《Geosynthetics International》

（国际土工合成材料）

<双月刊>

2025年第32卷第2期

摘要集

中国土工合成材料工程协会秘书处

目 录

A comparison between geomembrane-sand tests and machine learning predictions

A. T. Tanga[1], G. L. S. Araújo[2], F. Evangelista Junior[3]
1 PhD student, Department of Civil and Environmental Engineering, FT, University of Brasilia, Brasilia, DF, Brazil, E-mail: abenitefera@gmail.com (corresponding author)
2 Associate Professor, Department of Civil and Environmental Engineering, FT, University of Brasilia, Brasilia, DF, Brazil, E-mail: gregorio@unb.br
3 Associate Professor, Department of Civil and Environmental Engineering, FT, University of Brasilia, Brasilia, DF, Brazil, E-mail: fejr@unb.br

Abstract: The interaction between soils and geosynthetics plays an important role in the applications of these materials for reinforcement in geotechnical engineering. The complexities of soil-geosynthetic interactions vary depending on the type and properties of both the geosynthetic and the soil. This paper introduces a machine learning approach, specifically a random forest algorithm, for predicting interface friction angles. The dataset comprises 495 interfaces involving geomembranes and sand, with 14 influencing parameters recorded for each interface, influencing the shear strength outcome. In the analysis, Pearson's correlation coefficient is employed to measure the linear interdependence between each pair of input-input and input-output variables. Following the linear regression analysis, an optimized random forest is utilized to project the interface friction angle. The random forest algorithm divides the selected data into training and testing sets, and only 3% of the training set and 6% of the testing set exceed ±5° from the actual records. The coefficient of determination (R^2) indicates strong agreement between the predicted and laboratory study friction angles, with R^2=0.93 for the training set and R^2=0.92 for the testing set. Consequently, the random forest algorithm demonstrates effectiveness in predicting interface friction angles.

Keywords: Geosynthetics, Geomembrane, Interface friction angle, Machine learning, Random forest

Mechanical characteristics of geogrids produced from recycled polyester

G. T. Mehrjardi[1], R. Fuentes[2] and O. Detert[3]

1 Associate Professor, Department of Civil Engineering, Faculty of Engineering, Kharazmi University, Tehran, Iran, E-mail: ghtavakoli@khu.ac.ir (corresponding author)

2 Professor, Institute of Geomechanics and Underground Technology, RWTH Aachen, Germany, E-mail: raul.fuentes@gut.rwth-aachen.de

3 Head of Engineering Department, HUESKER Synthetic GmbH, Germany, E-mail: detert@huesker.de

Abstract: The use of recycled polyester (rPET) in construction materials offers significant benefits, including energy conservation, cost reduction, and decreased solid waste. This study compares the performance of rPET with that of virgin polyester (vPET) products. Therefore, two main testing programs including pull-out tests and creep performance tests were carried out in order to determine the interfacial properties of the geogrid-reinforced soil and time-dependent manner of the geogrids, respectively. Broadly speaking, this study showed that the performance of 'rPET' geogrid is comparable with 'vPET' geogrids. Pull-out tests revealed that pull-out resistance of both 'vPET' and 'rPET' geogrids were roughly the same and the 'vPET' geogrid mostly had lower dilation angles in comparison with 'rPET'. Moreover, based on the performance creep tests, it was understood that the long-term mechanical behaviour of 'rPET' does not differ from the long-term behaviour of 'vPET' products.

Keywords: Geosynthetics, Recycled polyester geogrids, Pull-out test, Tensile creep, Interfacial properties, Virgin geogrids

Rubber-sand infilled soilbags as seismic isolation cushions: experimental validation

J. Wang[1],M.Wu[2], F. Liu[3],J.Bin[4] and J. He[5]

1 Master's degree Candidate, College of Civil Engineering, Hunan University of Technology, Zhuzhou, China, E-mail: wangj.226@stu.hut.edu.cn

2 Assistant Professor, Department of Civil Engineering, Sichuan University, Chengdu, China, E-mail: mtwu@scu.edu.cn

3 Professor, College of Civil Engineering, Hunan University of Technology, Zhuzhou, China, E-mail: fcliu@hut.edu.cn (corresponding author)

