The Utilization of Kenaf Fiber as a Sustainable Stabilizer for Soft Marine Soils

N. F Bawadi[1], *, N. S Johan[1], A. F Mansor[1], M Nujid[2], M Ab Rahim[1], S Anudai[1]

[1]Faculty of Civil Engineering, Universiti Malaysia Perlis, Kompleks Pengajian Jejawi 3, 02600 Arau, Perlis, Malaysia
[2]Department of Civil Engineering, University of Technology MARA, 13500 Permatang Pauh, P.Pinang, Malaysia

*Corresponding author's email: norfaizah@unimap.edu.my

ABSTRACT: Generally, a soft marine soil has a high in-situ water content and as a result, it has low shear strength and bearing capacity. This condition, prone to excessive settlement, which makes coastal infrastructure building is challenging. Thus, for construction on soft marine soil, strength enhancement and settlement control should be critically considered. The main objective of this research is to evaluate the bearing capacity of treated soft marine soil using kenaf fibres. This research used several sizes and percentage of kenaf fibres to strengthen the soft marine soil. The effects of kenaf powder on marine soil were investigate through a series of laboratory experiments such as effect on moisture content rate of marine soils, Atterberg limits, soil compaction and penetration tests. Afterwards, all the experimented data have been validated in numerical analysis using PLAXIS software. This research concluded that kenaf with 0.25mm particle size are the optimum size to bond with clay marine soils. Meanwhile, the 0.8% is the optimum percentage needed to stabilize the soft marine soil. The kenaf powder acts as a binder between the stabilizer and the soil particles and has a potential to increase the bearing capacity of soft marine soils.

Keywords: *Bearing Capacity; Kenaf; Marine Soil; Natural Soil Stabilizer*

1. INTRODUCTION

Many researchers have proposed the filler either chemically or environmentally to increase the bearing capacity of soil marine soil (Fadzullah and Mustafa, 2017). Therefore, soil stabilization techniques using kenaf powder has been proposed in this study according to the mix sizing. Kenaf fibres are rapidly growing in the global market and currently being used as a composite to replace other expensive composite materials available in the market. Kenaf powder has the potential to replace other traditional fillers due to its low cost, low density, eco-friendliness, medium range tensile strength and stiffness, biodegradable and renewability. This research focuses on the laboratory studies which are index test, compaction test and CBR test will be set up for soil stabilization study. The main aim of this research is to review the effectiveness of the use of kenaf fibre as soil stabilized.

2. RESEARCH MATERIALS & METHODS

A production of kenaf fiber from a kenaf waste, the form of the potential stabilizer is successfully produced into three forms of sizing; 0.075mm, 0.106mm and 0,25mm by using grinding machine and sieving the kenaf. Then, a percentage of 0.5, 0.8 and 1.0 kenaf fibre has been mixed with the soft marine soil collected from Kuala Perlis, Malaysia as suggested by Shahar et. al., (2019).

Two main laboratory works will be carried out in purposed of physical characterization and strength identification. The physical tests included the performing of moisture content test and Atterberg limit test. Meanwhile, in order to determine the strength properties of control samples and treated soft marine soils using kenaf powder, the compaction and California Bearing Ratio (CBR) test has been performed in this research.

A several percentage mixings has been performed in this study for these three forms size particles in order to identified the influence of the percentage and size particles affected the changes of marine soils properties. Then, all the experimented data has been validated in the numerical analysis based on Mohr-Columb model in PLAXIS software. An assumption has been made for several important parameters based on correlation between relevant previous studies on marine soils.

3. RESULTS & DISCUSSION

The comparison index characteristics of the marine soil from Kuala Perlis are shown in Table 1. Based on the results obtained in this research, the average moisture content of control samples is 64.61% indicated that a positive correlation with fine particles. Based on previous studies, the major factor effects the rate of moisture content is the arrangement of soil particles (Mohammed Al-Bared M. A, 2017). It is because, the soil particles arrangement may affect the capacity of soil to hold water, where the air and water filled the pores between soil particles.

