

# Coconut Coir Mat for Slope Vegetation

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## ABSTRACT

Soil erosion is a common challenge faced by geotechnical engineers, occurring naturally in the environment due to wind, water, and gravity. The loss of soil from the land surface can be detrimental to both terrestrial and aquatic environments by depleting nutrients, increasing runoff and affecting aquatic life. Plenty of methods that can be used to control soil erosion. One of the common ways is using erosion control mat such as geotextile, turf reinforcement mats and fibromat biodegradable. The problems with the current mat are the manufacturer is focusing on the duration of the mat to decompose without considering the effectiveness to help vegetation grow. Through this research, the biodegradable erosion control mat was fabricated by using coconut coir as the main material (known as a coir mats) to promote the growth of vegetation roots, thereby reducing soil erosion. The research aim is to investigate the effectiveness of coir mats by monitoring vegetation roots growth whilst soil strength was evaluated by determining its shear strength, both with coir mat and without coir mat via Direct Shear Test. From visual observation, the results showed that the vegetation roots best developed in the soil covered with coir mat, where the fibrous of roots with coir mat is significantly uplifting compared to without coir mat. Besides that, the cohesion of soil for both with and without coir mat is 0 kN/m<sup>2</sup> and it validated that the soils have the same water content during the test. However, the friction angle of the soil with coir mat is lower than without coir mat. This due to the smaller coir mat opening size, thereby affect the penetration and development of the vegetation.

**Keywords:** ASTM D625, BS1377, coir mat, vegetation root, shear strength, slope vegetation, soil erosion

## 1. INTRODUCTION

Almost all development in hilly areas consists of cutting and filling. Hence, it is easily exposed to erosion and needs an urge to cover. Erosion mitigating measures shall be installed or constructed before commencement of site clearing and earthworks. This includes planning for 'work in stages' and also plans for diverting as much as possible surface runoff from the work areas. It should lead to trouble free slope. This involves all cut and exposed areas to be protected during and after construction against water and all fill areas to be well packed and similarly protected [1]. Construction of slopes therefore plays a very large role in behaviours of slope during the service. Bad slopes construction will require a lot of maintenance since they are very easily affected by the action of water leading to endless problems from erosions, settlements, seepages and slips to landslides [2].

Many methods have been introduced to control soil erosion. One of the common method is using erosion control mat such as geotextile, turf reinforcement mats etc. Erosion control mat should be established on patchy and barren slope faces or terraces to reduce erosion [3]. Such mats act as miniature dams and prevent the seeds or seedlings which used to be washed away by rain and wind and facilitating the growth [4]. Recently, erosion control mats by

biodegradable materials have gained popularity to protect disturbed slope and channel areas from wind and water erosion [5]. The biodegradable mat materials are natural or by-product materials such as straw, wood excelsior and agricultural fibres mats. Erosion control mats can be effective in minimizing the erosive effect of rainfall when used to cover bare or newly planted soil. Besides to control soil erosion, they also effectively to protect new vegetation and reduces the potential for introducing sediment into storm water run-off. Iannotti [3] stated that the vegetation can stabilize soil and prevent erosion on steep slopes by binding loose soil with roots and slowing the passage of water down the slope. Replanting disturbed locations after construction with a combination of trees, shrubs and ground/soil cover is key.

*Pueraria Phaseoloides* is one of the tropical forage with deep-rooted characteristics that are potential for soil erosion control. This species native to China and South East Asia and well adapted to numerous soils types and no significant pest and diseases was reported by Tian et al. [6]. *Pueraria Phaseoloides* becomes one of the cover crops chosen for soil erosion control since 1920s [7]. This species able to increase soil permeability and have been proved with research done by Pardomuantambunan et al. [8]. Vegetation roots can increase soil physical properties and strengthening soil infiltration. The roots system is able to reduce surface runoff in which it is important to minimize erosion [6].

Seedling growth of tropical kudzu is only moderately vigorous during the first 3-4 months [8]. Seedling vigour is superior to other cover crops such as Centro (*Centrosema Pubescens* Benth.) and Calopo (*Calopogonium Mucunoides* Desv.) [8]. Once established, it is very vigorous and quickly smothers weeds. In Malaysia, it reaches 60-70% cover after about 4 months and 90-100% after 8 months. It can form a tangled mat of vegetation 60-75 cm deep [8].

