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Research paper



Undrained Shear Strength of Peat Soil Improved with Pond Ash-Hydrated Lime Admixture

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Abstract

The low shear strength and high moisture content can be highly related to peat soil. It can be categorized as a baffling soil because of its high humidity in the peat soil particle. The reasons for why settlements need to occur after heavy load has been applied to the peaty soil need to be discovered. Therefore, in this study, the objective of work is linked to the strength of the untreated and treated peat soil with in an effective way but with a low budget. The strength of the untreated natural peat and treated peat soil with pond ash-hydrated lime which are reacting as a binder in the peat soil treated particles was designed. The different strength of soaking time (0, 7, 14 and 21 days) of the samples is compared to know the different strength of different soaking time by using Unconsolidated Undrained (UU) test. The results show that the shear strength was increased when the pond ash-hydrated lime was added to the soil.

Keywords: *Pond ash, hydrated lime, stabilization, peat soil, UU test.*

1. Introduction

The construction building on the soft soil is the most important part which needs to be considered because the soft or the baffling soil condition is yet the first thing to be investigated before proceeding into further stages.

Peat soil is a good example of the baffling soil or soft soil in Geotechnical engineering (Wong et al., 2008; Balamurugan and Boobathiraja, 2014). The physical and natural peat soil deposits are explained from the engineering behaviour (Md. Yusof et al., 2015 a & b; O'Kelly, 2015). Furthermore, the nature of the peat soil can be affected by other external factors in a long run. Therefore, the construction of peat soil, dealing with what type of method is needed to make sure the construction can be conducted smoothly without any failure due to the settling. The common thing which will happen when dealing with peat soils was settled. The settlement has a serious problem when dealing with construction because it can harm the extra cost of the maintenance like to overcome the cracks or damages in construction. Nowadays, the lands are expensive and becoming very limited due to the extensive population growth and an extreme cause of an increased demand. There are a lot of peat soil areas in Malaysia that are not suitable for developments as they are generally weak in both shear strength and bearing capacity. This imposes a major challenge for all engineers to counter the problem when it comes to utilizing the peaty area as a platform for a structure (Huat, 2004). Peat soil is a difficult and unconventional geomaterial which exhibits a low virgin shear strength and a very high compressibility, which presents significant challenges in ground engineering. The engineering problem with peats have tended to be dominated by issues which associates with the undrained shear resistance and settlement, with stability studies usually driven by consideration of the undrained shear strength of the peat (O'Kelly, 2015).

According to Wong's et al., (2008) previous studies, the secondary pozzolanic reaction of the cement stabilized peat is retarded due to insufficient silica (SiO_2) and alumina (Al_2O_2) that can react with calcium hydroxide ($Ca(OH)_2$)which was generated from the cement hydration to form secondary calcium silicates and aluminates, which are responsible for the long term strength gained from the stabilized peat soil. In Chand and Subbrao (2007), the hydrated lime ($Ca(OH)_2$) was used for in-place stabilization of pond ash by the lime column method. Furthermore, Nikoorkar et al., (2013) stated that the hydrated lime can used to treat peat soil and increase the strength of peat soil. Chand and Subbrao (2007) mentioned that in their previous studies, they identified that when mix pond ash with a hydrated lime in the soil, the admixture will be active and this can accelerate the reactions of pond ash and hydrated lime in soil which then improves the stabilization effect. Kolay et al., (2011) stated that a very few literatures are available for pond ash (PA) utilization, particularly its use as a stabilization material. Therefore, it is evident from research that engineering properties of peat can be improved with chemical reaction and the inclusion of pond ash (a byproduct of coal ash) and hydrated lime acting as a binder. Basically, inclusion of the filler procedures no chemical reaction, but it enhances the strength of the stabilized peat soil by increasing the number of soil particles available for the binders to unite and form a load which sustains the stabilized soil structure (Md. Yusof et al., 2015 a). Therefore, the objective of this study is to investigate the shear strength of untreated and treated peat soil after mixing with pond ash and hydrated lime.

