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Effect of Palm Fiber-Hydrated Lime Composition on the Permeability of Stabilised Sandy Soil

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Abstract: Sandy soil is one of the most conventional construction materials used as backfill materials in the retention of structures in foundations. This study to investigate the composition of admixture permeability experimental to stabilized sandy soil use the composition percentage (4, 6, & 8% hydrated lime only), sandy soil with 2% hydrated lime (0.5%, 1%, and 1.5% palm fiber) and 6% of hydrated lime (0.5%, 1% and 1.5% of palm fiber) proportionally. The results presented that the mixture of 2% and 6% hydrated lime with 0.5%, 1%, and 1.5% of palm fiber proportionally, decreased the percentage of reduction of permeability from 94.22% at 0 days to 66.67% at 7 days. The mixture of 6% of hydrated lime and 1.5% of palm fiber at 0 dan 7 curing time give a better performance. Thus, this helps in using the constant head method in Geotechnical practices.

Keywords: Permeability, stabilised, sandy soil, hydrated lime

1. Introduction

Having better strength of ground foundation can reduce the problems of project substructure and superstructure. The structure shows less performance because it faces underground behavior problems and the different characteristics of the soil. Each characteristic: some have great strength, and some are very weak with very compressive properties. Each ground foundation applies another way of bonding characteristics for increasing its mechanical characteristics (Aisyab S & Jamil B, 2013) (Al-Shammary AAG & Kauzani ZA, 2018). Cohesionless soil has different characteristics from cohesive soil and the use of this soil is also different (Al-Shammary AAG et al., 2018). Numerous methods for soil enhancement are available, such as soil stabilization or vertical drainage. Using additive improvers such as by-product materials can help increase the performance of weak soil such as cohesionless soil. In the study (Baalwy, H. A. et al., 2021), they used hydrated lime or calcium hydroxide mixed with pineapple fiber and soil. According to (British Standard Method of Test – BS 1377, 1990), the short polymer fibers or natural materials were used to improve the permeability of the soil. Natural resources have been proposed to have superior materials to improve the soil structure based on environmental and financial efficiency. The method of soil stabilization is to add material to the soil. The high costs of this method have contributed to the investigation of alternative approaches. In Malaysia, oil palm fibers are easy to access because they come in large quantities and most importantly, it's their strength. The fibers were used to test the efficiency of fiber in improving soil permeability (British Standard Method of Test – BS 1377, 1990) (Dang LC

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et al., 2016). Therefore, it is important to focus on the effect of the composition of by-product materials with palm fiber in the experiment of stabilized sandy soil.

2. Methodology

This study was based on experimental laboratory work. The sandy soil was used throughout the study as the main material, while palm fiber and hydrated lime as stabilizer agents. The study was carried out to investigate the behavior of permeability and the effect of a cure for the mixture of sandy soil with palm fiber (0.5, 1.0, and 1.5%) and hydrated materials of the total mass of the sample. To achieve this study, a relevant laboratory testing program was conducted. A basic property of untreated samples has been observed for specific gravity, density, particle size distribution, and permeability test. Sand and palm fiber – the hydrated lime mixture was prepared at several contents and then to determine maximum permeability. The samples were tested with no curing and after 0 and 7- days of curing. The permeability test was carried out for the study of the strength behavior of sand soil only and mixtures of sandy soil, and palm fiber hydrated lime. The assessment shall be limited to the results of the permeability (constant head method) conducted in accordance with the standards BS 1377:1990 (Hu X, et al., 2019). In this study, sandy soil was used to conduct all the tests. To ensure that the soil sample is native, the soil sample will be taken 20 cm below the surface. After taking all the soil, the characteristics of the soil samples were indicated according to the few tests that included the Atterberg limit, soil classification test (AASTHO), and compaction experimental. All experiments used the native soil, while permeability tests were used to define the sand soil by adding palm fiber and hydrated lime.

2.1 Materials

This section explained in more detail the procedure of the experimental work for this research.

Sandy Soil. The soil that was used in the study was taken from Taman Connaught, Persiaran Alam Damai, Klang, Valley, Malaysia, located specifically at latitude (3.07918175°) and longitude (101.74514270157755°). Fig. 1 shows the location of the sandy soil sample that was extracted.

Native cohesionless. Collected from the area Connaught, Persiaran Alam Damai as mentioned in Fig. 1.

