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# The Comparison of Performance of Root Vetiver Grass Between Coconut Fiber and Eggshell Toward Slope Stabilization

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**ABSTRACT**

Slope stability using vegetation has emerged as a more environmentally friendly and sustainable solution for slope stabilization, replacing traditional structural engineering methods and shotcrete cover. However, despite the application of Vetiver grass, failures in the form of deformation, cracks, and slope collapse still occur. The main objectives of this study are to identify the root properties and analyze the mechanical properties of Vetiver grass with coconut fiber and eggshell fertilizers. Laboratory testing was conducted to determine the mechanical properties of Vetiver grass roots using shear box and universal testing machine. As a result, the root diameter and root length with egg shell exhibit larger values than coconut fiber for 21 days (0.40 – 1.27 cm) and 35 days (11.5 – 61.4 cm). The direct shear test results for Vetiver root with eggshell showed highest shear strength which is 43.67 kN/m2 (21 days) and 168.17 kN/m2 (35 days) compared to Vetiver root with coconut fiber which is 42.94 kN/m2 (21 days) and 61.13 kN/m2 (35 days). For tensile strength, the Vetiver root with egg shell consist higher value which is 0.066 N/mm² (group 1) and 0.068 N/mm² (group 2) compared to Vetiver root with coconut fiber which is 0.059 N/mm² (group 1) and 0.060 N/mm² (group 2). Additionally, in group 1 and 2 of 35 days, eggshell fertilizer showed higher maximum tensile strength, measuring 0.071 N/mm² and 0.094 N/mm², respectively. While, coconut fiber fertilizer 1 and 2 recorded lower tensile strengths of 0.063 N/mm² and 0.062 N/mm², respectively. The significance of this study indicates that the eggshell fertilizers have greater impact towards Vetiver root than coconut fiber fertilizers and without fertilizer.

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***Keywords:***
Vetiver grass; Shear strength; Eggshell; Coconut fiber; Tensile strength

## 1. Introduction

The application of slope stability using vegetation has transformed into better bioengineering and sustainable solution for slope stabilization by replacing structural engineering methods and shotcrete cover. Abdullah *et al.,*[1] stated that the current method of using merely engineering material or heavy structures such as wire meshes, retaining walls, concrete and fencing are more high-budget,

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poor environmentally friendly, less ineffective over time, unsustainable, and inadaptable with the unstable changeable slope environmentally since they are less effective, while they also require more repair and preservation. Comino *et al.,* [2] mentioned that the method gap could potentially be labelled by using the theory of soil bioengineering or known as a soft method to soil stabilization and slope because it is able to turn out with minimal effect on the landscape and environment. Soil engineering is to relate the use of vegetation which can be parts or whole plants that focuses on the low and high hazard slope for the sake of sustainability and stability. According to Gray *et al.,*[6], Schwarz *et al.,* [9] and Baets *et al.,* [11], slopes with vegetation give protection against erosion and shallow sliding.

The research presents an idea about the understanding of the comparative performance of root Vetiver between coconut fiber and eggshell towards slope stabilization. Since Malaysia is known as a country which is unavoidable slope failure and inadequate research about Vetiver grass fertilizer for maintaining on the slope. The results of the research were analyzed through modeling and laboratory work. Both shear strength and tensile strength tests were carried out by using a direct shear box test and universal testing machine to analyze and compare the coconut fiber and eggshell Vetiver grass specimen.

