PROPERTIES OF SOFT SOIL CONTAINING OUTER LAYER FACE MASK

A. Abdullah, I.R. Abdul Karim

Abstract

In construction, soft clay soil is continuously being the biggest concern for engineer. It is classified as problematic soil because of its weak properties and it usually does not meet the construction requirement due to excessive settlement. In this research, the improvement of soft clay soil is made by adding a small percentage of the waste generated from face mask. By doing this, it is hoped to improve the soil's properties and preserve the environment by reducing the abundant waste. Several laboratory tests (particle size test, soil consistency test, standard Proctor test and unconfined compression test) were conducted to determine the soil properties. The outer layer face mask (OLFM), which was cut in pieces, was added in the amount of 0.25 %, 0.5 % and 1 % of the total volume. The results show that the mixture of 1 % of the outer layer face mask's into the soft clay soil is able to increase the soil's shear strength by 2.8 times.

Keywords: Soil improvement, Waste, Problematic soil, Compressive strength.

Introduction

According to the Construction Research Institute of Malaysia (2015), soft soil is found to be tabulated extensively, especially along the east and west coast of Peninsular Malaysia. This soil is

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well known for its problem, and any construction projects related to the soil need to be taken care of seriously. Many failures associated with the soil are related to high settlement and deformation to structure, such as embankment, which resulted from the high compressibility and low shear strength of soft soil (Mohamad et al., 2016). Although the construction on this soil could cause excessive problems, these problems are unavoidable. Therefore, there is a need to improve the basic properties and the shear strength of soft soil. Hence, utilising waste materials to enhance soft soil's properties is one method that may be considered.

There are several types of waste that can be used to improve the properties of soft soil, such as back sheet diapers (Mat Nor et al., 2018), palm oil clinker (Abdullah et al., 2021), gypsum (Abdullah et al., 2021), fibers (Rahgozar, et al. 2018) and slag (Hasan, et al., 2016). Utilisation of these waste in a specific proportion were found to be effective in improving the soil properties and compressive strength.

On the other hand, since mid-March 2020 up until now, wearing masks and face coverings is mandatory in almost all public spaces, especially in Malaysia. This is due to the pandemic that is happening worldwide and do not show any sign to stop in the near future. The number of cases have reached more than 10,000 cases in July 2021 (Kementerian Kesihatan Malaysia, 2021). Face mask is one of the best helps when it comes to protect the virus from spreading around. Each Malaysian is required to wear a face mask for minimising the risk of infection. The mask was advised to be worn once and discarded properly. As the result from that, the number of face mask waste is accumulated and leads to pollution problems in Malaysia.

Therefore, in order to solve pollution issue from the stockpiling of face mask waste, as well as the issue from the problematic soft soil, recycling of the waste can be considered. The face mask can be recycled to be an additive material to problematic soft soil after the disposable mask waste are cleaned and treated. The focus of this research is to assess the effectiveness of the OLFM to improve the soft clay soil in terms of basic properties and shear strength.

Methodology

Preparation of material

The soft soil used in this research was the powdered type known as the FMC kaolin. This type of kaolin was bought from the supplier, Orioner Hightech Sdn Bhd. When water is present in the soil, FMC kaolin has a very low strength and a high settlement. According to Mohd Hizam et. al (2020), kaolin absorbs water quickly and shrinks as it is drained, and due to that, this type of clayey soil contains clay minerals that can expand and contract in response to changing water content. Figure 1 shows the FMC kaolin that has been used in the research.

Figure 1: FMC Powdered Kaolin

On the other hand, the face mask waste that were used in this study are classified as plastic waste or polypropylene. In this research, only the outer layer’s face mask (OLFM), as shown in Figure 2, was used. Due to the safety issue and to avoid the treatment of the used face mask, only clean and new face masks were used in the research for the purpose of obtaining the preliminary findings.

