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Assessment of Consolidation Behavior for Stabilized Peat Using Cement and Ceramic Dust

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Abstract: Peat known as the most difficult soil and peat as organically complicated soil. This research examines the consolidation behavior of treated peat for primary and secondary consolidation using an oedometer test. In addition to this research, untreated behaviors and treated peat soils are also compared based on previous study result of consolidation parameters. In this research, the stabilizers used cement and ceramic dust. The quantity of stabilizer utilized in the sample is 4% and 8% for both stabilizer types. The RECESS laboratory and standard odometer test based on the BS 1377 employed in this research has produced sieved peat passing 2.36mm combined with stabilizer. The consolidation test was determined the settlement of sample for every interval time that has been set for data recorded for three days. The data was analysis by plotting graph and have determined Compression index, Coefficient of Consolidation and Secondary Compression index. From the analysis data it is show significant change due the peat has been treat with stabilizer and it is influenced by the total percentage of stabilizer used in the mixture. The analysis was obtained and compared with untreated peat from previous study and the different of treated and untreated of peat for consolidation parameter. From the result treated peat show the value of Cv was decrease when the load increased. The result also shows every increasing of stabilizer will decrease the value of Cc this happen to both type stabilizer which is cement and ceramic. However, value of secondary compression index and compression index ratio is higher than recorded by previous study for untreated peat, it may be caused by the peat from Parit Nipah have been mixed with stabilizer especially when percentage of stabilizer is increasing. From the result it concludes stabilizer to treat peat form Parit Nipah were affected consolidation parameter and it can be seen on settlement data taken from settlement data taken from consolidation test.

Keywords: Peat, Cement, Ceramic Dust, Consolidation

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1. Introduction

Peat is the most difficult soil feature to deal with. Peat soil is a kind of organic soil that has high combustibility, a high void ratio, and low shear strength [12]. Wet and anaerobic conditions cause plant and organic waste to degrade incompletely, resulting in peat deposits. Malaysia's peat land covers about 3 million hectares, or about 8% of the country's total land area [13]. The two types of peat found in Malaysia are amorphous and fibrous peat. The process of consolidation is split into three stages: initial compression, primary consolidation, and secondary consolidation. The coefficient of consolidation, C_v, the consolidation index, C_c, and the secondary compression index, C_α, are three crucial variables to be established in this study. For three reasons, further consolidation of peat deposits is critical. Peat has a high natural water content, void ratios, and compression index values [8]. Engineers working on peat land development have gotten into the habit of digging peat and replacing it with good soil. On the other side, this approach will result in greater upfront costs or an uneconomic soil design. Stabilization may be achieved via mechanical compaction, the use of chemical stabilizers such as lime, cement, or fly ash, or a combination of stabilizer. Soil stabilization is a technique for improving the soil's poor features and characteristics. The emphasis of this study will be chemical stabilization. Changes in chemical interactions between soil particles and chemical additives have improved chemical stabilization. Lime and Portland cement are the most used chemical stabilization additives. Understanding the characteristics of treated peat and how it responds under compression is important since any building constructed on peat soils is susceptible to significant initial and long-term secondary settlements.

The aim of this study is to compare performance in scope of consolidation test in between treated and untreated peat by using Odometer Test based on BS 1377 Part 5 1990. From this laboratory it can determine by plotting graph to determine Compression index, Coefficient of Consolidation and Secondary Compression index. Besides, the plotting data can compare void ratio of treated and untreated peat. Besides, this study also can show treated peat soil behaviour with different percentage of stabilizer. However, this study also will focused on perfomance of treated peat in settlement or consolidation parameter and compare on previous study for untreated parameter for consolidation.

