Journal of Rock Mechanics and Geotechnical Engineering 7 (2015) 147–154

Contents lists available at ScienceDirect

Journal of Rock Mechanics and Geotechnical Engineering

journal homepage: www.rockgeotech.org

Full length article

Influence of fabric anisotropy on seismic responses of foundations

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ARTICLE INFO

Article history:
Received 2 January 2015
Received in revised form
9 February 2015
Accepted 12 February 2015
Available online 23 February 2015

Keywords:
Soil mechanics
Angular sand
Centrifuge modeling
Fabric anisotropy
Seismic response

ABSTRACT

Earthquakes, as one of the well-known natural disasters, are highly destructive and unpredictable. Foundation failure due to liquefaction induced by earthquakes can cause casualties as well as significant damage to the building itself. Fabric anisotropy of soil grains is considered to be an important factor in dynamic soil response based on previous researches and laboratory tests. However, the limited availability of real physical data makes it less persuasive. In this study, a shake table installed on a geotechnical centrifuge is used to provide the designed seismic motions, and therefore, to simulate the realistic earthquake motion to foundations. Important parameters in the responses such as acceleration, excess pore pressure and deformation are evaluated to investigate the influence. Implications for design are also discussed.

1. Introduction

Earthquakes, like other major natural disasters, can impact people's lives every year. Structures often suffer serve damage and the induced casualties are huge. During an earthquake, the foundation failure due to liquefaction has been and continues to be a major type of damage. The direct and indirect costs associated with ground failure are enormous.

To better understand the earthquake damage, many researchers attempted to identify the key parameters contributing to the failure. Tokimatsu and Uchida (1990) studied the correlation between liquefaction resistance and shear wave velocity. Seed and Idriss (1971) developed a simplified procedure to evaluate liquefaction potential of soils, which became a standard procedure throughout North American and much of the world. In addition, Seed et al. (1983) found that anisotropy is one of the most important factors that influence strength, bearing capacity and liquefaction resistance of sand. Anisotropy means that the properties of soil are directionally dependent, and in most cases, is the result of weathering of hard rocks or sedimentary bodies (Brewer, 1964). Arulanandan et al. (1979) is one of the few researchers who worked on dynamic problems associated with fabric anisotropy. Recently, Zeng et al. (2010) conducted research on the effect of fabric anisotropy on seismic response of a retaining wall.

In this context, two groups of centrifuge tests were conducted on modeling dry and saturated sand samples in order to analyze the influence of fabric anisotropy. Shallow foundations were used in the tests. They are usually embedded in about 1 m soil. Three foundation shapes were selected, including regular rectangular foundation, circular foundation and multi-circular foundation. Pictures of model foundations are shown in Fig. 1.

2. Facilities and instrumentation

2.1. Centrifuge and control system

The Case Western Reserve University (CWRU) geotechnical centrifuge is located in a below-ground open and square chamber with a height of 1.8 m and sides of 4.2 m. The construction began at 1996 and completed in 1997. It is surrounded by 15 cm thick reinforced concrete walls and support slab. The control room floor level is raised about 1 m above that of the laboratory to provide additional safety.

The payload capacity is 20 *g*-t with a maximum acceleration of 200 *g* for static tests and 100 *g* for dynamic tests. The centrifuge arm has a radius of 1.07 m while the dual platforms lie at a radius of 1.37 m. By using the dual platforms, two models can be set up at the same time with a maximum payload of 182 kg.

In dynamic test, it is customary to have only one model, and the centrifuge arm is balanced by adjusting the counterbalance weights on the swing platform which is opposed to the testing platform. The

