Available online at www.sciencedirect.com

ScienceDirect

Procedia Earth and Planetary Science 15 (2015) 299 – 303

Procedia
Earth and Planetary Science

World Multidisciplinary Earth Sciences Symposium, WMESS 2015

Multiple Regression Model for the Prediction of Unconfined Compressive Strength of Jet Grout Columns

Recep Akan[a]*, S.Nilay Keskin[a], Soner Uzundurukan[a]

[a]*Suleyman Demirel University, Faculty of Engineering*

Abstract

Jet grouting is one of the most widely used techniques in soil improvement because of its possibility to strengthen cut-off groundwater and provide structural rigidity with a single application by this technique. The effectiveness of the jet grouting process influenced by many factors or application parameters such as soil properties, lifting (withdrawal) and rotation speed, grout/water/air pressure, etc. Jet grout column properties (diameter and mechanical properties) are the most important parameters for designing the project. There is still no credible method that can predict the properties of jet grout columns before field application, except extreme secured empirical rules and designers generally assume the characteristics of jet grout columns by perception. This process may cause waste of time and money due to inconsistency between assumed and observed properties of jet grout columns. In the present study, it was aimed to establish a model predicting the unconfined compressive strength of jet grout columns by using multiple linear regression analysis to overcome this problem.

Peer-review under responsibilty of the Organizing Commitee of WMESS 2015.

Keywords: Jet grouting; regression model; grout column;

1. Introduction

Soil improvement methods are used when the soil doesn't provide required criteria for geotechnical design of any engineering applications. Improvement methods can be categorized as compaction, stabilization, reinforcement, grouting, drainage, etc. (Jaritngam, 2003). Jet grouting method that is one of the most widely used grouting methods has been used for half a century in order to improve insufficient soil properties (Laefar et al., 2009; Flora et al., 2013). This method has use of applications in construction of seepage barriers, reinforcement of foundations and

* Corresponding author. Tel.: +90 246 211 11 97.
E-mail address: recepakan@sdu.edu.tr

Peer-review under responsibilty of the Organizing Commitee of WMESS 2015.
doi:10.1016/j.proeps.2015.08.072

retaining walls, tunnel supports, slope stabilizing and getting hazardous wastes under control (Bell et al., 2003 ; Jartingam, 2003 ; Flora et al., 2013).

Jet grouting method relies on the principle of creating a column called "soil-crete" in soil by eroding the unimproved soil with high pressured grout is generally water-cement mix. As first step, soil is drilled to the desired level and the rods push up till the requested level while rotating and injecting high pressured fluids as grout, air or water (Tinoco et al., 2011; Shen et al., 2013). It is possible that jet grouting columns may be generated quickly by this technique with its slight equipment in almost every kind of soils as long as it is able to erode the soil with high pressured fluids (Flora et al., 2013).

This improvement method is possible to be classified up to the number of fluids that are injected into soil. Single fluid system has just a grout, two fluid system has air and grout and three fluid system has air, water and grout as injected fluids (Shen et al., 2013). In jet grouting method, it is very important to determine optimum system to apply and the most effective values of jet grouting parameters such as injection pressure, the number and diameter of nozzles, flow rate, lifting and rotating speed for rods in order to have a successful and economic improvement process (Flora et al., 2013).

Although the jet grouting method is a widely used method, there is still no credible method that can predict the diameter and mechanical characteristics of jet grout (JG) columns, except extreme empirical rules (Tinoco et al., 2011 ; Flora et al., 2013). Because of this need, several studies were performed to have an accurate prediction for diameter and compressive strength of JG columns relative to any of parameters belonging to process by using different methods.

Nikbakhtan and Osanloo (2009) searched the impact of grouting pressure and flow rate on UCS of JG columns. Laefar et al. (2009) explored the act of fine grain ratio of soil on UCS and rigidity of JG columns.

Tinoco et al. (2009, 2011) tried predicting the UCS and Tinoco et al. (2014) attempted to forecast the Young's modulus of JG columns by using three different data mining methods and one analytical method. Nikbakhtan and Ahangari (2010) presented the relation between UCS and diameter of JG columns and water-cement ratio and rotation-lifting speed of rods. Shui- Long Shen et al. (2013) studied the determining of the diameter of JG columns by an analytical method and Flora et al. (2013) studied the same by using a numerical method differently.

In this study, it was aimed to predict the UCS of JG columns and to determine the effects of grouting parameter by using multiple regression analysis by means of some parameters such as grouting pressure, rotation-lifting speed, water-cement ratio and water flow rate used in this improving method. The data used in analysis were taken from Nikbakhtan and Ahangari (2010). The results are presented as tables and graphs and discussed.

2. Data and method

2.1. Data

The data used in this study were taken from Nikbakhtan and Ahangari (2010), which is a case study about soil improvement by jet grouting method in a clayey soil. Data comprises the application parameters and UCS of eighteen different trial jet grout columns. Ranges of the data in analysis are summarized in Table 1.

Table 1. Ranges of the data used for MLR analysis.

Model Parameter	Symbol		
		Maximum Value	Minimum Value
Grout Pressure (MPa)	GP	16	4.5
Lifting – Rotate Speed (cm/min)	LRS	7 .5	5
Cement- Water Ratio	CW	1.42	1
Water Pressure (bar)	WP	400	70
Water Flow (l/min)	WF	375	75
Unconfined Compressive Strength (MPa)	UCS	3.37	0.9

2.2. Multiple Linear Regression Analysis

In engineering and science, many problems involve investigating the relationships between two or more variables. Multiple linear regression (MLR) is a linear statistical technique that is very beneficial for predicting the best relationship between a dependent variable and several independent variables (Giacomino et al., 2011;Agha and