4 Instructor, College of Civil Engineering, Hunan University of Technology, Zhuzhou, China, E-mail: binjia@hut.edu.cn

5 Professor, College of Civil Engineering, Hunan University of Technology, Zhuzhou, China, E-mail: hejie_76@sina.com

Abstract: This study proposes soil bags filled with a rubber sand mixture (SFRSM) to enhance the stability of rubber sand layers for effective seismic isolation. To evaluate the dynamic characteristics of the SFRSM, large-scale cyclic simple shear tests were conducted to investigate the effects of rubber content, vertical pressure, shear displacement amplitude, fill percentage, and laying scheme. Furthermore, shaking table tests were carried out to evaluate the impact of vibration intensity and frequency on the seismic isolation of SFRSM layers. The results indicate that (1) SFRSM exhibits lower shear modulus and higher damping than traditional rubber-sand layers, suggesting superior seismic isolation and energy dissipation capabilities. (2) The dynamic characteristics of the SFRSM were influenced by the fill percentage and laying scheme, indicating the potential for creating resilient isolators suited to various conditions. (3) The isolating efficacy of SFRSM is due to its effective damping of high-frequency vibrations, with the threshold frequency reducing as more SFRSM layers are implemented. In summary, these experimental results provide evidence that the proposed innovative strategy enhances the strength and vertical stiffness of the original rubber-sand layer, making it well-suited for seismic design applications in low-rise buildings in less-developed regions.

Keywords: Geosynthetics, Soil bags, Rubber sand mixture, Dynamic analysis, Seismic isolation

Factors affecting the tensile strength of bituminous geomembrane seams

W. Francey[1] and R. K. Rowe[2]
1 PhD student, Queen's University, Kingston, Canada, E-mail: 15wjf@queensu.ca
2 Professor, Queen's University, Kingston, Canada, E-mail: kerry.rowe@queensu.ca (corresponding author)

Abstract: The tensile shear strength, break location, and constant tensile load failure times are examined for seams made from one 4 mm-thick bituminous geomembrane (BGM) product, with corresponding observations specific to that material. In short-term tests, failure is observed within the sheet material once the seam strength exceeded 0.8 times that of the sheet material. The effects of seam thickness reduction and overlap width on seam strength are examined for two methods of seaming. Seams with a short-term strength meeting or exceeding 80% of the sheet strength are subjected to constant tensile loads between 18 and 55% of sheet ultimate strength and the time to failure is reported. The relationship between short-term seam strength and time to failure under sustained load and thickness reduction and squeeze-out is investigated. Constant tensile load testing is proposed as a construction quality assurance procedure to assess the degree of geotextile engagement of field seams.

Keywords: Geosynthetics, Bituminous geomembrane, Seams, Welds, Tensile strength, Quality assurance

Shear modulus of sand-rubber mixtures: element testing and constitutive modeling

A. Kavand[1], S. Sarajpoor[2], A. Ghalandarzadeh[3], S. Akhyani[4] and P. Zogh[5]
1 Assistant Professor, School of Civil Engineering, College of Engineering, University of Tehran, Tehran, Iran, E-mail: akavand@ut.ac.ir (corresponding author)
2 Research fellow, School of Smart Underground Space Research Center, Institute for Smart City of Chongqing University in Liyang, Liyang, Jiangsu, P.R. China; Former PhD Graduate of University of Tehran, E-mail: s.sarajpoor@ut.ac.ir
3 Professor, School of Civil Engineering, College of Engineering, University of Tehran, Tehran, Iran, E-mail: aghaland@ut.ac.ir
4 PhD student, School of Civil and Environmental Engineering, The University of New South Wales, Sydney, NSW, Australia; formerly, MSc student at University of Tehran, E-mail: s.akhyani@unsw.edu.au
5 PhD Candidate, Department of Civil and Environmental Engineering, University of Nevada, Reno, NV, USA; formerly, MSc student at University of Tehran, E-mail: pzogh@nevada.unr.edu

Abstract: In this study, a series of resonant column tests was conducted to measure the shear modulus of sand-rubber mixtures at small strain amplitudes (i.e. between 10^{-4}% and 10^{-2}%), considering different rubber percentages and confining stress levels. The results were then combined with data obtained by dynamic hollow cylinder tests to investigate shear modulus degradation of the mixtures over a wider shear strain range. Based on the test results, a new expression was proposed to improve the prediction of maximum shear modulus of sand-rubber mixtures using the modified equivalent void ratio concept. A new constitutive model was also developed for estimation of strain-dependent shear modulus of the mixtures based on the modified hyperbolic framework. The shear modulus of the mixtures was found to be a function of rubber percentage, confining stress, the modified equivalent void ratio and the relative shear stiffness of rubber and sand. The experimental data and the developed models showed that the shear modulus decreased with rubber percentage and increased with confining stress. Moreover, the reference shear strain of the modified hyperbolic model increased with both rubber percentage and confining stress while its curvature coefficient increased more considerably with rubber percentage compared to the confining stress.

