APPLICATION OF NATURAL FIBER FOR SHORT TERM STABILIZATION OF MARINE CLAY SLOPE

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ABSTRACT: Existence of marine clay in civil engineering field leading to further investigation on the properties as well as the method of stabilization. The aim of this study is to investigate the shear strength parameter of marine clay slope stabilized with kenaf fiber. Laboratory testing has been conducted to determine the marine clay and stabilized marine clay properties and its characteristic by using soil classification of particle size distribution, specific gravity, Atterberg limit and unconfined compression test. The result shows that the shear strength of marine clay reinforced with kenaf fiber is improved by increasing the percentage of kenaf fiber mixed into marine clay soil. The safety factor obtained from slope stability analysis shows that addition of kenaf fiber to the marine clay soil improves the marine clay slope stability. By adding 5% and 10% of kenaf fiber improves safety factor to more than 1.2 as required for most of temporary slope construction.

KEYWORDS: *Kenaf Fiber; Short Term Stabilization; Slope Stabilization; Soil Stabilization*

1.0 INTRODUCTION

Marine clay basically found onshore in Peninsular Malaysia. Typically the content in marine clay has microcrystalline in nature and clay minerals such as chlorite, kaolinite and iolite and also non-clay

minerals like quartz and feldspar [1]. Marine clay is the clay that has low permeability and has the capability in an attenuation of inorganic contaminants found at coastal area of Peninsular Malaysia [2]. Marine clay contained a lot of organic matter, greenish black in colour and undesirable smell formed by the sedimentation of clayey soils in marine environments and characterized by physical like high liquid limit, low bearing capacity and it is necessary to improve its characteristics and make it suitable for construction [3]. Marine clay can be categorized as problematic soil as it has low bearing capacity which is unsuitable for construction purposes in order to retain loading from structure.

A low shear strength parameter of marine clay soil is a major issue and must be pre-treated to upgrade its usability and serviceability. Researchers have came out with a lot of researches in order to solve the problem caused by marine clay soil. Several technique of stabilization has been developed such as stabilization technique using cement, lime and fibers. During construction period, temporary earth cutting and excavation are required. The stability of the temporary slope formed must be sufficient for the safety of construction workers especially when dealing with problematic soil such as marine clay. Application of natural fibers as stabilization technique for short-term stabilization is important to reinforce a problematic soil and to improve the strength of marine clay [4]. The essential effect of natural fibers in geotechnical engineering and construction engineering has become a known fact to all engineers. Past research have utilized different fibers including natural and synthetics fibers to reinforce problematic soils especially to increase the shear strength of soil.

Kenaf fiber is widely used to enhance short term stability of soft clay and can be divided into a drainage element and tensile reinforcement [5]. Kenaf fibers was used traditionally at ancient time to make a rope, canvas and sacking. Nowadays, it is widely used in modern application such as automotive application, building material and corrosion resistance [6-8]. Kenaf grows very quick with height of 4-5 meter in 4-5 month and the diameter size is 25-35 millimeter [9]. Besides that, kenaf without the core can produce a 57% yield of the bast fiber [5]. In conventional method, arrangement of layer is introduced sequentially in alternating layer and distributed discrete natural fiber reinforced of soil [10]. Improving the engineering properties of soil in order to develop the shear strength parameters, compressibility, density and hydraulic conductivity is one technique of soil reinforcement [8, 11]. Kenaf fiber has been utilized as slope stabilization method by incorporating kenaf fiber in geosynthetic

form to stabilize clay embankment and the result shows that kenaf limited life geosynthetic can be applied to improve stability of slope [12]. Although many researches were conducted to make use of kenaf as soil stabilization technique, only a few focused on the performance of marine clay soil reinforced with kenaf as temporary slope. It is important to stabilize the temporary slope formed during construction to ensure the safety of workers during construction.

