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A Comparative Study on the Consolidation Test of Traditional and Non-Traditional Stabilized Peat

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Peat have been identified as highly organic soil, diverse mixture and undergo anaerobic condition at moderate and low temperature. The ojective of this study is to identify the settlement of original and stabilized peat. The effect of different types of stabilizers to the settlement properties of peat were observed. Two types of stabilizer used in this study which are polymer and cement. For comparison the settlement study also conducted for original peat. This study focused on the numerical study of peat settlement by using PLAXIS 2D. The geometry model were designed in 2D and then converted to the finite element model for the analysis process. The next process was carried out to the calculation phase to produce the settlement value and graph for all samples. The result show that the settlement of original peat is higher compared to the stabilized peat. Meanwhile, the settlement of stabilized peat with polymer show the lower value. Thus, it is important to study the settlement of soil in order to predict the ability of soil to support structures.

Keywords:Consolidation, PLAXIS 2D, cement, polymer

1. Introduction

Peat have been identified as highly organic soil, diverse mixture and undergo anaerobic condition at moderate and low temperature [1]. One major issue in peat research concerned is this type of soil is unsuitable for engineering works because of low shear strength, high compressibility and high moisture content [2]. Thus, this soil types is inefficient to resist huge load.

The properties of peat makes peat soils are less efficient for the constructions due to high settlements. It is unsuitable for the constructions such as roads and building. This becomes the common issues happened in Malaysia and always been faced by engineers regarding the high settlement of the peat [3]. There are many problems occur caused by the high settlement during and even after the constructions such as unstable building structure and road cracking. These problems can lead to the accidents and endangered the people's safety.

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A study on settlement of peat have been conducted using calcium fly ash as stabilizer[4]. The outcome of this study show the settlement are increase by time. Another study on stabilized peat using organic matter have been conducted[5]. The settlement of original and stabilized peat are compared and the stabilized peat show the lower settlement graph than original. Next, a study have been conducted to observe the settlement of stabilized group peat columns[6]. The result show the settlement are increase by the increasing the loads. The study of stabilized peat by adding the chemical admixture towards settlement[7]. The result show that the settlement are decrease with increasing the chemical admixture. Based on the result of previous study, peat is defined as very poor soil due to high settlement and can be reduce by adding the stabilizers.

This study concerned about the effect of traditional and non-traditional stabilizer towards the properties of peat to overcome the problems of high settlement of peat. The results of this study are obtaining by using the PLAXIS 2D software. This study aims to identify the settlement of original peat and to observe the effect of different types of stabilizers to the settlement properties of peat.

2. Materials and Methods

2.1 Material

2.1.1 Peat

Peat is a brown deposit resembling soil created by partial decomposition of organic matter in the damp acidic conditions of bogs and fens, and is commonly scraped out and dried for use as fuel and in gardening, according to the Oxford Dictionary. Peat's physical qualities include a highly organic soil, a diversified mixture, and the ability to undergo anaerobic conditions at moderate and low temperatures. Peat are also the common type of soil to be found at Malaysia. Besides, peat also show high compressibility, high water content, low bearing capacity and high holding capacity. These are the cause and main problems in the construction field. Thus, peat is contemplated not suitable for supporting foundations used in its raw state. To overcome the problems that will lead to critical settlement of peat, a few improvements are widely used to avoid the problems of failure. One of it is by consolidation vacuum method which is developed [8]. There are, however, only limited applications for peat ground at the present time[9].

2.1.2 Cement

This type of stabilizer is commonly used in increasing the strength of soil and act as additive or preservative. Cement is one of famous used as stabilizer. Since cement are invented to be as stabilizer, more construction works become easier. Cement contain tri-calcium silicate, dicalcium and solid solution that make it a heterogeneous compound [10]. Cement can undergo hydration when soil’s pore water encounter with cement. Cement as stabilizers has an economic advantage because it can decrease the cost used.