The maximum slope to be considered for vegetative stabilization is 1.5 horizontal to 1.0 vertical (1.5H: 1.0V). There are many good vegetation in the form of grasses, vines, shrubs a minor tree that can be used for slope stabilization projects. Vegetation selection is dependent upon the goals of erosion control program and site conditions. Typically, effective programs incorporate structural diversity in vegetation selections (trees/shrubs with ground covers) and use a mix of species [3]. Planting practically depends greatly on the character of the slope and particularly on the slope angle. A slope of 1.5H:1.0V (33 degrees) should be considered the dividing line between a manageable slope and a slope steep enough that vegetation would be difficult or impossible to establish without employing other reinforcement [3]. Furthermore, in an observation-based study by SBMS Group Malaysia, the steeper the slopes, the higher the shear stress and velocity. This study is focusing on the performance of coir mat in helping the growth of vegetation roots in order to reduce the erosion of soil and to identify shear strength parameter of soil with and without coir mat. The problem occurred with soil erosion is not only happened off-site but also on-site. The loss of soil from the land surface can be detrimental to both terrestrial and aquatic environments by depleting nutrients, increasing runoff and affecting aquatic life [9]. With one aim, to minimize the effects of water erosion on slopes, the material used in this research is coconut coir. This material degrades slowly, allowing vegetation that will be vegetation in the area to grow and take over the job of protecting the soil from erosion when the mats have finally degraded completely [4, 10]. In planting, coconut coir is used as a soil amendment [3]. It improves the air porosity of soils, even when wet, and aids in moisture retention. Coir absorbs 30 percent more water and much easier to re-wet, when dry. It helps loosen the texture of clay soil and improve drainage. It also allows the sandy soil to hold onto water longer [4].

## 2. MATERIALS AND METHODS

Two main materials were used in this research are coconut coir and *Pueraria Phaseoloides* seeds. The coconut coir was collected from T&H Coconut Fibre Sdn Bhd, Batu Pahat, Johor. While seeds of *Pueraria Phaseoloides* was collected from Ladang Tabung Haji Bukit Lawiang, Kluang, Johor. In this research, coconut coir was used for to produce coir mat as an alternative for helping *Pueraria Phaseoloides* roots to grow on the soil, thus protect the soil against

erosion. The success of the coir mats in –promoting the vegetation’s roots growth was analysed by visual monitoring. However, the soil strength with and without coir mats has been examined through a Direct Shear Test.

### 2.1 Fabrication of Coir Mat – ASTM D6525

The coir mats are fabricated in 297 mm length, and 210 mm width with thickness 6 mm as per refer to ASTM D6525 – Standard Test Method for Measuring Nominal Thickness of Rolled Erosion Control Products [11]. The coir mats were mainly produced at Composite Technology Workshop, UTHM Pagoh, Johor. 80 g of coconut coir was placed in a steel mould and then inserted it between two hot press plates. The coconut coir is compressed using Hydraulic Moulding Press Machine at a temperature of 160°C temperature with 30 kN pressure for 15 minutes.

### 2.2 Sample Preparation

The loam soils are placed into containers which have the same size as the coir mat. Firstly, put soil half of the container. The soil used was collected from Tan Ah Hwang Nursery, Muar, Johor. Next, loosen the top of the soil and make sure that the top of the soil is free from disturbance. 0.5 g of seeds was planted at 4 points inside the loam soil in every container. All seeds must be soaked for 6 hours in warm water to fasten the germination. The coir mats were then installed on the top of soil surface. However, the coir mat needs to be immersed in the distilled water for 15 minutes before used. After all the above procedures is done, spread 7 g of Egyptian Rock Phosphate (ERP) fertiliser on top of the soil and water it. This fertiliser was collected from SRAT Sdn Bhd, Simpang Renggam, Johor.

