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EFFECT OF CYCLIC LOADING DIRECTION ON SANDY SLOPE LIQUEFACTION

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INTRODUCTION

This article investigates the effect of cyclic shear loading direction, produced by earthquake on liquefaction resistance of a sandy carbonate slope (material obtained from Hormuz Island).

Presence of slopes produces initial static shear stress which may have different orientations with cyclic earthquake loading. In this paper, an experimental study performed cyclic undrained constant volume bidirectional simple shear test accomplished on reconstituting cylindrical specimen prepared by the dry pluvial deposition method.

Results published by Lee & Seed (1967), Vaid & Chern (1985) and Andersen & Hoeg (1992) showed that the cyclic resistance of the sands could decrease or increase in slopes based on the amount of the initial static shear value and specimen density. Yang & Sze (2011) studied the three factors of density, vertical stress and initial static shear on liquefaction behavior of silica sands independently and showed that in a constant relative density the value of static shear plays a considerable role in the dynamic behavior of sands.

Li et al. (2016) examined the effect of initial static shear produced by slopes on the monotonic behavior of silica sands under different conditions of stress and density; they found out that the monotonic behavior of sands varies based on the angle between monotonic loading direction and the initial static shear stress direction. Besides, Boulanger & Seed (1995) and Kammerer (2002) examined the effect of initial static shear on cyclic behavior of silica sands and concluded changing direction affects the liquefaction resistance and its behavior.

APPARATUS

Tehran University multidirectional cyclic simple shear device (MCSSD) which is used in this research is demonstrated in Figure 1 with its components. Monotonic and cyclic loading can be provided in three independent directions (X, Y, and Z in Figure 1) by hydraulic actuators and servo-controlled valves. With the programmable computer software which controls Servo-valves and actuators, various irregular stress paths can be imposed on the sample. Two orthogonal shear loads and one normal axial force can be applied to the Kjellman type shear box.

TEST PLAN

In this paper, the effect of initial static shear produced by slope and cyclic loading direction on the liquefaction resistance of Hormuz carbonate sand is investigated by a series of bidirectional cyclic simple shear tests. In order to achieve this purpose, different initial static shear stress ratios ($SSR = \tau_{st}/\sigma_v$) equal to 0, 0.1 and 0.29 are applied on loose (30%) and dense samples (75%) in four different cyclic shear direction angle (0, 30, 60, 90). Stress paths on soil samples are presented in Figure 2.

Figure 1. The multidirectional simple shear device which is used in this research.

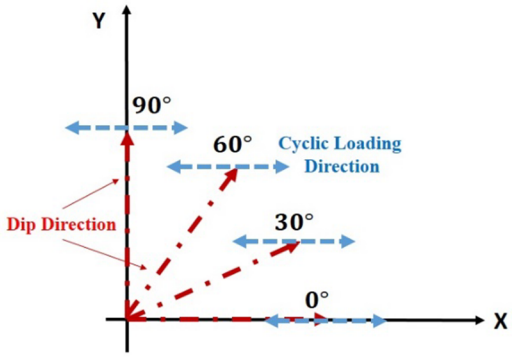

Figure 2. Stress paths on soil samples including the first static shear stress followed by undrained cyclic loading.

RESULT

Due to frequency variations and complicated cyclic loading in nature, it is challenging to simulate the same real condition for specimens in the laboratory. Hence in most studies, the equivalent harmonic loads are used just in the same direction of slopes. In this study, a multi-directional simple shear machine has been used to investigate the effect of loading orientation changes on carbonate sand. In order to eliminate the deficiency in technical literature, cyclic and initial static shear with different orientation angle (0, 30, 60, and 90) has been tested in this research. The results show that maximum liquefaction resistance occurs at a 90-degree angle. It means that when cyclic loading direction is perpendicular to dip direction, maximum liquefaction resistance happened.

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