

《Geotextiles and Geomembranes》

(土工织物与土工膜)

<双月刊>

2026年第54卷第3期

摘要集

中国土工合成材料工程协会秘书处

目 录

1. 标题: Impact of installation damage on the MIF of multi-layered geogrid-reinforced granular and subgrade layers 作者: Sireesh Saride, Shubham Jain, Vipul Arora.....	1
2. 标题: Consolidation model for soft ground under airlift-assisted vacuum preloading 作者: Xinbei Lin, Zhen Huang, Li Shi, Yuanqiang Cai.....	2
3. 标题: Erosion control performance of geomats on silty soil slopes under simulated rainfall 作者: Rui Zhang, Xiwei Zhang, Kang Chen, Yipeng Guo, Yanhua Yu, Huanhua Cai.....	3
4. 标题: Finite-strain modelling of PVD-assisted consolidation in clayey soils using a novel elastic–viscoplastic model with destructuration based on the equivalent time concept 作者: Peng-Lin Li, Zhen-Yu Yin, Ze-Jian Chen, Jian-Hua Yin.....	4
5. 标题: Energy analysis of geomembrane wrinkling caused by temperature rise 作者: Hai Lin, Xinwen Chen, Xian He, Mengxi Huang.....	5
6. 标题: Influence of geosynthetic encasement on liquefaction-induced deformations of stone column supported embankments 作者: Mingchang Ji, Fuxiu Li, Zhijian Qiu, Haizuo Zhou, Yewei Zheng.....	6
7. 标题: Evaluating tack coat compatibility and performance of geogrid reinforced asphalt mixtures 作者: Lek haz Devulapalli, Sreelakshmi Sajikumar, Suraj Vedpathak, T.V. Sreekumar.....	7
8. 标题: Reliability analysis for the progressive failure ultimate limit state design in geosynthetic-reinforced rigid pile-supported embankments 作者: Xiaoxuan Yu, Gang Zheng, Haizuo Zhou, Gaolin Xie, Jiapeng Zhao.....	8
9. 标题: In situ performance of wicking geotextile in seasonally frozen railway embankment 作者: Hongguang Jiang, Pengju Tang, Taifeng Li, Shun Liu, Yiyi Liu, Haojie Feng, Xia Liu, Zhanyong Yao.....	9
10. 标题: Influence of chemical enhancer injection timings on electrokinetic geosynthetics-assisted vacuum preloading combined with electroosmosis for dredged sediments dewatering and heavy metal removal 作者: Yang Shen, Ligao Zheng, Wencheng Qi, Chang Liu, Jianting Feng.....	10

Impact of installation damage on the MIF of multi-layered geogrid-reinforced granular and subgrade layers

Sireesh Saride ^{a,*}, Shubham Jain ^b, Vipul Arora ^c

a Professor, Department of Civil Engineering, IIT Hyderabad, Telangana, India

b Doctoral Scholar, Department of Civil Engineering, IIT Hyderabad, Telangana, India

c Manager-Design, KCC Buildcon Pvt. Ltd., Gurugram, India

Abstract: This study evaluates the influence of installation damage on the modulus improvement factors (MIF) obtained from a double layer geogrid-reinforced base and subbase layers through a full-scale field study and large-scale laboratory confirmation tests. Four different types of geogrids, viz., two knitted (polyester, PET) and two extruded (polypropylene, PP) geogrids, were considered in this study. Twenty-eight field plate load tests were conducted on control, single, and double-layer geogrid-reinforced pavement sections built along a National Highway on a subgrade with a California bearing ratio of 8 %. The geogrids were exhumed from the test sections before and after the plate load tests to estimate the installation damage. Results indicate that the PET grids provide a higher MIF value when placed at the subgrade-subbase interface, while the PP grids performed better when placed within the granular layers. The MIF values ranged from 1.8 to 2.3 for PET grids at the subgrade-subbase interface and from 1.7 to 1.9 for PP geogrids placed at the subbase and base interface. The average installation damage observed in the PET and PP grids is 25 % and 10 %, respectively. A detailed framework for estimating the field MIF values using laboratory MIF and corresponding installation damage-induced reduction factors was proposed.

