THE EFFECTIVENESS OF PVD INSTALLATION IN BAUXITE RESIDUE SOIL BY USING PLAXIS 2D FOR SETTLEMENTS ANALYSIS

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DEDICATION

This project report is dedicated to my beloved husband, my lovely kids, my understand parents, my supportive friends and last but not least my helpful supervisor.

The greatest thanks for all of you.

May Allah blessed you.

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"In the name of God, the most gracious, the most compassionate"

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ABSTRACT

The construction of an embankment on soft soil always leads to settlements. Bauxite residue soil has similar behaviour to clayey soils which consider as soft soil. This study focused on the effectiveness of Prefabricated Vertical Drain (PVD) installation in bauxite residue soil for settlements analysis. Data were collected from in-situ investigation and laboratory testing. PVD at different spacing and length have been used to analyse soil settlement and supported by Asaoka method. The results proved that PVD was able to accelerate the consolidation process and suitable to be used as soft ground improvement technique. Different PVD spacing and length affect the soil settlements analysis in term of settlement depth, settlement rate and excess pore water pressure. 0.5 m PVD spacing has fastest achieved required settlements at day 10 and at 13 m PVD length has highest rate dissipation with excess pore pressure 0.0030 kN/m^2. Further studies can be done to propose the practical PVD installation in terms of PVD spacing and length.

ABSTRAK

Pembinaan tambak atau benteng di atas tanah lembut akan menyebabkan berlakunya pemendapan tanah. Tanah bauksit mempunyai sifat yang sama dengan sifat tanah liat di mana tanah liat merupakan salah satu dari jenis tanah lembut. Kajian ini memberi tumpuan kepada keberkesanan pemasangan saliran tegak pra-fabrikasi (PVD) pada tanah bauksit untuk analisis mendapan tanah. Data diperolehi daripada siasatan tanah di tapak dan dari ujian makmal. Saliran tegak pra-fabrikasi (PVD) berbeza jarak dan panjang telah digunakan untuk menganalisa mendapan tanah dan disokong oleh kaedah Asaoka. Hasil dari kajian ini membuktikan bahawa saliran tegak pra-fabrikasi (PVD) mampu mempercepatkan process pembuangan air dan sesuai digunakan sebagai teknik untuk penambahbaikan tanah lembut. Beza jarak dan panjang saliran tegak pra-fabrikasi (PVD) ada memberi kesan kepada analisa mendapan tanah dari segi kedalaman mendapan, kadar mendapan dan lebihan tekanan air liang. Saliran tegak pra-fabrikasi (PVD) pada jarak 0.5 m mampu mencapai mendapan yang diperlukan paling cepat iaitu pada hari ke 10 dan panjang 14 m mampu membuang air paling banyak dengan lebihan tekanan air liang 0.003 kN/m^2. Kajian lanjut boleh dilakukan untuk memberi mencadangkan pemasangan saliran tegak pra-fabrikasi (PVD) yang praktikal dari segi jarak dan panjang saliran tegak pra-fabrikasi (PVD).

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LIST OF ABBREVIATIONS

ASTM	-	American Society for Testing and Materials
BH	-	Borehole
BS	-	British Standard
DS	-	Disturbed Sample
PI	-	Plasticity Index
PL	-	Plasticity Limit
PVD	-	Prefabricated Vertical Drain
PPL	-	Proposed Platform Level
SG	-	Settlement Gauge
SM	-	Settlement Markers
SI	-	Site Investigation
SPT	-	Standard Penetration Test
2D	-	Two Dimensional
UD	-	Undisturbed Sample
USCS	-	Unified Soil Classification System

LIST OF SYMBOLS

c	-	Cohesion
C_c	-	Compressibility index
qu	-	Compressive strength
D	-	Drain influence zone
H	-	Drainage path
γ_{sat}	-	Dry unit weight
φ	-	Friction angle
C_h	-	Horizontal coefficient of consolidation
β_0	-	Intercept value in Asaoka graph
ν	-	Poisson's ratio
P_c	-	Pre-consolidation pressure
Δt	-	Sampling interval
t_n	-	Settlement at time
δ_n	-	Settlement reading (Asaoka Method)
β_1	-	Slope value in Asaoka graph
S	-	Spacing
e	-	Void ratio
γ_{unsat}	-	Wet unit weigth
E	-	Young's Modulus

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CHAPTER 1

INTRODUCTION

1.1 Problem Background

Soil Settlement generally due to stress and environmental changes can cause the volumetric change in soil mass. When a load is applied on the ground, it increases the vertical effective stress. This stress increases the vertical strain in the soil and makes the ground to move downward, hence induced settlement. Settlement of the subsoil supporting the embankment will take place during and after filling.

The construction of an embankment on a weak subsoil always leads to settlements. To overcome this problem, ground improvement is needed. Prefabricated Vertical Drains (PVD) is one of the most selected technique for the ground improvement of soft soil. The purpose of PVD system is to reduce the drainage path of the pore water from a low permeable layer to free water surface or to pre-installed drainage layer, therefore, rate of primary consolidation or the process of settlement can be faster.