Using cement as the stabilizer is one of the most used method to treat the soil. Particles in a Portland cement is heterogenous which are containing tricalcium (C3A), minute tri-calcium silicate (C3S) dicalicum (C2S), and solid solution described as tetra calcium alumino-ferrite (C4A) [11].

When cement come into with the water from the soil, cement will undergo hydration quickly. Then major hydration of primary cementitious will produce hydrated calcium silicates. In addition, by adding the cement to the peat, the peat liquid limit will decrease. Previous study also states that by adding cement it will improve the engineering properties of the peat[12]. Furthermore, it will give a good result in term of strength and low plastic soil.

2.1.3 Polymer

Nowadays, polymer becomes priority to be used as stabilizer among the researchers and geotechnical expertise [13]. This stabilizer usually used as treatment for soil to maintain the structure of building above it. Polymer as non-traditional stabilizers are identified as chemical formulated stabilizer which is it compound are slightly different with traditional. A few additives are added to produce the non-traditional stabilizer such as enzymes, acid, resin and liquid polymer. This stabilizer produces less harm to environment thus decrease the soil and water erosion [14].

Reaction between polymer and soil refers to the polymer soil stabilization which is the process addition of polymers to enhance the physical properties of soils, most frequently for geotechnical engineering, construction, or agricultural projects. Even at very small concentrations within soils, various polymers are shown to extend water retention and reduce erosion, increase soil shear strength, and support soil structure a good range of polymers are wont to address problems starting from the prevention of desertification to the reinforcement of roadbeds.

Polymers mainly affect the aggregation and strength of soils through their interactions with fine clay particles. Coatings of adsorbed polymers on clays can increase their steric stabilization by preventing clay particles from approaching one another as closely. Alternatively, polymer molecules that bond with multiple clay particles promote flocculation. Hydrogel networks may result in additional indirect strengthening within soils by creating a scaffolding for soil particles. Additional strength may be imparted to polymer networks within soils through chemical cross-linking and curing.

2.2 Methods

Based from the **Figure 1**, the first step will begin with designing the sample. To design the sample, geometry line in PLAXIS 2D. The dimension is 1m x 1m. As the design of the sample has completed, the load will be insert to the model. The load inserted will determined from which direction load will be used. Next, material will be inserted to the model. In this test, the material that will be inserted are original peat, peat with cement and peat with polymer. After load and material being inserted, its initial condition will be determined. In initial condition, water pressure and initial stress will be generated. After all the input data being inserted, data will be calculated to find its settlement and graph time vs displacement will be plotted.

