《Geotextiles and Geomembranes》

（土工织物与土工膜）

<双月刊>

2026年第54卷第1期

摘要集

中国土工合成材料工程协会秘书处

目　录

Sorption and water distribution performances of a geosynthetic sheet used in naturally contaminated soils management

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Abstract: A novel hydrotalcite-coated geosynthetic sorption sheet shows potential for managing geogenic contamination in excavated soils and rocks. Employed in an attenuation layer, it retains contaminants in leachate before infiltration into surrounding soil. This study evaluates the arsenic (As) sorption efficiency and water distribution performance of this geosynthetic material to assess its field applicability. Batch experiments were conducted across a pH range of 3–9, temperatures of 5–40 °C, and with co-existing ions (HCO^{3-}, $SO4^{2-}$ at 0–500 mg/L). Results demonstrated effective removal of both As(III) and As(V), with higher efficiency for As(V). While pH, co-existing ions, and temperature had minimal effect on As(V) removal, they significantly influenced As(III) removal. Specifically, As(III) sorption efficiency decreased by 15 % as pH decreased from 9 to 3. The presence of HCO^{3-} and $SO4^{2-}$ reduced As(III) removal due to competition for sorption sites. Removal efficiency slightly improved at 40 °C due to the endothermic nature of the sorption process. Soil tank experiments indicated that soil particle size was the dominant factor controlling water retention and drainage patterns. Coarse sand promoted concentrated flow, while finer sands enhanced retention and dispersion. The geosynthetic sorption sheet showed only a limited hydraulic influence under the tested conditions.

Keywords: Excavated soils and rocks, Attenuation layer, Geosynthetics, Geogenic arsenic, Sorption, Water distribution

Predictive modeling of lateral pressure in geotextile flexible casings for karst pile construction

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Abstract: In modern geotechnical engineering, geotextile-integrated flexible casings have gained prominence over conventional steel counterparts for concrete containment in karst pile construction, primarily due to their economic advantages and operational simplicity. However, the dynamic behavior of casing lateral pressure development during concrete placement—a fundamental design consideration—has not been thoroughly elucidated, creating uncertainties in engineering practice. This study systematically investigates three key operational parameters through laboratory experiments: casing material characteristics, permeability performance, and concrete placement methods. The research yields two critical advancements: (1) Casing material and discontinuous casting significantly govern the maximum lateral pressure, whereas permeability predominantly regulates post-placement pressure dissipation patterns. Engineering specifications should therefore emphasize the integration of low-strain geotextiles with permeability characteristics and discontinuous placement methods. (2) An innovative predictive model has been developed, synthesizing material properties, permeability performance, and concrete placement methods. Field tests in a karst region show that the proposed model reduces lateral pressure estimates by 42 % compared to traditional hydrostatic designs while maintaining structural safety. These findings establish essential guidelines for performance-oriented design of flexible geotextile containment systems in geologically complex environments.

Keywords: Karst region, Flexible casing, Geotextile, Lateral pressure, Prediction model

Influence of wicking geotextile installation on moisture migration in silt under rainfall infiltration

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Abstract: Silt is widely used in subgrade construction in the middle and lower reaches of the Yellow River in China due to limited availability of high-quality fill. However, its high moisture sensitivity and low strength often lead to pumping, settlement, and deformation. This study investigates the hydraulic performance of a wicking geotextile in silt under simulated rainfall infiltration using one-dimensional soil column experiments. Three installation configurations were evaluated: (i) a control sample (CS) without geotextile, (ii) an embedded sample (ES) with the geotextile fully installed as a capillary barrier, and (iii) a surface-exposed sample (SES) with the geotextile extended to the atmosphere to improve drainage. Suction-volumetric moisture content relationships were monitored at multiple depths, and both water storage capacity and drainage mechanisms were assessed. Results indicate that ES and SES reached stabilization at similar suction thresholds, however, the SES more effectively delayed saturation and facilitated moisture migration by evaporation. Surface exposure induced a relative humidity gradient, generating suction and improving drainage, while a siphon effect redistributed water approximately 25 cm below and 15 cm above the geotextile. These findings confirm that the wicking geotextile can act as a capillary barrier and drainage medium, and provide guidance for silty subgrade design.