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2. Materials and Methods

Soil sampling: For laboratory investigation, peat soil was sampled from a site in Rejo Sari road, Batu Pahat, Johor, Malaysia. Trial pits were excavated to a depth of 0.6 to 1m below the ground surface in order to obtain both undisturbed and disturbed soil samples below the ground water level. Close examination of each trial pit indicates that the ground water level was about 0.3 to 0.6m from the ground surface. This shows that the peat soil had a very high water holding capacity. Visual observation on the peat soil indicates that the soil was dark brown in colour. When the soil was extruded on squeezed out and the plant structure was not easy being identified. Based on the visual observation, the soil can be classified as H3 to H6 according to von post system based on its degree of humification. Some basic properties of the peat are shown in Table 1.

Preparation of stabilized soil specimen: Stabilized soil specimen preparation, mixing and soaking procedures were adopted in the research based on the design guide of soft soil stabilization, which was prepared as part of the European Soil Stabilization (EuroSoilStab) projects. The design guide covers the different methods of stabilizing soft organic soil, the design approaches that are normally adopted, the test methods are used to determine the appropriateness of the binder and the site equipment as well as the installation procedure which is to be used. In accordance with the design guide, isolated roots and coarse material were removed from wet peat soil in its natural state before it was initially mixed for homogenization. The wet peat soil was oven dried first. The dried peat soil, which passing the 2 mm sieve was prepared in the remoulding, mixer with pond ash and hydrated lime at least 5 to 10 minutes before placing in a steel mould of sized 50 mm internal diameter x 100 mm height. The specimen was extruded properly and wrapped with plastic before leaving it in a tank without water for 24 hours. After that, the specimen was soaked with the water in the tank for the 0, 7, 14 and 21 days soaking time.

Laboratory mix design procedure: The laboratory testing was done in accordance with the Manual of Soil Laboratory testing (Head, 1995) based on the British (BS 1377:1990) and ASTM standards. The comparison between untreated and treated peat soil specimen with the soaking time (0, 7, 14 and 21 days) were evaluated using standard UU test apparatus. The sample preparation and the apparatus arrangement for the laboratory UU test are shown in Fig. 1 (a, b & c) respectively.

3. Result and Discussion

In the early stages of this study, the UU test was conducted only for natural peat soil. The reason for conducting this test is to make sure it becomes the control sample. The shear strength is a term used in soil mechanics to describe the magnitude of the shear stress that a soil can sustain. From Fig. 2, the graph has shown three specimens of the untreated peat after being tested. The dimension was used for these three particular specimen is 50 mm diameter and 100 mm high. Based on the Fig. 2 also, the maximum deviator stress for the peat sample A, B and C was 29.7 kPa, 224.9 kPa and 60.3 kPa respectively. For the treated peat soil samples, the three specimens (A, B & C) also was prepared for peat stabilized with 20% of pond ash and 12% of hydrated lime for 0 day, 7 days, 14 days and 21 days of soaking time were being tested using the UU test. The maximum deviator stress-strain average for treating peat soil samples was summarized in Fig. 3.

Table 1: Basic properties

Physical properties	Values
Degree of decomposition	H3 – H6/Fibrous peat
Moisture content (*w*)	811 – 856 %
Organic content (OC)	98.8 %
Specific gravity (Gs)	1.48
pH	3.35 – 3.82
Optimum Moisture Content (OMC)	42.31 %
Maximum Dry Density (MDD)	0.623 Mg/m^3

