

Effect of Different Peat Size and Pre-Consolidation Pressure of Reconstituted Peat on Effective Undrained Shear Strength Properties

ATS Azhar^{1*}, W Norhaliza B Ismail¹, AM Ezree¹ and ZM Nizam¹

¹Faculty of Civil and Environmental Engineering, Universiti Tun Hussein Onn Malaysia, 86400 Batu Pahat Johor, MALAYSIA

Corresponding author: saifulazhar870@gmail.com

Abstract. Shear strength of the soil is one of the most important parameters in engineering design, especially during the pre- or post-construction periods, since it is mainly used to measure and evaluate the foundation or slope stability of soil. Peat normally known as a soil that has a very low value of shear strength, and in order to determine and understand the shear strength of the peat, it is a difficult task in geotechnical engineering due to several factors such as types of fabrics, the origin of the soil, water content, organic matter and the degree of humification. The aim of this study is to determine the effective undrained shear strength properties of reconstituted peat of different sizes. All the reconstituted peat samples were formed with the size that passed the opening sieve of 0.425 mm (<R0.425) and 3.35 mm (<R3.35) and were pre-consolidated with the pressure of 50 kPa, 80 kPa and 100 kPa. The results of effective undrained shear strength properties for reconstituted peat <R3.35 samples were 16 kPa, 19 kPa and 21 kPa for cohesion, and 37°, 38° and 41° for the angle of friction, respectively. Moreover, the effective shear strength properties for the reconstituted peat <R0.425 were 11 kPa, 12 kPa and 12 kPa for cohesion and 23°, 27° and 30° for the angle of friction, respectively. The effective undrained shear strength properties result obtained from the tests show that the reconstituted peat <R3.35 has higher strength than reconstituted peat <R0.425. For relationship deviator stress- strain, σ_{\max}^d and excess pore pressure, Δu , show both of <R0.425 and <R3.35 are gradually increase as when as σ' and σ_c increased. However, at the final stage of the test, the graph is slightly declined due to the increment in stiffness of the specimen. The physical properties of the reconstituted peat <R0.425 and <R3.35 have also been investigated in order to correlate with the findings of the properties for the undrained shear strength.

1. Introduction

CREAM [1] states the peat soil is a soil that formed by the dead wetland materials that is unable to decay in a normal manner due to the presence of high water table. In Malaysia, there are about 2.6 million ha of peat and organic soils accounting for about 8% of the total land area of the country. In Peninsular Malaysia, the coastal areas are found in the east and west coast. While, in Sarawak, peat occurs mainly between the lower stretches of the main river course (basin peat) and in poorly drained interior valleys (valley peats).



Peat land in Johor has developed on marine soils, acid sulphate soils, and marine clays. The Johor west coast peat overlies acid sulphate soil and the east coast peat overlies sand and clay [2].

Azhar et al. [3] states that peat soil generally originated from plant and animal remains. Peat is usually found in limited areas in thick layers, it has high compressive deformation and low shear strength, which often results in difficulties when construction work is undertaken on the deposit. Peat is characterized by 8 m to 20 m thick layer of peat which is mainly semi-decayed plant material accumulated over 8,000 years. In natural state, peat consists of water and decomposed plant fragment with virtually no measurable strength [4]. The content of peat differs from one location to other due to the factor such as the origin fiber, temperature and humidity [5]. The texture of tropical soil consists of loose, branches, partly decomposed leaves, twigs and tree trunks with a low mineral content and the colour of peat soil in Malaysia is generally dark reddish brown to black [6].

The geotechnical engineers agreed that all soils with organic content of greater than 20 % is known as organic soil. Peat soil is an organic soil with organic content of more than 75% [3,5]. This classification is comparatively similar to ASTM D 2487 [7] classification; a soil with organic content less than 75% (or ash content more than 25%) is known as muck or organic soil, while a soil with organic content higher than 75% (or ash content less than 25%) is known as a peat. Magnan [8] divided the degree of peat decomposition into 3 classes for geotechnical purposes that were fibric or fibrous (least decomposed) tentatively ranging from H1 to H3, Hemic or semi-fibrous (intermediate decomposed) tentatively ranging from H4 to H6 and Sapric or amorphous (most decomposed) tentatively ranging from H7 to H10.