Keywords: Geosynthetics, Soil-rubber mixture, Strain-dependent shear modulus, Resonant column test, Constitutive model

NaCMC-amended clay: effect of mixing method on hydraulic conductivity and polymer elution

S. Taheri[1], A. El-Zein [2] and B. Yu [3]

1 PhD Candidate, School of Civil Engineering, The University of Sydney, Sydney, NSW, Australia, E-mail: sepideh.taheri@sydney.edu.au (corresponding author)

2 Professor, School of Civil Engineering, The University of Sydney, Sydney, NSW, Australia, E-mail: abbas.elzein@sydney.edu.au

3 Technical and R&D Laboratory Manager, Geofabrics Australia Pty Ltd, Gold Coast, QLD, Australia, E-mail: b.yu@geofabrics.com.au

Abstract: Desiccation-induced cracks in reactive soils reduce their mechanical strength and increase their hydraulic conductivity (HC). Polymer additives have demonstrated efficacy in improving the resistance of clay against desiccation cracking and retaining low HC when exposed to saline solutions. However, the risk of polymer elution from treated mixtures and its effect on the durability of gains have received little attention. This study evaluated polymer leaching during consolidation and permeation in reconstituted mixtures. Sodium carboxymethyl cellulose (NaCMC) was added to sodium bentonite via wet mixing and dry mixing. Conducting a series of HC tests on amended and unamended samples, polymer retention and elution were assessed using thermogravimetric and total organic carbon analyses. NaCMC incorporation under dry mixing reduced the HC by approximately 60%. The dry-mixed (DM) specimens exhibited higher levels of polymer leaching compared with the wet-mixed (WM) specimens, with increasing permeability over time. Nevertheless, despite polymer loss, the HCs of both DM and WM specimens remained lower than untreated bentonite for up to 100 days of permeation. Furthermore, introducing a slit-film geotextile as a potential remedy for leaching did not significantly enhance polymer retention in the DM samples. However, it reduced the polymer content in the effluent, suggesting that the geotextile, not the bentonite, could have retained the polymer.

Keywords: Geosynthetics, Bentonite, Polymer, Polymer quantification, Thermogravimetric analysis, Total organic carbon, Hydraulic conductivity

Centrifuge modeling of levees with geocomposite chimney drain subjected to flooding

B. V. S. Viswanadham[1], P. Kumar[2] and R. K. Saran[3]
1 Institute Chair Professor and Professor, Geotechnical Engineering Division, Department of Civil Engineering, Indian Institute of Technology Bombay, Powai, Mumbai, India,
E-mail: viswam@civil.iitb.ac.in (corresponding author)
2 Formerly Research Scholar and Institute Post Doc, Department of Civil Engineering, Indian Institute of Technology Bombay, Powai, Mumbai, India, E-mail: pankajk.civil@gmail.com
3 Formerly Research Scholar, Department of Civil Engineering, Indian Institute of Technology Bombay, Powai, Mumbai, India, E-mail: rishabh87saran@gmail.com

Abstract: The objective of present study is to evaluate the performance of a levee subjected to flooding and seepage through centrifuge model tests. For this, six model tests were conducted on a 240 mm high levee model at 30g in a 4.5 m radius large beam centrifuge. A custom-developed simulator is employed to induce identical flood rates on the upstream side of models. Further, using (a) geocomposite (GC) and (b) sand-sandwiched geocomposite (SSGC) as internal chimney drain, the suitability of GC material for dissipation of pore-water pressure (PWP) is also studied. The results of the centrifuge tests are discussed in terms of the development of upstream flood function, PWP within the levee body, and the surface settlements at the levee's crest. Further, the influence of an internal chimney drain, the material used for its construction, and its type and composition on the seepage response of the levee are discussed. It is observed that a GC-based chimney drain with sand cushioning on both sides in the horizontal portion of the chimney drain performs well. Further, digital image analysis of SEM micrographs of exhumed GC after centrifuge tests and the analyzed PWP data during sustained flooding-induced seepage is found to corroborate well.