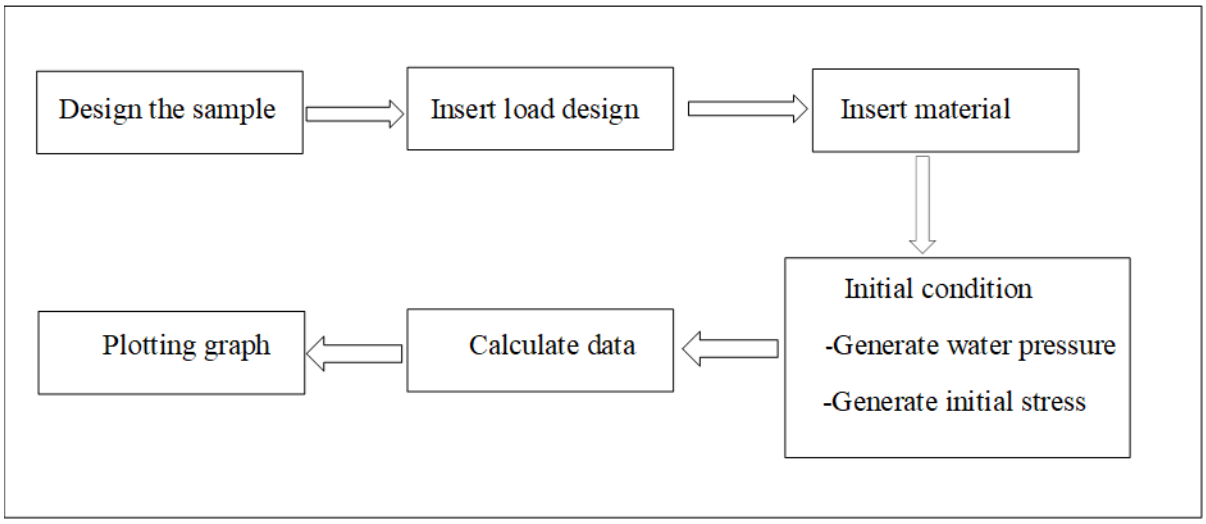


Figure 1: Flowchart of method using PLAXIS 2D

2.2.1 Input

The size of the geometry 2D model for the consolidation issue, which is 1.0 m x 1.0 m. The model receives its material qualities. On both sides, horizontal fixities are applied. At the bottom of the geometry model, the horizontal and vertical fixities are employed. The upper layer surface might drain while the other sides remain undrained while adopting a closed consolidation border condition.

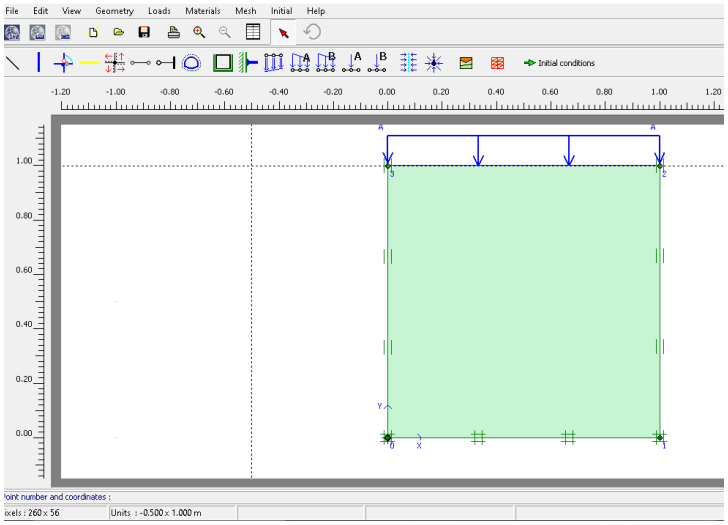
2.2.2 Generate mesh

As an element distribution, fine global coarseness meshing was used. It can assist a new user in obtaining certain parameters to advise them.

2.2.3 Initial condition

In water pressure mode consistent with prior research, general water levels at the top surface are anticipated.The closed consolidation boundary is applied to all sides except the top. Generate water pressure based on phreatic level. If not specify a closed consolidation limit, the settlement will be harmed and the computation will be impossible to do owing to the settlement being broken. While in the geometry configuration mode, the initial stress is created using the K0 method with the M-weight set to zero.