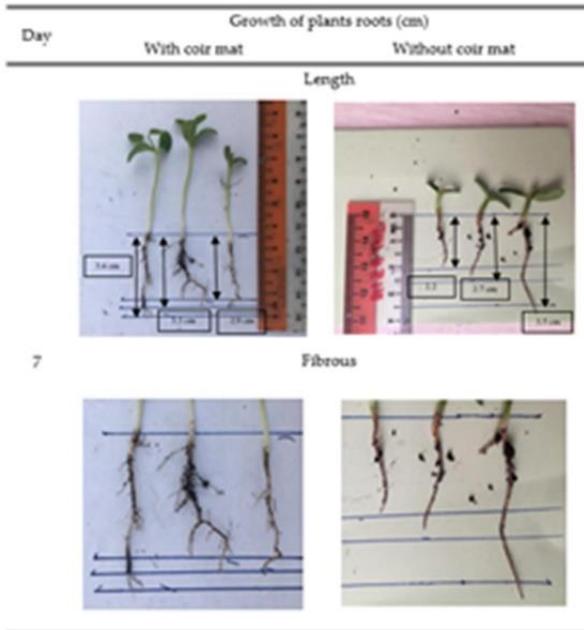
### 2.3 Testing

#### 2.3.1 Visual Inspection Test

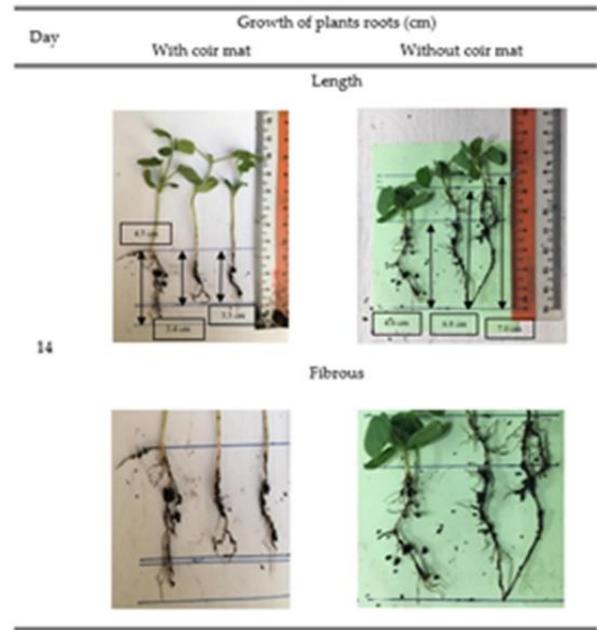
The visual inspection test was carried out to investigate the effectiveness of coir mat for growth of vegetation roots in order to reduce the soil from erosion. There are 8 samples were tested, where 4 samples were covered with coir mat on top of the loam soil whilst the other 4 samples were coverless. The progress of the vegetation roots was monitor by measuring the growth of vegetation in terms of length and fibrous every 7 days for a month.

#### 2.3.2 Direct Shear Test – BS1377 Part 7

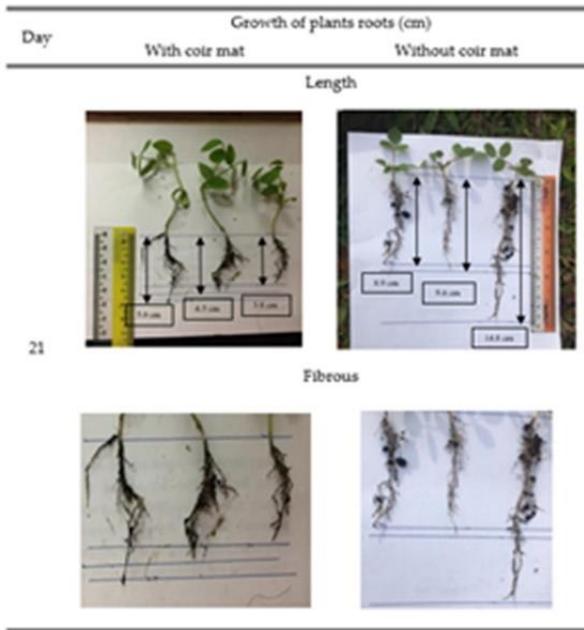
Direct Shear Test was conducted at Geotechnical Engineering Technology Laboratory, UTHM Pagoh, Johor. The aim of this test is to determine the shear strength parameters (include cohesion and friction angle) of soil with and without coir mat. This test was conducted followed by BS1377 Part 7 – Shear Strength Test (Total Stress) [12].



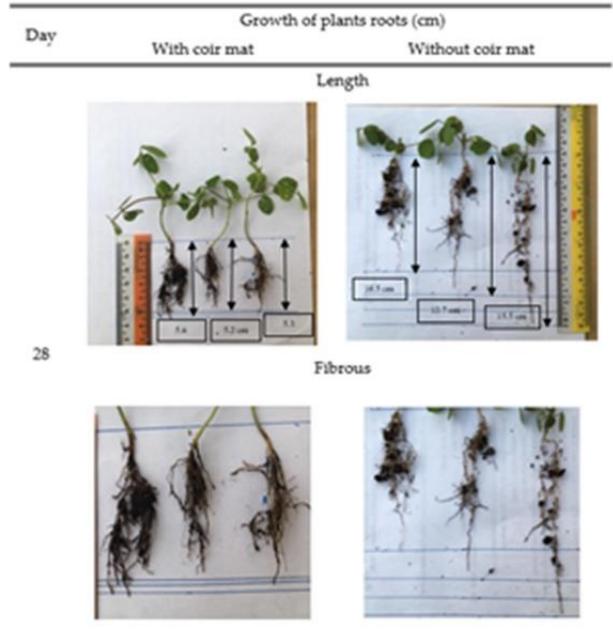
(a) 7 days



(b) 14 days



(c) 21 days



(d) 28 days

**Figure 1** comparison growth of pueraria phaseoloides roots with and without coir mat

The tests were performed on test samples of 60 mm square and 26 mm thickness. It is placed in a square box which is split into upper and lower halves. The constant horizontal shear force is applied to the upper half of the shear box with a shear rate of 0.5 mm/min. Three identical soil samples were tested under different normal load namely 1.0 kg, 2.0 kg and 3.0 kg for both soil conditions, which are with and without coir mat, respectively.

