《Geosynthetics International》

（国际土工合成材料）

<双月刊>

2021年第28卷第5期

摘要集

中国土工合成材料工程协会秘书处

目　录

Investigation on load-carrying capacity of geogrid-encased deep cement mixing piles

R. Sukkarak[1] P. Jongpradist[2] W. Kongkitkul[3] P. Jamsawang[4] S. Likitlersuang[5]
1 Postdoctoral Fellow, Centre of Excellence in Geotechnical and Geoenvironmental Engineering, Department of Civil Engineering, Faculty of Engineering, Chulalongkorn University, Bangkok, 10330 Thailand, E-mail: raksiri.s@fte.kmutnb.ac.th
2 Associate Professor, Civil Engineering Department, Faculty of Engineering, King Mongkut's University of Technology North Bangkok, Bangkok, Thailand, E-mail: pornkasem.jon@kmutt.ac.th (corresponding author)
3 Associate Professor, Civil Engineering Department, Faculty of Engineering, King Mongkut's University of Technology North Bangkok, Bangkok, Thailand, E-mail: warat.kon@kmutt.ac.th
4 Professor, Civil Engineering Department, Faculty of Engineering, King Mongkut's University of Technology Thonburi, Thung Khru, Bangkok, Thailand, E-mail: pitthaya.j@eng.kmutnb.ac.th
5 Professor, Centre of Excellence in Geotechnical and Geoenvironmental Engineering, Department of Civil Engineering, Faculty of Engineering, Chulalongkorn University, Bangkok, 10330 Thailand, E-mail: fceslk@eng.chula.ac.th

Abstract: This article discusses the feasibility of a geogrid-encased deep cement mixing (EDCM) pile for enhancing the load-carrying capacity (Q_{ult}) of a conventional deep cement mixing (DCM) pile, based on the results of experimental and numerical investigations. Firstly, physical model tests were conducted to observe the load–settlement response and load-transfer mechanism. Subsequently, a series of three-dimensional (3D) finite-element analyses was performed to investigate the effect of the stiffness and length of the geogrid encasement. The results indicated that the geogrid encasement effectively improves the Q_{ult} of the DCM piles by a factor of two. With the additional confinement provided by the geogrid encasement, the geogrid can also provide a greater contribution to the loading transfer. The increase in Q_{ult} became more significant with a lower strength of the DCM. For a particular amount of geogrid, the EDCM pile with a thicker geogrid provided a higher Q_{ult} than that with a longer geogrid. The optimum length of the geogrid-EDCM pile was found to be approximately twice that of the pile diameter. Finally, a chart for estimating the efficient effect of geogrid encasements on the Q_{ult} of EDCM piles was proposed.

Keywords: Geosynthetics, Geogrid, Deep cement mixing pile, Load carrying capacity, Physical model test, Finite element analysis

Direct measurement of geomembrane strain from aggregate indentations

B. A. Marcotte[1], I. R. Fleming[2]
1 Graduate student, Department of Civil, Geological and Environmental Engineering, University of Saskatchewan, Saskatoon, S7N 5B4, Canada, E-mail: bryce.marcotte@usask.ca (corresponding author)
2 Professor, Department of Civil, Geological and Environmental Engineering, University of Saskatchewan, Saskatoon, S7N 5B4, Canada, E-mail: ian.fleming@usask.ca

Abstract: High localized strain in geomembranes caused by indentations from coarse, uniform drainage aggregate is associated with long-term stress cracking and has been widely studied. A number of large-scale lab tests were carried out with direct measurement of the distribution of the major and minor principal (engineering) strain across the area of a large laboratory sample of geomembrane. This 'grid-point' method of strain estimation is compared to the method developed by Tognon et al, which has been recommended as the best available approach at this time. It has been found that the method by Tognon et al. tends to over- and under-predict geomembrane strain depending on the aggregate and protection layers used. Indentations with higher smaller ratios of membrane to bending strains tend to be underestimated. A correction factor is proposed based on the ratio of membrane to bending strains and fits the measured grid strain method used in this study well.