Thus, this research was carried out to investigate the performance of marine clay slope reinforced with kenaf fiber as short term stabilization technique. This study examined the undrained shear strength of saturated marine clay with various kenaf fiber contents. Then based on these results, the slope stability analysis has been carried out to determine the minimum kenaf fiber content. Moreover, as kenaf fiber is biodegradable, it is suitable to be applied as temporary measures for slope stabilization. This will provide new method of temporary slope stabilization and at the same added the variety on the usage of kenaf fiber.

2.0 MATERIALS AND METHODS

2.1 Kenaf Fiber

Kenaf fiber coir used in this research was obtained from kenaf factory. Kenaf is a natural fiber that can be used in assembling industry to promote sustainability and green material.

2.2 Marine Clay

The type of soil used is marine clay which collected at Kampung Seberang Ramai, Kuala Perlis, Perlis. 10 kg of disturbed sample was collected from site. The sample is used to determine the characteristic of marine clay, shear strength and safety factor of slope. The liquid limit, plastic limit and plasticity index of soil is 46, 30 and 45, respectively. The marine clay sample were mixed with different percentage of kenaf fiber to improve its shear strength parameter.

2.3 Sieve and Hydrometer Analysis

The objective of this test is to determine the particle size distribution. This will confirm the type of soil used in the research. The type of soil used is marine clay which collected at Kampung Seberang Ramai, Kuala Perlis, Perlis. 10 kg of disturbed sample was collected from site. The sample is used to determine the characteristic of marine clay,

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2.4 Atterberg Limit Test

This test was conducted to identify the plastic limit, liquid limits and plasticity index of soil. The results of this test can be correlated with soil characteristics such as permeability, shear strength, compatibility and compressibility.

2.5 Specific Gravity

The specific gravity of soil is a value of the mass of a given volume of the material at a standard temperature to the mass of an equal volume of de-aired or gas-free distilled water at a standard temperature.

2.6 Unconfined Compression Test

The unconfined compressive strength (qu) is defined as the compressive stress at where the specimen of soil will fail in a sample compression test where failure sample means the reading gauge of loading is slightly decrease. This test is suitable for clayey sample to determine the shear strength parameter of soil. The percentage of kenaf fiber added into marine clay sample is 0%, 1%, 5% and 10% named as Sample A, Sample B, Sample C and Sample D, respectively.

2.7 Slope Stability Analysis

The safety factor of slope is the ratio of shear strength of soil to the shear stress developed along the potential failure surface. The safety factor can be obtained from slope stability analysis. In this study, Slope/W (Geo Studio 2018) used to carry out slope stability analysis. The gradient of slope model used in this study is 5V:1H which suits the gradient of temporary excavation during construction while the minimum safety factor adopted is 1.2. The height of the slope is 6m. The input of soil shear strength parameter and properties were obtained from soil physical test and also unconfined compression test that have been carried out earlier in laboratory. Four analyses were conducted for sample A, sample B, sample C and sample D.

3.0 RESULTS AND DISCUSSION

3.1 Unconfined Compression Results

The summary of results of the unconfined compression test is shown in Figure 1. In general, the results of unconfined compression indicates the shear strength parameter of cohesive marine clay sample which is an unconsolidated undrained (UU) test where the lateral confining pressure equal to zero (atmospheric pressure). The unconfined compressive strength for all sample are shown in Table 1. It is clearly seen that the unconfined compressive strength of marine clay soil increases as the amount of kenaf fiber added increases. The maximum unconfined compressive strength was sample D (10% kenaf fiber) which is 69.64 kPa. This trend of results can be understood as the fiber added to the marine clay sample provided reinforcement and act as resistance to the shear stress subjected to the soil particle resulting in higher compressive stress. It meant that more fiber added providing more reinforcement. The improvement in term of strength with the addition of kenaf can be explained from the appearance of interlocking force that improves the friction between fibers and soil matrix and also increase in bonding strength. Besides, the increment in strength is also due to better adhesion of fibers and soil matrix [13].

