Permeation of Ultra-Fine Particle Cement to Sandy Ground and Cement Stabilization

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ABSTRACT

This paper describes study on permeation of ultra-fine particle cement grout to sandy ground. The cement grouting method was one of the improvement methods to strengthen the sandy ground. However, the conventional cement grout was difficult to permeate into sandy ground. The purpose of this study is to clarify the permeation of the ultra-fine particle cement grout, the shape and strength of the cemented sandy mass. The author conducted both column and model ground injection tests to examine the permeability of ultra-fine particle cement. As a result, ultra-fine cement grout had high permeability against finer sand and the stabilized area was wider. Furthermore, the strength of the improved ground was higher than that of normal Portland cement.

KEY WORDS: ultra-fine particle cement, ground improvement, cement stabilization, sandy ground, penetration behavior.

INTRODUCTION

Large liquefaction disasters were reported in recent big earthquakes such as, the 2011 Tohoku earthquake (Bhattacharya et al., 2011) and the 2018 Hokkaido Iburitobu earthquake (Serikawa et al., 2019). In the liquefaction disasters, many houses were damaged due to the unequal settlement and the lateral slide of ground. Large area ground improvement was carried out in Urayasu city after the 2011 Tohoku earthquake to restore the damaged ground (Sato, 2017). The cost of ground improvement is too expensive for the personal expense. Therefore, the effective and economical ground improvement techniques were eager to develop.

The cement grouting method is one of the ground improvement methods, the injectability of cement grout is restricted by the size of voids in sandy soil because the grout material contains particles of cement. Ultra-fine particle cement is one of the grout materials that permeates well into sandy ground and has excellent strength. Although the ultra-fine particle cement has the smaller particle size than that of normal Portland cement, its permeation behavior and the shape of the cemented mass in the ground are unknown. Therefore, in this study, the author carried out a series of column penetration tests and small size injection tests into the sandy model ground. The permeation behaviors of ultra-fine particle cement and the shape of cemented mass are compared with different size of sandy ground.

ULTRA-FINE PARTICLE CEMENT GROUT

Cement Grouting

Cement grouting fills cracks or voids in soil and rock and permeates granular soils to create a cemented mass as shown in Fig.1. The popular uses of cement grouting were to create barriers to groundwater flow, underpin foundations, provide excavation support, stabilize and strengthen sandy soils. The cement grouting was also known as slurry grouting, it fills voids in sandy soils with flowable cement grouts. The grout particle size of cement grout and void size of soil must be matched properly to allow the cement grout to permeate (see in Fig.1(b)). Depending on the ground conditions, normal Portland cement or fine cement grout is injected under pressure at strategic locations. The cemented soil mass has a high strength/stiffness and reduced permeability.

Cement grouting sometimes has an economic advantage for underpinning applications over alternative approaches such as removal and replacement or piling, and it can be applied in cases of difficult access and limited spaces. The cement grouting is expected as the liquefaction countermeasure (Gallagher and Mitchell, 2002). Since the effectiveness of cement grouting is independent of structural connections, this technique is readily adaptable to existing foundations of buildings and can typically be accomplished without disrupting underground installations. Also, the cement grouting is applicable for the living houses without removal and relocation works. Therefore, the cement grouting is expected as the liquefaction countermeasure for personal houses, because of the low cost and the high applicability.

Ultra-Fine Particle Cement

In this study, normal particle size cement (average particle size bigger