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Liquefaction potential of clean and silty sand

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Abstract

Soil liquefaction is one of the most interesting and complex phenomena studied in geotechnical earthquake engineering. The liquefaction resistance of a saturated fine to medium sand mixed with varying amounts of non-plastic fines was evaluated by laboratory cyclic triaxial tests at same relative densities and a constant confining pressure. The test results were used to conclude on the effect of low non-plastic contents (0 to 20%) and grading characteristics on the liquefaction resistance of the sand. The test results indicate that the undrained residual strength reduced with the increase of non-plastic fine content. Also, shear strength of gap graded sand mixed with low non-plastic fine content increases with decrease in effective size (D_{50}). In other words, in this state, we can use the D_{50} as a parameter to control of silty sand's undrained resistance. Besides, the undrained residual strength of pour sand specimens with same effective size increases due to increase of coefficient of uniformity (Cu).

Keywords: Liquefaction, Silty sand, Shear resistance, Grading characteristics, effective size

1. INTRODUCTION

Liquefaction of saturated granular soils during earthquakes has been one of the most important and challenging problems in the field of geotechnical earthquake engineering. During earthquakes, the ground shakes, causing cohesionless soils to lose their strength and behave like a liquid. This phenomenon is called soil liquefaction and occurs due to an increase in the excess pore water pressure and a corresponding decrease in the effective overburden stress in a soil deposit and will cause the settlement of buildings, landslides, the failures of earth dams, or other hazards.

Although more than 60 years that the focus of the researches has been on the phenomenon of liquefaction, but large part of these researches has been done on the clean sands, assuming that the behavior of clean sand can be generalized to the natural sands such as silt sand. In fact, most of these researchers believed that firstly plastic fines in sand lead to the increase of the undrained shear resistance (Ishihara and Koseki, 1989; Yasuda et al., 1994) and secondly existence of the silt in sand does not affect the sand residual resistance, because silt fines are similar to sand grains and do not have magnetic forces on their surfaces (Ishihara, 1993). Various tests on different sands have confirmed the first part of idea mentioned above which is based on shear resistance of sand improved by increased amount of plastic fines in sand. The reason behind this issue is due to the fact that liquefaction is so state that increase of pore water pressure causes grains to separate and also sand grains are suspended, but the existence of plastic fines in the soil with magnet forces in their surface causes to situation of almost constancy of grains. Hence, more amount of plastic fines in sand causes the improvement of the undrained shear resistance. However, researches have not confirmed the second part of idea mentioned above; these researches showed that the behavior of clean sand in comparison with sand–silt mixtures is completely different. Yet, there is a disagreement over this difference so that some believed silt in the sand reduces undrained resistance of sandy-soil mixtures (Chang et al., 1982), while others had dissenting opinion (Vaid, 1994; Tronsco and Verdugo, 1985), but Lade and Yamamuro (1997) obviously showed, having performing the tests, that the increase of silt in sand remarkably leads to the decrease in undrained resistance of sand–silt mixtures at constant total void ratio. They justified their reasoning by saying that when an amount of silt is added to sand, a part of silt will be placed in void within the grains, so this amount of silt does not have considerable effect on soil behavior. On the other hand, a part of silt that is placed in contact surfaces of sand grains leads to separation and sliding the grains during loading. This leads to the increase of soil compressibility and the decrease of soil undrained resistance. Polito (1999) modified viewpoint of Lade and Yamamuro (1997) showing that the increase of silt in sand to the threshold value ($FC_{th} \approx 35\%$) reduces undrained resistance of silt sand, but after this the increase of silt improves undrained resistance at constant void ratio (Fig. 1). Thevanayagam et al. (2002) stated that silt fines