion methodology. Short-term CP-TTS and SR-TTS tests were conducted at multiple temperature stages to construct master creep and master stress relaxation curves using the time–temperature superposition principle. Empirical SR-to-CP relationships were then established by linking time increments and irreversible strain increments during creep and stress relaxation at identical irreversible strain rates. Temperature acceleration significantly extended the effective duration of experimental data, with 12 h of testing for the PP geogrid producing creep histories equivalent to 115 h and 16 h of testing for the HDPE geogrid yielding stress relaxation histories equivalent to 4000 h. Application of the SR-to-CP framework further extended the predicted creep durations to average values of 666 h for PP and 25,078 h for HDPE. The predicted creep strain–time histories showed close agreement with those obtained from CP-TTS and from 10-day conventional creep tests, validating both the master curves and the SR-to-CP conversion framework.

Keywords: Geogrid, Creep, Stress relaxation, Time–temperature superposition (TTS), SR-to-CP prediction, Long-term performance

Seismic response and mitigation mechanism of cantilever retaining walls with EPS composite soil isolation structures in liquefiable ground

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Abstract: A series of shaking table model tests were conducted to investigate the seismic response and mitigation mechanism of a wall-EPS composite soil (EPSCS) isolation structure in a liquefiable Nanjing fine sand site. The experiment compared three models: a conventional wall-sand system (WSS), a system with an EPSCS isolation pile (WEP), and one with an EPSCS isolation wall (WEW). The results demonstrate that the EPSCS structure effectively inhibits the development of excess pore water pressure (r_u). Compared to the WSS model, the WEP and WEW models reduced the r_u by approximately 25% and 40%, respectively. The EPSCS isolation wall exhibited the best performance in protecting the retaining wall. Under 0.6g Taft excitation, the EPSCS isolation wall reduced horizontal and rotational displacements of the retaining wall by 85.6% and 91%, respectively, and yielded a significantly lower earth pressure coefficient than the WSS model. The WEW system possesses a lower natural frequency and higher damping ratio, indicating superior energy dissipation capacity. The primary protection mechanism is that the EPSCS structure absorbs the seismic energy through its own controlled deformation and damage, acting as a sacrificial element. Consequently, the damage index (D_I) of the retaining wall in the WEW model remained below 0.5% even under strong shaking, indicating that the wall was essentially undamaged. This study confirms that the EPSCS isolation wall is a highly effective seismic mitigation measure for retaining structures on liquefiable sites, providing valuable guidance for its engineering design and application.

Keywords: Retaining wall, Seismic behavior, EPS composite soil, Isolation structure
Liquefiable site, Multiscale sample entropy

Full-scale field studies on performance evaluation of geogrid reinforced flexible pavements through cyclic plate load tests

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Abstract: To address the growing demand for mechanistic and performance-based inputs in pavement design, field-scale cyclic plate load tests were conducted to investigate the effect of subgrade strength, expressed as the California Bearing Ratio (CBR), on the structural behaviour of geogrid-reinforced flexible pavements. For this purpose, CBRs of 6%, 8%, 10%, and 15% were considered with three different geogrids, namely PP30 (polypropylene), PET60, and PET80 (polyester) geogrids. The reinforcement benefit quantifiers were evaluated in terms of the Traffic Benefit Ratio (TBR), Modulus Improvement Factor (MIF) and Layer Coefficient Ratio (LCR). The findings revealed a clear inverse relationship between subgrade CBR and reinforcement benefit, with the maximum TBR of 3.3 observed at a CBR of 6%, and the lowest TBR of 1.5 at a CBR of 15%. PET80 performed comparatively better than other geogrids in all subgrade conditions. Additionally, an optimized pavement section was tested over the 15% CBR subgrade to evaluate design optimization. The comparable performance metrics (TBR = 1.75, MIF = 1.54, LCR = 1.19) demonstrated the feasibility of achieving significant material savings without compromising structural capacity. The overall findings confirm that geogrid reinforcement is most effective in low-CBR soils, while at the higher subgrade strengths, TBR gains are minimal.

Keywords: Geogrid, Traffic benefit ratio (TBR), Cyclic plate load tests, California bearing ratio (CBR), Modulus improvement factor (MIF)

Barrier-drainage performance of a wicking geotextile in controlling capillary rise in silt: Experimental evaluation

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Abstract: Capillary rise in silt significantly degrades its strength and durability, yet the hydraulic mechanisms governing moisture control using wicking geotextile in silt remain insufficiently understood. This study investigates the barrier-drainage performance of a wicking geotextile in silt through one-dimensional column experiments, supported by preliminary trials. Three configurations were examined: a control specimen without geotextile (CS), an embedded configuration (ES), and a surface-exposed configuration (SES). Volumetric moisture content and matric suction were monitored, capillary responses at the soil-geotextile interface and water storage behavior were evaluated. The results show that the wicking geotextile initially acts as a temporary capillary barrier due to pore-size contrast, delaying upward moisture migration. In the ES, restricted lateral discharge leads to progressive interfacial water accumulation and eventual capillary barrier failure as hydraulic equilibrium is approached. SES exhibits a coupled barrier-drainage response, in which capillary-driven lateral transport within wicking yarn, together with atmospheric exposure, sustains unsaturated drainage and effectively suppresses long-term capillary rise. A pot-cover effect was observed when the geotextile was installed close to the water level, highlighting the importance of placement within the unsaturated zone and provision of an effective discharge boundary. These findings provide practical guidance for the design of wicking geotextiles in silty subgrades.