Keywords: Geosynthetics, Levees, Geocomposite, Chimney drain, Seepage, Centrifuge models, Digital image analysis, UN SDG 9: Industry, innovation and infrastructure, UN SDG 13: Climate action

Investigation of the mechanical response of recovered geogrids under repeated loading

A. Ibrahim[1], R. L. E. Desbrousses[2],J.Xu[3] and M. A. Meguid[4]
1 Postdoctoral researcher, Department of Civil Engineering, McGill University, Montreal, QC, Canada, E-mail: ahmed.ibrahim5@mcgill.ca (corresponding author)
2 Graduate student, Department of Civil Engineering, McGill University, Montreal, QC, Canada, E-mail: romaric.desbrousses@mail.mcgill.ca
3 Graduate student, Department of Civil Engineering, McGill University, Montreal, QC, Canada, E-mail: jiahao.xu@mail.mcgill.ca
4 Professor, Department of Civil Engineering, McGill University, Montreal, QC, Canada, E-mail: mohamed.meguid@mcgill.ca

Abstract: This study investigates the mechanical response and performance of biaxial polypropylene geogrid specimens' cyclic loading. This work assesses the influence of embedment depths and subgrade strengths on the geogrids. The experimental program involved subjecting the geogrid specimens to 100 repeated tensile loading cycles at four distinct load targets: 20%, 40%, 60%, and 80% of the geogrid ultimate tensile strength. The analysis focused on evaluating the effects of preloading factors such as California Bearing Ratio (CBR) values, embedment depth, and the response to cyclic testing. Results show trends in stiffness reduction and changes in damping ratio with increased number of cycles. A comparative analysis was conducted with a control specimen from the same batch, highlighting the difference in mechanical response attributed to precycling variables. The findings indicate that the overall mechanical behavior of recovered geogrids is comparably consistent with new geogrids. However, variations in strain and stiffness reduction were observed among the recovered specimens, suggesting a pattern of yielding before failure. The findings suggest a minimal effect of embedment depth on the damping ratio at lower CBR. Overall, it was found that precycling and subgrade conditions have minimal effect on the mechanical response of the recovered specimens when tested in isolation.

Keywords: Geosynthetics, Cyclic loading, Subgrade strength, Recovered geogrids, Soil reinforcement, Geogrid stiffness

Permeability of needle-punched nonwoven geotextiles subjected to uniaxial tensile strains

K. Y. Li[1],X.W.Tang[2],M.L.Fei[3], J. Chou[4], X. L. Chen[5], Q. Q. Xiang[6] and T. Q. Wang[7]
1 PhD candidate, Research Center of Coastal and Urban Geotechnical Engineering, Zhejiang University, Hangzhou, P.R. China; Engineering Research Center of Urban Underground Space Development of Zhejiang Province, Hangzhou, P.R. China, E-mail: 20lky@zju.edu.cn
2 Professor, Research Center of Coastal and Urban Geotechnical Engineering, Zhejiang University, Hangzhou, P.R. China; Engineering Research Center of Urban Underground Space Development of Zhejiang Province, Hangzhou, P.R. China, E-mail: tangxiaowu@zju.edu.cn (corresponding author)
3 PhD candidate, MOE Key Laboratory of Soft Soils and Geoenvironmental Engineering, Institute of Geotechnical Engineering, Zhejiang University, Hangzhou, P.R. China, E-mail: feiminliang@zju.edu.cn
4 Senior Engineer, Zhejiang Guangchuan Engineering Consulting Co. Ltd, Hangzhou, P.R. China, E-mail: 20464576@qq.com
5 Senior Engineer, Zhejiang Guangchuan Engineering Consulting Co. Ltd, Hangzhou, P.R. China, E-mail: 2859411792@qq.com
6 MS student, Research Center of Coastal and Urban Geotechnical Engineering, Zhejiang University, Hangzhou, P.R. China; Engineering Research Center of Urban Underground Space Development of Zhejiang Province, Hangzhou, P.R. China, E-mail: 22212010@zju.edu.cn
7 MS student, Research Center of Coastal and Urban Geotechnical Engineering, Zhejiang University, Hangzhou, P.R. China; Engineering Research Center of Urban Underground Space Development of Zhejiang Province, Hangzhou, P.R. China, E-mail: 22112186@zju.edu.cn