Table 1. Comparison marine soil index properties

Physical Properties	Range of Value	
	This Research	Wan Salim et al., (2012)
Moisture Content, w	64.61	62.6 – 70.2
Liquid Limit, LL (%)	65	70.5 – 71.6
Plastic Limit, PL (%)	54	38.3 – 40.1
Plasticity Index, PI (%)	11	31.4 – 32.1
Specific Gravity, Gs	2.27	2.0 – 2.2

Theoretically, the water molecules are drawn to one another and tend to stack on top of one another (Nujid M. et al., 2020). They even cling to fine particles more strongly than sand. The high moisture content indicates that the marine soil can absorb a lot of water and focuses specifically on the volume stability issue that is linked to the absorption and loss of water by marine soil (Zhang, 2017). When estimating allowable bearing capacity and foundation settlement, the liquid limit of soil can also be

applied to evaluate the consolidation parameters of the soil. Hence, the reported liquid limit of the sample is 65, average plastic limit of the water content is 54% and plasticity index of the soil is 11. The association between the Atterberg limits and soil compaction as measured by the compaction test, it is possible to estimate the potential optimum moisture content and maximum dry density for soil compaction.

Generally, the liquid limit and plasticity index of clay marine soils proportional to level of compressible and cohesive condition, respectively (Wan Salim et. al.,2012). As shown in Table 2, the result shows that increasing of kenaf percentage direct proportional to unit weight. Meanwhile the water content proportionally decreases with the addition of kenaf fibre. The findings support to the theory of density for soil particles. The soil organic matter has two major influences on density; which via a mass effect (expressed as a mixture ratio between organic and mineral soil components) and via a quality effect (expressed as calculated changes in particle density of organic soil components). The decrease in the dry density value is related to the decrease in fibre particles. It is due to the high of water content may separate fibre particles from each other.

Table 2. Soil compaction of treated marine soils with 0.106mm size of kenaf fibre.

Kenaf Fibre (%)	0.5	0.8	1.0
Moist unit weight (kN/m^3)	18.86	18.90	19.47
Dry unit weight (kN/m^3)	16.19	16.27	17.29
Water content (%)	16.47	16.18	12.63

As shown in the Figure 1, 0.106mm kenaf fibre size contribute to the optimum force to the clay marine soils with the 0.8% fibre mixing.

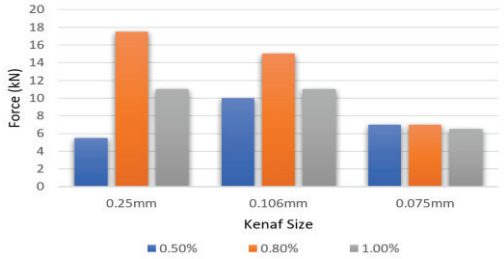

Figure 1. Force Performance for Treated Marine Soils

This is because as the treated sample undergo compaction process, the spaces between the sand particles are filled with fines (clay particles) due the least percent mixing with soil. The CBR value increase is due to the presence of higher cellulose as the primary structural to give strength and stability. The kenaf powder is acting as a binder between the stabilizer and soil particles which give reactions for the increase in the CBR. Thus, the soil particles can resist a higher force by penetration acting on it and therefore the CBR value increase. This performance can be concluded that kenaf with bigger size have higher void that it tends to joint with fine soft marine soil. Based on the experimented data, the model of control and treated samples using kenaf fibre has been validated using Plaxis software. In this research, the total displacement of control and treated are 433.86×10^{-6}m and 100.61×10^{-6}m, respectively. The numerical analysis on treated soil samples has validated all the data in the experimental works with about 77% decrement of deformation.

4. CONCLUSION

As a summary, the strength test of soil compaction and the bearing ratio of marine soil with the influence of kenaf powder as a natural stabilizer for geotechnical properties were investigated. The bearing ratio results shows that the presence of kenaf powder helps to improve the CBR value. The kenaf powder acts as a natural binder between the stabilizer and the soil particles, generating reactions that causes the CBR to rise. As a result, the soil particles can withstand a greater force from penetration, increasing the CBR value. Further improvement is recommended such as the soaking process should be considered during mixing the kenaf powder with marine soils.

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