《Geotextiles and Geomembranes》

（土工织物与土工膜）

<双月刊>

2018年第46卷第2期

摘要集

中国土工合成材料工程协会秘书处

国际土工合成材料学会中国委员会秘书处

2018年11月26日

目 录

Hydraulic conductivity behaviour of soil blended with geofiber inclusions

P.V. Divya [a], B.V.S. Viswanadham [a,*], J.P. Gourc [b]
a Department of Civil Engineering, Indian Institute of Technology Bombay, Powai, Mumbai 400076 India
b LTHE, University of Joseph-Fourier 1, Grenoble, F 38041, France

Abstract: Efficiency of fiber reinforcements to ensure the sealing efficiency of the landfill cap soil barriers so as to isolate the waste from the environment was demonstrated in the present study. Evaluation of hydraulic conductivity of soil barrier materials with different types of fibers, fiber dosage and fiber lengths are very important to ensure the sealing efficiency of the fiber reinforced soil barriers. An attempt was made to evaluate the hydraulic conductivity of the soil barrier material at a known effective stress using a flexible wall permeameter. Soil samples of 100 mm diameter and 100 mm height were prepared and tested in the present study. In all the cases, the hydraulic conductivity test phase was started after the completion of initialisation, saturation and isotropic consolidation phases of the soil samples. In the present study, seventeen (17) hydraulic conductivity tests were conducted on two different soil types for studying the influence of fiber content, fiber length and fiber type on the hydraulic conductivity of fiber reinforced soil. The fiber content, f used were 0.25%, 0.50% and 0.75% and the fiber lengths, l were 30 mm, 60 mm and 90 mm. Two types of fibers namely polyester (PET) fibers and polypropylene tape (PP-T) fibers were used for hydraulic conductivity tests. The repeatability of test results was also demonstrated. As the fiber content and fiber length were increased, initially there was a marginal decrease in hydraulic conductivity of the soil and thereafter marginally increased. Short fibers and low fiber contents were found to have greater influence in reducing the hydraulic conductivity of the soil and the variation was found to depend on the soil type also. Even with long fibers, the hydraulic conductivity of selected barrier material remained within the permissible limit required for a barrier material. The hydraulic conductivity of PP-T fiber reinforced soil is more, compared to hydraulic conductivity of PET fiber reinforced soil at all the fiber contents varied in the present study. The use of Scanning Electron Microscopy (SEM) is also attempted for the interpretation of the results.
Keywords: Geosynthetics; Reinforced soils; Fibers; Flexible wall permeameter;

Evaluating leakages through GMB/GCL composite liners considering random hole distributions in wrinkle networks

Liang-tong Zhan [a], Cheng Chen [a,*], Abdelmalek Bouazza [b], Yun-min Chen [a]
a MOE Key Laboratory of Soft Soils and Geoenvironmental Engineering, Zhejiang University, Hangzhou 310058, China
b Department of Civil Engineering, Monash University, 23 College Walk, Melbourne, Vic. 3800, Australia

Abstract: This paper presents a study on the development of a hydraulic connectivity analysis-based approach for evaluating leakage rates through geomembrane (GMB)-geosynthetic clay liner (GCL) composite liners considering random hole distributions in a GMB wrinkle network. An algorithm for hydraulic connectivity analysis was developed to find the hydraulically connected wrinkles from a wrinkle network, and an explicitly expressed criterion is proposed to define the hydraulic connection between wrinkles under the assumption that only one of the two adjacent wrinkles is possible to be damaged. A Monte Carlo simulation was used to evaluate the probability weighted average of the total leakage through multiple randomly distributed holes considering numerous possible combinations of locations of holes. The proposed approach was applied to typical examples reported in the literature and shows that it can objectively quantify the effect of the hydraulic properties of the liner and overburden pressure on the hydraulic connectivity between wrinkles in a wrinkle network. The proposed approach also allowed assessing the effect of different probabilities of various hole distributions on the calculated leakage, which was demonstrated to be non-negligible, especially when the hole frequency is small.
Keywords: Geosynthetics; Leakage; Geomembrane; Hole; Wrinkle; Composite liners; Monte carlo simulation

Comparative analysis on performance of vertical drain improved clay deposit under vacuum or surcharge loading

Zhen Zhang [a,*], Guan-Bao Ye [a], Yan Xu [b]
a Department of Geotechnical Engineering, Tongji University, Shanghai 200092, China
b Key Laboratory of Land Subsidence Monitoring and Prevention of Ministry of Land and Resources of China, Shanghai 200072, China