Abstract: During their service life, needle-punched nonwoven geotextiles are frequently subjected to uniaxial tensile strains, which may impact their permeability behavior. The basic model of the permeability coefficient in nonwoven geotextiles was extended to the uniaxial tensile strain condition, considering the influence of the fiber orientation distribution. The model is expressed as a function of the tortuosity fractal dimension, pore size characteristics, fiber orientation, physical parameters, and tensile strain. To address errors in the results of traditional permeability tests attributed to the inhomogeneity and multiple layers of specimens, in situ X-ray computed tomography was used to acquire three-dimensional (3D) images of geotextiles during stretching. The 3D imaging technique was employed to extract the microstructure, facilitating fluid flow simulations for determining the permeability of two nonwoven geotextiles, thereby validating the theoretical method. The simulated permeability coefficient decreased slightly and then increased with increasing uniaxial tensile strain and the necking ratio. The theoretical permeability model exhibited a decreasing trend and then increases around 0.3% strain. The theoretical model accurately predicted the permeability and rate of change of geotextiles subjected to specific uniaxial tensile strains, thereby offering valuable insight into their effective utilization in various engineering applications.
Keywords: Geosynthetics, Permeability, Uniaxial tensile strain, Nonwoven geotextile, In situ CT

Geotextile-encased cinder gravel columns: a coupled DEM–FDM analysis

K. Liu[1,2], R.Qiu[3], P. Zhou[4], T.Wang[5,6], D. P. Connolly[7] and J. Xiao[8]

1 Associate Professor, School of Civil Engineering, Southwest Jiaotong University, Chengdu, China

2 MOE Key Laboratory of High-Speed Railway Engineering, Southwest Jiaotong University, Chengdu, China, E-mail: kaiwen.liu@queensu.ca

3 PhD candidate, School of Civil Engineering, Southwest Jiaotong University, Chengdu, China, E-mail: qiuruizhe@my.swjtu.edu.cn

4 Junior Engineer, Guangzhou Metro Design and Research Institute Co., Ltd, Guangzhou, China, E-mail: 136880746@qq.com

5 Associate Professor, School of Civil Engineering, Southwest Jiaotong University, Chengdu, China

6 MOE Key Laboratory of High-Speed Railway Engineering, Southwest Jiaotong University, Chengdu, China, E-mail: w@swjtu.edu.cn (corresponding author) (Orcid:0000-0003-4079-0687)

7 Professor, School of Civil Engineering, University of Leeds, Leeds, UK, E-mail: d.connolly@leeds.ac.uk

8 Master’s candidate, School of Civil Engineering, Southwest Jiaotong University, Chengdu, China, E-mail: 2744876189@qq.com

Abstract: Cinder gravel, a porous, lightweight, and durable volcanic byproduct, has the potential to be a sustainable and cost-effective alternative to conventional stone columns for ground improvement applications. Its use in soft soils, however, requires sufficient confining pressure to prevent bulging and thus performance degradation. Geotextile-encased cinder gravel (GECG) columns are an innovate method to overcome this, but studies on bearing response and pressure–deformation characteristics are limited. A comprehensive numerical analysis of GECG columns was conducted using a combination of the discrete-element method (DEM) and finite-difference method (FDM). The hybrid DEM–FDM framework enabled simulation of individual particle behavior while maintaining efficiency in modeling continuous, homogeneous materials. The key novelties were examining the macro and mesoscopic behavior of GECG columns under triaxial compression. The developed numerical model was validated and calibrated against triaxial test results. A parametric analysis of GECG columns investigated the influence of relative density and gradation on the compression behavior and load capacity. Upon triaxial compression, the results showed significant radial expansion near the column top, with stress and deformation fields aligning with the column's bearing capacity. The relative density had limited influence on the geotextile's radial deformation, while a higher content of coarse particles in the gradation enhanced the bearing capacity of the GECG columns.

Keywords: Geosynthetics, Ground improvement, Cinder gravel, Stone column, DEM–FDM, Triaxial test