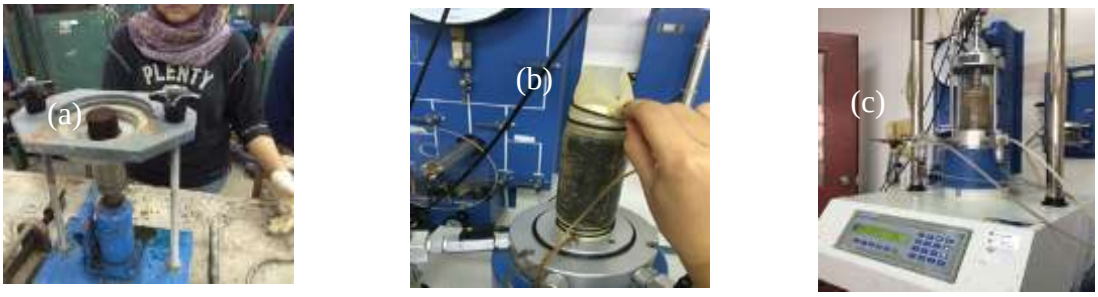


Fig. 1: a) Sample preparation, b) sample setup & c) sample tested UU test.

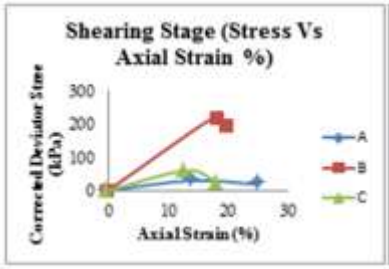


Fig. 2: Stress-strain curve for natural.

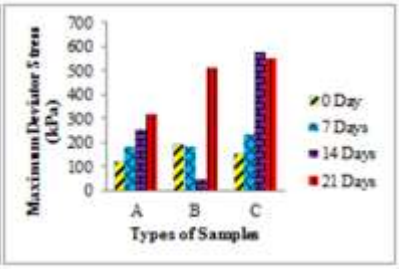


Fig. 3: Max. deviator stress-strain.

From Table 2, the result was analysed that the shear strength increase in soaking time. The high shear strength is achieved at 21 days with soaking time of 230.67 kPa and the lowest is at 0 day soaking of 79.67 kPa. The strength increases rapidly after 14 days and then increased with small difference in 7 days of soaking time. It can be concluded that the strength of the peat soil treated is being increased when the soaking time of the sample has been increased. Each maximum deviator stress from the graph was taken to get the average reading. From the average reading, the graph plotted was based on the soaking time and percentages of pond ash – hydrated lime was used. Table 2 also shows the comparison between the soaking time of the samples with the value of average shear strength is for 0, 7, 14 and 21 days achieved at 79.67 kPa, 101 kPa, 220.33 kPa and 230.67 kPa respectively. Soaking time and treated peat soil was depending on each other. Based on Fig. 4, the strength of the peat soil was increased at the soaking time of the samples are increased. Fig. 4 also shows the strength of peat soil treated has been increased constantly when the soaking time was increased from 0 day to 7 days. However, when the soaking time was increased to 14 days, the strength was increased drastically incomparable to 0 day to 7 days. This is because the longer soaking time it tends to give a better duration for the pond ash and hydrated lime bonding well and harden. This result shows a similar trend to which reported by Kolay et al., (2011). The UU test was producing the Mohr Circle, which is given the value for different composition of hydrated lime and pond ash. The average value of maximum shear strength is achieved after 21 days soaking time. From the value, the normal stress can be produced with equations of shear stress. Table 3 shows the value of Cu and ϕ° develops from Mohr Circle.

Table 2: Shear strength of peat samples

Sample	Shear Strength, τ (kPa)			Average
	A	B	C	
Untreated peat	14	107	30	50.33
0 day	63	97	79	79.67
7 days	91	93	119	101
14 days	128	244	289	220.33
21 days	160	256	276	230.67

