Geotextiles and Geomembranes 29 (2011) 462–471

Contents lists available at ScienceDirect

Geotextiles and Geomembranes

journal homepage: www.elsevier.com/locate/geotexmem

Static liquefaction behavior of saturated fiber-reinforced sand in undrained ring-shear tests

Jin Liu[a,b,c], Gonghui Wang[a,*], Toshitaka Kamai[a], Fanyu Zhang[a], Jun Yang[d], Bin Shi[b]

[a] Research Centre on Landslides, Disaster Prevention Research Institute, Kyoto University, Gokasho, Uji, Kyoto 611-0011, Japan
[b] School of Earth Sciences and Engineering, Nanjing University, Nanjing 210093, China
[c] School of Earth Sciences and Engineering, Hohai University, Nanjing 210098, China
[d] Department of Civil Engineering, The University of Hong Kong, Hong Kong, China

ARTICLE INFO

Article history:
Received 10 October 2010
Received in revised form
25 February 2011
Accepted 3 March 2011
Available online 11 April 2011

Keywords:
Static liquefaction
Fiber-reinforced sand
Undrained shear
Ring-shear test

ABSTRACT

The problem of static liquefaction of sand is nowadays a classical soil mechanics subject. Using a ring-shear apparatus, we explore the possibility of fiber reinforcement as a new method to improve the liquefaction resistance of sand. In order to understand the effect of the fiber content and sand density on the static liquefaction behavior of fiber-reinforced sand, a series of undrained ring-shear tests were carried out on saturated samples with different fiber content and sand density, and the test results and mechanisms of fiber reinforcement were then analyzed. The results indicate that the undrained shear behavior of fiber-reinforced loose samples is not greatly influenced by the presence of fiber, but for medium dense and dense samples, the presence of fiber clearly affects their undrained behavior. Untreated specimens showed a continuous decrease in shear resistance after failure, while the specimens treated with fiber showed fluctuations even after shear failure, and these fluctuations become stronger with increasing fiber content. The peak shear strength increases with the fiber content, especially in dense specimens. After shearing, all the fiber-reinforced and untreated dense samples maintained structural stability, while the unreinforced loose samples showed a completely collapse of structure. The presence of fibers may thus limit or even prevent the occurrence of lateral spreading that is often observed in unreinforced sand.

1. Introduction

The problem of static liquefaction of saturated sand is nowadays a classical soil mechanics subject. Castro (1969) found that sudden increases of pore water pressure, induced by monotonic shearing under undrained conditions, lead to the liquefaction of sand layers. Sand liquefaction can result in landslides, subsidence of foundations, damage to earth structures, lateral movement of structures resting on soil, and disruption of services. It is thus important to consider the liquefaction potential of dams, embankments, slopes, foundation materials and placed fills (Krishnaswamy and Isaac, 1994). At present, the methods most commonly adopted to prevent liquefaction are densification, draining and soil reinforcement (Krishnaswamy and Isaac, 1994). Nevertheless, densification of deep deposits and draining is often ineffective and require suitable field equipment, so soil reinforcement has been considered recently (Vercueil et al., 1997; Li and Ding, 2002; Unnikrishnan et al., 2002; Boominathan and Hari, 2002; Diambra et al., 2010).

Soil reinforcement using tension-resisting material is an attractive method of improving the property of soils in geotechnical engineering and other fields (Rowe and Li, 2002; Rowe and Taechakumthorn, 2008; Li and Rowe, 2008; Long et al., 2007). Distributed fiber used as a new reinforcing material has recently become a focus of intense interest (Maher and Ho, 1993; Santoni and Webster, 2001; Santoni et al., 2001; Zornberg, 2002; Consoli et al., 2003, 2007, 2009a,b; Heineck et al., 2005; Park and Ann Tan, 2005; Yetimoglu et al., 2005; Diambra et al., 2007, 2008, 2010; Michalowski, 2008; Tingle et al., 2002; among others). Compared with conventional reinforcement materials (strips, geotextile, geogrid, etc.), the mixing of discrete fibers with a soil mass is simple and quite similar to adding other mixtures such as cement and lime. One of the primary advantages of randomly distributed fibers is the absence of potential planes of weakness that can develop parallel to oriented reinforcement (Tang et al., 2007). A number of conventional triaxial tests, unconfined compression tests, and direct shear tests on this subject have been

* Corresponding author. Tel.: +81 774 38 4839; fax: +81 774 384300.
E-mail address: gonghui.wang@gmail.com (G. Wang).

0266-1144/$ – see front matter © 2011 Elsevier Ltd. All rights reserved.
doi:10.1016/j.geotexmem.2011.03.002