Shear strength of a soil mass is classified as the internal resistance per unit area where the soil mass can offer to resist failure and sliding along any plane within its area [9]. The cohesion and the angle of internal friction are classified in the strength properties of the soil. Cohesion refers to strength gained from the ionic bond between grain particles and is predominant in clayey (cohesion) soils. While, the angle of internal friction refers to the strength gained from internal frictional resistance and is predominant in granular soils (cohesion-less) [10]. The effective friction angle of peat was typically determined in triaxial consolidated undrained compression test (CU-Test). In order to obtain the effective strength parameters such as the effective cohesion (c') and the effective angle of shearing resistance (ϕ') of highly organic peat, the consolidated undrained test with pore pressure measurement is suitable and reliable. This triaxial testing is one of the most common method used in soft soil because the result obtained is generally good and accurate [11,12].

Aljouni [13] stated that the undrained shear strength of peat is a critical parameter as other soil. Undrained shear strength of peat rapidly increased during and after construction. The lower bearing capacity of peat soil can cause a failure such as slide or collapse due to low shear strength and high settlement due to high compressibility characteristic of peat [14]. In general, fibric peat (H1- H3) had higher shear strength than hemic (H4- H6) and sapric (H7- H10) peat. The hemic and sapric peat had lower shear strength than the fibrous peat [15].

There are several factors that contribute to the strength of the soils; namely soil compaction, structure, state (initial), loading method and etc [16]. Salih and Kassim [17] stated that the strength of soil was lead to the resistance to the movement (failure) of molecules associated together, thus failure is relevant to the shear strength where it is one of the foremost important soil engineering properties. Huat [5] determined the undrained friction angle of peat in West Malaysia is in the range of 3° to 25° and O'Kelly and Orr [18] postulate that the cohesion value of fibrous peat is higher than zero.

In triaxial analysis test, the stress-strain relationship was developed as the failure criteria in the shear strength. The magnitude of the strain in the soil depends on the parameters such as the magnitude of applied load, the soil structure, past stress history, void ratio, and manner in approach in which the stress is applied [19, 20, 21, 22]. In this study, the effects of reconstituted peat size and pre-consolidation pressure for <R0.425 and <R3.35 were measured to determine the shear strength properties.

2. Materials and Methods

2.1 Peat Sample

Peat samples were taken from Parit Nipah Darat, Batu Pahat, Johor at the depth from 0.3 m to 1.0 m below the ground surface. The classification of peat was done at the field and defined as hemic peat, as the fresh peat passed through at approximately one-third of finger and the actual color are muddy dark brown as determined by Von Post classification. Hence, peat at Parit Nipah can be classified as moderately decomposed (H5). All the disturbed peat samples were then placed into containers to form reconstituted sample in order to study the physical properties of the peat.

2.2 Reconstituted Peat Sample

A relatively homogeneous slurry paste was obtained by gently pressing and rubbing the disturbed peat material to pass the opening size of the sieve from the range of 0.425 mm and 3.35 mm with the aid of water to produce the slurry sample as shown in Figure 1 (a). The range of size was selected based on the particle sieve distribution that has been chosen for this study. Next, the slurry peat samples were placed into a mould by using large strain consolidation equipment under initial consolidation pressure of 50 kPa, 80 kPa and 100 kPa. The peat sample in the mould was assumed to be completed when there is no water flowing out from the bottom part of the tube as shown in Figure 1 (b). Then, a PVC tube with a sharp edge at the end of the tube sized 50 mm of diameter and 150 mm of height were used to obtain the reconstituted peat samples. These reconstituted samples were then cut to get 100 mm height for the triaxial undrained test. The remaining reconstituted peat samples were collected and tested to identify the physical properties of reconstituted peat for comparison purposes.