Palm Fiber. Palm fiber to be used in this analysis is a fiber obtained from the sap of palm trees and typically stored in a material store with a diameter of 0.15 mm. It will be used in different proportions (0.5%, 1%, and 1.5%). The palm fiber material is produced from natural materials made in the local areas.

Hydrated Lime / Calcium Hydroxide. By-product materials produced in packaging by the local company were addressed by (Ko, Y. N. et al., 2021) (Md Yusof Z et al., 2022) (Md. Yusof Z et al., 2015) (Pino LFM & Baudet BA, 2015).

Fig. 1 - Area latitude and longitude of sample study

2.2 Material and Procedure for Experimental Works

Soil classification tests experimental following the standards (Hu X, et al., 2019). The specific references of each test are tabulated in Table 1. The permeability test was performed and applied to ten (10) different sample mixes. The first sample included sand only with a curing time of 0-day as a control sample, which is sand without palm fiber, and hydrated lime was also prepared accordingly. The three (3) samples with hydrated lime (4%, 6%, and 8%) at a curing time of 0 to 7 days. Two groups of samples; sand without palm fiber and hydrated lime, 2% and 6% of hydrated lime with 0.5%, 1%, and 1.5% palm fiber each percentage, respectively, have been prepared in specimen mold at their optimal water content. 14% of water was used in each mixture.

Palm fiber and hydrated lime were mixed proportionally with the sand to give an even distribution of the mixture agent in the specimen. The mix of soil and palm fiber–hydrated lime was placed in the cylinder. The constant head size used in the study was 77 x 190 (both units in mm). The specimen was then extruded from the cylinder and ready for permeability test.

Table 1 - Test method

Properties test	Test method
Particle size distribution	BS 1377:1990 standards
Specific gravity	BS 1377:1990 standards
Maximum Dry Density & Optimum Moisture Content	BS 1377:1990 standards
Permeability (constant head method)	BS 1377:1990 standards

PSD. To measure defines the variability of the particle size of soils (Sandoval GF et al., 2017). The representative soil sample was passed through a series of sieves with progressively smaller openings until a minimum of the No. 230 (63μm) sieve. The particle size distribution test was performed according to the standards of BS 1377:1990 (Hu X, et al., 2019).

Relative Density. Use stipulated standards (Hu X, et al., 2019) as shown in equation (1).

$$G_s = \frac{M_2 - M_1}{(M_2 - M_1) - (M_3 - M_4)} \quad (1)$$

Compaction Test. Compaction tests as mentioned in (Yusof, Z. M., 2020) (Yusof, Z. M., 2015) were carried out as stipulated in 1377:1990 British standards (Hu X, et al., 2019).

Distributed Granular Soil Sample. Ability determines the flow of water in soil (Yusof, Z. M., 2015) (Yusof, Z. M., 2021) as stipulated in 1990 British standards (Hu X, et al., 2019).

2.3 Tabulation of Data

The tabulation of data was recorded as mentioned in Table 2.

Table 2 - Tabulation sample reading

Label	CH (%)	PF (%)	Parameter	Time	
				0	7
				No. of specimen	
a	-	-	Sand only	3	-
b	4	-	S + 4	3	3
c	6	-	S + 6	3	3
d	8	-	S + 8	3	3
e		0.5	S + 2 + 0.5	3	3
f	2	1	S + 2 + 1	3	3
g		1.5	S + 2 + 1.5	3	3
h		0.5	S + 6 + 0.5	3	3
i	6	1	S + 6 + 1	3	3
j		1.5	S + 6 + 1.5	3	3

3. Results and Discussion

PSD Graph. The size curve was according to 1990 British standards (Hu X, et al., 2019), mentioning about samples of 1000kg dry samples were taken in this study. In Fig. 2 mentioned percentages of 8.73%, 70.13%, and 21.14% respectively for the soil samples. The C_u, Cc, and D_{10} were calculated to have a value of 11.54, 0.74, and 0.065 mm respectively.