Abstract: This paper presents two well-instrumented large-scale field tests of PVD-improved soft soil with vacuum and surcharge preloading, respectively. The two large-scale field tests were conducted adjacent to each other with the same preload. A comparative analysis was performed to investigate the performance of subsoil (i.e., the ground settlement, the layered settlement, the lateral displacement of subsoil and pore water pressure) under vacuum preloading and equivalent surcharge preloading. Some design methods were verified based on the field data. Cone Penetration Tests (CPT) and Vane Shear Tests (VST) were conducted to assess the improvement effects on subsoil after preloading. The results showed that as compared with surcharge preloading, vacuum preloading mitigated the differential settlement of the ground. The vacuum pressure transmitted into the soil with a minor loss through the PVD length. From a practical point of view, the improvement effects by vacuum preloading and surcharge preloading were similar in terms of influence depth and soil strength based on the insitu tests.
Keywords: Geosynthetics; Vacuum preloading; Surcharge preloading; Prefabricated vertical drain; Clay deposit; Pore water pressure

Modelling tensile/compressive strength ratio of fibre reinforced cemented soils

Lucas Festugato[a,*], Anderson Peccin da Silva [b], Andrea Diambra [c], Nilo Cesar Consoli [a], Erdin Ibraim [c]

a Dept. of Civil Engineering, Federal University of Rio Grande do Sul, Brazil

b Federal University of Rio Grande do Sul, Brazil

c Queen's School of Engineering, University of Bristol, UK

Abstract: The present work proposes a theoretical model for predicting the splitting tensile strength (qt) - unconfined compressive strength (qu) ratio of artificially cemented fibre reinforced soils. The proposed developments are based on the concept of superposition of failure strength contributions of the soil, cement and fibres phases. The soil matrix obeys the critical state soil mechanics concept, while the strength of the cemented phase can be described using the Drucker-Prager failure criterion and fibres contribution to strength is related to the composite deformation. The proposed developments are challenged to simulate the experimental results for fibre reinforced cemented Botucatu residual soil, for 7 days of cure. While the proposed analytical relation fits well the experimental data for this material, it also provides a theoretical explanation for some features of the experimentally derived strength relationships for artificially fibre reinforced cemented clean sands. A parametric study to analyse the effect of adding different fibre contents and fibre properties is provided. The proposed modelling developments also confirm the existence of a rather constant qt/qu ratio with moulding density, cement and fibre contents .

Keywords: Geosynthetics; Modelling; Residual soil; Portland cement; Fibres; Tensile strength; Compressive strength; Porosity/cement index

Development of a numerical model for performance-based design of geosynthetic liner systems

E. Kavazanjian Jr. [a,*], X. Wu [a], M. Arab [b], N. Matasovic [c]

a School of Sustainable Engineering and the Built Environment, Arizona State University, Tempe, AZ85282, USA

b Department of Civil and Environmental Engineering, University of Sharajah, Sharajeh, United Arab Emirates

c Principal & Director of Earthquake Engineering, Geo-Logic Associates, Costa Mesa, CA92626, USA

Abstract: A numerical model for performance-based design of the geosynthetic elements of waste containment systems has been developed. The model offers a rational alternative to the current state of practice for design of geosynthetic containment system elements in which neither the strains nor the forces in liner system elements are explicitly calculated. To explicitly assess the ability of the geosynthetic elements of a containment system to maintain their integrity under both static and seismic loads, a large strain finite difference model of waste-liner system interaction was developed. Modular features within the model allow the user to select the appropriate features required for any particular problem. A beam element with zero moment of inertia and with interface elements on both sides is employed in the model to represent a geosynthetic element in the liner system. This enables explicit calculation of the axial forces and strains within the liner system element. Non-linear constitutive models were developed to represent the stress-strain behavior of geomembrane and geosynthetic clay liner beam elements and the load-displacement behavior of the beam interfaces. The use of the various features on the model is illustrated using available experimental data, including shaking table test data on rigid and compliant blocks sliding on geomembranes. Analysis of geomembranes subject to waste settlement and subject to seismic loading demonstrate applications of the model and provide insight into the behavior of geosynthetic liner system elements subject to tensile loads.