Figure 1. (a) Reconstituted Wet Sieving (B) Reconstituted Pre- Consolidation Pressure

2.3 Consolidated Undrained Test (CU-Test)

A Monotonic Triaxial machine was used to perform the shear strength properties of reconstituted peat. The specimen with the size of 50 mm diameter and 100 mm height was mounted at the both side rubber membrane with two rubber O-rings at the top cap and the other two at the bottom cap to avoid the water enters into the specimen during the test. Then, water was filled into the mould and the presence of air bubble is eliminated in the confining mould to minimize errors in data acquisition. In CU-Test, there were three major stages, namely saturation, consolidation and shearing stage. At the first stage, the sample was saturated by the increment of 50 kPa cell pressure and 40 kPa back pressure until the coefficient B indicates that the saturation is achieved or the value is equal to 0.95. Then the sample was consolidated isotropically within 24 hours based on each effective stresses (25, 50 and 100 kPa), respectively. While, in the final stage, the sample was applied with axial load with the constant strain rate of 0.1 mm/min until the specimen yields and reach 20% of axial strain. All the triaxial tests were conducted in accordance to BS 1377: Part 8: 1990 [20] and the test apparatus are shown in Figure 2.



Figure 2. Reconstituted Peat Sample on Triaxial Test Machine

3. Results and Discussions

3.1 Peat Properties

The physical properties of the moisture content for the Parit Nipah reconstituted peat <R0.425 and <R3.35 were 349 % and 403 %, respectively. For liquid limit, <R3.35 shows the highest value at 326 % followed by <R0.425 at 303 %. Kolay and Pui [21] states that sample contains lots of fiber results in high water absorption capacity. The fiber content of <R0.425 was 12.98% and for <R3.35 was 51.12%. Since the opening size of sieve for the size 3.35 mm is comparatively larger than the size of 0.425 mm, hence the percentage of fiber content for the <R3.35 is higher than <R0.425. The specific gravity for <R0.425 and <R3.35 are within the range with the previous study, which were recorded at 1.41 and 1.33, respectively. Table 1 show the result of physical properties that was obtained and the results are within the range with the previous studies.

Table 1. Physical Properties of Typical Peat

Parameters	Moisture Content (%)	Liquid Limit (%)	Fiber Content (%)	Specific Gravity (mg/m ³)
Reconstituted Peat Passing 0.425mm (<R0.425)	349	303	12.98	1.41
Reconstituted Peat Passing 3.35mm (<R3.35)	403	326	51.12	1.33
Past Researchers [3], [5], [23], [24]	200-1000	190-360	33-77	1.38-1.80

3.2 Consolidated Undrained Analysis

Salih and Kassim [17] states that the soil deformation is commonly considered to be found at approximately 15% to 20% of strain. In this case, the shear strength of peat can be defined as the maximum stress applied on any plane in a peat mass at some strain considered as a failure. By plotting deviator stress-strain relationship and excess pore water pressure-strain relationship, the Mohr-Coulomb Circle could be determined. Hence, the effective shear strength properties (c' and ϕ') also could be obtained.

3.2.1 Stress- Strain Relationship and Variation of Excess Pore Water Pressure vs. Axial Strain.

Figure 3 (a) and (b), and Figure 4 (a) and (b), show the stress-strain relationship and excess pore pressure relationship performance between <R0.425 and <R3.35 in determination of the maximum value of deviator stress σ_{\max}^d versus axial strain, ϵ_a and excess pore pressure, Δu versus axial strain, ϵ_a during the shearing stage. The σ_{\max}^d for <R0.425 and <R3.35 gradually increase as when σ_c and σ' increased. Based on the results, the σ_{\max}^d and Δu increased along with σ_c and σ' . Das [25] explained about the variation of σ_{\max}^d and Δu versus ϵ_a for loose sand was gradually increased. However in this study, the graph for both σ_{\max}^d and Δu are slightly declined at the end of the strain limit ranging at 20%. This is due to the specimen is slightly denser than the loose sand after pre-consolidated with the high load pressure.