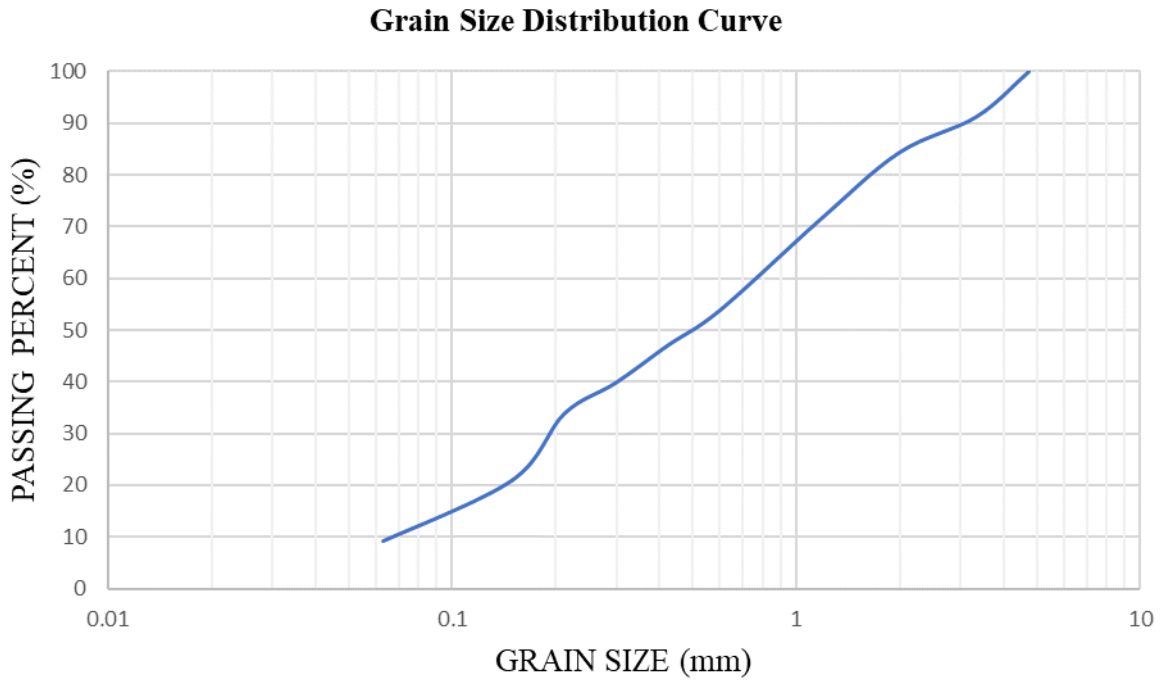

Fig. 2 - Grain-size distribution curve

Relative Density. The naturally range between 2.65 and 2.67. This experimental work the finding for soil was 2.66.

Compaction Test. The results assumed to have an optimal moisture content (OMC) for the sand sample of 14% and the MDD value is 1.42 g/cm^3 [Fig. 3].

Distributed Granular Soil Sample. According to the 1990 British standard (Hu X, et al., 2019). Constant head permeability test samples are tested for two curing durations, which are 0- and 7-day. The samples that have been tested consist of 0, 4, 6, and 8% hydrated lime-mixed sandy samples. Results in Fig. 4 mentioned the permeability of stabilized sandy soil mixture for 0 and 7 days with hydrated lime or calcium hydroxide, while Fig. 5 shows the results of the permeability for 0 and 7- days permeability of the stabilized sandy soil mixture with palm fiber and hydrated lime.