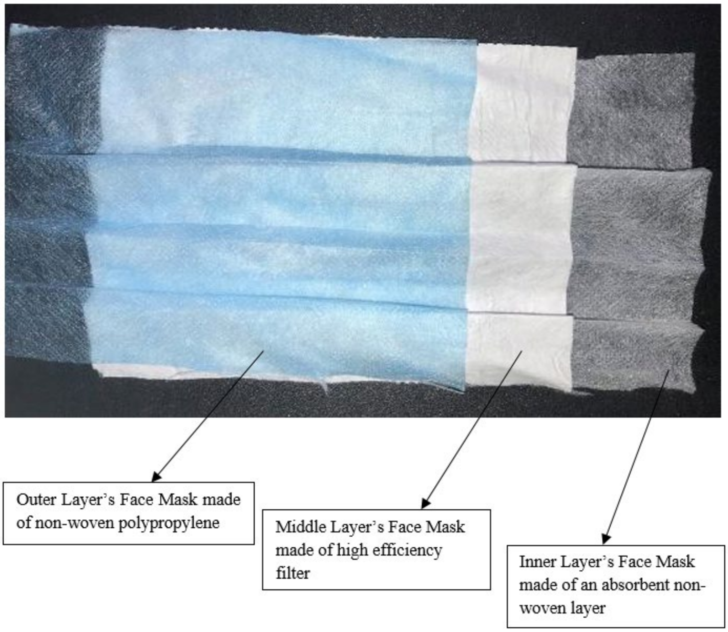


Figure 2: Layers of non-medical face mask

The OLFM waste were cut into different sizes, which are 10 x 10 mm, 10 x 20 mm, 10 x 30 mm and 10 x 40 mm, as shown in Figure 3. OLFM is a hydrophobic layer of non-woven synthetic material (Malaysian Health Technology Assessment Section, 2020).

The OLFM was mixed randomly in soil by using several proportion of volume (0.25 %, 0.50 %, 1.00 %), as shown in Figure 4. The mixture was remoulded in size of 76 mm height with 38 mm diameter. A total of 13 samples has been prepared, as shown in Table 1.

Experimental Procedure

The untreated soil samples were tested for its basic properties (particle size, soil consistencies, specific gravity) in the laboratory by following the American Society of Testing Material (ASTM) as the standard guideline (ASTM D422-63, 2007; ASTM D4318, 2017 and ASTM D854, 2014). Meanwhile, the treated soil samples (soil with OLFM strips) were tested to determine the maximum dry unit weight and the strength properties (ASTM D698-07, 2009 and ASTM D2166). Controlled sample containing purely soil were also tested to determine the maximum dry unit weight and the strength parameters for comparison.

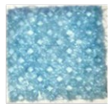
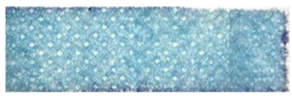
Size of Strips	Strips
10 x 10 mm	
10 x 20 mm	
10 x 30 mm	
10 x 40 mm	

Figure 3: Sample Sizes of Outer Layer's Face Mask Strips

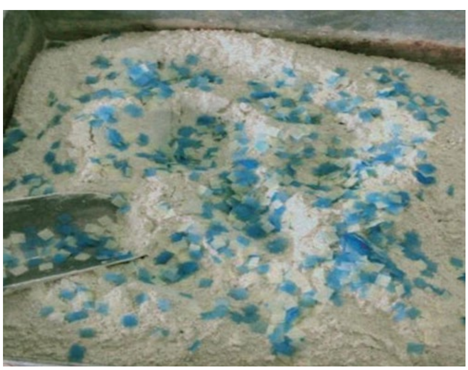


Figure 4: Mixture of soil and OLFM

Table 1: Mixture of soil and various size of OLFM strips

FMC kaolin (%)	Size of OLFM strips (mm)	Proportion (%)
100.00	none	0
99.75	10 x 10	0.25
99.50		0.50
99.00		1.00
99.75	10 x 20	0.25
99.50		0.50
99.00		1.00
99.75	10 x 30	0.25
99.50		0.50
99.00		1.00
99.75	10 x 40	0.25
99.50		0.50
99.00		1.00

Result and Discussion

Basic properties of the untreated soil

Figure 5 shows the particle size distribution for the soil as obtained from hydrometer analyses. The size distribution of the soil was found in the range of 0.0575 mm to 0.0008 mm. Thus, from the hydrometer analyses, 20 % of the particle is classified as sand, 10 % of the particle is silt and the remaining 70% is clay. According to the literature, the size of the kaolin soil is in the range of 0.3 mm to 0.0006 mm, which is almost similar to the result obtained for other kaolin clay (Tripathy et al., 2014).