The results in Figure 3 and 4 were tabulated in Table 2, it show that the σ_{\max}^d and Δu are increased with the increment of σ_c and σ' . The value of σ_{\max}^d and Δu for <R3.35 are highest than <R0.425. These results affected by the size of peat and pre-consolidation pressure applied, which give a significant difference in results between both reconstituted peat samples. Cola and Cortellazo [26] and Zolkefle et.al [27] recognize in the rapport between deviator stress by means of axial strain for peat are increasing with the increment of effective stress.

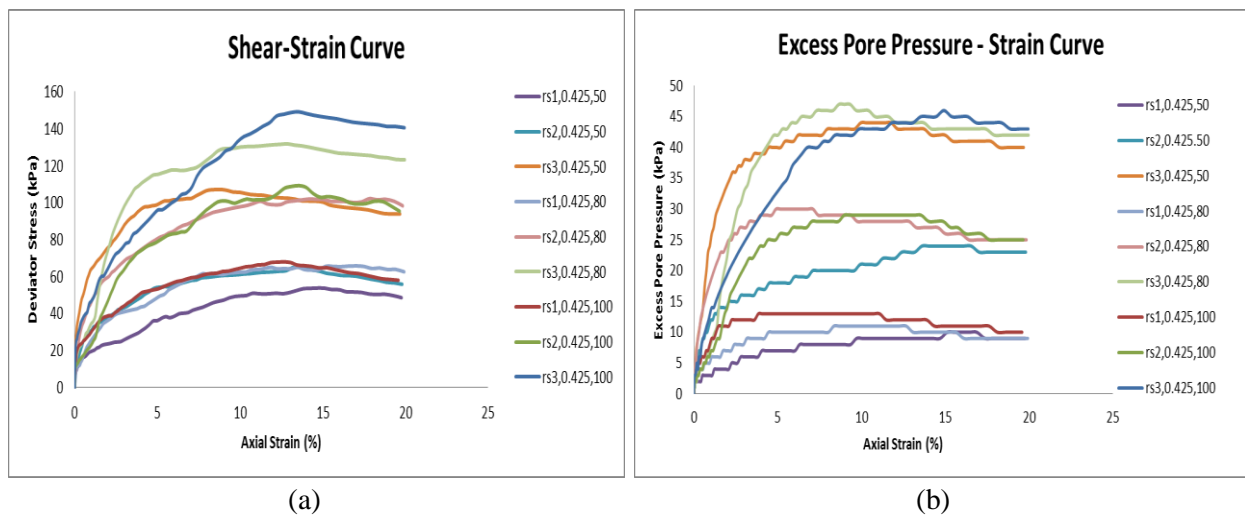


Figure 3. Graph of Deviator Stress and Excess Pore Pressure vs. Axial Strain (<R0.425 for σ_c 50 kPa, 80 kPa and 100 kPa)

