

UNIVERSITI TEKNOLOGI MARA

**INFLUENCE OF STONE COLUMN
LENGTH ON CONSOLIDATION
PERFORMANCE OF FLOATING
STONE COLUMN IN SOFT CLAY**

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ABSTRACT

Construction on weak or soft soils often requires ground improvement to ensure stability. Stone columns are effective in enhancing load-bearing capacity, reducing settlement, and accelerating consolidation. When the soft layer is too thick for full penetration, floating stone columns partially embedded columns that do not reach a firm stratum are used. However, predicting their consolidation behavior, particularly in double layered soils, remains challenging as stone column improved layer are having higher stiffness and faster consolidation rate compared to the below untreated layer. This study investigates the consolidation performance of floating stone columns, focusing on excess pore pressure dissipation and stress concentration ratio. A series of physical model tests were conducted on single floating stone columns installed in kaolin clay using a unit cell tank under an applied load of 11 kPa. Column lengths of 0 mm (unreinforced clay), 80 mm, 160 mm, 240 mm, 320 mm, and 400 mm (end-bearing) were examined with area replacement ratios (A_r) of 15% and 33%. Results were validated using PLAXIS 3D finite element analysis. The findings show settlement reduction up to 68.06% and faster pore pressure dissipation with increasing column length. Settlement differences between laboratory and numerical analysis ranged from 3.64% to -9.47% for $A_r = 15\%$ and 9.14% to -7.23% for $A_r = 33\%$. Stress concentration ratios increased with column length and A_r , ranging from 2.01 to 4.51 (laboratory) and 1.68 to 4.59 (numerical). Besides, the lab and numerical result were verified with existing analytical solutions where good agreement were obtained. Finally, a new equation is proposed to predict the settlement improvement factor for floating stone columns.

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TABLE OF CONTENTS

	Page
CONFIRMATION BY PANEL OF EXAMINERS	ii
AUTHOR'S DECLARATION	iii
ABSTRACT	iv
ACKNOWLEDGEMENT	v
TABLE OF CONTENTS	vi
LIST OF TABLES	xi
LIST OF FIGURES	xiii
LIST OF SYMBOLS	xix
LIST OF ABBREVIATIONS	xxi
CHAPTER 1 INTRODUCTION	1
1.1 General Background	1
1.2 Problem Statement	2
1.3 Research Question	4
1.4 Hypothesis	4
1.5 Objectives of Study	4
1.6 Scope of Study	5
1.7 Significant of Study	6
1.8 Thesis Organization	7
CHAPTER 2 LITERATURE REVIEW	8
2.1 Introduction	8
2.2 History of Stone Column	8
2.3 Installation Techniques of Stone Column	10
2.3.1 Vibro-Compaction	10
2.3.2 Vibro-Replacement Methods (Wet top feed)	12
2.3.3 Displacement Methods (Dry top feed)	13

CHAPTER 1

INTRODUCTION

1.1 General Background

The rapid growth of global infrastructure has greatly reduced the availability of suitable land for construction. Consequently, the remaining undeveloped areas often consist of soft soil deposits, which tend to exhibit excessive settlement and have low bearing capacity. This poses a challenge for geotechnical engineers as these weak and compressible soils can reduce the stability of structures built upon them. To address this issue, it is crucial to enhance the properties of soft soils. Various ground improvement techniques are available to strengthen these weak, compressible soils, ensuring they meet the necessary standards for construction.

Among the various ground improvement methods, stone columns are widely recognized as an effective solution for enhancing the performance of soft soils with low bearing capacity. This technology has a proven history of successful applications. The installation of stone column is both quick and straightforward. Most of the deep replacement columns can be used to support industrial, residential, embankments, and roadway widening. This technique not only increases the bearing capacity but also improved the shear strength of the surrounding soil. The interaction between the stone columns and the soil can be described by concept of composite stiffness, characterizes the combined response of both materials under loading conditions.

Stone columns exhibit significantly greater stiffness compared to the surrounding soil, allowing them to support a substantial portion of the applied load. When a load is applied to a foundation, the stone columns act as stiff inclusions within the soft soil matrix. This stiffening effect enables the columns to carry more load while transferring the remaining load to the surrounding soil in a more controlled manner. This increased stiffness is crucial in reducing ultimate settlement, which is a primary concern in foundation design. By distributing loads more effectively, stone columns help mitigate differential settlement and enhance overall stability. The installation of densely compacted gravel columns is the cornerstone of this technique. These columns can reduce the risk of liquefaction which a critical consideration in seismic prone areas. Additionally, stone columns facilitate accelerated consolidation of the surrounding soil,