Table 1: Summarize of Method Used

Steps	Remarks
Input	

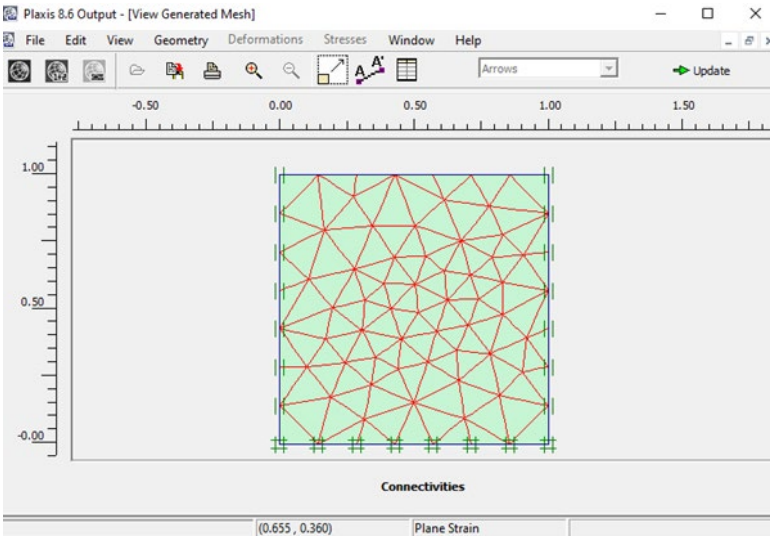
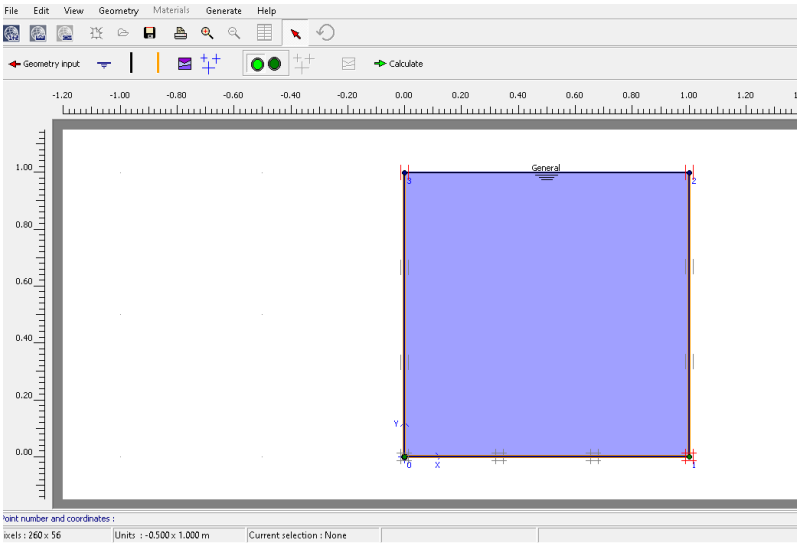
Generate mesh	
Initial condition	

Table 1 shows the methods flow which are used while using PLAXIS 2D. The step is started with inserting the input which is its geometry model. Then, the model will undergoes generate mesh to obtain its Finite Element Model. Lastly, its initial condition will be decided.

2.2.4 Calculation

In Phase 1, the distributed load is turned on. Plastic analysis is the calculating method. The option to reset displacement to zero is chosen. Furthermore, eight consolidation phase analyses are carried out for 24 hours at varied activation loads as shown in **Figure 2**.