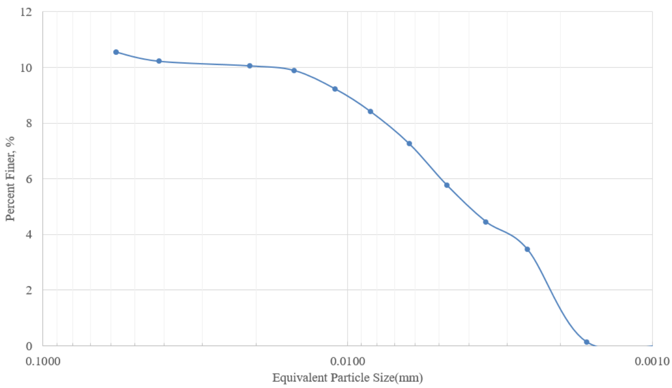


Figure 5: Particle size distribution of the soil

The plastic index can be obtained by calculating the difference between liquid limit (LL) and plastic limit (PL), as summarised in Table 2. Based on the plasticity index (PI), the soil can be best described as high plasticity soil, since the PI is within the range of 20% and 40%.

This is the expected result for kaolin clay, as typical ranges of the liquid limit are anywhere within 20 % for silts or over 100 % for high plasticity clays. The plasticity index for high plasticity clay can be over 50 % (Muluneh, 2016). In addition, Kaliakin (2017) indicated that the value of the liquid limit of clay contains kaolinite, usually in the range of 35 to 100 % and plastic limit range between 20 to 40 %.

Table 2: Basic properties of the soil

Properties	Soil
Liquid Limit, LL (%)	69.00
Plastic Limit, PL (%)	42.10
Plasticity Index, PI	26.90
Shrinkage Limit (%)	1.49
Specific Gravity, G_s	2.54
Maximum Dry Unit Weight, γ_{dmax} (kN/m³)	12.75
Optimum Moisture Content, w_{opt} (%)	28

Basic properties of the treated soil containing the OLFM

Figure 6 shows the variations of maximum dry unit weight versus moisture content for all soil samples containing various size of OLFM strips. The results of the untreated soil were also included in the graph.

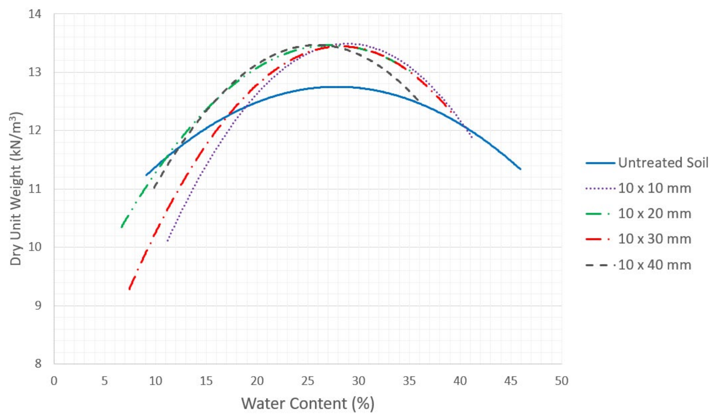


Figure 6: Variations of dry unit weight and water content for all samples of soil containing OLFM

The results indicate that there are increments of dry unit weight after adding an additive material and before adding an additive material. The size of OLFM waste strips that gives the highest value of dry unit weight among the three sizes is 10 x 10 mm, which is 13.50 kN/m^3. However, there are slight difference between 10 x 10 mm strips and the other three sizes in the value of dry unit weight. From the result shown, this shows that the size plays a role on the improvement of dry unit weight. This is because, the smaller the size of the strips added, the more void ratio is reduced from the soil to reach the optimum moisture content and maximum dry unit weight.