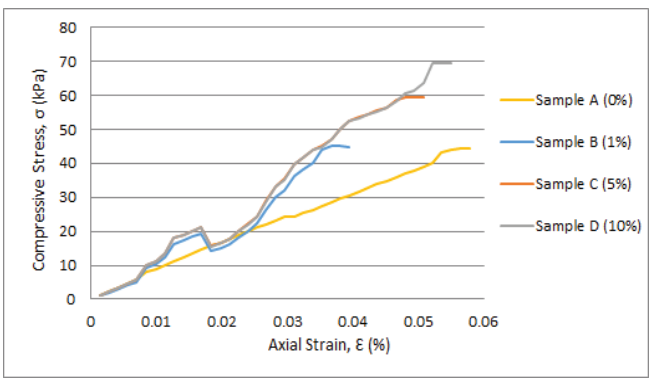

Figure 1: Compressive stress vs axial strain

Table 1: Unconfined compressive strength and undrained shear strength for different sample of marine clay

Type	Sample A	Sample B	Sample C	Sample D
q_u (kPa)	44.25	44.95	59.47	69.64
c_u (kPa)	22.13	22.48	29.74	34.82

The result as expected and supported by several studies conducted on soil improvement technique using fiber namely polymer fiber, waste cornsilk fiber and bagasse fiber which shows improvement in term of

strength of soil [13-15]. According to results of unconfined compressive strength, the addition of 1% kenaf fiber shows no significant improvement and both sample A and B can be categorized as soft clay having unconfined compressive strength lower than 50 kPa. However, when the percentage of kenaf fiber added reached more than 5% the unconfined compressive strength start to increase more than 34% compared to the original pure clay. The value indicates that the improvement of shear strength parameter is significant and can be categorized as medium stiff clay.

Although the unconfined compressive strength in this study can be considered in a low side, it is still acceptable and sufficient for the application of temporary slope which will discussed under the slope stability analysis part. The results also indicates that sample A shows the highest value of strain follows by sample D, sample B and sample A. It meant that the pure marine clay soil gives the highest deformation before failure occur.

3.2 Slope Stability Analysis Results

The safety factor of slope with different soil strength parameter shows in Figures 2 until 5 and the summary of factor of safety are shown in Table 2. It is important to determine safety factor that required to investigate whether the slope are in stable or unstable condition.