Keywords: Geosynthetics; Geomembrane; Liner system; Performance based design; Settlement; Seismic loading

Swell – compression characteristics of a fiber – reinforced expansive soil

Amin Soltani *, An Deng, Abbas Taheri
School of Civil, Environmental and Mining Engineering, The University of Adelaide, Adelaide, SA 5005, Australia

Abstract: This study presents results of an experimental program with respect to fiber's capacity of mitigating the swelling behavior of an expansive soil. Two types of tape – shaped fibers, i.e. fiber A (width fw = 2.5 mm) and fiber B (fw=7 mm), were used as the reinforcements. The fibers were included at three contents, i.e. fc=0.5%, 1% and 1.5%, each having two lengths or aspect ratios (f_{AR} = 15/2.5 and 30/2.5 for fiber A, and f_{AR} = 15/7 and 30/7 for fiber B). For a given fiber type (constant fw), improvement in swelling potential/pressure was observed to be a direct function of f_c and fl (fiber length) or f_{AR}, with the former taking on a more pronounced role. In addition, for a given fc and fl, the wider fiber (lower f_{AR}) was more efficient in restricting swelling. The compression characteristics were cross – checked with the swelling properties to arrive the optimum stabilization scenarios. For both fiber types, fc=0.5% suggested an optimal case. However, where compressional deformations are not a primary concern, higher inclusions up to 1% could also be an acceptable choice.

Keywords: Geosynthetics; Expansive soil; Tape-shaped fibers; Aspect ratio; Swelling potential; Swelling pressure

Use of cellular confinement for improved railway performance on soft subgrades

Sagar Raj Satyal [a,] Ben Leshchinsky [b,*], Jie Han [c], Madan Neupane [d,e]

a Oregon State University, 101 Kearney Hall, Corvallis, OR 97331, United States

b Oregon State University, Department of Forest Engineering, Resources and Management, 204 Peavy Hall, Corvallis, OR 97331, United States

c Glenn L. Parker Professor of Geotechnical Engineering, The University of Kansas, 1530 W. 15th St., Lawrence, KS 66045-7609, United States

d Gannett Fleming, Inc., 5 Eves Drive Suite 200, Marlton, NJ 08053, United States

e The University of Kansas, 1530 W. 15th St., Lawrence, KS 66045-7609, United States

Abstract: Due to extensive right-of-way, railroads are inevitably subject to poor subgrade conditions and interrupted service for significant maintenance due to excessive deformations and loss of track geometry. Geocell confinement presents itself as a possible solution for improving performance of ballasted railroad embankments over weak subgrade. To investigate the efficacy of geocell confinement on ballasted railway embankments, a set of well-instrumented, large-scale cyclic plate loading tests and numerical simulations were performed on geocell confined ballast overlaying a weak subgrade material. The agreement of results from tests and simulations served as a basis for simulating practical track geometry and performance for various geocell configurations and subgrades using three-dimensional (3D) finite element (FE) analyses. The study showed that geocell reinforcement significantly decreased track settlement, decreased subgrade deformations with lower and uniform distribution of vertical stresses on subgrade and inhibited lateral deformation and serviceability under cyclic loading. These results demonstrate that geocell confinement can be an effective alternative to subsurface improvement or shorter maintenance cycles, particularly on weak subgrades.

Nonwoven geotextiles from nettle and poly (lactic acid) fibers for slope stabilization using bioengineering approach

Navdeep Kumar, Dipayan Das *
Department of Textile Technology, Indian Institute of Technology Delhi, Hauz Khas, New Delhi 110016, India

Abstract: This article deals with needle-punched nonwoven geotextiles prepared from nettle and poly (lactic acid) fibers in different weight proportions for potential slope stabilization application using bioengineering approach. The geotextiles were tested for tensile strength, biodegradability, and enhancement of soil fertility. The tensile strength of the geotextiles was found to decrease with addition of stronger nettle fibers. This apparently surprising behavior was explained in the light of theoretical tensile mechanics of nonwovens. Further, the nettle fibers displayed higher biodegradability than the poly (lactic acid) fibers, and when buried under soil, all the geotextiles exhibited a loss in tensile strength. Interestingly, the fertility of the soil was remarkably improved after biodegradation of poly (lactic acid) fibers. Overall, the nonwoven geotextiles prepared in this work were found to be promising for slope stabilization application.