2. Basic Properties Peat Soil Parit Nipah

Basic parameters, such as moisture content, organic content, fiber content, specific gravity, and degree of humification, are essential to grasp while studying peat soil characteristics. According to a review of past studies on Parit Nipah peat soil, there are various data sources that may be utilized in this research. Table 1 illustrates the fundamental characteristics of peat soil from Parit Nipah, which was studied before. Table 1 indicates that the moisture content ranges from 500 to 750 percent at Parit Nipah, which is consistent with assertion that the moisture level ranges from 200 to 2207 percent throughout Malaysia [6]. Moisture content data may also be linked to peat fibrousness, with the more fibrous the peat, the greater the water content. Almost all of the data for organic content is greater than 75 percent, according to data from Table 1. Peat has a high organic content of more than 75 percent [6]. Organic content is one of the reasons peat soil is the most troublesome soil. Organic content causes peat to be spongy, highly compressible, and flammable, according to experts [6].

Table 1: Basic properties of peat soil at Parit Nipah.

Reseacher	Moisture Content, %	Organic Content, %	Fiber Content, %	Specific Gravity, G_s	Von Post Scale
[8]	635	95.5	37.8	1.34	H6
[11]	605	66	-	1.4	H5
[1]	710.44	78.77	40.97	1.34	H6
[2]	546.43	86.24	-	1.56	H5

2.1 Stage of Consolidation

Elastic compression (immediate settlement), primary compression (occurs during effective stress variations), and secondary compression (occurs under continuous vertical effective stress) are the three kinds of peat soil compression (settlement)[4]. Primary compression is the stage between the ending of the previous phase, which is Initial Compressive, and the end of the primary' phase, which is compression with pore water pressure discharge. Primary consolidation of peat layers, according to [4], is quite fast, requiring just a few weeks or months to complete. The primary compression process in clay, on the other hand, will take several years to complete. During the main consolidation stage, the load transfer process from excess porewater pressure to the soil particle and soil volume produced by water move out or expulsion of water from void in soil is also addressed.

Secondary compression, also known as creep, is the continuation of primary compression under continuous vertical effective stress after initial compression is finished [6]. In addition, secondary consolidation is the last step of the settlement curve. When a point of comparison, as the load rises, the rate of secondary settlement may also grow, decrease, or stay constant[4]. Secondary consolidation, on the other hand, may increase when organic content rises, and is also affected by moisture content and void ratio [6]. Tertiary consolidation did not result in enough porosity reduction to produce post-yield deformation, but it can fill the gap between yield and primary consolidation. After a certain length of time, the logarithm of time increases, then gradually decreases until it disappears over very long periods of time, resulting in a new stage known as tertiary compression.

2.2 Parameter of Consolidation of Parit Nipah Peat

Preconsolidation (Pc), compression index (Cc), swell index (Cs), coefficient of consolidation (Cv), and coefficient of volume of compressibility are some of the parameters determined by [9]. The data was gathered using a one-dimensional oedometer consolidation test. According to consolidation testing, the sample's Pc value ranged from 13 kPa to 33 kPa, and this value was calculated using the void ratio against a logarithmic pressure graph. Aside from the PC's worth. Natural compressibility of peat soil in Parit Nipah is high, according to this study, and this may be influenced by organic and fiber content in peat soil.Summary parameters of consolidation of peat soil at Parit Nipah are defined by the values of Cc and Cs and by 1.700 to 2.361 and 0.143 to 0.217 for that parameter [9]. The study shows that particle size of the soil may influence all consolidation parameters since Table 2 shows a reduction in Cc value, when particle size decreases and big particles are included in the sample it may contain greater fibre than smaller particles of sample size.

Table 2 : Summary of Consolidation Parameters of Untreated and Reconstituted of Peat Soil from Parit Nipah [9].

Passing (mm)	Parameter				
	Void Ratio, e	Pc (kPa)	Cc	Cs	Cv (m^2/yr)
3.35	5.714	24	2.364	0.217	13.594 – 0.064
2.36	4.785	33	1.867	0.278	35.946 – 0.977
1.0	8.345	15	2.242	0.143	1.666 – 0.195
0.425	5.252	16	1.811	0.162	5.314 – 0.425
0.300	5.271	16	1.700	0.200	2.880 – 0.006

2.3 Stabilizer

Cement stabilization is the most common soil remediation stabilization technique [3]. The cement particle of Portland is a heterogenous material which contains minute tri-calcium silicate, dicalcium, tricalcium and solids, also called calcium tetra alumina ferrite. When pore water reaches from the cement from the earth, it moisturizes rapidly and the main hydration (primary cement) generates hydrated calcium silicates and hydrated lime. Cement will also reduce the liquid limit of the soil.

