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Study On Compressive Strength Of Micro-jet Grouting Columns By Physical Modeling

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ABSTRACT: Jet grouting method is considered as one of the most widely used improvement methods among the others and is applicable in most geotechnical problems such as increasing bearing capacity, reducing settlement, creating seals, stabilizing slopes, etc. One of the challenges faced by designers is finding the strength and geometry of the elements made using this method. The most effective components in the resistance of jet grouting columns are the type and parameters of injection, soil characteristics (such as aggregation), the amount of cement inside the sample, water to cement ratio of slurry, the type of cement and the method of sampling (coring or wet sampling). In this paper, after the construction of small scale jet grouting columns (micro jet grouting volumns) in the laboratory and taking core of them, the impact of various factors such as the effect of construction speed, the position and direction of coring, as well as the effect of coring operation on unconfined compressive strength is studied. Also, the point load test was used to study more about the strength parameters of the microjet grouting columns. Based on the results, the compressive strength of microjet grouting columns is high (approximately up to 59 MPa), and these values are confirmed by the point load test. It was also observed that with increasing speed of soil-cement columns construction, compressive strength decreases. Based on the compressive strength results, it is found that coring operation reduces resistance by 60%. Also, the cores taken in the horizontal direction showed about 33% less uniaxial compressive strength than the vertical cores and cores taken from the upper parts of the columns have more compressive strength.

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1. INTRODUCTION

Jet grouting is a method of soil remediation in which high-pressure water or slurry is injected from the nozzles into the soil, damaging the soil structure and causing soil-cement composition [1]. This method can improve the mechanical and physical components of a wide range of cohesive and granular soils. Also run in different horizontal, oblique and vertical directions and create different shapes such as seal curtains, columns and rigid blocks and be constructed in restricted positions such as adjacent buildings. This technique is sometimes lightweight and low volume equipment [2] and costs less than other injection methods in terms of effectiveness and improvement of soil parameters [3].

Physical modeling is a very important and efficient tool in geotechnical engineering, which, depending on the geotechnical conditions of the phenomenon under investigation, if done correctly,it can increase confidence in developing a theoretical model [4]. Therefore, a laboratory-scale Jet Grouting capability was developed at the Iran University of Science and Technology [5].

Two parameters of resistance and the geometry of the jet grouting element are of great importance in the design of jet grouting. According to Slizyte et al., And based on previous research by researchers, soil-cement compressive strength generally depends on four factors of soil type, cement content, water-cement ratio, retention time [6]. The amount of cement in the improved soil has a great impact on its strength. This has a direct impact on costs and should be considered to optimize the project and to balance the cost and the amount of resistance [7]. Kirsch and Sondermann stated that when cement is used for jet grouting and the cement content in the body is about 150 to 400 kg/m^3, the following values can be considered for unconstrained compressive strength of the soil [8]:

$$\text{In the sand and gravel:} \quad q_u = 1.0 \ to \ 15.0 \ MPa$$
$$\text{In the silt and clay:} \quad q_u = 0.5 \ to \ 3.0 \ MPa \qquad (1)$$

The purpose of this study is to investigate the effect of some variables such as run speed, change of height and coring direction on the compressive strength of the specimens, as well as to investigate the dependence of the parameters and the relationship between the physical and mechanical properties of the soil-cement columns made with a micro jet grouting. Based on the simple regression analysis performed on the data of this study and data provided by other researchers, relationships for sand and silt were obtained.

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Fig. 1. Micro-jet grouting machine with steel enclosure and its [5]transmission system

Fig. 2. Columns inserted in the box for curing

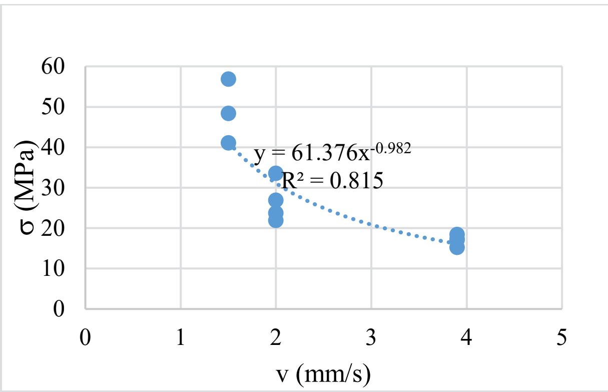

Fig. 2. Changes in run speed and compressive strength of micro-jet grouting columns

2. METHODOLOGY

In order to construct laboratory-scale jet grouting columns, a micro-jet grouting machine manufactured at Iran University of Science and Technology, a mixer, slurry pump and steel enclosure were used. The image of the device in position on the steel housing is shown in Fig. 1.

The soil materials used in this study are 161 silica sand of Firoozkooh. Drinking water and Portland Type 2 cement were used to make cement slurry. The weight ratio of water to cement (w/c) was 1 in all micro-jet grouting columns.

The dry soil mass with a relative density of 27-33% was deposited in a steel chamber for the purpose of jet grouting operation. After adjusting the drill rod to the desired point, the drilling was rotated and then injected by jet grouting through a 1.5 mm diameter nozzle at 6 bar pressure during drilling and raising the drilling head. In order to construct jet grouting columns in laboratory scale, different speeds of drilling rod rise during injection were used. After the columns were curing (Fig. 2), coring and capping were performed on them.

3. DISCUSSION AND RESULTS

A uniaxial compression test was performed on 14 cores taken from micro-jet grouting columns in both vertical and horizontal directions. The lower part of the two columns were also inserted directly under the pressure jack with respect to the length-to-diameter ratio of 2. The purpose of this work was to investigate the effect of coring on compressive strength.

Fig. 2 illustrates the relationship between the execution speed (v) against the uniaxial compressive strength (σ).

According to Fig. 2, it is observed that with decreasing speed of compression, the compressive strength increases markedly. The reason for this increase in resistance can be attributed to the increase in the amount of slurry injected into the soil. The average compressive strength at 1.5 mm/s rise rate was 175% higher than the average compressive strength at 3.9 mm/s rise speed.

4. CONCLUSIONS

In this study, the compressive strength of fabricated specimens was investigated by the development of a laboratory-scale high-pressure jet grouting machine. For this purpose, the columns were first constructed in sandy soil in the laboratory. The following results were obtained from these experiments:

1. Based on the results of unconfined compressive tests, the amount of compressive strength in the cement soil samples varied from 15.57 to 59.9 MPa. The results also show that as the column speeds up, the compressive strength decreases due to the decrease in the amount of cement injected into the soil. According to the obtained relation, the trend of decreasing resistance with increasing speed of construction was observed exponentially.
2. The average compressive strength of the vertical cores was 26.53 MPa (columns made when the average raising velocity was 2 mm/s) and the mean compressive strength of the cores was 17.9 MPa. By comparing these two numbers, the vertical core strength is 1.5 times the average compressive strength of the lateral specimens.
3. Based on the results, the resistivity parameters in the upper part of the column have relatively higher values. For example, in two columns, the compressive strength was about 38.5 to 42 percent higher in the upper than in the lower part. This increase in resistance may be due to the

effects of effluent during the top portion of the sample and the washing of the soil particles. The bottom of the two micro-jet grouting columns from the top of the core was inserted without jacking. Based on the results, it was found that the samples with no coring have a resistance of 2.7 to 3.27 times that of cores, which is a considerable amount. This result could explain the destructive effects of coring stresses on reducing the strength of the control sample.

4. Based on the results of the point loading test, the high compressive strength values obtained from the uniaxial compression test were confirmed.

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