## 2. Assessment of Vegetation and Vetiver Grass

Abdullah *et al.,* [1] and Noorasyikin *et al.,* [8] reported that the green technique of employing plants to reduce slope instability has been used all around the world. Similarly, both aboveground and belowground attributions are commonly addressed for the two plant characteristics, namely hydrological and mechanical. According to Comino *et al.,* [2], Ali *et al.,* [3], Leung *et al.,* [5] and Noorasyikin,M.N and Zainab,M [7], through mechanical reinforcing, anchoring, and compaction, vegetation cover improves soil shear strength by utilizing its root network. Furthermore, Dorairaj,D and Osma,N [10] stated that cover crops protect the soil surface from the effects of rainfall by reducing the erosive capacity of flowing water and restoring slope physical condition. Plant litter, on the other hand, protects the soil surface from raindrop contact and slows water transport over the soil surface. Plants also serve an important role in lowering soil moisture content through evapotranspiration, allowing the soil to absorb more water. Thus, Comino *et al.,* [2] stated that the vegetation is defined as a soft engineering structure because it maintains the soil surface from landslides through mechanical, hydrological, and hydraulic effects. Besides that, Noorasyikin,M.N and Zainab,M [7] mentioned that root tensile strength is mainly influence by percentage of moisture content and root morphology. It described that the root of vegetation is mainly play a role influence the soil slope strength.

Shamontee,A and Mohammad,S.I. [12], Unruan,L & Suched,L [13], Nitish Kumar and Sunita Kumari [14] and Md A.I *et al.,* [15] reported that the Vetiver plantation is a practical choice for controlling soil erosion and its harmful impacts. Several studies have shown that Vetiver can help with soil and water conservation. According to Badhon *et al.,* [4], the usage of Vetiver grass strips and mulch improves soil conservation and nutrient and water absorption efficiency. Furthermore, they demonstrated that Vetiver plating on a modelled terraced slope had superior slope stability than a non-vegetated slope.

## 3. Materials and Method

The methodologies were adopted through conducting experimental studies, laboratory work, and physical modelling on the performance of Vetiver grass with different fertilizers. There are a lot

of procedures required to follow systematically when executing the research before obtaining the final results. Sample preparation and physical modelling need to be done first in order to obtain the collect some samples of soil. Moreover, the research consists of 9 specimens' types of Vetiver grass, which divide into two groups of durations that are 21 days and 37 days. The sample preparation was brought into UTHM Geotechnical Engineering Laboratory Room for the purpose of setting up physical modelling and laboratory testing.

### *3.1 Materials*

The purchased item for the main sample preparation are Vetiver grass, sample soil, and PVC pipe.

### *3.2 Methods*

The shear box test was performed by applied according to BS1377: Part 7: 1990 as 3 soil samples with different fertilizers were tested under varied vertical loadings of 1.75 kg, 2.5 kg, and 3.25 kg for soil with eggshell, coconut fiber, and no presence of fertilizer after visually inspected for 21 and 35 days. In order to obtain the results from direct shear test.

The UTHM Universal Testing Machine based on BS 1610 was used to test the tensile strength of the Vetiver grass specimens. The purpose of the test was to measure the strength of the link between the root matrix system of Vetiver 47 specimens and the soil. Individual primary roots have a 21 days and 35 days category that was tested for root tensile strength. The root sample's unit tensile strength was measured in MPa (MN/m2).

### *3.3 Equations*

Equation of shear strength need to be applied to find out the cohesion, friction of angle and shear strength as shown in Eq. (1).

$$\tau f = c + \sigma \tan \varphi \quad (1)$$

## 4. Results and Discussion

A series of laboratory test have been conducted at the Geotechnical Engineering Laboratory Faculty of Engineering Technology, Universiti Tun Hussien Onn Malaysia. The tests were carried out on main two types of fertilizers for Vetiver grass growth, which are: eggshell and coconut fiber and both types of Vetiver grass were performed to determine the shear and tensile strength by using direct shear test and universal testing machine.

### *4.1 Results*

The root diameter has been measured by Vernier caliper and it shows the 35 days of eggshell sample 1 and 2 has the wider diameter, which are 1.27 mm and 1.22 mm according to Table 1. As for the root of length, it has been measured by steel ruler and the longest root is also from the 35 days of eggshell sample 1 and 2, which are 55.6 cm and 61.4 cm according to Table 1. Furthermore, the root morphology of Vetiver grass is all heart root system (Noorasyikin M. N. & Zainab M., 2016), however the root morphology of 35 days can be seen more fibrous than 21 days. Moreover, the 35

days of original or no involvement of fertilizer has longer root length than 35 days of coconut fiber, however coconut fiber has wider root diameter than the original.