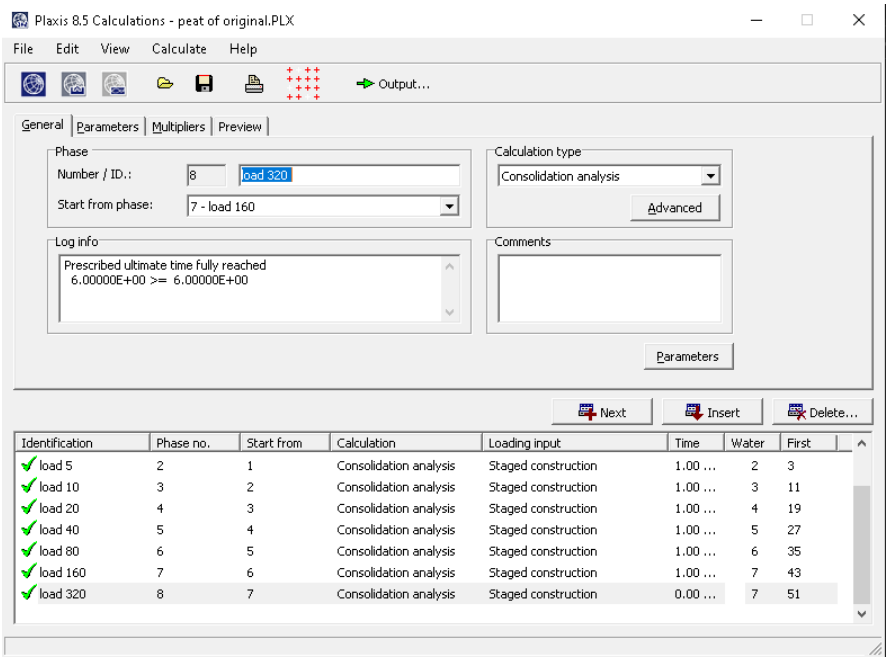


Figure 2 :The Calculations Window With The Parameters Tab Sheet

3. Results and Discussion

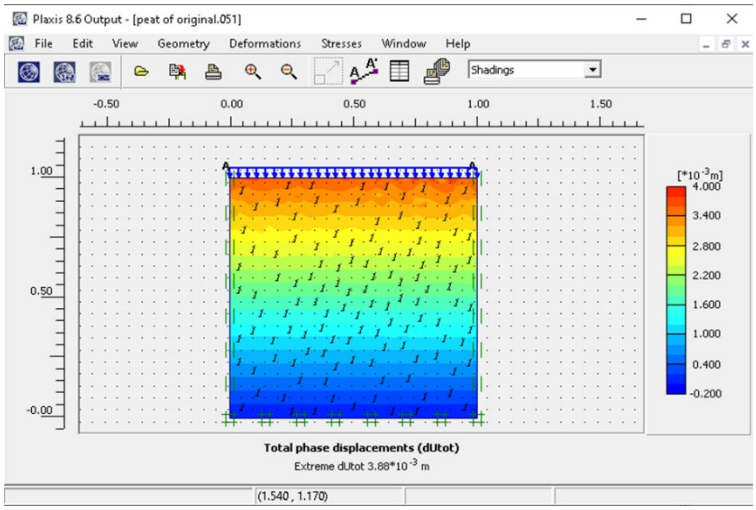
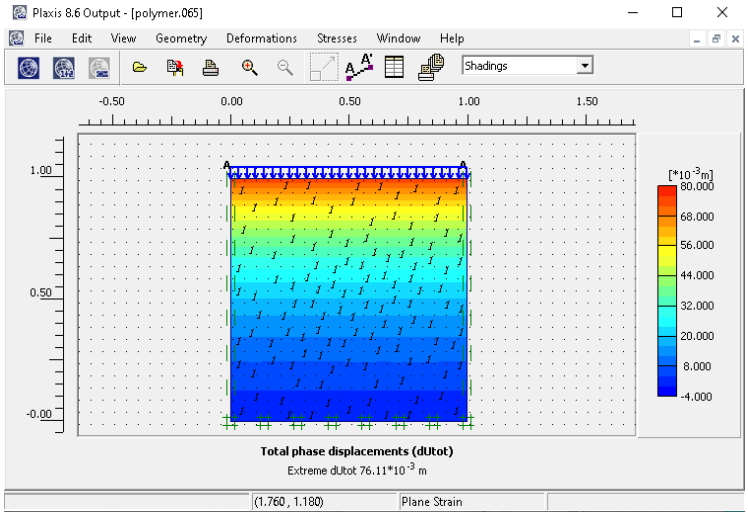
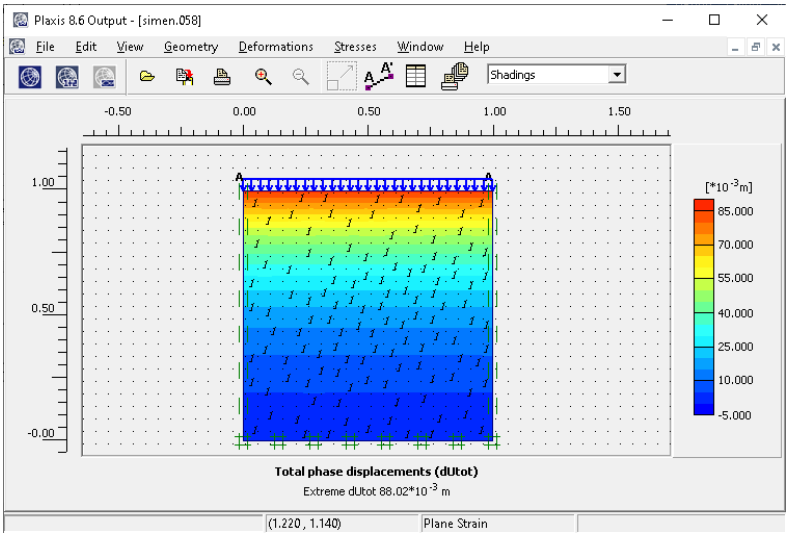
3.1 Result

