International Journal of Engineering & Technology, 8 (1.9) (2019) 74-76

SPC

International Journal of Engineering & Technology

Website: www.sciencepubco.com/index.php/IJET

Research paper

Permeability of the Treated Peat Soil Mixtures with Pond Ash – Hydrated Lime

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Abstract

Peat soil has been identified as a Geotechnical engineering problem in the construction works because of its difficulties to predict it's Geotechnical behaviour due to its volume instability. The aim of this paper was to analyse the permeability of the treated peat soil's mix with the various percentages of pond ash (PA) (5, 10, 15 & 20%) and constant hydrated lime's (HL) (12%) composition. The role of using PA and HL is to act as the reactant and accelerator in treating peat soil. The treated soil properties are great importance of the vital as the design contributes to the improvement of the peat soil. Therefore, this study investigated the significant evidence on the effect of untreated and treated peat soil from the laboratory works testing. The results of this study show that by increasing PA content from 5 to 20%, the admixtures were able to reduce the coefficient of vertical permeability of the treated peat soil in soaking time compared with the untreated peat soils. It is a significant evidence of the positive effects composition of the treated peat soil was discovered during the laboratory works.

Keywords: *Pond ash, hydrated lime, peat soil, permeability*

1. Introduction

Peat soil is a good example of the weak soil at the Geotechnical problematic foundation. Generally, the water content of the peat soil is very high when it was recognized more than 1000% incomparable to mineral soils such as silt, clay and sand. Due to this fact, the alternative in the soil improvement methods of peat soil is much needed.

Many methods or techniques were implemented to improve the engineering properties of peat soil regardless from chemical stabilization or even chemical grouting. Mostly this method is popular for peat soil improvement today. In the hindrances of the peat soil characteristics shown that it has a high compressibility, and medium to low permeability. It also has the lowest shear strength and instability volume. The consequence of that, it is assumed as the weak foundation soil, make the peat soil is not selected as a foundation for the substructures and superstructures of the high rise buildings because of it is spending much expensively construction. Therefore, an economically attractive alternative of the soil stabilization technique is often used as it contributes to remove the untreated deep peat soil and replace it with the piles for the deep foundation. Furthermore, the deep peat soil stabilization is formed by the soil mixture. It produced in the interaction of the binder with weaker soil leads to a material which has shown a better reaction in engineering properties more than the untreated soil (Wong et al., 2008; Thamer et al., 2015).

According to Wong's et al., (2008) previous studies, it was shown that the secondary pozzolanic react with the cement when it treated with the peat soil. It was shown that the cement retarded due to its insufficient silica (SiO2) and alumina (Al2O2) that has reacted to form as a calcium hydroxide (Ca(OH)2). It is generated from the cement hydration to become as the secondary calcium silicate and aluminates. This calcium silicate and aluminates are responsibility to gain the long term strength of the treated peat soil. Furthermore, Chand & Subbrao (2007) stated that the hydrated lime (Ca(OH)2) or calcium hydroxide (Ca(OH)2) can use for stabilizing of pond ash. The hydrated lime was prepared commercially when the quick lime was slaked in the laboratory. The purity and the percentage of the lime in hydrated lime was 67.6%.

Nikookar et al., (2013) also added that the hydrated lime can be used to treat peat soil and increase its strength of the peat soil. Chand & Subbrao (2007) and Kolay et al., (2011) also mentioned in their previous studies, they have identified that when the pond ash mix with hydrated lime in the soil, the admixture is active and thus it can accelerate the reactions of pond ash and hydrated lime in soil which contributes to the improvement of the stabilizing effect. The structure particles of the pond ash act as sand or finer aggregate increases the volume stability in the solid particles of the weak soil. It can see that, very few literatures related to the available for the pond ash (PA) utilization. It is concluded that the PA was still very less used as a stabilization material in the construction work.

Therefore, it is a positive prove by those researches that studies the mechanical properties of peat soil can be treated with chemical reactions by increasing the percentage of the two materials which are pond ash (a byproduct of coal ash) and hydrated lime (a binder). Basically, the materials enhance the strength of the treated peat soil by increasing the percentage of the volume soil particles that available for the binders to form a load sustainable treated the soil structure (Md. Yusof et al., 2015 a & b). The studies focused to investigate the materials that used to increase the volume stability and also to reduce the void ratio of the soil by adding the solid spaces within the soil during soaking time. Therefore, the study of the effect of pond ash and hydrated lime in stabilizing peat soil should be done by investigating the decreasing of the coefficient of vertical permeability of treated peat soil by increasing the soaking time for peat treated through laboratory works with the design mixture and testing works.