Ceramic dust comes from crushed material made of roof tile, floor tile, ceramic brick, stoneware and other artificially burned artefacts. All this material may be acquired via construction, abandonment of the building site or demolition. This material is normally one of the wastes in construction, as an estimate of waste in daily ceramic industry production are around 30 percent according to the journal article Engineering 2018. However, the characteristic of ceramic may assist to improve problem soils such as the turf soil, that the ceramic product has a capacity to absorb moisture and the analysis of water absorption by the ASTM test technique is proving its ability. This feature may be helpful in soil with a high water content, particularly problematic with peat soil [10].

3. Materials and Methods

This study will conduct in Parit Nipah which one of the Parit Raja zone, located in Johor, Malaysia.

3.1 Materials

Specifications and properties of materials, equipment, and other resources used in the current study used in this study.

- Sieved peat soil with 2.36 mm of sieve size.
- Cement as stabilizer and the percentage of cement used in this study 4% and 8%.
- Ceramic as stabilizer and the percentage of cement used in this study 4% and 8%.
- One Dimensional Consolidation Test

Cement and ceramic are the two kinds of stabilizers that will be utilized. Ordinary Portland Cement, which may be purchased from a local source, will be utilized as an agent. Rejected, broken, and waste ceramic dust will be acquired from the tile business, demolition, or building sites. The tiles will be shattered with a hammer, then sieved using a 0.425mm IS size. A series of loading is 12.5, 25, 50, 100, and 200 kPa by increasing the load increments every three days. The oedometer test is a one-dimensional consolidation test that is used to derive soil characteristics from the compression curves used to estimate settlements. Treated sample and has been curing for 7 days. The mixed sample is put into PVC pipe and sealed using aluminum coil, then left to curing for 7 days.

3.2 Methods

The main objective of this research is to determine the behavior of treated peat soil with stabilizer. Figure 3.1 shows the details of the methodology process from the overall project flow. Phase 1 included literature review, determine sampling location for this study and basic properties based on previous study like shown in section 2.4 in Chapter 2. Phase 2 collected data by conducting laboratory testing. Phase 3 is an overall analysis based on data gain from phase 2.