The findings of the study illustrated in **Table 2.** Area which located directly the load applied will undergo high pressure thus it will experience high settlement. This statement can be represent by Figure 3 as the upper layer of peat is in red colour. Going down the peat layer, pressure of the load will decrease so, blue represent the area with low pressure and low settlement.

That the initial peat placement was 0.183m. Compression characteristics of native and stable peat was studied using the consolidation test under normal pressure as much as 5, 10, 20, 40, 80, 160 and 320 kPa

Displacement vs logarithm time scale for native peat and stable peat for loading conditions 5, 10, 20, 40, 80, 160 and 320 kPa. It can be observed that the displacement decreased with increasing time and normal pressure applied means the vacancy ratio decreases in line with normal pressure increase[15].

Table 2: Total Displacement Phase for all samples

Total Displacement Phase	Remarks
Original	
Polymer	
Cement	

The graph in **Figure 3** plainly demonstrates that the pt sample has the highest resolution of all the samples. The PtP samples then had low resolution since they were stable. The PtC sample was the middle of the three, with a moderate value in the solution. Because each samples are subjected to identical stress, what distinguishes its high durability and displacement. When it reaches a certain time each sample will experience the same decrease and comparison between samples. It can be observed that the solution increased in line with the increase of normal pressure which means the vacancy ratio decreases in line with normal pressure increase. Pt sample will obtain more settlement than PtC and PtP because Pt sample is full of void which contain water and air. While, PtC and PtP sample's void will be filled with cement and polymer. Thus, strength of the PtC and PtP samples are greater than the Pt sample which will lead to a lower settlement.

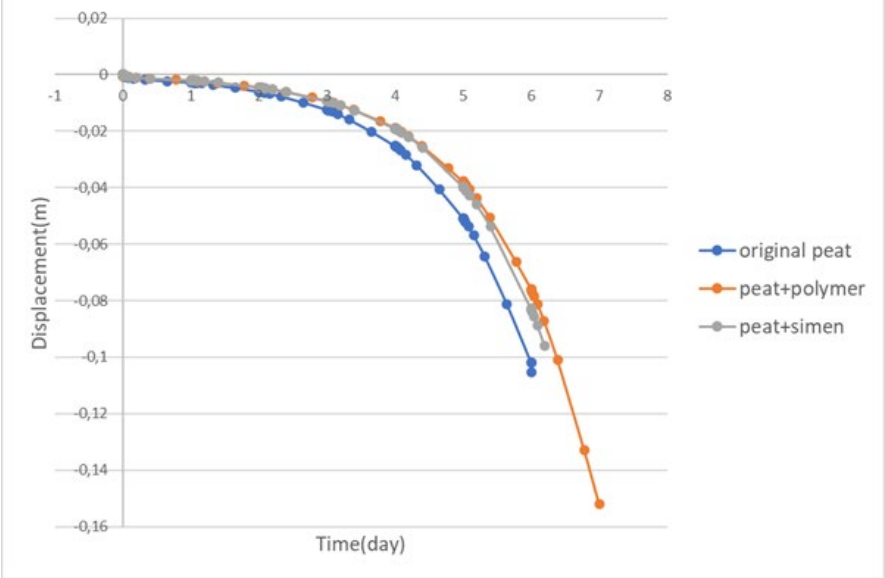


Figure 3 : Relationship of settlement against time of samples

3.2 Displacement

The tests on original and stabilized peat samples are stimulated using finite element software PLAXIS 2D. The total displacement for Pt is 105.74 x10^{-3}while PtC is 171.0 x 10^{-3} and PtP is 152.06 x 10^{-3}. The size of the deformed mesh of the Pt sample is larger than the other two samples. This is because the original samples are not being added with any additives. While the others are being added with cement and polymer. When the size of the deformed mesh is bigger, its tendency undergoes settlement is higher. Then, the size of deformed mesh of peat with cement and peat with polymer slightly different from each other make their total displacement slightly different..