2. Materials and Methods

Soil sampling: In these studies, the collection of the materials for the laboratory works was started with collected the peat soil from a site Rejo Sari road, Batu Pahat, Johor, Malaysia. After reaching the site, the soil surface was started clearing from debris and dead roots before starting the trial pits. The soil surfaces were excavated from a depth of 0.6 to 1 m below the ground surface area in order to obtain the undisturbed and disturbed peat soil samples below the ground water level. It was observed that each trial pit indicates that the ground water level was about 0.3 to 0.6 m from the ground surface. This is shown that the peat soil holding very high capacity of the water. From the visual observation also, the colour of the peat soil indicates was dark brown. When the peat soil was extruded by manual hand, it was squeezing out yet the dead plant structure and it was not easy to be identified. The degree of humification peat soil was classified in a range between H3 to H6 according to von post system. As shown in Table 1, some of the basic properties of the peat soil are identified after several testing.

Table 1: Basic property.

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

Preparation of the Treated soil specimen: The treated peat soil specimen was prepared, mixture and soaked regarding to the several procedures which are adopted in this research based on the European Soil Stabilization (EuroSoilStab, 2002). Hebib & Farrell (2003) were added, this design guideline covers different methods based on the soft organic soils classification. The design approaches normally adopted the procedure of the test to determine the appropriateness of the binder. According to the design guideline, the isolated roots and the coarse material were removed from the wet peat soil before dried. It is the natural state before it was initially mixed with homogenization. Then, the wet peat soil was oven dried first before sieving process. For the dried peat soil, the size passing through 2 mm sieve was prepared in a remoulding before mixed with pond ash and hydrated lime for at least 5 to 10 minutes before placing and compacted 27 times in a steel mould. The specimen for laboratory works was tested by using falling head test equipment. The falling head samples were prepared in the same manner. But, it was placed and soaked together with a steel mould in sizes of 104.2 mm internal diameter and the height is 130 mm. For falling head tests, the specimen was not removed from the mould because it was tested together after soaking time and was removed from the mould after testing.

Laboratory mix design procedure: The laboratory testing works were based on according to the Manual of Soil Laboratory testing as stated by Head (1994) by following the procedure British standards (BS 1377: 1990) and related ASTM standards. The comparison between the initial vertical permeability of both samples untreated and treated peat soil with the soaking time 0, 30, 60 and 90 days were evaluated by using falling head apparatus in the laboratory. The apparatus was arranged properly in the laboratory as shown in Fig. 1 (a, b & c) respectively.

Fig.1: Apparatus arrangement for (a) sample falling head, (b) set up equipment falling head tests, (c) adjustment air bubble.

3. Result and Discussion

A comparison between the untreated and treated peat soil samples was tested using equipment falling heads test is presented in Table 2. In untreated condition, the coefficient of vertical permeability shown that the results peat soil flowing in 1.79 x 10-5 m/s, 1.84 x 10-5 m/s and 1.8 x 10-5 m/s for S1B1, S2B2 and S3B3 respectively. Meanwhile, range between 1.55 x 10-5 m/s to 1.83 x 10-5 m/s for remoulding samples and the range between 1.79 x 10-5 to 1.84 x 10-5 m/s for undisturbed sample. It is shown that the undisturbed sample flow was reduced permeable and incomparable with other soil such as a very fine and silty sand. However, it was change after the treated peat soil was mix with the various percentages of pond ash (PA) (5, 10, 15 & 20%) and constant hydrated lime (HL) (12%) composition for 90 days, its coefficient of vertical permeable was reduced from 3.38 x 10-7 m/s to 6.53 x 10-7 m/s for sample Q. The decrease of the coefficient of vertical permeability of the treated peat soil is compared with the untreated peat soil totally change to the attributable when the chemical reacts with pond ash and hydrated lime. It can observe that by increasing the soaking time give the void fill up the spaces of the soil particles when the pond ash applied immediately after mixing the peat soil with the hydrated lime. Fig. 2 (a – d) shows the relationship between the flow velocity and the type of the sample during curing time in falling head tests. The decreasing soil coefficient of vertical permeability shown that some fact was happening due to the soil when pond ash and hydrated lime mixing in fully saturated means the peat soil interact with water to produce bondage strength of the cemented soil. The pores of the peat soil were blocked to reduce the permeability of the peat soil and it was increased to reduce when the soaking time was increasing.