Keywords: Geogrid, Modulus improvement factor (MIF), Double reinforced, Field plate load test, Installation damage, Large-scale laboratory tests

Consolidation model for soft ground under airlift-assisted vacuum preloading

Xinbei Lin ^a, Zhen Huang ^b, Li Shi ^{b,*}, Yuanqiang Cai ^{a,b}

a Research Center of Coastal and Urban Geotechnical Engineering, College of Civil Engineering and Architecture, Zhejiang University, Hangzhou, 310058, China

b Institute of Geotechnical Engineering, College of Civil Engineering, Zhejiang University of Technology, Hangzhou, 310014, China

Abstract: Recently, a novel soft ground improvement technique termed airlift-assisted vacuum preloading (AAVP) has been proposed, which is featured by cyclically injecting pressurized air at the bottom of prefabricated vertical drains (PVDs) to expel water from the drain. This airlift process can achieve nearly lossless transmission of vacuum pressure along the PVDs and induce pneumatic fractures that enhance soil permeability. In this study, a nonlinear consolidation model was developed with full consideration of the time-varying pressure condition and the permeability improvement associated with cyclic airlift operations. The analytical solution was obtained by employing the piecewise linearization technique, and was first verified by degenerating it into conventional vacuum preloading (CVP) process and comparing to the classical drain-well solution. The complete solution was further validated against large-scale model test data. Parametric analyses revealed that, compared with CVP, AAVP significantly accelerates the consolidation process, exhibiting not only faster pore pressure dissipation but also a greater magnitude of dissipation that exceeds the applied vacuum. Theoretical results indicate that the advantages of AAVP become more pronounced under greater treatment depths and in soil with adverse conditions such as smear and clogging effects, highlighting its strong potential for application in ultra-thick soft deposits and high-water-content reclamation land.

Keywords: Consolidation, Ground improvement, Airlift, Vacuum preloading, Vertical drains

Erosion control performance of geomats on silty soil slopes under simulated rainfall

Rui Zhang ^{a,b,c}, Xiwei Zhang ^a, Kang Chen ^a, Yipeng Guo ^{d,*}, Yanhua Yu ^e, Huanhua Cai ^f

^a School of Transportation, Changsha University of Science and Technology, Changsha, 410114, China

^b National Key Laboratory of Green and Long-Life Road Engineering in Extreme Environment (Changsha), Changsha University of Science and Technology, Changsha, 410114, China

^c Engineering Research Center of Catastrophic Prophylaxis and Treatment of Road & Traffic Safety of Ministry of Education, Changsha University of Science and Technology, Changsha, 410114, China

^d School of Civil and Environmental Engineering, Changsha University of Science and Technology, Changsha, China

^e Beijing Shoufa Tianren Ecological Landscape Co., Ltd., Beijing, 10000, China

^f Huaishaoheng Railway Co., Ltd., Changsha, 410008, China

Abstract: Geomats are widely used for erosion control on slopes, yet quantitative links between their structural characteristics and erosion resistance remain insufficiently understood. This study investigates the influence of geomat geometry on erosion mitigation of silty slopes reinforced with five geomats. Erosion tests under simulated rainfall were conducted. An integrated structural–hydraulic–erosion framework was applied to relate geomat structural parameters, including porosity, pore-structure characteristics, compressed thickness, and mass per unit area, to hydraulic indicators (surface flow velocity and kinetic energy of surface runoff) and erosion indicators, including collected runoff mass, soil loss, sediment concentration, eroded area fraction, and maximum connected erosion area fraction. The results show that geomats substantially reduced erosion relative to the bare slope, decreasing cumulative soil loss by up to 89.1%, sediment concentration by up to 84.3%, and kinetic energy of surface runoff by 87.7–95.2%. Geomats reduced erosion-domain connectivity and inhibited the development of continuous scouring channels, indicating effective attenuation of near-surface hydraulic forcing. Porosity and compressed thickness emerged as the dominant structural controls on erosion resistance. Geomats with porosity $\leq 26\%$ and compressed thickness ≥ 16 mm exhibited the best performance under the tested conditions. These findings provide mechanism-informed, preliminary guidance for erosion control on geomat-covered silty slopes.