Keywords: Geosynthetics, Wicking geotextile, Silt, Capillary rise, Soil column test, Barrier-drainage mechanism

Beyond Fickian diffusion: Stefan-based modelling of coupled thermo-water vapour transport in geomembranes for pit thermal energy storage liners

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Abstract: Accurate prediction of water vapour transport through geomembranes is critical for ensuring the long-term performance of pit thermal energy storage (PTES) lining covers. Conventional assessments commonly rely on Fickian diffusion under ambient conditions, neglecting the elevated temperatures and high water vapour pressures encountered in service, where coupled diffusive–convective transport mechanisms become significant. This study investigates the temperature- and pressure-dependent water vapour transmission rates (WVTR) of high-density polyethylene (HDPE) and Ethylene Interpolymer Alloy (EIA) Polyvinyl chloride (PVC) geomembranes at temperatures ranging from 25 to 90 °C and vapour pressures from 20 to 70 kPa, replicating the elevated thermo-water vapour environments encountered in service. Under these conditions, Fick's law underestimated vapour fluxes by up to 73.8% due to the omission of the vapour–air counter-convective flow. In contrast, a Stefan-based framework that accounted for coupled diffusion and convection reproduced the experimental trends with substantially improved accuracy, reducing mean average errors to 0.9–2.1% for HDPE and 3.3–13.4% for EIA geomembranes. Resistance analysis within the Stefan framework further demonstrated HDPE's superior thermo-water vapour barrier performance at elevated temperatures. The results establish a mechanistically based modelling approach that moves beyond Fickian assumptions and supports performance-based design of geomembrane liners for high-temperature PTES applications.

Keywords: Geosynthetics, Geomembranes, Water vapour transmission rate, Fick's diffusion law, Stefan's diffusion law, Pit thermal energy storage

Determination of lateral impact zone under vacuum consolidation method: Field study

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Abstract: Numerous advancements have been made in vacuum consolidation method (VCM) over the years, however, our understanding of lateral displacement behaviour, particularly its variation with distance from the embankment toe, remains limited, making it difficult to reliably determine the corresponding lateral impact zone. This study therefore investigates the VCM-induced lateral displacement with depth and horizontal distance, aiming to delineate the lateral impact zone. To this end, novel field-scale experiments with extensive instrumentation were conducted under two different geological conditions. This current paper details site features, soil properties, monitoring, data analyses and interpretations for those two VCM sites. Unlike past studies, monitoring is made at different distances from the embankment, enabling the variation of lateral displacement with space to be fully estimated. Further, the coupled effect of vacuum and surcharge loads is examined based on comprehensive data of settlement, excess pore water pressure and lateral displacement. The results provide insightful understanding of how the lateral displacement, and the associated impact zone can develop with time and space. The research emphasizes the decisive role of vacuum-surcharge load ratio and the treatment scale on the behaviour of lateral displacement under VCM, giving valuable implications to the practical design, risk assessment and construction planning.

Keywords: Ground improvement, Vacuum consolidation method (VCM), Lateral displacement, Lateral impact zone, Vacuum pressure, Settlement

Stability prediction of deformed geosynthetic-reinforced-soil bridge abutments using SA–NM–XGBoost model

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Abstract: Predicting the factor of safety (FOS) of geosynthetic-reinforced-soil (GRS) bridge abutments is crucial for assessing their structural stability. While existing methods can predict FOS during the design phase using reinforcement parameters, soil properties, and structural layout characteristics, there is a lack of effective approaches for evaluating the FOS of deformed abutments. In this study, a database of the FOS was established using the strength reduction method based on the FLAC numerical model. This database was then used to train an extreme gradient boosting (XGBoost) model to develop a robust prediction framework method. To enable comprehensive FOS prediction, the model incorporated reinforcement parameters, soil properties, structural layout variables, and abutment deformation behaviour as feature variables. During model training, a strategy combining the simulated annealing (SA) algorithm and the Nelder–Mead (NM) method was employed for hyperparameter optimisation. The resulting SA–NM–optimised XGBoost model was compared with other model, and demonstrated superior predictive performance. Furthermore, the SHapley Additive exPlanations method was applied to interpret the SA–NM–XGBoost model, quantifying the specific contributions of each input parameter to the prediction results. The proposed model effectively predicts the FOS of GRS bridge abutments after deformation, offering methodological support for the safety assessment of in-service abutment structures.

Keywords: Geosynthetics reinforced soil, Abutments, Deformation, Machine learning, Factor of safety