The existence of bauxite in the Kuantan area, Peninsular Malaysia was first recognized by the Geological Survey in 1937 (Fitch, 1952). In January 2014, Kuantan boosted its name on the global markets in mining bauxite industry. (Sunil *et al.*, 2006) found that the red mud (bauxite residues) on site has compression behaviour which is similar to clayey soils and frictional behaviour that is similar to sandy soils. Therefore, any construction on former bauxite mine may face the same settlement problem and need a ground improvement technique to overcome the problem.

This project is related to soil settlement on the former bauxite mine. Figure 1.1 shows the studied area that is located 20 KM from Kuantan City Centre, Pahang Darul Makmur. This area was a former an oil palm plantation and earmarked for property development. The developer discovered bauxite deposits during clearing the land for its property development initiative. The mining activity had started on mid-2014 and ceased at early of 2016 to proceed with the proposed residential development.

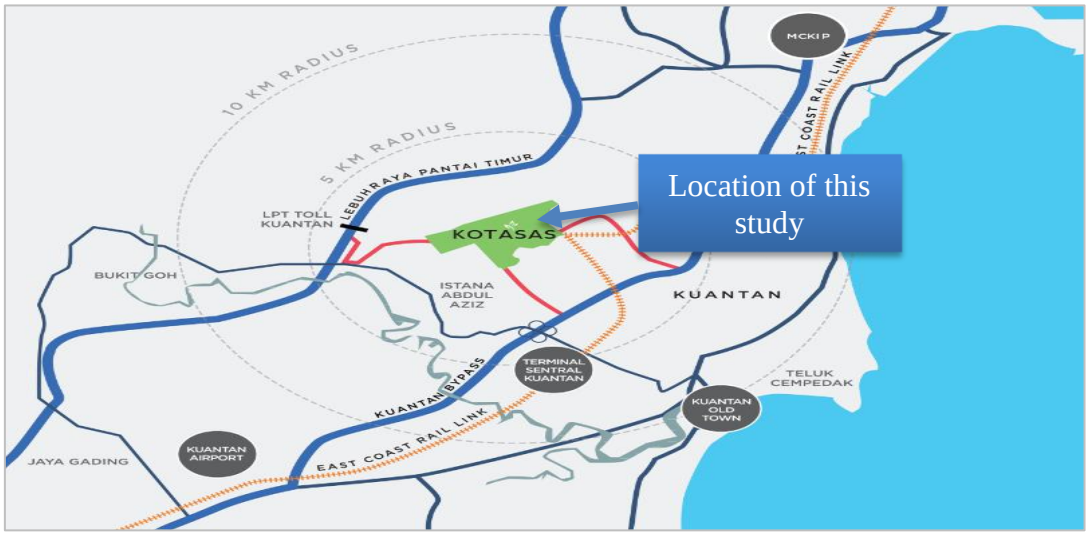

Figure 1.1 : Site Location (after web: http://www.kotasas.com).

Today the use of numerical calculation programs especially those based on the finite element method are becoming more practical. It is because, the numerical analysis which is PLAXIS 2D is used in this study to develop the PVD model and to analyse the effectiveness of PVD installation in Bauxite residue soil on settlements. Finding and comparison of soil settlement between field measurements and numerical analysis are discussed.

1.2 Problem Statement

The number of project failures regarding with soil settlements and deformation of structure has increased either locally or internationally. Some of the failures were resulted from the low shear strength and high compressibility of soft soil. Settlement problem can be defined as the ground to move downward in the soil caused of the applied stresses. As a result of soil settlements, the load carrying system will be reformed. If the ground water level is high, a part of the fill material will tend to float which will affect the total surcharge loading and the strength of the soil.

Based on classification criteria, bauxite residue would be characterized as a clayey silt (1979, Somogyi). Therefore, this study area will face some settlements problems due to their plan. The developer had done some site investigations and they decided to do prefabricated vertical drain as the ground improvement technique to overcome that problem. Figure 1.2 shows the red mud area that involved with residential development.

This study is intended to carry out a soil settlement analysis due to the effectiveness of PVD installation on former bauxite mine. At the same time, to make some predictions based on the field measurement and numerical analysis of the soil settlement.