Table 3: Value of the Cu and ϕ° develop from Mohr Circle

Days	Cu (kPa)	ϕ°
Remoulded	0	30°
0	11	27°
7	0	41°
14	15	42°
21	39	40°

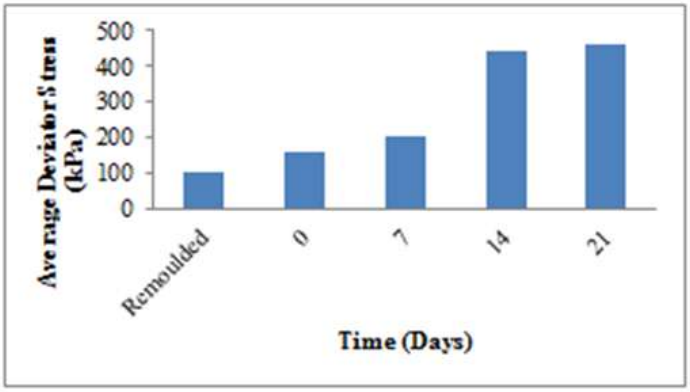


Fig. 4: Maximum deviator stress over different days.

4. Conclusion

Based on the laboratory investigation, it can be concluded that a longer soaking time and additional of hydrated lime and pond ash have a better stabilization. From the UU test result, a longer soaking time and the addition of the hydrated lime and pond ash have a better result, hence promote a better strength. The UU test also gives a different value for different in soaking tie of admixture pond ash and hydrated lime. The average value was achieved for the result 0 day, 7 days, 14 days and 21 days. Moreover, from the results the unconsolidated undrained test was given a different value for different in soaking time of an admixture of hydrated lime and pond ash into peat soil.

References

[1] Balamurugan, P., & Boobathiraja, S. (2014). Study on strength of peat soil stabilized with cement and other pozzolanic materials. International Refereed Journal of Engineering and Science (IRJES), 3(2), 35 – 41.
[2] BS 1377:1990. Soil for Civil Engineering Purposes. BSI.Chand, S. K., & Subbarao, C. (2007). In-place stabilization of pond ash deposits by hydrated lime columns. Journal of Geotechnical and Geoenvironmental Engineering, 133, 1609 - 1616.
[3] EuroSoilStab (2002). Development of design and construction methods to stabilize soft organic soils: design guide soft soil stabilization, CT97-0351. Project No. BE 96-3177. Industrial and Materials Technologies Programme (Brite-EuRam III), European Commission, 15-60.
[4] Chand, S. K., & Subbarao, C. (2007). In-place stabilization of pond ash deposits by hydrated lime columns. Journal of Geotechnical and Geoenvironmental Engineering, 133, 1609 – 1616.
[5] Head, K. H. (1994). Manual of soil laboratory testing (Vol 2: Permeability, Shear strength and Compressive Tests). 2nd edition, Pretech Press, London, ISBN; 0 –7273 – 1319 – 3.
[6] Huat, B. B. K. (2004) Organic and peat soil engineering, 1st edition, University PutraMalaysia Press, Serdang, Malaysia.

[7] Kolay, P. K., Sii, H. Y., & Taib, S. N. L. (2011). Tropical peat soil stabilization using class F pond ash from coal fired power plant, International Journal of Civil and Environmental Engineering, 3 (2), 79 – 83.
[8] (a) Md. Yusof, Z., Mohd Harris, S. N., & Mohamed, K. (2015). Compressive strength improvement of stabilized peat soil by pond ash – hydrated lime admixture. Applied Mechanics and Materials. 747, 242 – 245.
[9] (b) Md. Yusof, Z., Mohamed. K., Henary, O. M., & Yahya, N. A. (2015). Effects of hydrated lime – pond ash admixtures on the compaction characteristics of treated peat soil. Australian Journal of basic and applied science, 9(13), 359 – 361.
[10] Nikookar, M., Nikookar, H., & Arabani, M. (2013). Peat soil stabilization by hydrated lime. 7th National Congress on Civil Engineering. University of Sistan and Baluchestan, Zahedan, Iran, 1 – 5.
[11] O'Kelly, B. C.(2015). Atterberg limits are not appropriate for peat soils. Geotechnical Research. 2 (3).
[12] Wong, L. S., Hashim, R., & Ali, F. H. (2008). Strength and permeability ofstabilized peat soil. Journal of Applied Sciences. 8 (21), 3986 – 3990.