An Experimental Study on Liquefaction Strength Property of Improved Sand by Micro-Particles

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ABSTRACT

In this study, micro-particles with several tens μm in diameter were investigated as a reasonable grouting material for liquefaction countermeasures. It was presumed that sand’s liquefaction resistance in loose sand or gravel ground was able to be reinforced when being improved by injecting micro-particles without breaking the soil skeleton. Whereas, the mechanism of improved effect by permeating micro-particles is still unclear. Therefore, in order to confirm the improved effect of micro-particles, the static and dynamic triaxial tests of the improved specimens were carried out in this report. From the results of these tests, it was suggested that the factors of improved effect by micro-particle were both increase of apparent cohesion and improvement of characteristics of dilatancy.

KEY WORDS: Micro-particle; Liquefaction countermeasure; Triaxial test; Permeation grouting

INTRODUCTION

In Japan, large earthquakes have occurred every few years such as the 2011 Tohoku earthquake and the 2016 Kumamoto earthquake. These earthquakes caused liquefaction in urban area. In particular, liquefiable alluvial ground and reclaimed land have received serious liquefaction damage. Therefore, it is necessary to take an efficient countermeasure against liquefaction urgently in such grounds. Although conventional countermeasures such as a sand compaction pile method provide a loose ground with durability, these methods are applied only to important structures and buildings. The reason is that they need high cost and large machines. On the other hand, a grouting method has an advantage that it utilizes small-facilities for the construction and produces less construction byproduct. A chemical grout (Yonekura et al., 1992) or a very fine cement grout (Zebovltz et al., 1989) is widely used as an effective injection material of grouting method. Their long-term durability and strength have been verified through previous laboratory tests and field experiments, (Nakayama et al., 2013; Fukushima et al., 1998). In addition, newly-developed suspension grouts such as an ultrafine cement grout with an average size of 1-3 μm (Koizumi et al., 2012) and a superfine spherical silica grout with sub-micrometer scale (Yamada et al., 2010) can be permeated in relatively fine sand. The durability and performance of these grouting materials are as high as those of conventional cement grout. However, it is difficult to apply them to individual existing buildings because the costs are still high. Therefore, relatively reasonable micro-particle which cost is lower than other material was adopted in this study. The improvement effect is to increase the density of sandy grounds by permeating the micro-particles. Fig.1 shows the mechanism of ground improvement by micro-particles. According to F.L method which is a simple ground liquefaction evaluation method (Architectural Institute of Japan, 2008), liquefaction resistance strength increases according as fine-grained soil fraction increases. On the contrary, several studies reported that the liquefaction resistance of the sand containing non-plastic fines became smaller than the sand without non-plastic fines (Chang et al., 2008; Kuwano et al., 1993; Sato et al., 1997). According to some literatures (Sato et al., 1997; Yoneda et al., 1993), it is said that this result on the non-plastic fine containing sand