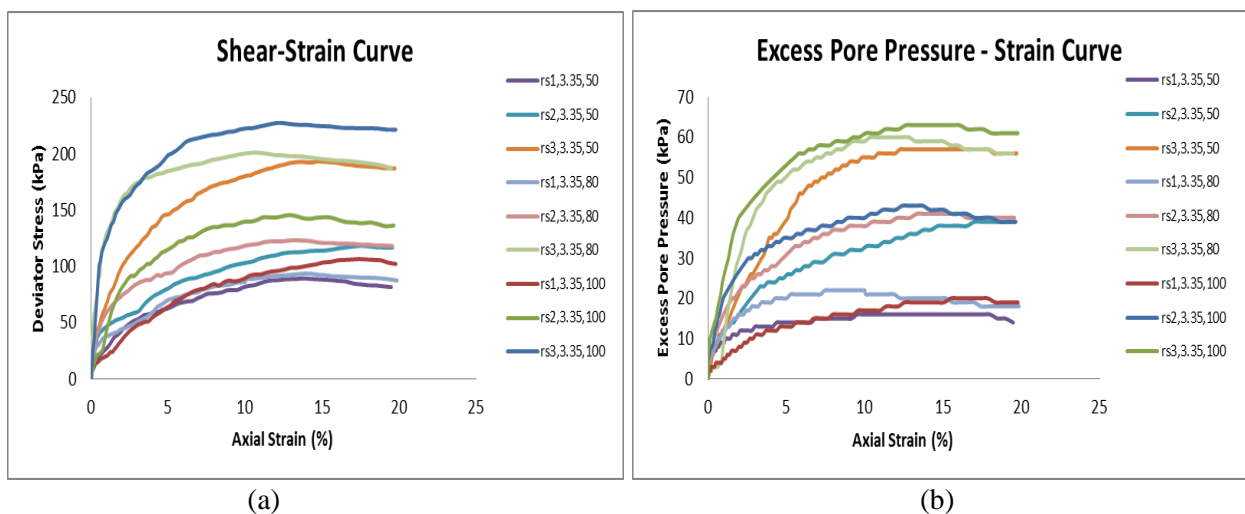


Figure 4. Graph of Deviator Stress vs. Axial Strain (<R3.35 for σ_c 50 kPa, 80 kPa and 100 kPa)

Table 2. Triaxial Value for <R0.425 and <R3.35

Sample	Pre-consolidation Pressure, σ_c (kPa)	Effective Stress, σ' (kPa)	Axial Strain, ϵ_a (%)	Deviator Stress, σ_{\max}^d (kPa)	Excess Pore Pressure, Δu (kPa)
<R0.425	50	25	14.69	53.71	9
		50	13.60	65.29	24
		100	8.91	107.00	43
	80	25	17.02	65.70	9
		50	17.81	102.07	25
		100	12.86	131.73	44
	100	25	12.66	68.86	12
		50	13.56	109.15	29
		100	13.53	149.11	45
<R3.35	50	25	13.79	89.56	16
		50	17.50	118.57	39
		100	13.74	193.01	57
	80	25	13.91	93.86	20
		50	13.33	123.36	41
		100	10.75	201.32	60
	100	25	17.40	106.71	20
		50	12.85	145.84	43
		100	12.62	227.30	63

3.2.2 Effective Undrained Shear Strength Properties.

Table 3 shows the value of effective shear strength properties (c' and ϕ') for <R3.35 and <R0.425 with the pre-consolidation pressure of 50 kPa, 80 kPa and 100 kPa. The shear strength properties for σ_c 50 kPa, 80 kPa and 100 kPa for <R3.35 are higher than <R0.425. The cohesion value for <R3.35 were recorded at 16 kPa, 19 kPa and 21 kPa, respectively. While, the cohesion value for <R0.425 were recorded at 11 kPa, 12 kPa and 12 kPa. In addition, the angle of friction value for <R3.35 were 37°, 38° and 41°, whereas for <R0.425 the angle of friction value were 23°, 27° and 30°. As shown in Table 3, the result of undrained shear strength properties for reconstituted peat <R3.35 is higher than reconstituted peat <R0.425. This is due to the peat size and peat fabric. In addition, the pre-consolidation pressure affects the the initial void and moisture content of the reconstituted samples. The wet sieving and pre-consolidation pressure change the peat structure and allow the particle of the soil to bind very well among other particles. Mesri and Ajlouni [28] and O'Kelly et al. [29], stated that the compressibility of peat can affect the fabric and the arrangement of the constituent fibers and inter-particle of chemical bonding in the soil. As shown in Table 3, the initial water content and initial void ratio for <R3.35 was higher than <R0.425. The increasing value of the initial water content and initial void ratio was due to the peat size that contains large fiber, which produce a large amount of void in the soil thus, allows the peat to retain the water content. However, the initial water content and initial void ratio was decreased with the increment value of σ_c . This phenomenon occurs due to the reconstituted peat was compressed or compacted with certain pre-consolidation pressures.