**Table 1**
The comparison growth of root diameter, length and morphology

| Fertilizers | Sample | Days | Root Physical Properties | | |
|---|---|---|---|---|---|
| | | | Diameter | Length | Morphology |
| Eggshell | 1 | 21 | 0.55mm, 0.56mm, 0.50mm, 0.60mm, 0.66mm | 12.4cm, 12.5cm, 15.6cm, 17.1cm, 18cm | Less fibrous |
| Eggshell | 2 | 21 | 0.54mm, 0.57mm, 0.65mm, 0.64mm, 0.60mm | 11.5cm, 12.4cm, 12.6cm, 14.5cm, 16.7cm | Less fibrous |
| Coconut fiber | 1 | 21 | 0.40m, 0.42mm, 0.54mm, 0.35mm, 0.43mm | 10.2cm, 11.5cm, 12.7cm, 17cm, 24.6cm | Less fibrous |
| Coconut fiber | 2 | 21 | 0.41mm, 0.45mm, 0.55mm, 0.36mm, 0.48mm | 12.5cm, 12.6cm, 12.9cm, 13.6cm, 18.6cm | Less fibrous |
| Eggshell | 1 | 35 | 0.75mm, 0.92mm, 0.98mm, 1.06mm, 1.27mm | 51cm, 52cm, 53.5cm, 54.7cm, 55.6cm | More fibrous |
| Eggshell | 2 | 35 | 0.40mm, 0.53mm, 0.71mm, 0.91mm, 1.22mm | 30.4cm, 42.5cm, 50.2cm, 52.5cm, 61.4cm | More fibrous |
| Coconut fiber | 1 | 35 | 0.79mm, 0.88mm, 0.97mm, 1.03mm, 1.11mm | 8cm, 11.1cm, 11.4cm, 12.3cm, 12.7cm | More fibrous |
| Coconut fiber | 2 | 35 | 0.86mm, 0.93mm, 1.08mm, 1.10mm, 1.14mm | 11.3cm, 12.6cm, 13.2cm, 14.5cm, 22.5cm | More fibrous |
| Original | - | 35 | 0.38mm, 0.47mm, 0.61mm, 0.69mm, 0.95mm | 15.4cm, 27.7cm, 33.5cm, 38.5cm, 41.5cm | Less fibrous |

The direct shear test shows that the highest cohesion is the 35 days of eggshell and the lowest is the 21 days of coconut fiber according to Table 2. As for the friction angle, the lowest is the 21 days of coconut fiber with 32.37° and the highest is the 35 days of eggshell with 87.88° Thus, the 35 days of eggshell fertilizer has higher cohesion, friction angle and shear strength than coconut fiber fertilizer and original.

**Table 2**
Cohesion and friction angle of 21- and 35-days sample

| Days and fertilizers | Cohesion, c | Friction Angle, $\phi$ | Shear strength, τf |
|---|---|---|---|
| 21 days of Eggshell | 28.36 | 58.02° | 43.67 kN/m$^2$ |
| 21 days of Coconut fiber | 32.37 | 51.23° | 42.94 kN/m$^2$ |
| 35 days of Eggshell | 65.43 | 87.88° | 168.17 kN/m$^2$ |
| 35 days of Coconut fiber | 47.47 | 57.85° | 61.13 kN/m$^2$ |
| 35 days of Original | 50.82 | 35.37° | 57.13 kN/m$^2$ |

The 21 days consist of 40 samples, which are coconut fiber 1, coconut fiber 2, eggshell 1 and eggshell 2. In addition, all 40 samples have been concluded in as shown in Figure 1. Thus, the graph shows that the eggshell group has slightly higher tensile strength than coconut fiber. The maximum strength for 21 days has also been recorded and the highest maximum tensile strength is the eggshell group 2 of 21 days, which recorded 0.068 N/mm$^2$. Meanwhile, the second highest maximum tensile strength is the eggshell group 1 of 21 days, which recorded 0.066 N/mm$^2$. Furthermore, the lowest maximum tensile strength is the coconut fiber group 1, which recorded 0.059 N/mm$^2$.