Keywords: Geosynthetics, geomembrane, strain, stress cracking, tire derived aggregate, landfill

Experimental study of a geosynthetic-reinforced soil bridge abutment

P. Jelušič[1], B. Žlender[2]
1 Assistant Professor, Faculty of Civil Engineering, Transportation Engineering and Architecture, University of Maribor, Maribor, Slovenia, E-mail: primoz.jelusic@um.si (corresponding author)
2 Professor, Faculty of Civil Engineering, Transportation Engineering and Architecture, University of Maribor, Maribor, Slovenia, E-mail: bojan.zlender@um.si

Abstract: The article presents an experimental study of a geosynthetic-reinforced soil (GRS) bridge abutment (BA). The BAs are seated on a saturated soft foundation layer and support a 16 m long concrete bridge. Laboratory tests were conducted on the foundation soil, geogrid, and fill material. The BA is constructed from 14 geogrids and has a total height of 4.2 m. The strain values in the geogrids were measured and recorded during the construction of the abutments and after installation of the bridge structure. The test results show that more than 50% of the total strain in the geogrids was developed during the construction of the BAs, mostly embedded in the ground. The remainder of the measured strain was a consequence of installing the prefabricated bridge girders, back fill placement, concreting the top slab, and placing the asphalt concrete. The strain distribution along the geogrids shows that the maximum strain was recorded below the sill, and was 50% higher than at the center of the BA. Based on an analysis of the construction costs, it can be concluded that conventional reinforced concrete abutments could cost up to five times the amount of optimally designed GRS-BAs.
Keywords: Geosynthetics, Bridge abutment, Geosynthetic-reinforced soil, Field instrumentation, Numerical modeling

Study of silty sand slope protection from seepage flows using short fiber-sand mixtures

X. Bao[1], L. Li[2], Z. Liao[3], H. Cui[4], W. Tang[5], X. Chen[6]

1 Professor, Key Laboratory for Resilient Infrastructures of Coastal Cities, MOE, College of Civil and Transportation Engineering, Shenzhen University, Shenzhen 518060, China, E-mail: bxh@szu.edu.cn (corresponding author)

2 Master student, Key Laboratory for Resilient Infrastructures of Coastal Cities, MOE, College of Civil and Transportation Engineering, Shenzhen University, Shenzhen 518060, China, E-mail: 1810332078@email.szu.edu.cn

3 Master student, Key Laboratory for Resilient Infrastructures of Coastal Cities, MOE, College of Civil and Transportation Engineering, Shenzhen University, Shenzhen 518060, China, E-mail: liaozhiguang2016@email.szu.edu.cn

4 Professor, Key Laboratory for Resilient Infrastructures of Coastal Cities, MOE, College of Civil and Transportation Engineering, Shenzhen University, Shenzhen 518060, China, E-mail: h.z.cui@szu.edu.cn

5 Associate Professor, School of Architecture and Built Environment, The University of Newcastle, Callaghan, NSW 2308, Australia, E-mail: patrick.tang@newcastle.edu.au

6 Professor, Key Laboratory for Resilient Infrastructures of Coastal Cities, MOE, College of Civil and Transportation Engineering, Shenzhen University, Shenzhen 518060, China, E-mail: xschen@szu.edu.cn

Abstract: Silty sand slopes are prone to damage due to seepage or rainfall. A partial reinforcement method using short polypropylene fiber and sand mixtures was proposed to protect silty sand slopes from seepage flow failure. The effects and the reinforcement mechanism were explored. First, triaxial tests were performed on sand samples reinforced with fiber lengths (6 and 12 mm) and contents (0.25 and 0.50%) to verify the reinforcement effect. Then, model tests were conducted on sand slopes under lateral seepage flow and the failure mode with different fiber contents and reinforcement method were examined. The results showed that the cohesion and shear strength of sand were significantly improved with the increase of fiber content and length. The suction of unsaturated sand was also enhanced by the fibers. The change in stress-strain behavior from strain softening to strain hardening indicated that static liquefaction could be effectively prevented. The failure mode and extent of slope damage depended on the fiber content. However, it was noted that the slope surface with small reinforcement range performed similarly to that with large reinforcement range. In conclusion, the partial reinforcement method with short discrete synthetic fibers can be used as an effective alternative for slope reinforcement.