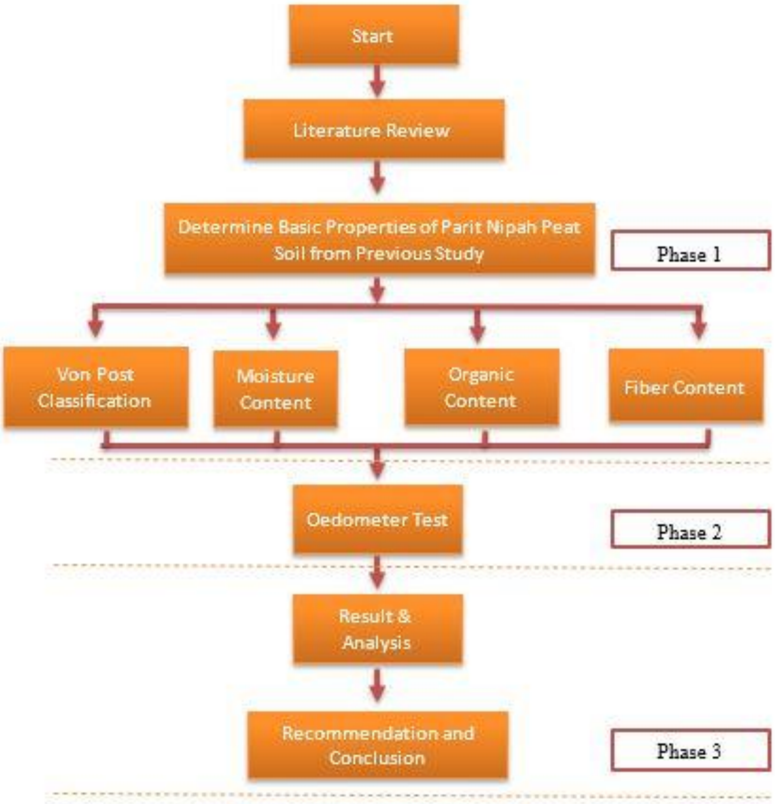

Figure 1: Methodology flow chart

4. Results and Discussion

The result was based the determination of consolidation parameters of treated soil such compression index, coefficient of consolidation and secondary compression index. The oedometer test is a one-dimensional consolidation test that is used to determine soil parameters from the compression curves used to estimate settlements. Table 3 show the value of C_v for treated peat soil. However, the data shows irregular readings where there is an increase and decrease in the value of C_v when the load is added especially for treated soil with 8% ceramic. This is because, the value will be affected by the settlement data taken from the lab.

Table 3: Value of C_v

Loading	Cement 4%	Cement 8%	Ceramic 4%	Ceramic 8%
	Cv (m^2/year)			
12.5	11.591	8.31	9.85	1.95
25	10.059	8.5	10.95	7.36
50	7.068	10.590	13.77	3.10
100	7.165	8.49	9.80	15.08
200	8.60	8.03	9.55	3.74

Compared to treated peat data shows the value of coefficient of consolidation decreased when peat treated with stabilizer which is cement and ceramic. Additional increasing of percentage of stabilizer also shows the value of coefficient of consolidation decrease for an example at pressure 12.5 kPa value of coefficient of consolidation for 4% is higher than 8%. It may caused by reaction of amount of stabilizer to Parit Nipah peat properties. Based on data in Table 4, each stabilizer increase will decrease the value of Cc this happens to both cement and ceramic type stabilizer.

Table 4 : Value of C_c.

Cement 4%	Cement 8%	Ceramic 4%	Ceramic 8%
	Cc		
0.189	0.146	0.136	0.0997
	Cs		
0.026	0.026	0.033	0.037

The ratio of Cα/Cc was calculated using previous data which Cc, which is compression index ratio. The secondary compression index, on the other hand, was calculated using a graph of void ratios versus time (log scale). The secondary compression index ratio and the compression index ratio are summarized in Table 5. According to Table 5, raising the percentage stabilizer on peat soil raises the value of the secondary compression and compression index ratios. This tendency holds true for both types of stabilizers used to treat Parit Nipah peat soil. Table 5 shows that the value of secondary compression index and compression index ratio is greater than in earlier studies, which may be due to the fact that peat from Parit Nipah has been combined with stabilizer, particularly when the proportion of stabilizer is rising. However, according to [11] there has compiled the ratio of secondary compression and compression index ratio which is for peat and muskeg is 0.075±0.01 then from the result it is how the value of Cα/Cc were categorised as peat. Compared on data have been determine in Table 5 it show the value of secondary compression index and compression index ratio is higher than recorded by previous study, it may be caused by the peat from Parit Nipah have been mixed with stabilizer especially when percentage of stabilizer is increasing.

Table 5: Secondary Compression Index and Compression Index for Treated Peat

Pressure	Cement 4%		Cement 8%		Ceramic 4%		Ceramic 8%	
	Cα	Cα/Cc	Cα	Cα/Cc	Cα	Cα/Cc	Cα	Cα/Cc
12.5	0.0032	0.017	0.0030	0.021	0.0020	0.015	0.0064	0.064
25	0.0064	0.038	0.0032	0.022	0.0060	0.044	0.0080	0.080
50	0.0170	0.090	0.0064	0.044	0.0097	0.071	0.0060	0.060
100	0.0032	0.017	0.0400	0.274	0.0090	0.066	0.0072	0.072
200	0.0064	0.034	0.0024	0.016	0.0090	0.066	0.0014	0.014

The void ratio graph in Figure 2 indicates that a greater stabilizer % may reduce the quantity of void ratio. This may be shown in graphs where cement and ceramic for 8% is lower than cement and ceramic for 4%. It may be because stabilizer particles can fill voids in the sample; as previously stated, peat soil samples were sieved at 2.36mm and ceramic samples were sieved at 0.425mm, with particle size variations resulting in smaller particle sizes being able to cover empty spaces on bigger particles. In this research, the void ratio for sieve size was greater than in prior experiments, indicating that treated peat performed better. For sieve 2.36mm, void ratios vary from 4.6 to 2.1.