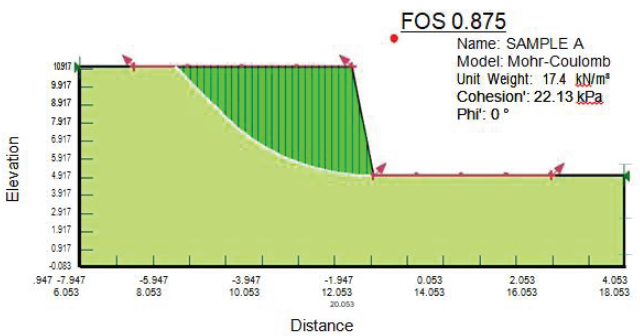

Figure 2: Slope analysis result for Sample A

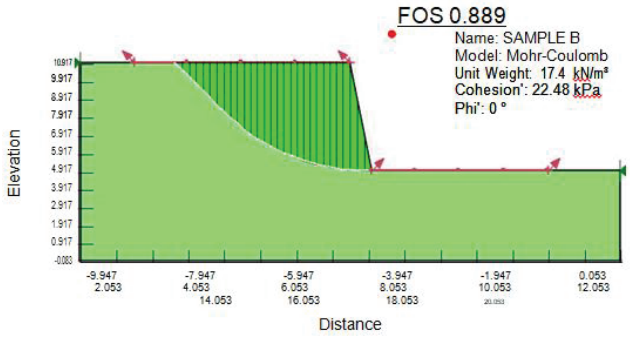

Figure 3: Slope analysis result for Sample B

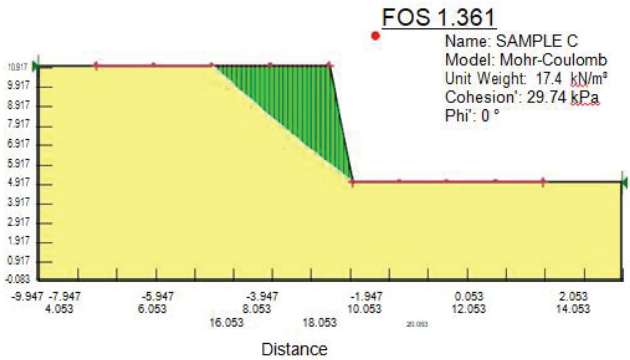

Figure 4: Slope analysis result for Sample C

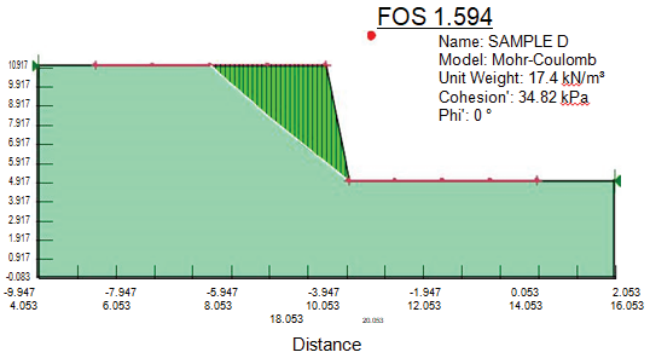

Figure 5: Slope analysis result for Sample D

Table 2: Summary of factor of safety

Slope	C (kPa)	Unit Weight (kN/m³)	Factor of Safety
Sample A	22.13	17.4	0.875
Sample B	22.48	17.4	0.889
Sample C	29.74	17.4	1.361
Sample D	34.82	17.4	1.594

Sample A shows the soil sample of pure marine clay. There are 0% kenaf fibers in marine clay and the value of cohesion is 22.13 kPa with safety factor value of 0.875. For Sample B, the percentage of kenaf fiber mixed in marine clay is 1% with the value of cohesion of 22.48 kPa. The safety factor for sample B after analysis is 0.889. From the comparison between results for sample A and B, the value for cohesion and safety factor for sample B is slightly higher with both factory of safety are less than the minimum value of 1.2. This indicates that the improvement in undrained shear strength for sample B is insufficient to stabilize the slope to the required condition. Sample C shows higher factor of safety than sample A and B with increament of the kenaf fiber percentage to 5%. The increased of safety factor shows that kenaf fibers is a good reinforcement for marine clay soil due to increment of the shear strength parameter of soil. The value of safety factor for Sample C is 1.361 with cohesion value of 29.79 kPa exceeding the requirement of 1.2 of safety factor.

This indicates that 5% kenaf fiber is sufficient to provide minimum stability for the temporary slope. Sample D shows the value for safety factor, 1.594 which the highest value compared to other sample. Although the factory of safety for sample D is high and exceed the requirement for permanent slope, it is not recommended as the kenaf fiber is biodegradable and unsuitable for long term stability purposes. The increment of safety factor is due to addition of reinforcement provided by kenaf fiber that improves the cohesion value of marine clay soil.

4.0 CONCLUSION

The sample of marine clay soil collected in Kampung Seberang Ramai, Kuala Perlis, Perlis has been tested and analysed to investigate whether it can be treated using kenaf fiber. As a conclusion it was found that the kenaf fiber was effective to be used as stabilization technique for short term stabilization of marine clay slope. Addition of kenaf fiber provides reinforcement to the soil resulting higher shear strength parameter. Higher percentage of kenaf added will provide more reinforcement and provide higher resistance to the shear stress. The improvement in the shear strength characteristics resulting in higher stability of marine clay slope. Although the highest unconfined compression strength is given by 10% sample, based on the slope stability analysis only 5% of kenaf fiber is required to stabilize the temporary slope to meet minimum requirement for safety factor of 1.2.

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