Table 3. Effective Undrained Triaxial Summary Results

Sample	Pre- consolidation Pressure, σ_c (kPa)	Initial Water Content, w (%)	Initial Void Ratio, e_0	Effective Undrained Shear Strength Properties	
				c' (kPa)	ϕ' (°)
<R0.425	50	330.15	5.20	11	23
	80	320.54	5.11	12	27
	100	312.94	4.98	12	30
<R3.35	50	383.10	5.25	16	37
	80	361.12	5.22	19	38
	100	327.78	5.19	21	41

3.2.3 Relationship of Effective Shear Strength Properties with peat size and σ_c .

Figure 5 (a) and (b) show the relationship of shear strength properties for reconstituted peat <R0.425 and <R3.35 for σ_c of 50 kPa, 80 kPa and 100 kPa. As shown in Figure 5 (a) and (b), the shear strength properties for cohesion and angle of friction were increased with the increment of pre-consolidation pressure. Yusoff et.al [30] stated that the strength of soil specimen texture was affected when the sample was compacted. Wong et.al [31] stated that peat sizes, shape, fabric and packing of the soil particles effect on the soil permeability, compressibility and shear strength. The size and shape of soil particles, the arrangements and the forces between particles were the factors that contribute to the determination of the properties values such as strength, permeability and compressibility [32,33]. Thus, it can be concluded that the size and shape of peat can affect the initial water content, initial void ratio and fiber content, and thus affect the shear strength properties.

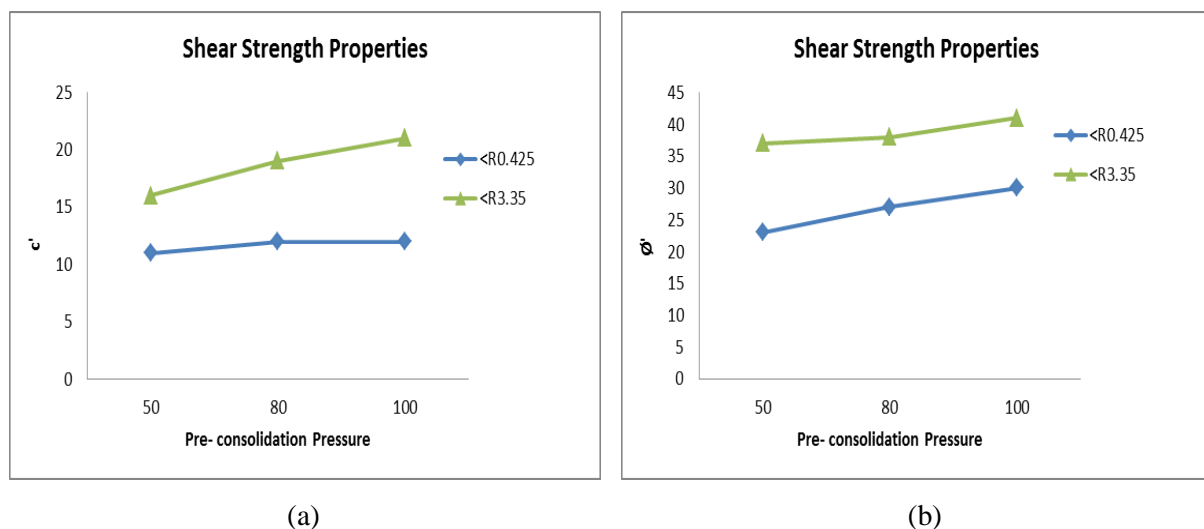


Figure 5. Relationship of Effective Shear Strength Properties for Reconstituted Peat <R0.425 and <R3.35 for σ_c 50kPa, 80kPa and 100kPa