Keywords: Geosynthetics, Silty sand, Fiber reinforcement, Slope model tests, Seepage flow

Behaviour evaluation of a gravelly soil–geogrid interface under normal cyclic loading

F. Y. Liu[1], C. Zhu[2], G. H. Yuan[3], J. Wang[4], Z. Y. Gao[5], J. F. Ni[6]
1 Professor, School of Mechanics and Engineering Science, Shanghai University, No. 99, Shangda Road, Shanghai, 200444, PR China, E-mail: lfyzju@shu.edu.cn
2 Graduate student, School of Mechanics and Engineering Science, Shanghai University, No. 99, Shangda Road, Shanghai, 200444, PR China, E-mail: zcshu1995@163.com
3 Research assistant, College of Architecture and Civil Engineering, Wenzhou University, Wenzhou 325035, PR China, E-mail: guohui_yuan@wzu.edu.cn
4 Professor, College of Architecture and Civil Engineering, Wenzhou University, Wenzhou 325035, PR China, E-mail: sunnystar1980@163.com (corresponding author)
5 PhD student, Department of Civil Engineering and Architecture, Saga University, 1 Honjo-machi, Saga-City, Saga 840-8502, Japan, E-mail: gziyoung@163.com
6 PhD student, Department of Civil Engineering and Architecture, Saga University, 1 Honjo-machi, Saga-City, Saga 840-8502, Japan, E-mail: nijunfeng007@163.com

Abstract: Reinforced soil structures are often subjected to both static and dynamic loads. However, experimental data concerning the interaction of soil–geosynthetic interfaces under normal dynamic loads are scarce. This paper reports on a series of large-scale direct shear tests that are used to investigate the shear behaviour of a gravelly soil–geogrid interface under normal cyclic load (NCL) conditions. The results show that the shear stress magnitude under NCL conditions is generally between the shear stresses under normal static load (NSL) conditions corresponding to the upper and lower bounds of the NCL. The upper and lower envelopes of the shear stress–displacement curve increase with increasing initial stress and amplitude. The enhancement coefficient (α) is used to describe the degree of influence of the additional cyclic load on the shear stress of the interfaces. The relative time shift between the shear stress ratio (R_{NCL}) and the normal stress (σ_n) is nearly a constant of 0.5 cycles, and the influence of the initial stress on the stress ratio is opposite to that of the amplitude. Finally, the volume change response is discussed under different normal load conditions.

Keywords: Geosynthetics, Soil–geogrid interface, Direct shear test, Normal cyclic load, Initial stress, Amplitude

Shear strength characteristics of interlocked EPS-block geofoam-sand interface

A. T. Özer[1], O. Akay[2]
1 Associate Professor, Civil Engineering Department, Vice Dean, Faculty of Engineering, Gebze Technical University, 41400, Gebze, Kocaeli, Turkey, E-mail: tolgaozer@gtu.edu.tr (corresponding author)
2 Associate Professor, Civil Engineering Department, Gebze Technical University, 41400, Gebze, Kocaeli, Turkey; E-mail: onurakay@gtu.edu.tr