In addition to that, Figure 7 shows the result of shear strength using 10 x 30 mm size of strip with different proportion of percentage. The sample with 1.00% of 10 x 30 mm OLFM waste strips gives the highest value of UCT, which is 37 kPa and followed by 0.25 % and 0.50 %, which differ 1 kPa from each other. The UCT value for 0.25 % is 27 kPa and 28 kPa for 0.50 %. The shear strength of the sample without OLFM strip (untreated sample) was found to have the lowest value. Figure 8 shows the condition of treated and untreated samples at the end of the compression test, where it can be seen that the failure of the untreated soil is found to occur extensively across the soil sample. Meanwhile, in the treated sample, the shear failure happens to be limited. The sample with 1.00 % of 10 x 30 mm strip content is estimated to be 2.8 times stronger than untreated soil. Thus, this concludes that shear strength also increases together with the increase in the proportion percentage.

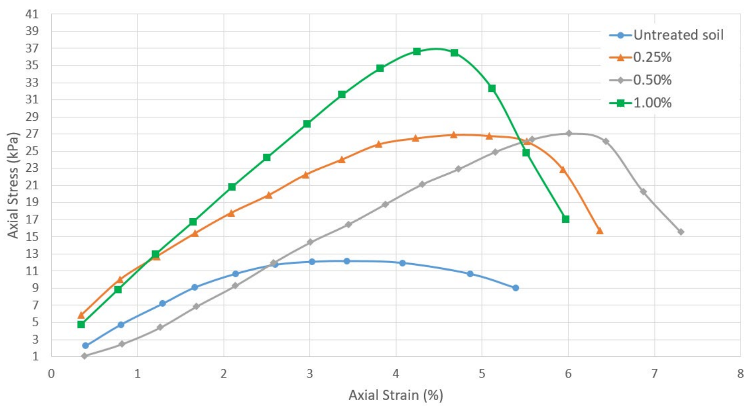


Figure 7: Comparison of UCT results for the untreated soil sample and the treated soil sample by using 10 x 30 mm OLFM strips

The result obtained in this research is almost similar with previous research by Mat Nor et al. (2018). Their study was using the back sheet from diapers to improve the properties of soft clay. The maximum strength of treated soil obtained in their research was approximately 2.50 times stronger than untreated soil, and the optimum percentage and size that give the highest strength were 0.50% of 10 x 30 mm strips. Whereas, in this research, the maximum UCT value of treated FMC kaolin is 2.8 times stronger than the untreated soil, and the optimum percentage and size that give the highest improvement in strength were 1.00% of 10 x 30 mm.

Figure 8: Comparison of shear failure for the untreated soil sample and the treated soil sample added with 1% of 10 x 30 mm of OLFM strips

Conclusion

This research was conducted to assess the effectiveness of the OLFM strips to improve the basic properties and shear strength of soft kaolin clay. It was found that the OLFM was identified as a significant material to improve the properties of soft soil. The findings are concluded as follows:

i. The plasticity index of the untreated soil (FMC powdered kaolin) showed high plasticity material as the plastic limit, w_p (%) and the liquid limit, w_l have a value of 42.1% and 69%, respectively. The shrinkage limit was found to be 1.49 with a specific gravity of 2.54 and shear strength of 13 kPa.
ii. The optimum content and size of outer layer's face mask (OLFM) that give the maximum shear strength are 1.00% of 10 x 30 mm size OLFM.
iii. The shear strength value is found to be increasing with the addition of 1.00% of 10 x 30 mm outer layer's face mask (OLFM) in the soil. This value is approximately 2.8 times higher compared to the shear strength of the untreated soil.

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