Feasibility Study on Countermeasure against Liquefaction Using Micro Bubble

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ABSTRACT

A micro bubble is an independent bubble of 10~100μm in diameter. A soil improvement method using the micro bubbles is a newly developed technology injecting water containing micro bubbles into ground. The method provides not only a cost-effective and simple countermeasure against liquefaction but also an environment benefit. The feasibility of the micro-bubble injection method proposed was examined by conducting a series of triaxial tests and a series of laboratory column tests. From the results, the effectiveness of the micro bubble injection method was confirmed.

KEY WORDS: Soil liquefaction; Micro bubble; Unsaturated sand; Liquefaction strength

INTRODUCTION

A major earthquake has occurred repeatedly in Japan, and there are many important infrastructures in high risk area of liquefaction such as alluvial plain or coastal reclaimed land. These areas are concerned about large-scale liquefaction damage by earthquakes, because the soft ground has been accumulated loosely. Therefore, it is necessary to devise the countermeasure against liquefaction. A sand compaction pile method or a chemical grouting method and so on were historically employed for its countermeasure. In fact, these methods have been used for important structures and buildings. However, most of high risk areas of liquefaction still remain not to be reinforced by such countermeasures. One of the reasons is that these conventional methods are high cost. To promote to enhance earthquake safety of the high risk urban area, selections of countermeasures against liquefaction should be increased so that they can respond to every situation such as type of structures, its important degree, cost and required performance.

The soil improvement method using the micro bubble water is expected to increase the lineup of liquefaction countermeasures because it has simpler procedure, lower cost of material used, and higher cost performance than any other methods. And also, in ecological aspect, the method will provide better performance.

In this paper, the feasibility of the micro-bubble injection method proposed was examined by conducting a series of triaxial tests to specimen improved by the method and a series of laboratory column tests to confirm the mechanism of decreasing the saturation degree of ground by injecting the micro bubbles.

MICRO BUBBLE INJECTION METHOD

It is well known that liquefaction resistance of a soil increases with decreasing the saturation degree of the soil (Yoshimi et al, 1988), and decreasing the saturation degree of ground can prevent infrastructures from liquefaction damage. Therefore, a countermeasure against liquefaction by feeding air into ground and decreasing the saturation degree of ground is expected as a method to solve some problems on liquefaction countermeasure, which are including high cost, environmental defect and limited construction space.

A micro bubble injection method proposed here is one of the countermeasures by feeding air into ground. In the method, a micro-bubble water, which is the water containing a lot of air bubbles with a diameter of 10~100 micro-meters, is injected into ground. Because of its quite small diameter, the micro bubble can retain submerged for several tens of minutes. The mechanism of decreasing the saturation degree of ground by the micro bubble injection method is thought as follows. Most of bubbles can easily permeate into voids among sand particles because of its small diameter. Some of bubbles, however, are