Abstract: Translation of entire geofoam embankment at the bottom of geofoam block assemblage and bedding sand is a possible internal failure mode due to unbalanced hydrostatic forces. In addition, available shearing resistance along the bottom of geofoam block assemblage and bedding sand is an important design issue for internal seismic stability analysis. This study has focused on the methods to increase the interface shear resistance along the traditional flat surface geofoam block and bedding sand interface. In addition to traditional flat surface geofoam-sand interface, the effect of four different interlock configurations composed of geofoam blocks with one- and four-triangular and one- and four-square ledges were quantified by using direct shear tests. Two different densities (EPS19 and EPS29) and two different types of sand (Ottawa sand and Adapazari sand) were used. Therefore, the effects of geofoam stiffness, interface geometry, grain size and particle shape of the bedding sand on the interface stress-strain behavior was quantified. Manufacturing ledges along the traditional geofoam surface significantly improved the geofoam block-sand interface shear resistance. In addition, interrupting the failure plane with ledges changed the interface shear mechanism of the traditional flat surface geofoam block-bedding sand interface from purely frictional to frictional-cohesive behavior.

Keywords: Geosynthetics, EPS-block geofoam, hydrostatic sliding, interface shear

Settlement-based cost optimization of geogrid-reinforced pile-supported foundation

C. Chen[1], F. Mao[2], G. Zhang[3], J. Huang[4], J.G. Zornberg[5], X. Liang[6], J. Chen[7]
1 Professor, Hunan University, Key Laboratory of Building Safety and Energy Efficiency of the Ministry of Education, Changsha, PRC; Hunan University, College of Civil Engineering, Changsha, Hunan, PRC, E-mail: cfchen@hnu.edu.cn
2 PhD Candidate, Hunan University, Key Laboratory of Building Safety and Energy Efficiency of the Ministry of Education, Changsha, PRC; Hunan University, College of Civil Engineering, Changsha, Hunan, PRC, E-mail: mfengshan@hnu.edu.cn
3 Assistant Professor, Hunan City University, College of Civil Engineering, Yiyang, Hunan, PRC, E-mail: gbzhang@hnu.edu.cn (corresponding author)
4 Associate Professor, The University of Texas at San Antonio, Department of Civil and Environmental Engineering, San Antonio, TX, USA, E-mail: jie.huang@utsa.edu
5 Professor, The University of Texas at Austin, Department of Civil, Architectural, and Environmental Engineering, Austin, TX, USA, E-mail: zornberg@mail.utexas.edu
6 Assistant Professor of Research, University at Buffalo, the State University of New York, Department of Civil, Structural and Environmental Engineering, Buffalo, NY, USA, E-mail: liangx@buffalo.edu
7 Assistant Professor, Hunan University of Science and Technology, School of Information and Electrical Engineering, Xiangtan, Hunan, PRC, E-mail: chenjuan@hnust.edu.cn

Abstract: Cost optimization of Geogrid-Reinforced Pile-Supported Foundation (GRPSF) requires the minimum construction cost among all design alternatives within both ultimate limit state (ULS) and serviceability limit state (SLS) criteria. Usually, the optimization is conducted by selecting a limited number of design alternatives based on experience and then comparing them, which often does not lead to the real optimal design. This paper presents a novel optimization framework to systematically determine the design parameters to achieve the minimum construction cost for GRPSF, considering both ULS and SLS constraints that are relevant to post-construction performance and constructability. This framework is a hybrid of surrogate modeling and Finite Element Method (FEM) to calculate the post-construction settlement of GRPSF and search for the optimal design. Genetic Algorithm improved Black Hole Algorithm (BH-GA) was developed to determine the optimal values of design variables, including pile length and spacing, pile cap geometry, and geogrid layers and layout. The proposed approach can quickly identify the optimal design by exhausting all possible combinations of design parameters. Two well-documented case histories of GRPSF were redesigned using this framework, which validated its applicability and effectiveness in optimizing the design of GRPSF.
Keywords: Geosynthetics, surrogate modeling, post-construction settlement, cost optimization, Geogrid-Reinforced Pile-Supported Foundation