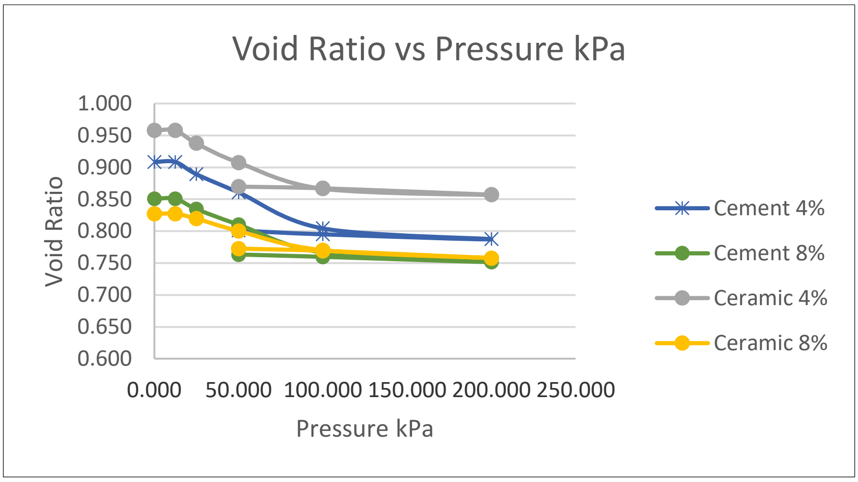

Figure 2: Graphs Void Ratio, e against pressure kPa

The trend of decreasing curve also is happened to Figure 3 which is data for settlement of sample against pressure. It is showing the value of settlement of sample decreased when applied or increase the pressure for both type of stabilizer. Also, the graph of settlement of sample versus pressure shows the settlement of sample affected by type and percentage stabilizer used to treat peat soil which is value of settlement of sample for cement is higher than ceramic. From Figure 3 the graph shows the value of settlement cement is higher than ceramic. The graph from Figure 3 also showed a settlement at a percentage of 8% lower than 4%. This can be seen in both types of stabilizers used. From the Figure 3 also show ceramic is better that cement it is because the settlement of ceramic is lower than cement. Settlement of peat mixed with cement showed that the reading of settlement decreased sharply. It can be seen that the value of treated peat with cement exceeds the value of 1 when subjected to a load of 100 kPa while the treated peat with ceramic is still below the value of 1 at a load of 100 kPa. Meanwhile, the reading of treated peat with ceramic with a total mixture of 8% at a load of 200 kPa is still below the value of 1 which is 0.815.

