Fundamental Study of Application Sodium Silicate-Based Chemical Grouting to Indonesian Soil

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1. Introduction

Chemical grouting is a method of chemical material injection into the ground to prevent ground water flow and/or reinforcement of underground soil/rock. The advantages of this method are such as lower viscosity and faster improvement yet has shrinkage behavior which is suitable for overcoming impermanent work cases. However, environmental consideration is sensitive issue due to accidents occurred in the past decades involving acrylamide type chemical grouting. From this point of view, less toxic sodium silicate chemical grouting type was used on the application in Indonesia, by virtue of infrastructure development increasing and the past accident that also occurred in this country. Based on these reasons, study of sodium silicate type chemical grouting's effectiveness and safety were conducted.

2. Materials and Methods

Table 1 Chemical Grouting Components

Grouting Type	Sodium Silicate		Reactant 1	Reactant 2
			$NaHCO_3$ (60-80%)	$NaHCO_3$ (40-60%)
			$KHCO_3$ (10-30%)	$KHCO_3$ (40-70%)
	(% wt)	(% Vol)	(% wt)	(% wt)
Type 1	25.08	25	4.5	-
Type 2	25.31	25	-	2.9

Two types of sodium silicate-based material, as required in field work, was used as main chemical grouting materials (Table 1). A sequence of experiments was conducted in order to obtain chemical grouting properties and grouted-soil characteristics, such as gelling time, solidified pH, viscosity, bleeding ratio, uniaxial compressive strength and hydraulic conductivity tests, completed by scanning electron microscope (SEM) and thin section analysis for mechanism explanation. In order to clarify safety of the grouting application, leaching test, ion chromatography (IC) and inductively coupled plasma (ICP) were conducted. In this study, we consider river sand from Japan for characterization experiments and three main types of Indonesian soils, they are rock sand, beach sand and volcanic sand. Based on result of experiment that had been conducted aforementioned, a field experiment test was conducted to confirm performance in the site. The tests that have been carried out in field experiment are geo-electric and bore hole profile analysis to ensure the suitability of test area, soil penetration test and recovery-pumping test to ensure the improvement performances, as well as pH monitoring for 6 months to measure pH change, and AAS to confirm the element content.

3. Results and Discussions

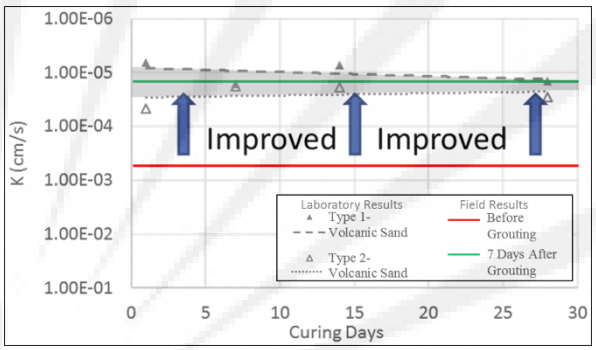

Figure 1 Hydraulic Conductivity Improvements in Field Tests

Characterization Experiments: The results show the difference gel character between chemical grouting Type 1 and Type 2. In chemical grouting properties test result, it was obtained that Type 1 has faster gelling time, higher pH, lower bleeding ratio and more solid gel appearance than that of Type 2. It strongly affected by reactants amount and compounds. However, in injection into soil, the grouted soil of Type 2 generates stronger grouted-soil than that of Type 1. It relates to leaching of K^+ which is in consonance with strength improvement decreasing of chemical grouting. It is caused by larger surface contact area to the grain of Type 2 as observed from SEM analysis. Moreover, according to thin section analysis, porosity sealing characteristic difference is obtained between Type 1 and Type 2 which influences hydraulic conductivity improvements. Regarding to the environmental issue, according to leaching test, water samples of grouted-soil samples show higher pH value due to high alkalinity of chemical grouting. However, the leached metal shows insignificance leaching. High amount of Na^+ and K^+ leaching also occurred due to chemical grouting content, yet known as harmless elements.

Application on Indonesia Soil Experiments: Good improvements were shown on the results that influences by several factor of sand characteristics. In case of strength improvement, the grain surface character has important role that differentiate the improvement of Indonesian soils. Besides, shape of grains also influences the improvement of hydraulic conductivity. In case of leaching behavior of Indonesian soils, it was found similar pattern of pH; pH increases with relatively same value even with higher pH of Indonesian soil compare to characterization test result. It indicates that the increasing of pH is purely influenced by chemical grouting. The amount of metal leaching is also shown insignificant different with the presence of chemical grouting, yet the cation and anion leaching shows higher amount which is affected by the sand contains.

Field Confirmation Tests: Field test scale result shows coherent hydraulic conductivity improvement with laboratory scale, which can be seen in Figure 1. However, it is difficult to obtain the strength improvement from SPT test due to large gravel contains on the soils. The result of field test shows the increasing of pH but insignificance. Furthermore, there are increasing of leached element yet still low.

4. Conclusion

Characteristics of sodium silicate-based chemical grouting shows beneficial improvement to be applied on Indonesian soil, which is proven by using several sands types. Field confirmation results convinced both safety and improvement by using this method.