Keywords: Geosynthetics, Silty soil slope, Rainfall, Erosion response, Image analysis, Mantel test

Finite-strain modelling of PVD-assisted consolidation in clayey soils using a novel elastic–viscoplastic model with destructuration based on the equivalent time concept

Peng-Lin Li ^{a,b}, Zhen-Yu Yin ^{a,b,*}, Ze-Jian Chen ^{a,b}, Jian-Hua Yin ^c

a Department of Civil and Environmental Engineering, The Hong Kong Polytechnic University, Hung Hom, Kowloon, Hong Kong, China

b State Key Laboratory of Climate Resilience for Coastal Cities, The Hong Kong Polytechnic University, Hung Hom, Kowloon, Hong Kong, China

c College of Civil and Transportation Engineering, Shenzhen University, Nanshan District, Shenzhen, China

Abstract: Prefabricated vertical drains (PVDs) are widely adopted to accelerate the consolidation of clayey soils. However, long-term settlement during the service period of infrastructure is often not adequately captured when soil structure degradation and creep are neglected. Existing models rarely consider the coupled effects of soil destructuration, creep, and nonlinear water flow in PVD-assisted consolidation. This study develops an axisymmetric finite-strain consolidation model incorporating an elastic–viscoplastic model with destructuration (EVPS) based on the equivalent time concept. The formulation is applicable to clays possessing inherent structure that may undergo structure degradation under mechanical loading or PVD installation. The model considers soil creep, destructuration, smear effects, and nonlinear water flow, and is solved using an alternating direction implicit (ADI) finite-difference scheme. Finite-element comparisons are employed solely to verify the numerical implementation of the consolidation equations. Model performance is evaluated through comparisons with laboratory oedometer tests on natural structured clays and long-term field observations from the Haarajoki embankment. The results indicate that the proposed model can consistently reproduce pore-pressure dissipation and settlement evolution, including deformation occurring after primary consolidation over periods of several years to decades. Parametric studies reveal that soil destructuration, smear effect, and non-Darcian flow jointly govern the consolidation process. The proposed model enables more reliable prediction of consolidation behaviour in natural structured clays, which is essential for assessing long-term settlement and supporting rational design of ground improvement schedules.

Keywords: Clayey soils, Destructuration effect, Prefabricated vertical drains, Elastic–viscoplastic model, Equivalent time concept, Finite-strain modelling

Energy analysis of geomembrane wrinkling caused by temperature rise

Hai Lin ^{a,b}, Xinwen Chen ^{a,b}, Xian He ^{c,*}, Mengxi Huang ^b

a Engineering Research Center of Watershed Carbon Neutralization, Ministry of Education, Nanchang University, 999 Xuefu Avenue, Honggutan District, Nanchang, Jiangxi Province, 330031, China

b School of Infrastructure Engineering, Nanchang University, 999 Xuefu Avenue, Honggutan New District, Nanchang, Jiangxi Province, 330031, China

c School of Physics and Materials Science, Nanchang University, 999 Xuefu Avenue, Honggutan New District, Nanchang, Jiangxi Province, 330031, China

Abstract: High density polyethylene (HDPE) geomembranes tend to wrinkle and deform as temperature increases, which in turn deteriorates the contact conditions and hydraulic performance of landfill composite bottom liner systems. To clarify geomembrane wrinkle behavior under combined temperature and overburden pressure effects, this study employs the energy conservation principle using a simplified two-dimensional model to theoretically derive and analyze: (1) wrinkle formation due to temperature rise without overburden pressure, (2) wrinkle formation due to temperature rise with overburden pressure, and (3) changes in existing wrinkles caused by pressure. Comparative analysis of theoretical predictions with laboratory-scale model experiments validates the applicability of the energy method for characterizing geomembrane wrinkling behavior. Furthermore, the combined effects of temperature and overlying soil pressure on geomembrane wrinkles are quantitatively elucidated by model calculations. This work provides a theoretical basis and a reference for understanding the formation mechanism of geomembrane wrinkles and for developing corresponding engineering preventive measures.

Keywords: Geomembrane, Wrinkle, Temperature, Pressure, Energy method

Influence of geosynthetic encasement on liquefaction-induced deformations of stone column supported embankments

Mingchang Ji ^a, Fuxiu Li ^b, Zhijian Qiu ^c, Haizuo Zhou ^d, Yewei Zheng ^{b,*}

a School of Civil Engineering, Henan Polytechnic University., Jiaozuo, Henan, 454003, China

b School of Civil Engineering, Wuhan University, Wuhan, Hubei, 430072, China

c School of Architecture and Civil Engineering., Xiamen University., Xiamen, Fujian, 361005, China