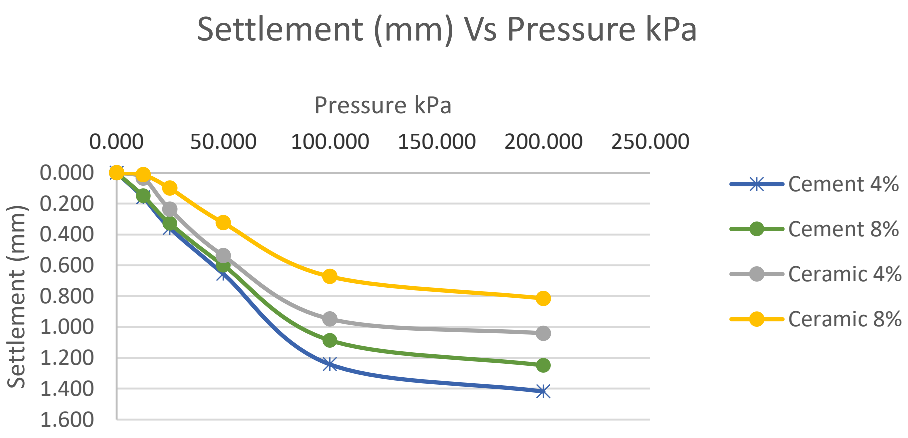

Figure 3: Graphs vertical strain against pressure kPa

5. Conclusion

As a result, the percentage of cement and ceramic used to treat peat soil had an impact on every peat consolidation parameter. The void ratio graph shows that when the amount of stabilizer rises to 8%, the void ratio decreases. Aside from that, the impact of the stabilizers may be observed in settlement data from consolidation tests, which displays ultimate settlement for each pressure and stabilizer applied on peat sample. When the proportion of stabilizer is raised, the settlement of peat decreasing, and the settlement value of ceramic is lower than cement. Additional, when applying or increasing the pressure on the sample, the value of settlement of the sample reduced for both types of stabilizers. Furthermore, the graph of sample settlement against pressure illustrates how sample settlement is influenced by the type and percentage stabilizer used to treat peat soil which for both type stabilizer used 4% and 8%, with the value of sample settlement for cement being greater than ceramic. As a consequence, settlement of cement has a greater value than ceramic. To sum up, the author expects that this study and its findings will offer information on treated peat performance, particularly in terms of consolidation tests, and that future research on treated peat performance will be conducted in greater depth.

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References

[1] A. Zainorabidin, S. Nurul, and A. Zolkefle, "Dynamic Behaviour of Western Johore Peat, Malaysia," 2014.

[2] A. bin Zainorabidin, N. binti Saedon, I. bin Bakar, and N. F. bt Mohd Seth, "An Investigation of Soil Volume Changes at Four Dimensional Points of Peat Soil Sample in Parit Nipah and Pontian," *Appl. Mech. Mater.*, 2015, doi: 10.4028/www.scientific.net/amm.773-774.1491.

[3] Bergado, & D. T. (1996). Soil compaction and soil stabilization by admixtures. *In Proc. of the seminar on ground improvement application to Indonesian soft soils. Indonesia: Jakarta*, pp. 23-26.

[4] G. Mesri and M. Ajlouni, "Engineering Properties of Fibrous Peats," *J. Geotech. Geoenvironmental Eng.*, 2007, doi: 10.1061/(asce)1090-0241(2007)133:7(850).

[5] G. Mesri and P. M. Godlewski, "Time And Stress-Compressibility Interrelationship," *ASCE J Geotech Eng Div*, 1977, doi: 10.1061/ajgeb6.0000421.

[6] Huat, B. B.K. 2004. Organic and Peat Soils Engineering. Universiti Putra Malaysia Press,

Serdang, Malaysia, pp. 20-80.

[7] H. M. M. Adnan Zainorabidin, "Engineering Properties of Integrated Tropical Peat Soil in Malaysia," *J. Geotech. Eng.*, vol. 22, no. May 2017, pp. 1–9, 2017, [Online]. Available: http://ejge.com/2008/Ppr0834/Ppr0834.pdf.

[8] M. I. Ab Kadir, "Long Term Consolidation Study on the Tropical Peat At," no. November, 2009.

[9] N. N. Johari, I. Bakar, and M. H. A. Aziz, "Consolidation Parameters of Reconstituted Peat Soil: Oedometer Testing," *Appl. Mech. Mater.*, vol. 773–774, pp. 1466–1470, 2015,

doi: 10.4028/www.scientific.net/amm.773-774.1466.

[10] P. L. Berry and T. J. Poskitt, "The consolidation of peat," *Geotechnique*, 1972, doi: 10.1680/geot.1972.22.1.27.

[11] S. N. M. Razali, A. Zainorabidin, I. Bakar, and H. M. Mohamad, "Strength changes in peat-polymer stabilization process," *Int. J. Integr. Eng.*, vol. 10, no. 9, pp. 136–141, 2018, doi: 10.30880/ijie.2018.10.09.007.

[12] Z. Ahamad, "Compressibility and shear strength behaviour of peat soil in Sarawak," *Univ. Malaysia Sarawak*, vol. 1, p. 23, 2005.

[13] Z. A. Hassan, M. N. M. Daud, M. A. Yahya, and M. S. Shaharuddin, "Effect of granular material on the rate of consolidation of peat soil," *Electron. J. Geotech. Eng.*, 2013.