Keywords: Geosynthetics, Wicking geotextile, Silt, Installation, Capillary barrier, Drainage

Erosion control performance of natural geotextiles for slope stabilization

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Abstract: Two innovative geotextile-based slope stabilization and erosion control approaches were developed in this study, including vegetation-geotextile composites and geotextiles treated with alkali-activated binder (AAB). Experimental investigations were conducted to evaluate the effectiveness of different slope protection measures in delaying runoff onset, lowering erosion rates, and improving slope stability under varied rainfall intensities and slope gradients. It was found that bare slopes deteriorated rapidly under high-intensity rainfall, progressing from splash to severe gully erosion. Vegetation-geotextile system (tall fescue with coconut fiber blankets) considerably delayed runoff, decreased erosion, and improved soil structure and water retention. By contrast, AAB-treated geotextiles displayed superior mechanical stability and erosion resistance due to densified fiber networks and optimized pore structures compared to untreated bare slope. Furthermore, AAB-treated geotextiles delivered the highest erosion resistance, while vegetation-geotextile composites provided significant ecological benefits in terms of soil temperature regulation and organic matter release. As a result, integration of AAB treatment with vegetation-geotextile systems can serve as a long-term slope stabilization solution that simultaneously addresses engineering requirements and environmental objectives under climate change scenarios.

Keywords: Alkali-activated geotextiles, Vegetation-geotextile composites, Anti-erosion performance, Rainfall infiltration, Eco-slope protection

Influence of column spacing on geosynthetic-encased columns behavior in very soft clay

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Abstract: This study evaluates the influence of column spacing on the mechanical behavior of geosynthetic-encased columns (GECs) installed in very soft clay under vertical surcharge loading. A large-scale physical model (1.6 m × 1.6 m × 1.2 m) was instrumented with settlement gauges, piezometers, and pressure cells to monitor performance. Column spacing varied between 2.0D and 3.5D (D = column diameter) to assess effects on settlement, excess pore pressure, stress distribution, and the lateral earth pressure coefficient (K). Smaller spacings led to reduced settlements, faster pore pressure dissipation, and more efficient stress transfer to the columns. In contrast, larger spacings resulted in higher excess pore pressures and reduced system effectiveness. The coefficient K varied with spacing and depth: higher K values were associated with smaller spacings and shallower depths due to increased lateral confinement and interaction among columns. Conversely, deeper measurements showed lower K values due to limited lateral deformation. Comparison between measured and predicted settlements and encasement forces demonstrated good agreement, validating existing analytical models. The findings highlight the critical role of column spacing in optimizing the performance of GEC-reinforced soft soils under surcharge loading.
Keywords: Geosynthetics, Encased column, Column spacing, Coefficient of lateral earth pressure, Excess pore pressure, Soft soil improvement

Effect of the driving process for construction of geotextile-encased columns on the deformation of soft foundation soils

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Abstract: The construction of geosynthetic encased columns for embankment support involving the tube driving technique may induce vertical and horizontal stresses throughout the soft soil foundation and neighboring columns, which is often not accounted for in design. Investigating this unknown effect is a difficult task for which the use of the transparent soil method is a promising tool when combined with Digital Image Correlation (DIC) techniques. This study investigates the effect of GEC column installation on the deformation of the soft foundation soil. The specific focus is on how the driving process affects the lateral and vertical deformations of the surrounding soft soil, as well as the interaction with neighboring columns. Different column configurations, spacing, and installation sequences were investigated. After evaluation and quantification of the deformation patterns, a methodology is proposed to study the extent of displacements caused by the tube's driving. Results showed that an increase in the spacing between columns reduced the influence of the tube's driving. Interestingly, adopting the alternating GEC installation may lead to higher lateral displacements than the sequential installation process. Increasing the number of GECs from three to four elements further reduced the displacements magnitude in the region adjacent to the first column installed.

Keywords: Geosynthetics, Transparent soil, Laponite RD®, Soft soil, GEC, PIV, Installation, Driving

Pore size of woven slit-film geotextiles subjected to unequal biaxial tensile strains obtained from wet sieving tests