4. Conclusion

The geometry model of consolidation test have been developed by using PLAXIS 2D software and the settlement for original and stabilized peat were obtained. It can be concluded that the combination between peat and polymer is the best comparison between other settlements compared to the original peat and peat with cement. Non – traditional stabilizer which is polymer make the settlement lowest among the other samples because the polymer particles filled better in the peat void than the traditional stabilizer which is cement. The peat yield of the polymer combination is better among the other peat samples in the graph shown measuring the settlement against time. As a suggestion, more reseraches about the stabilized peat must be done to identify the better stabilizer can be used to overcome the settlement problem of peat soil.

Acknowledgement

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References

[1] H. Hayashi, O. Hatakeyama and H. Hashimoto, "Reducing the Secondary Consolidation of Peat Ground Using Vacuum Consolidation, Civil Engineering Research Institute for Cold Region (CERI)," Sapporo, Japan and CERI, Sapporo, Japan. 2019.

[2] N.Latifi, et al., Micro-structural analysis of strength development in low- and high swelling clays stabilized with magnesium chloride solution — A green soil stabilizer, 2015.

[3] N. Latifi, et al., "Xanthan gum biopolymer: an eco-friendly additive for stabilization of tropical organic Peat." Springer-Verlag Berlin Heidelberg, 2015.

[4] B. K. H. Bujang, S. Kazemian, A. Prasad, "A study of the compressibility behavior of peat stabilized by DMM", Lab Model and FE analysis, 2011.

[5] A. M. Zahri and A. Zainorabidin, "An overview of traditional and non-traditional stabilizer for soft soil" Universiti Tun Hussein Onn Malaysia, 2019.

[6] M. I. A. Kadir, "Long Term Consolidation Study On The Tropical Peat At Pekan, Pahang, Malaysia." Faculty Of Civil Engineering & Earth Resources University Malaysia Pahang, 2009.

[7] P. L. Berry and T. J. Poskitt, "The consolidation of peat." Gtfotechnique 22, No. 1,-21, 1972.

[8] S. Kazemian et al., "A State of Art Review of Peat:Geotechnical Engineering Perspective", International Journal of the Physical Sciences, vol.6, no.8, 2011.

[9] Z. Adnan, D.C. Wijeyesekera, and M.I.M. Masirin, "Comparative Study of Malaysian Peat and British Peat Pertaining to Geotechnical Properties." In Proceedings of Sri Lankan geotechnical Society's First International Conference on Soil and rock Engineering, 5-11 August 2007, ed. Pinnaduwa H.S.W, Colombo, Sri Lanka, 2007.

[10] Z. Adnan and W. D. Chitral, "Geotechnical Characteristics of Peat University of East London Institutional Repository", 2008.

[11] S. Paramananthan, "Malaysian Soil Taxonomy(Second Approximation): A Proposal for the Classification of Malaysian Soils. Malaysian Society of Soil Science, Param Agricultural and Soil Surveys (M) Sdn. Bhd., Kuala Lumpur, Malaysia, 1998.

[12] K. Scwarzel and, M. Renger, "Soil physical characteristic of Peat", Institute of Ecology, Department of Soil Science and Soil Protection, Technical University of Berlin, 2002.

[13] PLAXIS 8 Tutorial Manual, 2020.

[14] H. Moayedi, and R. Nazir, "Malaysian Experiences of Peat Stabilization, State of the Art." Geotech Geol Eng, 2017, doi:10.1007/s10706-017-0321-x.

[15] L. Zhang, C. Brendan, and O. Kelly, "Effect of salt grain additions on fibrous peat consolidation." Proceedings of the Institution of Civil Engineers Ground Improvement 168 February 2015 Issue GI1 Pages 14–21, 2015.