d School of Civil Engineering, Tianjin University, Tianjin, 300072, China

Abstract: This paper numerically investigates the influence of geosynthetic encasement on liquefaction-induced deformation of stone column supported embankments on liquefiable soil. A pressure-dependent multi-yield constitutive model was used for the soil and stone columns (SC), and the geosynthetic encasement was simulated with linear elastic geogrid elements. The three-dimensional numerical model was validated using centrifuge test data, including embankment deformation, excess pore water pressure, and acceleration response. A comparative analysis was conducted between embankments supported by SC and geosynthetic encased stone columns (GESC), followed by a parametric analysis to assess the influence of key design parameters on the seismic response of GESC supported embankments. Results indicate that the maximum shear strain occurs within the liquefiable layer, suggesting that this region is most susceptible to sliding shear failure under seismic loading. The GESC foundation develops discontinuous shear planes due to the additional shear resistance provided by the encasement compared with SC. Moreover, the geosynthetic encasement under the embankment toe experiences the highest tensile stress, indicating that seismic design should prioritize reinforcing GESCs at the toe to ensure stability. Overall, GESC effectively improves the seismic performance of embankments on liquefiable soil by enhancing shear resistance and mitigating dynamic deformations.

Keywords: Geosynthetic encasement, Geosynthetic encased stone column, Dynamic response, Liquefaction-induced deformation, Liquefiable soil

Evaluating tack coat compatibility and performance of geogrid reinforced asphalt mixtures

Lek haz Devulapalli ^{a,*}, Sreelakshmi Sajikumar ^a, Suraj Vedpathak ^b, T.V. Sreekumar ^a

a The Bombay Textile Research Association, Mumbai, 400086, India

b Strata Geosystems India Pvt Ltd, Mumbai, 400093, India

Abstract: This research evaluates the feasibility of using geogrid in reinforced asphalt mixtures and the compatibility of tack coats i.e., Rapid Setting (RS) and Modified Bitumen (MB). Geogrid reinforced asphalt mixtures are laid on Dense Bituminous Macadam (DBM) as the base layer, Bituminous Concrete (BC) as the surface layer, and uniaxial geogrid as reinforcement. The Indirect Tensile Strength (IDT), Tensile Strength Ratio (TSR), and rutting test results confirm that the geogrids improved the tensile strength, moisture resistance and rutting respectively. The Interface Shear Strength (ISS) results showed that the incorporation of geogrid without tackcoat reduced shear strength; however, MB tack coat geogrid specimens presented improved performance. Whereas, the RS tack coat specimens experienced delamination and lower interlayer bonding. The laboratory installation damage test results revealed that the installation process had damaged the geogrids, and the MB tack coat geogrids showed less damage compared to the geogrid without tack coat and RS tack coat. SEM analysis confirmed yarn fibre rupture and coating loss in RS and without tack coat geogrids, whereas MB geogrid fibres remained intact. Overall, the research confirms that the type of tack coat critically influences the performance of geogrid reinforced asphalt mixtures, with MB showing superior compatibility and reinforcement.

Keywords: Geogrids, Geosynthetics, Tack coat, Rapid-setting (RS) emulsion, Modified bitumen, Installation damage

Reliability analysis for the progressive failure ultimate limit state design in geosynthetic-reinforced rigid pile-supported embankments

Xiaoxuan Yu ^{a,b,c}, Gang Zheng ^{a,b,c}, Haizuo Zhou ^{a,b,c,*}, Gaolin Xie ^{a,b}, Jiapeng Zhao ^d

a School of Civil Engineering, Tianjin University, Tianjin, 300072, China

b Key Laboratory of Coast Civil Structure Safety, Tianjin University, Ministry of Education, Tianjin, 300072, China

c Key Laboratory of Earthquake Engineering Simulation and Seismic Resilience of China Earthquake Administration, Tianjin University, Tianjin, 300350, China

d China Railway Design Corporation, Tianjin, 300308, China

Abstract: Geosynthetic-reinforced rigid pile-supported (GRRPS) embankments are widely used for construction on soft ground. Field observations indicate that local pile bending may progressively develop into system-level failure. However, most existing stability assessments are deterministic and do not quantify the influence of spatial variability in soil properties on progressive failure. This study develops a probabilistic analysis framework that explicitly accounts for progressive pile failure and the spatial variability of embankment and clay. A validated deterministic limit-equilibrium model is extended using the first-order reliability method. Its predictions are further verified against Monte Carlo simulations. Results indicate that spatial variability in foundation soil governs the failure probability, whereas embankment soil exerts limited influence due to spatial averaging. Geometric parameters have a stronger impact on reliability than soil strength parameters. Soil variability affects pile behaviour through progressive failure coefficients, negative skin friction and axial head forces, with the coefficient of the pile intersecting the deepest slip surface showing the strongest correlation with global stability. A shorter autocorrelation distance reduces the spatial coherence of weak zones, thereby limiting load redistribution among neighboring piles and slowing the transition from local pile bending to system-level progressive failure. The framework establishes a reliability-consistent basis for assessing GRRPS embankment stability.