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Abstract: The pore sizes of three woven silt-film geotextiles subjected to four groups of unequal biaxial tensile strains were examined via wet sieving tests. The strains in the weft direction of a geotextile for the four groups were the same (5 % and 10 %), with the weft strain to warp strain ratios set to 1, 2, 3, and 4, respectively. The variations of pore size distribution (PSD), O_{90} and O_{50} were analyzed. And the change of the pore shape, the thickness of geotextiles and the percentage of blocked mass in the specimens were also investigated. It is shown that for the same strain ratio, the values of O_{90} and O_{50} increase with increasing strain, and the rate of change of O_{90} in the 5 %–10 % weft strain range is larger than that in the 0 %–5 % range. The decrease of the thickness for geotextiles mainly occurs in the 0 %–5 % weft strain range, which may offset the enlargement of plane pores. The pores in a plane, the interstices in the thickness, and the variation of pore shape subjected to different strain ratios are found to impact the results of the wet sieving test.
Keywords: Geosynthetics, Pore size, Unequal biaxial tensile strain, Wet sieving, Strain ratio

Seismic bearing capacity and fragility analysis of geogrid-encased stone column composite foundations

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Abstract: Geogrid-encased stone columns (GESCs) have shown notable potential in improving performance, thereby reducing the seismic failure probability (P_F) of soil. This research proposes a limit equilibrium-based formulation for predicting the ultimate seismic bearing capacity (q_u) of GESC composite foundations. Subsequently, a fragility analysis framework is developed based on the bearing capacity formula to quantify P_F. The fragility analysis incorporates machine learning to evaluate the influence of tensile strength (T), column diameter (D_c), column and soil strength parameters (φ_c, c_c, φ_s, and c_s), shear strength utilization ratio (n), area replacement ratio (m), vertical load demand (P_v), footing width (B), footing embedded depth (h_0), and seismic coefficients (k_h and k_v). Results demonstrate that encasement substantially enhances qu and reduces earthquake-induced settlements. The fragility function demonstrates a critical behavioral transition at $n \approx 0.5$. P_F decreases with increasing T, m, φ_c, c_c, φ_s, c_s, B, and h_0, but increases with k_v, D_c, and P_v. The significant impact and indeterminacy of soil properties suggest P_F shall be reduced by selecting the controllable parameters (e.g., T and D_c). Larger B improves load diffusion, and increased h_0 maximizes vertical effective stress. Large D_c delays confinement mobilization, potentially reducing the reinforcement effectiveness and increasing the failure risk.

Keywords: Geogrid-encased stone column, Ultimate seismic bearing capacity, Seismic fragility, Limit equilibrium method, Machine learning, Shaking table test

Centrifuge model study on the influence of PVD installation depth under surcharge preloading

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Abstract: To investigate the effect of PVD installation depth on the efficiency of surcharge preloading for soft ground improvement, centrifuge model tests were conducted based on a typical airport runway project. Four test groups were designed with PVD installation depths of 18, 22, 26, and 30 m. Key indicators, including settlement, pore-water pressure, water content, and undrained shear strength, were monitored to systematically analyze the influence of PVD depth variation on soil consolidation behavior. The results showed that with each 4 m increase in PVD depth, the settlement increment was 10.39 %, 4.44 %, and 0.81 %, respectively. When the installation depth exceeded 22 m, the improvement effect tended to plateau. Therefore, under the conditions of this project, the reasonable installation depth of PVDs lies within the range of 18–22 m, while the precise optimal depth still requires further investigation. Based on one-dimensional and multidimensional consolidation theories, this study proposed a settlement prediction method that converts multi-stage surcharge into an equivalent single-stage load through stress-time integration correction. The predicted results agreed well with the experimental data, with errors in shallow and deep settlement controlled within 5.3 % and 11.6 %, respectively, both within the acceptable range for engineering applications.

Keywords: Surcharge preloading, PVD installation depth, Centrifuge model test, Ground treatment, Settlement calculation

Effects of fiber and particle shape on the critical state line

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Abstract: This paper investigates the influence of particle shape, fiber length, and fiber content on the critical state line (CSL). By using artificial particles with three shapes (i.e., ball, cylinder, and triangular prism) and polypropylene fibers with three contents (0.2 %, 0.35 %, and 0.5 %) and three lengths (6 mm, 9 mm, and 12 mm), we analyze how CSL moves on the q vs. p plane and the ec vs. $(p/p_a)^{\alpha}$ plane: (1) Addition of fibers results in an obvious increase in the critical stress ratio M on the q vs. p plane, and CSL shifts downward and rotates clockwise on the plane of e_c vs. $(p/p_a)^{\alpha}$; (2) In the presence of fibers, further increasing the fiber length or content results in a slight increase of M; (3) As particle irregularity increases, M increases, λ overall increases, and Γ first increases and then decreases; (4) The increase of particle irregularity weakens the fiber-enhanced effect of M. Two forecast models, namely GRNN (Generalized Regression Neural Network) and multiple linear regression, are used to fit the test data. It is shown that multiple linear regression leads to a wrong trend of M vs. fiber content, while GRNN has very good fitting accuracy.