Conclusion

In this study, the reconstituted peat <R0.425 and <R3.35 samples with 50 kPa, 80 kPa and 100 kPa pre-consolidation were used. The effective shear strength properties for reconstituted peat <R3.35 was higher than <R0.425. This condition may occur due to the peat size and pre-consolidation pressure that were used

to form the reconstituted peat, which leads to a significantly remarkable soil strength. The results of the effective shear strength properties for reconstituted peat <R3.35 samples were 16 kPa, 19 kPa and 21 kPa for cohesion, whereas the angle of friction were 37°, 38° and 41° respectively. Moreover, the effective shear strength properties for the reconstituted peat <R0.425 were 11 kPa, 12 kPa and 12 kPa for cohesion and for the angle of friction 23°, 27° and 30°. The differences of cohesion and angle of friction that were obtained in this study between reconstituted peat samples <R0.425 and <R3.35 are due to several factors. Here, the factors that contribute to the differences are pre-consolidation pressure, initial void ratio, size and shape of peat and physical properties, as well as initial water content, fiber content and liquid limit. Thus, it can be concluded that reconstituted peat with the passing sieve opening of 0.425 mm and 3.35 mm and pre-consolidation pressure with 50 kPa, 80 kPa and 100 kPa can increase the shear strength properties of peat soil.

Acknowledgment

The authors greatly appreciate and express gratitude to the supervisory team for the guidance, encouragement and valuable support and to all the staff members of Faculty of Civil and Environmental Engineering Department (FKAAS, UTHM), Research, Innovation, Commercialization and Consultancy Office (ORICC), Centre for Graduate Studies (PS) and Ministry of Higher Education Malaysia for supporting this research under the Fundamental Research Grant Scheme (FRGS), Vot. 1458 and Vot. 1455.

References

- [1] CREAM, 2015 Guidelines for Construction on Peat and Organic Soils in Malaysia. Kuala Lumpur, Malaysia: Construction Research Institute of Malaysia (CREAM).
- [2] Wetlands International, 2010 A Quick Scan of Peat lands in Malaysia, Wetlands international-Malaysia: Petaling Jaya, Malaysia, 50 pp.
- [3] Azhar, A.T.S., Norhaliza, W., Ismail, B., Abdullah, M.E. and Zakaria M.N. 2016 Comparison of Shear Strength Properties for Undisturbed and Reconstituted Parit Nipah Peat , IOP Conference Series: Materials Science and Engineering, 160, 012058.
- [4] Munro, N., 2005 Dealing With Bearing Capacity Problems on Low Volume Roads Constructed on Peat. ROADDEX II Northern Periphery.
- [5] Huat, B.B.K., 2004 Organic and Peat soil Engineering. University Putra Malaysia, Serdang, Malaysia.
- [6] Wust, R. A. J, Bustin, R. M., & Lavkulich, L. M., 2002 New Classification Systems for Tropical Organic Rich Deposits based on Studies of The Tasek Bera Basin, Malaysia. www.elsevier.com/locate/catena, 133- 163
- [7] ASTM Standard D 2487, 2000, Standard Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System), Vol. 04.08.
- [8] Magnan, J.P. 1980 Classification geotechnique des sols: 1- A propos del la classification LPC, Bulletin de Liaison des Laboratoiresdes Ponts et Chaussees, Paris, PP. 19- 24.
- [9] Das, B.M. (2007). *Principles of Foundation Engineering*. 7th Ed. United States of America: Christopher M. Shortt.
- [10] Liu, C. and Evett, J. B., 2005 Soils and Foundations. *6th Edition*. Pearson Prentice Hall. Pg 486.
- [11] Long, M., 2005 Review of peat strength, peat characterisation and constitutive modelling of peat with reference to landslides. *Studia Geotechnica et Mechanica* 27 (3-4): pg 67-90
- [12] Zhang, L. and O'Kelly, B. C., 2014 The Principle of Effective Stress and triaxial compression testing of peat. *Proceedings of the Institution of Civil Engineers*. Institution of Civil Engineers (ICE). pp. 40-50
- [13] Ajlouni, M. A., 2000 Geotechnical Properties of Peat and Related Engineering Problems. PhD Thesis. Univ of Illinois at Urbana- Champaign. Urbana, Ill.
- [14] Kazemian, S., Huat, B. B., Prasad, A., and Barghchi, M. A., 2011 A State of Art Review of Peat: Geotechnical Engineering Perspective, *International Journal of The Physical Sciences*, volume 6 (8), pp. 1974- 1981