Keywords: Geosynthetics; Nettle; Poly(lactic acid); Nonwoven geotextile; Tensile strength; Biodegradability; Soil fertility

Geocell reinforcement for performance improvement of vertical plate anchors in sand

Sujit Kumar Dash [a,*], Awdhesh Kumar Choudhary [b]
a Department of Civil Engineering, Indian Institute of Technology Kharagpur, Kharagpur 721302, India
b Department of Civil Engineering, Indian Institute of Science Bangalore, Bangalore 560012, India

Abstract: In this paper influence of geocell reinforcement on performance of vertical plate anchors is studied. A series of model tests were carried out in a test bed-cum-loading frame assembly. The anchor used was a steel plate of size 100 mm × 100 mm. With geocell reinforcement the anchor could sustain deformations as high as 60 – 70% of its height when the load carrying capacity was increased by four fold. The optimum length, width, and height of geocell mattress giving maximum performance improvement are found to be 5, 3 and 2.8 times the anchor height respectively. For adequate performance improvement size of geocell pocket opening should be close to the anchor size. The load dispersion angle that depicts the rigidity of the geocell mattress tends to increase with increase in its width, height and reduction in pocket size. A numerical study using fast Lagrangian analysis of continua was carried out. The agreement between observed and computed results is found to be reasonably Good.

Keywords: Geosynthetics; Vertical plate anchor; Load carrying capacity; Reinforced sand; Geocell reinforcement; Model tests; Numerical analysis

Development of geomembrane strains in waste containment facility liners with waste settlement☆

Yan Yu, R. Kerry Rowe *
GeoEngineering Centre at Queen's−RMC, Department of Civil Engineering, Queen's University, Kingston, ON K7L 3N6, Canada

Abstract: The development of tensile strains in geomembrane liners due to loading and waste settlement in waste containment facilities is examined using a numerical model. Two different constitutive models are used to simulate the waste: (a) a modified Cam-Clay model and (b) a Mohr-Coulomb model. The numerical analyses indicate the role of the slope inclination on the maximum geomembrane liner strains for both short-term loading (immediately post closure) and long-term waste settlement. A geosynthetic reinforcement layer over the geomembrane liner is shown to reduce the maximum geomembrane liner strains, but the strain level of the geosynthetic reinforcement itself may become an engineering concern on steeper slopes (i.e., greater than 3H:1V) for cases and conditions examined in this paper. The paper considers some factors (e.g., slope inclination, use of a high stiffness geosynthetic over the geomembrane liner) and notes others (e.g., the designer selection of interface characteristics below and above the geomembrane, use of a slip layer above the geomembrane) that warrant consideration and further investigation to ensure good long-term performance of geomembrane liners in waste containment facilities.
Keywords: Geosynthetics; Waste settlement; Geomembrane strain; Geosynthetic liner system; Waste containment facility; Numerical modelling; FLAC.

Pilot tests on vacuum preloading method combined with short and long PVDs

Liqiang Sun [a,b], Xin Gao [a,b], Daokun Zhuang [c], Wei Guo [b,*], Jinfang Hou [d], Xiaoqiang Liu [b,e]

a State Key Laboratory of Hydraulic Engineering Simulation and Safety, Tianjin University, 135 Yaguan Road, Jinnan District, Tianjin 300350, China

b School of Civil Engineering, Tianjin University, 135 Yaguan Road, Jinnan District, Tianjin 300350, China

c School of Civil Engineering, Hebei University of Engineering, 199 Guangming Street, Hanshan District, Handan City, Hebei Province, 056038, China

d CCCC Tianjin Port Engineering Institute Co. Ltd, Tianjin 300222, China

e Tianjin Research Institute of Water Transport Engineering, Ministry of Transport, Tianjin 300456, China

Abstract: Dredged marine clay has been widely used as a filling material for land reclamation in China. The difficulty of using the vacuum preloading method to improve the dredged marine clay together with the bottom sediment clay is the different spacing requirement of the PVDs. To solve this problem, the Vacuum Preloading method combined with the Short and Long PVDs (VPSL) is proposed in this paper. The short PVDs are installed only into the dredged marine clay layer in-between the long PVDs which are installed through the whole clay layer. Pilot tests are also conducted at a land reclamation site in Tianjin, China, to investigate the performance of the proposed method. The ground settlement, the applied vacuum pressure and the pore water pressure in the soil are monitored during the pilot tests. The average degrees of consolidation are calculated based on the monitored settlement and pore pressure data. It is found that the proposed VPSL method is more effective for improving top dredged clay together with the bottom sediment clay than the conventional vacuum preloading method. The vane shear strength profiles of soil layers after ground improvement also show that the VPSL method is more effective to achieve a uniform soil strength profile.

Keywords: Geosynthetics; Land reclamation; Soil improvement; Vacuum preloading.