Keywords: Fiber, Particle shape, Critical state line, Triaxial tests, Critical state parameters

Experimental study on shear bond strength and bearing capacity of lightweight cellular concrete fill around plastic pipes

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Abstract: Lightweight cellular concrete (LCC) has great potential to be used as a backfill material for buried pipes due to its low self-weight, high strength, and good thermal insulation properties. However, the shear bond strength between LCC and plastic pipes and its load-bearing capacity over these pipes have not been well studied. This study conducted pushout tests to investigate the shear bond strengths between LCCs at densities ranging from 400 to 650 kg/m^3 and smooth polyvinyl chloride, high-density polyethylene, and steel pipes. To take advantage of the test specimens, bearing capacity tests were conducted to evaluate the bearing capacities of the LCCs over pipes. Test results indicate that the steel pipe exhibited a higher shear bond strength than the plastic pipes and the LCC density did not significantly impact the peak shear bond strength. The measured ultimate bearing capacities of LCCs were close to their unconfined compressive strengths and the calculated results using Meyerhof's method based on the cohesion from small direct shear tests. In addition, LCC at a density of 400 kg/m^3 showed a shear failure pattern, while LCC at densities of 475, 550, and 650 kg/m^3 exhibited a splitting failure pattern.
Keywords: Bearing capacity, Plastic pipe, Lightweight cellular concrete, Shear bond strength

Mechanical and economic performance of geogrid-reinforced base pavements: An integrated numerical, experimental, and field study

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Abstract: Inorganic binder-stabilized bases often suffer from insufficient lateral confinement and poor fatigue resistance, limiting pavement longevity. This study aims to enhance their mechanical behavior and durability using a geogrid-reinforced graded crushed stone base (GCS-GR). A multi-scale evaluation integrating Discrete Element Method (DEM) simulations, laboratory fatigue testing, field monitoring, and life-cycle cost analysis was conducted. Results show that geogrid reinforcement alleviates stress concentration and deflection instability under high-void conditions by forming a lateral force-chain network. Laboratory tests demonstrate that the single-layer structure (GCS-GR1) increases ultimate flexural strength and failure displacement by 31 % and 44 %, respectively. Under a high stress level (σ/σ_f = 0.8) corresponding to 80 % of the ultimate flexural strength, the fatigue life increases nearly threefold. Field monitoring reveals reduced deflection, rutting, and Pavement Condition Index (PCI) degradation rates of 31.6 %, 36.6 %, and 47.9 %, respectively. The vertical-to-transverse strain ratio decreased by 47 %, in good agreement with DEM predictions (3.1 % deviation), confirming the reliability of the DEM model. Furthermore, life-cycle cost analysis indicates that GCS-GR1 has the lowest total present value, reducing costs by approximately 8 % compared to the GCS. Overall, GCS-GR effectively enhances structural stability, fatigue life, and long-term economic sustainability of pavement bases.
Keywords: Geogrid-reinforced base, DEM simulation, Flexural fatigue performance, Field monitoring, Life-cycle cost analysis, Flexural strength

Seismic damage and energy distribution of pile-geogrid supported high-speed railway subgrade

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Abstract: This study investigates the seismic damage and energy distribution of pile-geogrid supported high-speed railway subgrades using shaking table tests and time-frequency analysis methods such as STFT, SPWVD, WPD, and EMD. We found that cracks begin to appear at the base of the foundation when PGA reaches 0.2 g and severe damage occurs after PGA exceeds 0.6 g. The geogrids enhance soil integrity and mitigate PGA amplification factors. They distribute shear stresses to surrounding soil or other geogrids. Low-frequency waves play a predominant role in seismic damage due to their longer propagation distances. Scattering leads to changes in energy distribution as seismic waves propagate through caustic surfaces. The energy attenuation characteristics of high-frequency signal components and the increased contribution of low-frequency components under high PGA conditions are observed. An increase in the difference in variance contribution rate (VCR) indicates inconsistencies in the vibration characteristics of the soil. The sudden changes in Intrinsic mode functions (IMFs) suggest that the energy of seismic waves is amplified and attenuated to varying degrees. These findings provide a more solid theoretical foundation and novel approaches for the seismic design and performance assessment of high-speed railway subgrades.

