AIN SHAMS UNIVERSITY
FACULTY OF ENGINEERING

SOIL IMPROVEMENT USING REINFORCED GRANULAR COLUMNS

A THESIS

SUBMITTED IN FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF DOCTOR OF PHILOSOPHY IN STRUCTURAL ENGINNERRING

By
Mohammed Gamal EL Din Labeeb EL Kaissouny

Supervised by

Prof. Dr. Mona Mostafa Eid
Prof. of Geotechnical Engineering
Department of Structural Engineering
Faculty of Engineering
Ain Shams University

Dr. Hesham Mohamed Helmy
Associate Prof. of Geotechnical Engineering
Department of Structural Engineering
Faculty of Engineering
Ain Shams University

Cairo
2014

STATEMENT

This dissertation is submitted to Ain Shams University in partial fulfillment for the requirements of the degree of Doctor of Philosophy in Structural Engineering.

The work included in this thesis was carried out by the author in the Structural Engineering Department, Ain Shams University.

No part of this thesis has been submitted for a degree or a qualification at any other University or Institution.

Date : / /2014

Signature:

Name : Mohammed Gamal El Din Labeeb El Kaissouny

EXAMINER COMMITTEE

Name, Title and Affiliation **Signature**

1- Prof. Dr. Ahmed Wael El Gamal
Prof. of Structural Engineer
Department of Structural Engineering
University of California, San Diego

2- Prof. Dr.Ali Abdel Fattah Ali Ahmed
Prof. of Geotechnical Engineering
Department of Structural Engineering
Faculty of Engineering-Ain Shams University

3- Prof. Dr. Mona Mostafa Eid
Prof. of Geotechnical Engineering
Department of Structural Engineering
Faculty of Engineering-Ain Shams University

4- Ass. Prof. Dr. Hesham Mohamed Helmy
Associate. Prof. of Geotechnical Engineering
Department of Structural Engineering
Faculty of Engineering-Ain Shams University

Date / / 2014

ACKNOWLEDGMENTS

I would like to express my deep gratitude to **Professor Dr. Mona Mostafa Eid**, Professor of Geotechnical Engineering, Ain Shams University, for her supervision, constant support, scientific assistance and precious advice and strong support throughout all the phase of this research.

Also, very grateful to **Dr. Hesham Mohamed Helmy**, Ass. Professor of Geotechnical Engineering, Ain Shams University, for his inspiration, encouragement, excellent guidance and endless support through all phases of this research.

Finally, deep thanks are dedicated to my Parents , my wife and my sister who continuously supported and encouraged me throughout the course of my tuition period and their prayers enabled me to successfully pursue my study.

Above all, praise and thanks to a gracious and loving **God**, for the strength, hope and mercy provided throughout my life.

Mohammed Gamal El Din Labeeb EL Kaissouny

AIN SHAMS UNIVERSITY
FACULTY OF ENGINEERING
STRUCTURAL ENGINEERING DEPARTMENT

Abstract of the Ph.D. Thesis submitted by:

Eng. Mohammed Gamal El Din Labeeb El Kaissouny

Title of Thesis:

SOIL IMPROVEMENT USING REINFORCED GRANULAR COLUMNS

Supervisors:

1) **Prof. Dr. Mona Mostafa Eid**
2) **Ass. Prof. Dr. Hesham Mohammed Helmy**

ABSTRACT

The stone column technique is suitable for improvement of weak soil as it increases the bearing capacity, reduces the total settlement, and accelerates consolidation settlement due to reduction in flow path lengths. Recently, encasement, besides increasing the strength and stiffness of the stone column, prevents the lateral squeezing of stones when the column is installed even in extremely soft soils. A three-dimensional numerical model using the finite element system ABAQUS was developed to investigate the behavior of encased stone column (ESCs) in soft soil. A series of finite element simulations are carried out to

evaluate the benefits of integrating a high modulus geosynthetic material with the stone column technique for soil improvement. Parametric analyses were carried out to study the effect of different parameters which help in increasing efficiency of the encased stone column technique. These parameters are encased stone column diameter and depth, stiffness and length of encased material, angle of internal friction (φ) of the stone column, and properties of soft clay around the stone column. The results are compared with those obtained from ordinary stone column. In addition, the finite element model for grouping of ESC is noticed to be resilience of fulfilling a limiting displacement criterion under maximum loads and a good bearing resistance of weak soil using different parameters.

CONTENTS

LIST OF FIGURES