Keywords: Geosynthetic-reinforced rigid pile-supported, Embankments, Spatial variability, Probabilistic analysis framework, Stability assessment

In situ performance of wicking geotextile in seasonally frozen railway embankment

Hongguang Jiang ^a, Pengju Tang ^a, Taifeng Li ^b, Shun Liu ^{c,e,*}, Yiyi Liu ^a
, Haojie Feng ^a, Xia Liu ^d, Zhanyong Yao ^a

a School of Qilu Transportation, Shandong University, Jinan, 250002, China

b Railway Engineering Research Institute, China Academy of Railway Sciences Corporation Limited, Beijing, 100081, China

c Navier, Ecolé Nationale des Ponts et Chaussées, Institute Polytechnique de Paris, 77455 Marne-la-Vallée, France

d Jining Hongxiang Highway Survey and Design Research Institute Co. Ltd., Jining, 272000, China

e Department of Civil and Environmental Engineering, The Hong Kong Polytechnic University, Hong Kong, China

Abstract: To address the challenge of rainfall infiltration and freezing–thawing cycles, in situ tests were performed along the Harbin–Yichun railway line, considering various arrangements of wicking geotextiles (WGs). Temperature, volumetric water content (VWC), and matric suction were recorded during the monitoring. The results demonstrated that the thermal insulation from the WG delayed freezing and thawing in the embankment. However, an extreme air temperature of -31.7°C resulted in a frozen depth of 2.1 m. The application of a lower WG layer did not produce a notable reduction in moisture content in the ballast or subballast. Conversely, owing to the lower WG, the maximum VWC variation in the embankment declined by 2.4%, and a VWC recession was observed even during rainy season. The upper WG acted more effectively for water drainage before seepage, preventing water infiltration into embankment. The consistent matric suction recorded during concentrated rainfall events further substantiated the drainage functionality of the WG. Although the frequency domain reflectometer exhibited limitations from the freezing to thawing period, the stable VWC during winter confirmed an absence of air–water exchange. Furthermore, based on the hydraulic conductivity functions and atmospheric suction data, the optimal WG parameters can be determined during design.

Keywords: Geosynthetic, In situ, Railway, Freezing–thawing, Unsaturated soil

Influence of chemical enhancer injection timings on electrokinetic geosynthetics-assisted vacuum preloading combined with electroosmosis for dredged sediments dewatering and heavy metal removal

Yang Shen ^a, Ligao Zheng ^a, Wencheng Qi ^a, Chang Liu ^b, Jianting Feng ^{a,*}

a Key Laboratory of Ministry of Education for Geomechanics and Embankment Engineering, Hohai University, Nanjing, 210098, China

b School of Civil Engineering, Hunan University of Science and Technology, Xiangtan, 411201, China

Abstract: Effective dewatering and heavy metal removal of dredged sediments using the electrokinetic geosynthetics-assisted vacuum preloading combined with electroosmosis (VPE) technique can convert dredged sediments into valuable resources for construction use. Chemical enhancers are commonly employed to enhance VPE performance, but their optimal injection timing remains largely unclear. This study investigated the influence of ethylenediaminetetraacetic acid (EDTA) and citric acid (CA) as well as their injection timings on the VPE efficacy for dredged sediment improvement. It compared drainage volume and drainage rate, moisture content, electric current and effective voltage, Cu concentration and speciation, and energy consumption under early- ($I_t = I_0$), mid- ($I_t = 70 \%I_0$), and late-stage ($I_t = 40 \%I_0$) injections. The results showed that CA generally outperformed EDTA, achieving approximately 200 mL greater final drainage volumes and averagely reducing Cu concentrations from ~ 1640 mg/kg to ~ 745 mg/kg (EDTA was ~ 755 mg/kg). Late-stage CA injection optimized drainage efficiency and moisture content uniformity. It reduced the moisture content gradients between the cathode and the anode to $\sim 4 \%$ (it was $\sim 12 \%$ for the injection of $I_t = I_0$). The mid-stage injection of CA may achieve a balance between Cu removal and energy efficiency. EDTA, while less energy-intensive, retained higher weak-acid extractable Cu ($\sim 15 \%$), posing leaching risks.

Keywords: Chemical enhancers, Dewatering, Electrokinetic geosynthetics, Heavy metal removal, Injection timings, Vacuum preloading combined with, electroosmosis