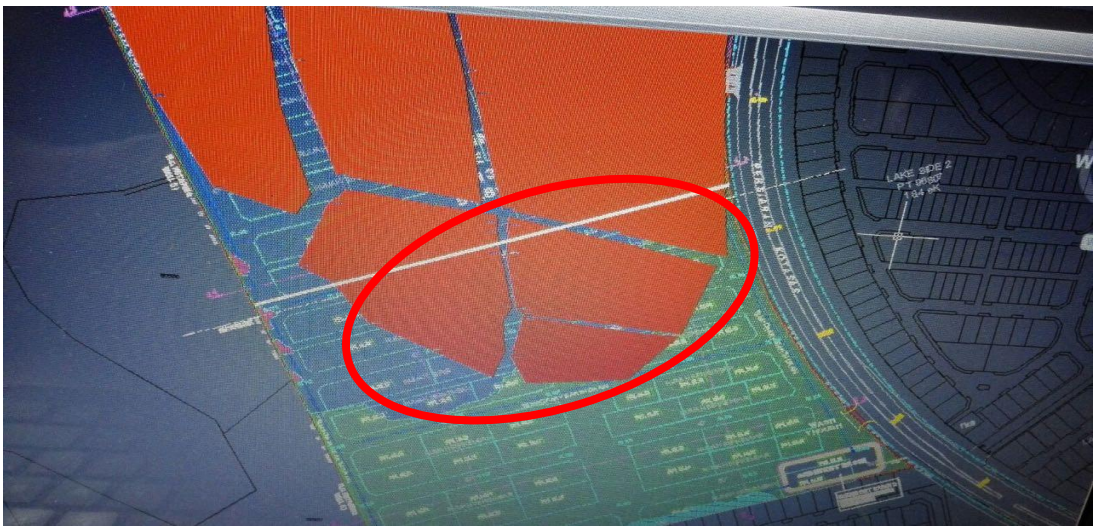

Figure 1.2 : Proposed residential development (in circle) on former bauxite mine.

The finding of this study will the benefit the society to understanding the effect of PVD installation as ground improvement. Thus, the engineers can apply or consider the finding as guideline in designing the PVD installation on soft ground.

1.3 Project objectives

The aim of this project is to study the effectiveness of PVD installation in the Bauxite residue soil by using Plaxis 2D for the settlements analysis. The objectives of the project are:

(a) To compare between field measurements and numerical analysis on soil settlement in former bauxite mine.

(b) To determine the effect of PVD at different spacing.

(c) To determine the effect of PVD length at optimum PVD spacing.

1.4 Project scope

Based on the layout plan in Figure 1.3, from 2 acre of former bauxite mine (purple colour) that proposed for residential development, only infrastructure area (red colour) are installed with PVD as the ground improvement technique whereas the housing area will used piling as the foundation. The red colour areas are involved with three types of function areas (A) road reserved in front of between two semi-D terrace houses, (B) landscape and (C) back lane behind between two semi-D terrace houses.

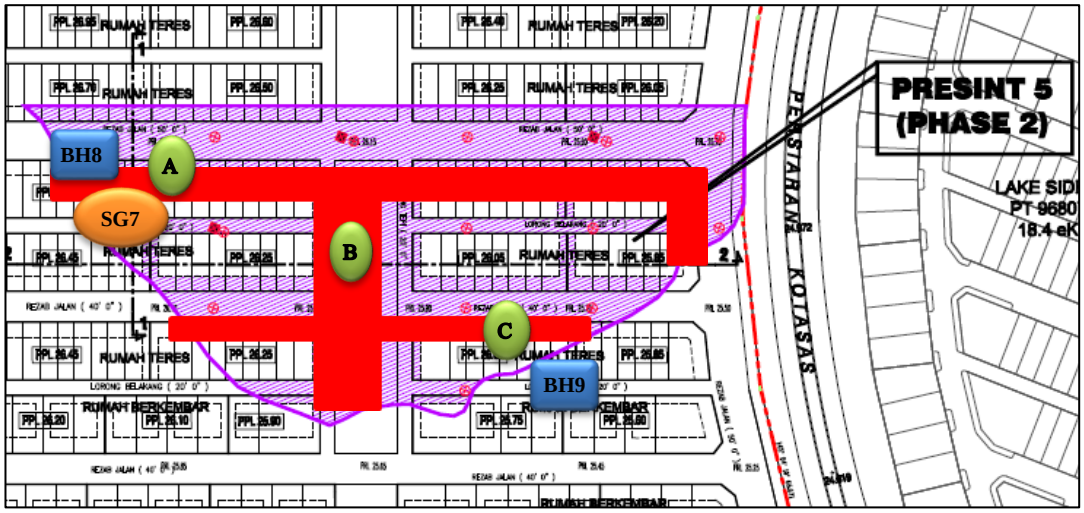

Figure 1.3 : Layout plan of PVD installation.

Data collected from the site investigation report have 6 number of boreholes BH3, BH4, BH5, BH6, BH8 and BH9 which are executed to investigate the sub-surface condition and to determine their engineering parameter for designing work purposes. Soil settlement readings are recorded once a week in 6 month duration using 16 settlement gauges.

This project focused on the function area type (A) reserved road between two semi-D terrace houses. The data for soil engineering parameter was taken from BH8 and the soil settlement reading for field measurement was taken from the settlement gauge number 7 (SG7). PLAXIS v8 was used to develop the soil model and to analyse the effectiveness of PVD installation and was supported by Asaoka method.

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