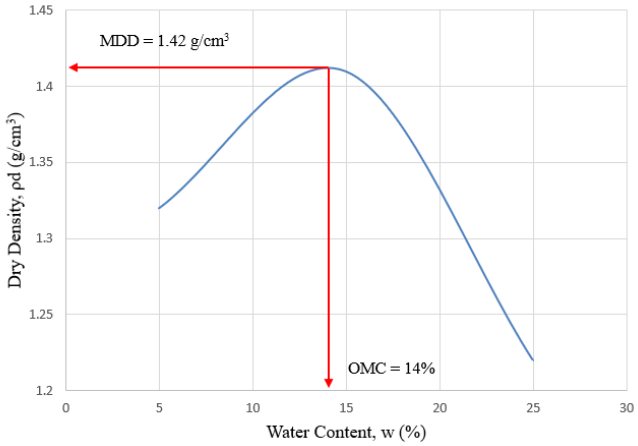

Fig. 3 - Optimum moisture content curve for the sand sample

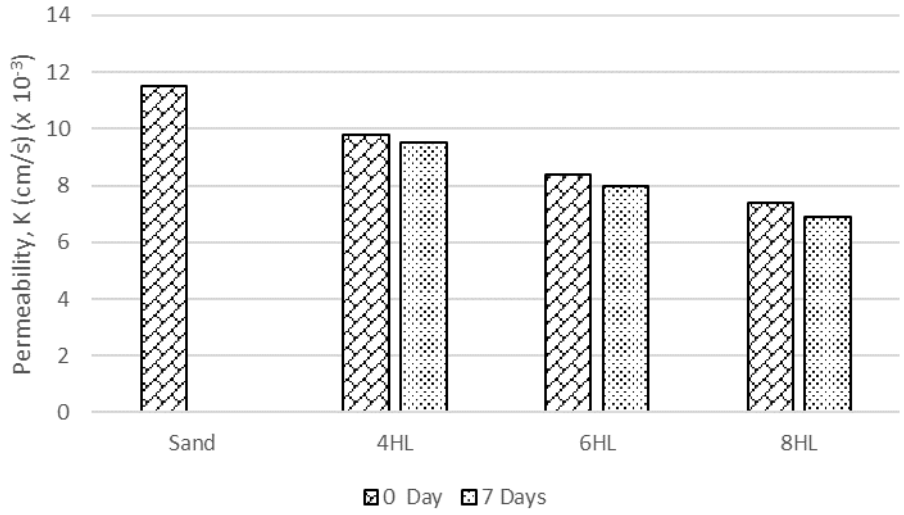

Fig. 4 - Stabilized sample CH/HL

Fig. 5 illustrated graph resulted to having a change in the coefficient of permeability of the sand. With a curing time of 0- day, palm fiber and hydrated lime content of 6% and 1.5%, respectively, the coefficient of permeability had a percentage of reduction of 94.22% from the k value of 11.5 x 10^{-3} m/s to 0.09 x 10^{-3} m/s. Furthermore, for a curing time of 7 days, palm fiber and hydrated lime content of 6% and 1.5% respectively, and the coefficient of permeability had a percentage of reduction of 66.67% from K value of 11.5 x 10^{-3} m/s to 0.07 x 10^{-3} m/s.

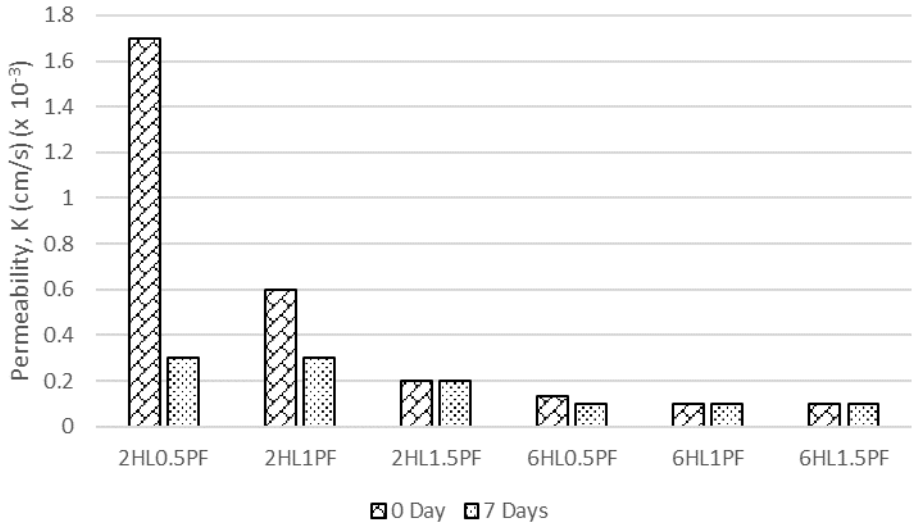

Fig. 5 - Stabilized sample PF

From the results, it can be observed that the addition of palm fiber-calcium hydroxide helps in lowering permeability. By increasing the curing time of the mixture, the voids of the sand are filled, (British Standard Method of Test – BS 1377, 1990) which means the spaces of the soil particles are reduced compared to the constant permeability test applied immediately after the mixture of the sandy soil with the palm fiber and hydrated lime.

4. Conclusion

The research investigated physical properties and by-product materials in the experimental works of permeability of sandy soil.

- Sample in the percentage of the gravel, sand, and fines were found to have a value of 8.73%, 70.13%, and 21.14% respectively.
- Relative density is 2.66, which is in the ideal range of sandy soil between 2.65 and 2.67.

- The average results of the bulk and dry density mentioned have values of 1.51 g/cm^3, and 1.32 g/cm^3 respectively.

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