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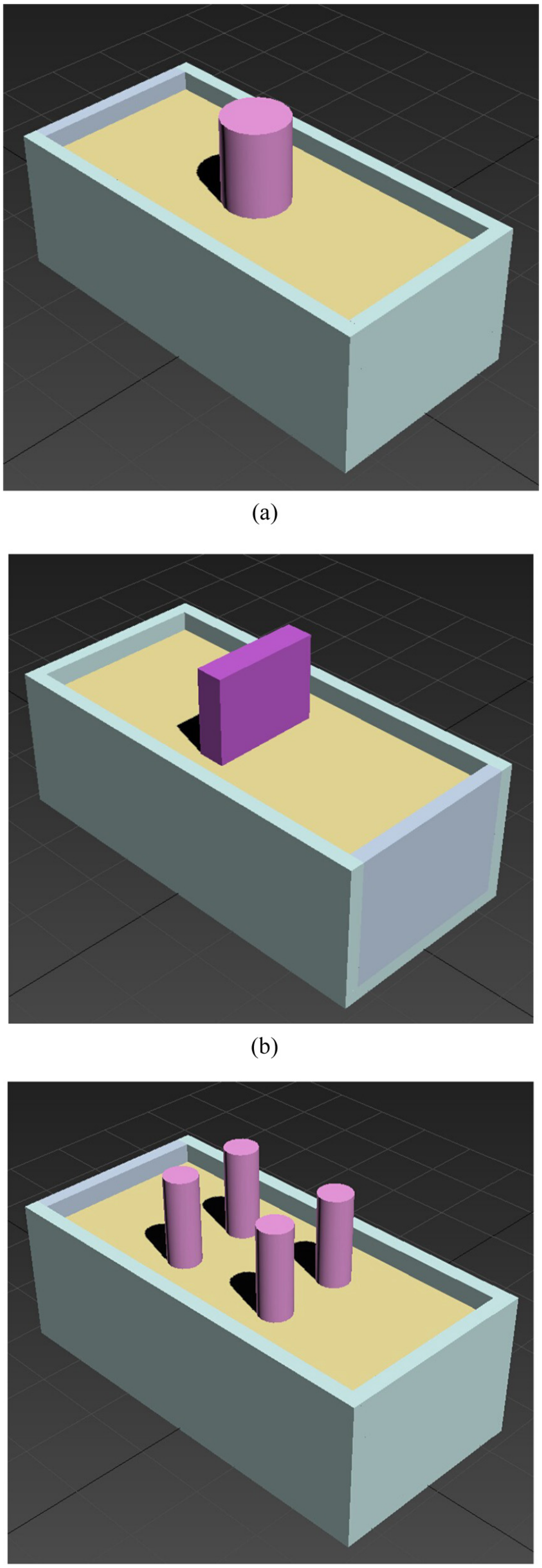
Peer review under responsibility of Institute of Rock and Soil Mechanics, Chinese Academy of Sciences.

http://dx.doi.org/10.1016/j.jrmge.2015.02.003



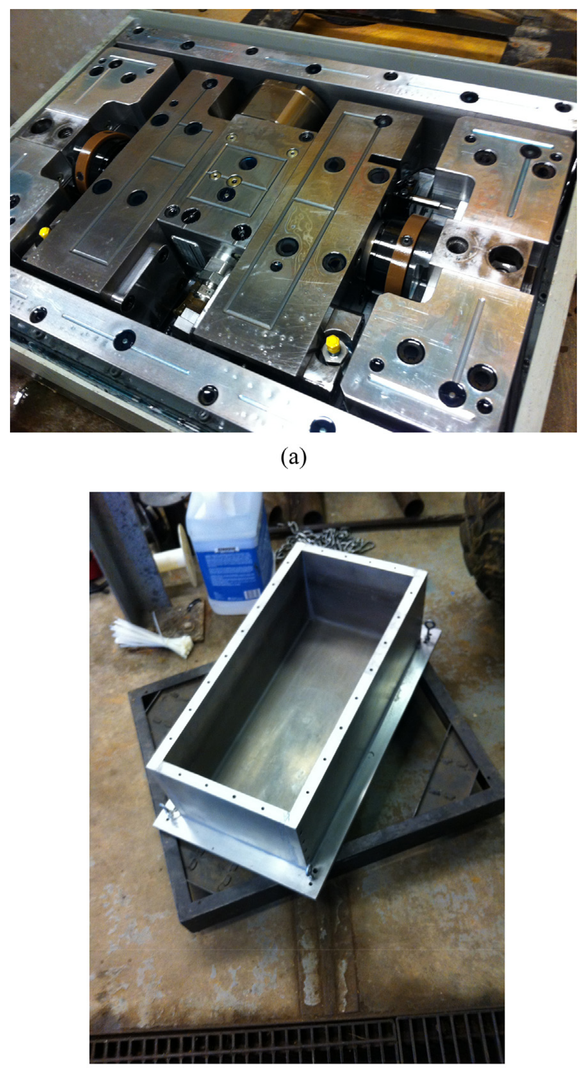
(a)

(b)

(c)

Fig. 1. Model foundations. (a) Circular foundation, (b) Rectangular foundation, (c) Multi-circular foundation.

Fig. 2. CWRU geotechnical centrifuge.



(a)

(b)

Fig. 3. (a) Electro-hydraulic shaker on centrifuge and (b) model container.