- [15] Huat, B.B.K., Asadi, A. and Kazemian, S., 2009 Experimental Investigation on Geomechanical Properties of Tropical Organic Soils and Peat. *American Journal of Engineering and Applied Sciences* 2 (1): 184- 188
- [16] Poulos, S. J., 1989 Jansen, R. B., ed., “Liquefaction Related Phenomena”, *Advance Dam Engineering for Design* (Van Nostrand Reinhold): 292-320.
- [17] Salih, A.G. and Kassim, K.A., 2012 Effective Shear Strength Parameters of Remoulded Residual Soil. *Electronic Journal of Geotechnical Engineering*, 17, 243- 253.
- [18] O’Kelly, B.C. and Orr, T.L.L., 2014 Briefing: Effective Stress Strength of Peat in Triaxial Compression. *Proceedings of The Institution of Civil Engineers. Institution of Civil Engineers (ICE)*. pp. 417-420
- [19] Anggraini, V., 2006 Shear Strength Improvement of Peat Soil Due To Consolidation. Master Dissertation, Universiti Teknologi Malaysia.
- [20] British Standard Institution (BSI)., 1990 *British Standard Methods of Test for Soils for Civil Engineering Purposes. Part 8: Shear strength Tests (effective stress)*. BS1377.
- [21] Kolay, P.K. and Pui, M.P., 2010 Peat Stabilization Using Gypsum and Fly Ash. *Unimas E Journal of Civil Engineering*; Vol 1.Issue 2.
- [22] Ling J H, Sabarudin M , Saiful A A T , Syazie N A M, Ismail B, Mohd I M M, Adnan Z & Ali A W M, 2016 Construction of Infrastructure on Peat: Case Studies and Lessons Learned, *MATEC Web of Conferences*, 47 03014.
- [23] Rahman, J. A. and Chan, C. M., 2013 Influence of Temperature on the Mass Losses of Tropical Peat at Different Decomposition Level, *Soft Soil Engineering international Conference*.
- [24] Razali, S. N. M., Bakar, I., and Zainorabidin A., 2013 Behaviour of Peat Soil in Instrumented Physical Model Studies, *Procedia Engineering*, Volume 56, Pp 145 – 155.
- [25] Das, B. M., 2010 *Principles of Geotechnical Engineering, 7th Edition*. Stamford, USA: Cengage Learning.
- [26] Cola, S. and Cortellazo, G., 2003 The Shear Strength Behaviour of Two Peaty Soils,” *Geotechnical and Geological Engineering*, pp. 679-695.
- [27] Zolkefle, S.N.A, Zainorabidin, A. and Mohamad, H.M 2014. The Characteristics of Pontian Peat under Dynamic Loading. *International Civil and Infrastructure Engineering Conference*, Kota Kinabalu, Sabah, Malaysia.
- [28] Mesri, G. and Ajlouni, M., 2007 Engineering Properties of Fibrous Peats. *J. Geotech. Geoenviron. Eng.*, 133(7): 850-866.
- [29] O’Kelly, B.C., Pichan, S.P., 2013 Effects of Decomposition On The Compressibility of Fibrous Peat- A Review, *Geomech. Geoeng.* 8(4), 286-296.
- [30] Yusoff, S.A.N.M, Bakar, I., Wijeyesekera, D.C., Zainorabidin, A., Madun, A., 2015 Comparison of Geotechnical Properties of Laterite, Kaolin and Peat. *Applied mechanics and material* 773, 1438-1442.
- [31] Wong, L.S., Hashim, R. and Ali, F.H., 2009 A Review On Hydraulic Conductivity And Compressibility of Peat. *Journal of Applied Sciences*, 9: 3207-3218.
- [32] Mitchell, J.K, 1993 *Fundamentals of Soil Behavior*. J. Wiley & Son Inc.
- [33] Ali A W M, Sabarudin M , Mohd I M M , Saiful A A T , Ismail B , Adnan Z , Azrul Z K & Ling J H, 2016 Construction of Buildings on Peat: Case Studies and Lessons Learned, *MATEC Web of Conferences* 47 03013