CHAPTER 1

INTRODUCTION

1.1 **Background**

In construction project, soft soil always become concern for geotechnical structure. Soft soil in Indonesia could be located in some major islands, especially Java. The problem for soft soil includes its low permeability, low shear strength, and settlement that cause change with the soil geometry (Widodo, 2013). Due to rapid development of construction sector, many lands with suitable soil for construction is continuously used. As a result, many unused land are currently consist of soft soil (Mohamad et al., 2016).

Consolidation occurs in soil that is categorized as soft soil. Soft soil properties contain high amount of water content, and structure will cause load increment towards it. The load increment caused to the soil will then cause deformation towards the soil, followed by settlement due to plastic behavior of the soil. Stresses applied to soil element tends to be compressed by the soil. However, due to soil in soft condition, clay soil, have low permeability, water inside it will not escaped from the soil all at once but gradually. This time-delay process of water escaping clay process will gradually decrease the volume of the soil. The condition is named consolidation and it is the major concern for geotechnical engineering (Espinoza et al., 2018a; Ishibashi & Hazarika, 2010).

A vertical drain is a method used to greatly shortened settlement time caused by the consolidation of saturated soft clay, by shortening the waterway of the soil. The construction of vertical drain is done by drilling the soil until its impervious layer, then installing the hole with coarse aggregate and the drain. Constructing such vertical drain proves to cause more cost for the project and also the risk of shear failure during the settlement. To avoid the risk, a type of vertical drain called Prefabricated Vertical Drain (PVD) has been found to have lower project cost and no shear failure. In this study, PVD design to obtain the least cost is developed by finding the most economic model of the PVD, mainly finding an optimum variety of the diameter and spacing of PVD (Espinoza et al., 2018a).

For construction project, it is always expected to find the economic model for the project. In economic model, design that fulfil design criteria while getting least cost for the project is desired (Wang & Kulhawy, 2008). To find economic design in this study, simplified Particle Swarm Optimization (PSO) will be used to construct the PVD. The design criteria will include finding 95% of consolidation rate for 365 days, and the optimization target will be the spacing and equivalent diameter of the PVD. The cost model will then be constructed based on the PVD specification using Sun's cost appropriation method (Sun et al., 2020).

By using Optimization, PVD length ranging from 10m to 50m with 1m increment and PVD spacing ranging from 0.8m to 4m with 0.2m increment will be used as variation. After inputting the variables, cost estimation will be formed in the model to select the economic design of the PVD. Model with lowest cost estimation will be selected as the economic design of the PVD construction. The

model will be programmed using MATLAB R2013a software. Code for the design will be developed to obtain the best variation of spacing and diameter of PVD.

In PVD optimization, various model using numerical method have been researched from previous study (Kim et al., 2014; Sun et al., 2020). This model provides PVD installation in certain soil condition with lowest cost possible based on its dimension variation, and also fulfilling design code required for the project. However, previous study has not stated which soil properties affects PVD cost installation the most. Soil properties and its uncertainties will affect the performance of PVD due to consolidation that will occur towards the clay soil used. It is then necessary to find which soil properties that affect PVD the most as soil properties could not be modified in the design but it creates different design criteria if different soil properties are used.

1.2 **Problem Statement**

Soft soil is a soil that have not good quality for construction due to consolidation problem that cause settlement. It is required to perform soil stabilisation for such condition to reduce negative impact caused by settlement (Espinoza et al., 2018b). Cost for soil stabilisation will make overall cost of the project to raise due to material cost and treatment cost for the soil (Santos et al., 2018). Without using optimization, the cost will fluctuate up to 30% which cause profit erosion for the project (Rabiei & Janalizadeh Choobbasti, 2018). Profit erosion will cause non-desired result for construction work, as it lowers the overall benefit of the project.

1.3 Objective

The objective of this study is to perform optimization technique to obtain lowest cost possible for PVD installation to obtain targeted degree of consolidation. Degree of consolidation that is desired for the project is 95% for 365 days. The parameter randomize for the cost calculation will be spacing (S) and Equivalent Diameter (d_{eq}) of the PVD as it is the relevant parameter for the degree of consolidation calculation. Additionally, soil properties that affect PVD construction cost will also be analysed. The properties investigated in this research are coefficient of volume change (Mv), coefficient of vertical permeability (Kv), unit weight of soil (ɣ), and ratio between horizontal and vertical coefficient of permeabilith (Kh / Kv).

1.4 Limitation

1. The optimization method used in this project is modelled using MATLAB R2013a
2. Minimum cost for PVD construction project is obtained through minimum PVD dimension
3. PVD specification used in this project is based on PVD available in the market
4. The variation existing in soil properties and material properties is not considered in the modelling
5. The soil used in considered as fully saturated single layer clay soil
6. The drain system used is one way drainage

7. The shear strength of the soil is not included in the modelling

1.5 **Research Benefit**

The research is expected to get PVD economic design model and knowing which soil properties affects PVD construction cost the most

1.6 **Originality of the research**

Referring from (Sun et al., 2020), PVD optimization using numerical method with different software already exist that could form PVD cost estimation model. The model is formed by finding optimum combination of PVD dimension such as length and effective diameter that produce lowest cost of PVD model based on the data of soil properties in the site. However, soil properties that affect the cost of PVD the most has not yet been researched in previous study.