There are 50 samples total across the 35 days, including original, eggshell 1, eggshell 2, and coconut fiber 1 and 2. The graph shows that the eggshell group has shown higher tensile strength than coconut fiber especially eggshell 2. The maximum strength for 35 days has also been recorded and the highest maximum tensile strength is the eggshell group 2 of 35 days, which recorded 0.094 N/mm$^2$ as shown in Figure 2. Meanwhile, the second highest maximum tensile strength is the eggshell group 1 of 35 days, which recorded 0.071 N/mm$^2$. Furthermore, the lowest maximum tensile strength is the coconut fiber group 2, which recorded 0.062 N/mm$^2$. Thus, it can be concluded that eggshell from 35 days has higher tensile strength than coconut fiber and original of 35 days. This also indicate that eggshell fertilizers bring more effect by contributing the tensile strength to the Vetiver grass root than coconut fiber fertilizers.

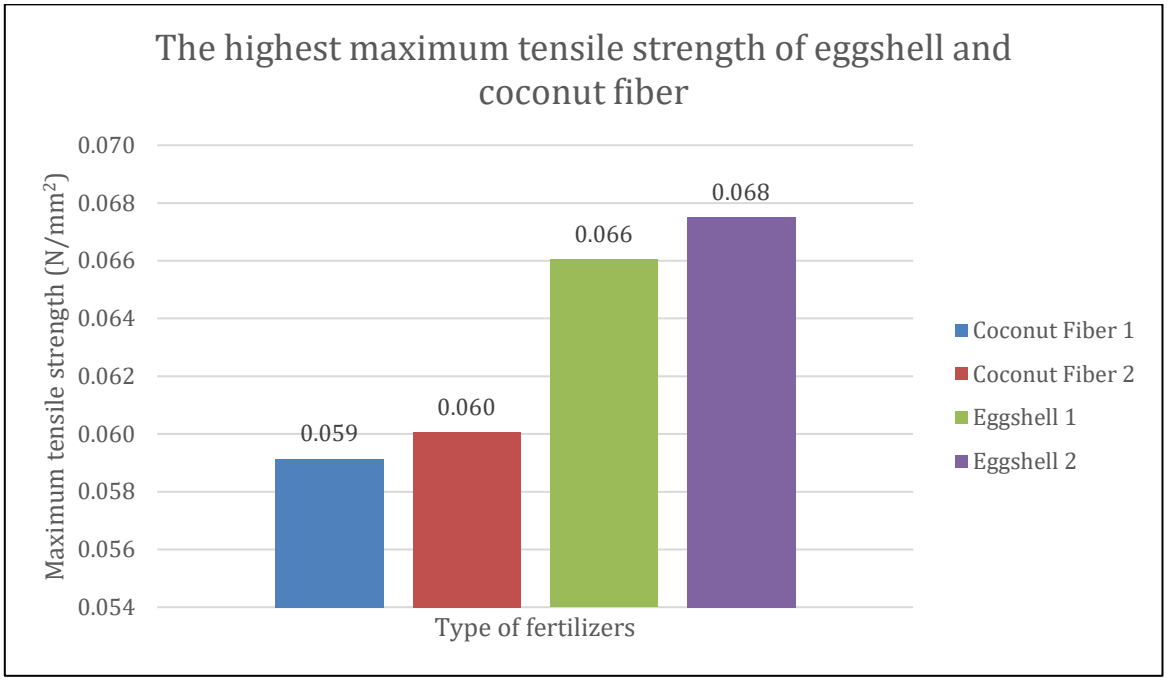


**Fig. 1.** The column bar graph of highest maximum tensile of eggshell and coconut fiber in 21 days

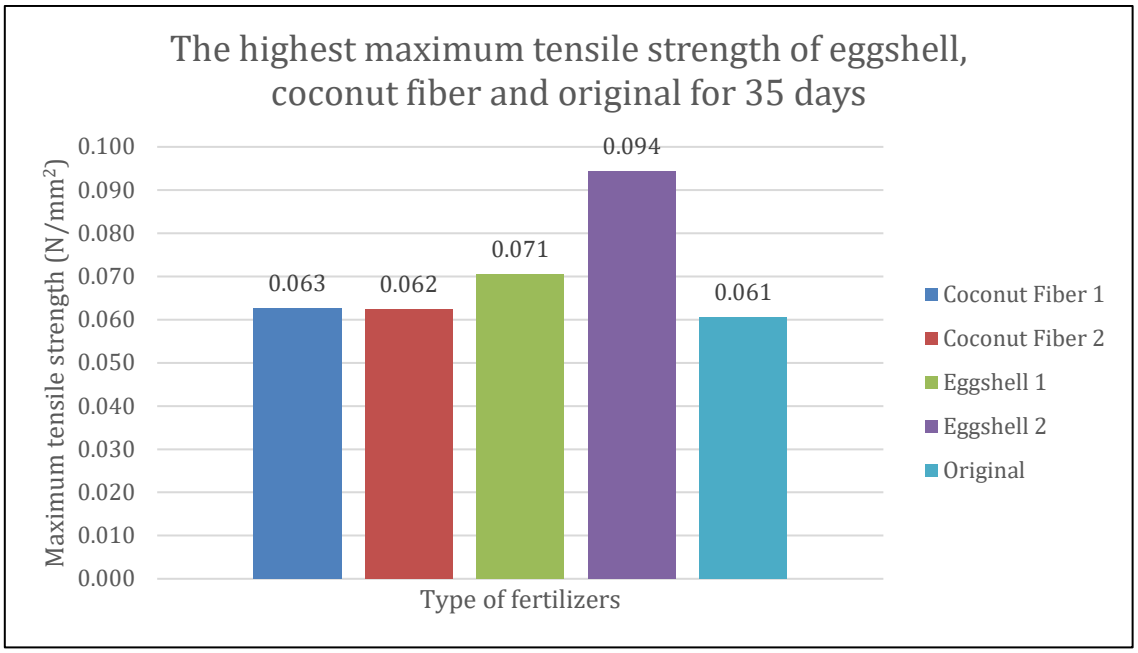


**Fig. 2.** The column bar graph of highest maximum tensile of original, eggshell and coconut fiber in 35 day

## 5. Conclusion

The eggshell fertilizers shows that it has impact the root properties than coconut fiber fertilizers and original. This is because the eggshell has contributed the most to the height of vetiver grass. Moreover, the diameter and length of root are the widest and longest than coconut fiber fertilizers. The root morphology also shows the eggshell and coconut fiber of 35 days were more fibrous than the original and 21 days of eggshell and coconut fiber samples. Thus, it shows a huge difference gap between the 21 and 35 days of progress. Despite the coconut fiber fertilizers has lesser impact on the root properties of vetiver grass, it still has wider root diameter than original.

Eggshell fertilizers are more effective on the growth of Vetiver grass height and root of diameter, length and morphology as this contribute to the shear and tensile strength. The coconut fiber only has a slightly effect on the growth of Vetiver grass height and root of diameter, length and morphology as this contribute less to the shear and tensile strength than eggshell fertilizers. Although the original sample has longer root than coconut fiber, the coconut fiber still contributes more shear and tensile strength than the original sample. Thus, it can be concluded that eggshell and coconut fiber fertilizers have higher performance of shear and tensile strength than the original sample.

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