Keywords: Shaking table test, Seismic damage, Time-frequency domain, Wavelet packet decomposition, Variance contribution rate

Predicting long-term stress relaxation of geogrids using time–temperature superposition and the nonlinear three-component model

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Abstract: This study presents a method for predicting the long-term stress relaxation (SR) behavior of geogrids using short-term testing combined with the time–temperature superposition (TTS) technique, known as SR-TTS. Two polymer geogrids—polypropylene (PP) and high-density polyethylene (HDPE)—were tested under constant tensile strain at multiple temperatures: 30 °C, 40 °C, and 50 °C for PP; and 30 °C, 37 °C, 44 °C, and 51 °C for HDPE. Master stress relaxation curves were constructed at a reference temperature of 30 °C by horizontally shifting short-term tensile load histories at elevated temperatures along the logarithmic time axis. Using this approach, 12-h tests for PP and 16-h tests for HDPE were extended to 115 and 4000 h, respectively, demonstrating the effectiveness of temperature-accelerated testing. A numerical simulation using the nonlinear three-component (NTC) model was also applied to replicate SR-TTS behavior. The master curves obtained from experimental SR-TTS tests showed excellent agreement with those from NTC-based simulations. Furthermore, both the experimental and simulated master curves closely matched long-term load decrement time histories from conventional stress relaxation (SR-CON) tests. These results confirm that SR-TTS, supported by numerical simulation, offers a reliable and efficient method for predicting long-term stress relaxation behavior of polymer geogrids under varying temperatures.

Keywords: Geogrid, Stress relaxation, Temperature, Time-temperature superposition, Nonlinear three-component model

Large-scale field experiment on vibration screening characteristics of continuous panel-based geofoam-infilled wave barrier

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Abstract: This study investigates the vibration screening efficiency of geofoam-infilled (*GB*) and open trench (*OB*) wave barriers. Field-scale vibration tests are conducted to evaluate the performance of different barriers under active and passive screening conditions. A modular panel-based system is adopted for the *GB* to facilitate easy installation, uninstallation, and reinstallation. The impact of input frequency, source-barrier distance, and measurement direction on the performance of *GB* and *OB* is thoroughly examined. The results indicate that both barriers perform satisfactorily under different screening conditions, with superior effectiveness observed under active screening. For active screening, the performance of barriers improves with decreasing source-barrier distance. The screening efficiency of *GB* and *OB* is higher along the centerline than along the angular line. The performance of *OB* and *GB* improves with increasing input frequency for both active and passive screening techniques, irrespective of the source-barrier distance. Additionally, simplified design expressions are developed to predict the performance of *GB* under active and passive screening conditions. The predicted outcomes of the proposed expressions compare well with the findings reported in the literature.

Keywords: Geosynthetics, Active screening, Passive screening, Geofoam-infilled barrier, Open trench barrier, Amplitude reduction factor

Numerical modelling of dredged sediment improvement under electrokinetic geosynthetics assisted vacuum preloading combined with electroosmosis

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Abstract: The absence of multi-physics modelling frameworks limits the optimisation of electrokinetic geosynthetics (EKG) assisted vacuum preloading combined with electroosmosis (VPE) technique for the consolidation and remediation of dredged sediments. A multi-physics coupling model was therefore developed that integrates electrical, hydraulic, mechanical, and chemical fields to simulate the consolidation and remediation processes in VPE. EKG assisted VPE experiments were conducted to verify this model. Results for electric field intensity, excess pore water pressure, settlement and Cu concentrations showed that the model accurately captured both consolidation and remediation behaviour in VPE treatment. Numerical results further revealed that electrical conductivity variations led to uneven distribution of electric potential. Electric potential was concentrated near the anode over time, subsequently influencing electroosmotic flow and electromigration. The dissipation of excess pore water pressure within the dredged sediments was promoted by VPE through the formation of negative pressure. At the anode, the dissipation of excess pore water pressure and the transport of Cu were primarily controlled by electrical conductivity variations, whereas at the cathode, excess pore water pressure dissipation and Cu accumulation were predominantly influenced by clogging.
Keywords: Dewatering, Dredged sediments, Electrokinetic geosynthetics, Heavy metal removal, Multi-physics coupling model, Vacuum preloading combined with, electroosmosis