Table 2: Permeability of undisturbed peat and treated peat

Type of specimen		Curing time (Day)	Coefficient of vertical permeability, k_v (m/s)		
			S1B1	S2B2	S3B3
Undisturbed peat		-	1.79×10^{-5}	1.84×10^{-5}	1.8×10^{-5}
Remoulded peat		-	1.71×10^{-5}	1.83×1^{-5}	1.55×10^{-5}
Soil with 5%PA + 12%HL	E	0	1.3×10^{-5}	1.3×10^{-5}	1.29×10^{-5}
Soil with 10%PA + 12%HL	I		1.09×10^{-5}	1.15×10^{-5}	1.22×10^{-5}
Soil with 15%PA + 12%HL	M		1.91×10^{-6}	3.41×10^{-6}	1.03×10^{-6}
Soil with 20%PA + 12%HL	Q		5.38×10^{-7}	6.53×10^{-7}	3.38×10^{-7}
Soil with 5%PA + 12%HL	E	30	1.28×10^{-5}	1.28×10^{-5}	1.28×10^{-5}
Soil with 10%PA + 12%HL	I		1.05×10^{-5}	1.05×10^{-5}	1.14×10^{-5}
Soil with 15%PA + 12%HL	M		9.27×10^{-6}	9.47×10^{-6}	9.42×10^{-6}
Soil with 20%PA + 12%HL	Q		8.20×10^{-6}	6.73×10^{-6}	6.34×10^{-6}
Soil with 5%PA + 12%HL	E	60	2.52×10^{-6}	1.28×10^{-5}	1.28×10^{-5}
Soil with 10%PA + 12%HL	I		2.52×10^{-6}	1.05×10^{-5}	1.14×10^{-5}
Soil with 15%PA + 12%HL	M		1.87×10^{-7}	9.47×10^{-6}	9.42×10^{-6}
Soil with 20%PA + 12%HL	Q		1.76×10^{-6}	6.73×10^{-6}	6.34×10^{-6}
Soil with 5%PA + 12%HL	E	90	7.18×10^{-6}	7.2×10^{-6}	7.35×10^{-6}
Soil with 10%PA + 12%HL	I		7×10^{-6}	7.08×10^{-6}	7.22×10^{-6}
Soil with 15%PA + 12%HL	M		4.56×10^{-6}	4.68×10^{-6}	4.83×10^{-6}
Soil with 20%PA + 12%HL	Q		2.41×10^{-6}	2.56×10^{-6}	2.57×10^{-6}

4. Conclusion

Based on the laboratory works on the effect of pond ash and hydrated lime at treating peat soil, the permeability of the treated peat by mixing peat, pond ash and hydrated lime was significantly reduced the coefficient of vertical permeability than that of undisturbed peat. It was shown that the effect of pond ash and hydrated lime in treating peat soil was identified that the coefficient of vertical permeability of the pond ash and hydrated lime treated peat soil acting as filler for 90 days of soaking lower than undisturbed peat. At the same binder dosage, pond ash- hydrated lime and soaking time, the treated peat soil was soaked with further lowered hydraulic conductivity.

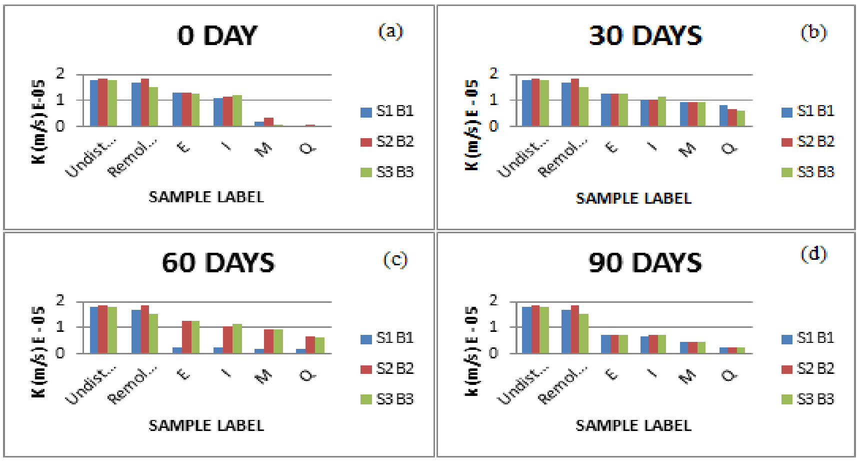

Fig. 2: (a – d): Relationship between flow velocity and type of sample during curing time in falling head tests

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