### 3. RESULTS AND DISCUSSION

#### 3.1 Vegetation Development

The visual observation of the development of Pueraria Phaseoloides roots with and without coir mat at different days (7, 14, 21 and 28 days) are shown in Figure 1. Based on its fibrous, roots were best developed in the soil covered with coir mat. It can be seen since days 7 where the fibrous of the roots with coir mat is uplifting compared to without coir mat. Even though roots without coir mat is longer than with coir mat, but the fibrous of the roots is influencing its hold towards soil. Therefore, coir mat does not significant in increasing length of roots but it does significant in increasing the fibrous of roots. Fageria and Moreira [13] stated that the stronger the roots hold soil, the lesser the potential of soil to erode as roots bind soil particles at the ground surface reducing their susceptibility to erosion which is beneficial to slope stability.

**Table 1** Comparison growth of roots length with and without coir mat

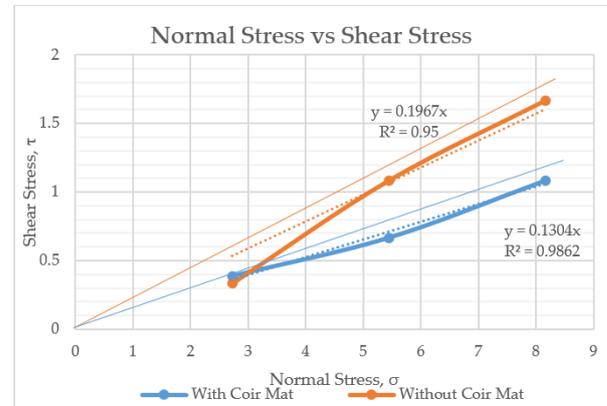
Visual Inspection Test		
Durations	With Coir Mat (cm)	Without Coir Mat (cm)
7 days	3.3	2.8
14 days	3.7	6.2
21 days	4.4	11.1
28 days	5.4	12.9

Based on Table 1, only days 7 shows the average length of roots with coir mat longer than without coir mat. Differ for the following days, where length of roots with coir mat is shorter than without coir mat. Dasaka and Sumesh [14] claimed that the increasing nutrient supplies in the soil may also decrease root length but increase root weight in a quadratic fashion. Roots with adequate nutrient supplies may also have more root hairs than nutrient-deficient roots [14]. Thus, coir mat can help in increasing nutrients supplies in the soil along with helping vegetation get established to reduce soil erosion.

#### 3.2 Shear Strength Characteristics

Figure 2 indicates the shear strength parameters are envelopes through the relationship of shear stress versus

normal stress based on the peak shear strength obtained from Direct Shear Test.



**Figure 2** Mohr – Coulomb criterion of failure

Table 2 showed the summary of the shearing resistance (cohesion and friction angle) of the soils, with and without coir mat. The cohesion of soil for both with and without coir mat is 0 kN/m<sup>2</sup> and it validated that the soils have the same water content during the test. Moreover, it was shown that the loam soil is non-cohesive soil as it does not have cohesive forces. Thus, the particles have internal friction and their shear strength depends upon the angle of internal friction between particles. The results showed that the soil with coir mat had a lower friction angle than without coir mat. This may be attributed to the limited opening sizes of coir mat in forms of apertures such that vegetable roots are not able to penetrate. Thus vegetable growth does not progress generously. Nonetheless, Sidhar and Prathap Kumar [15], Sidhar and Prathap Kumar [16] and Rahman, Musa & Jeni [17] reported that the reinforcement of coir mat on soil can help in strengthening shear of soil.

**Table 2** Comparison growth of roots length with and without coir mat

	With Coir Mat	Without Coir Mat
Cohesion, c kN/m <sup>2</sup>	0	0
Friction Angle, Φ	7.4°	11.1°

### 4. CONCLUSION

The paper presents is to investigate the effect of coir mat on vegetation root growth and soil strength. The visual observation revealed that the roots were better developed in the soil covered with coir mat. However, no significant effect has been seen on the shearing resistance of soil with and without coir mat. Through the observation, it can be

inferred that the opening size is one of the significant parameters that should be considered in the fabrication of the coir mat, where the large opening size helps the vegetation to penetrate and grow rapidly as reported by Paz et al. [18]. The following suggestions have been drawn for further research.

- a. Pueraria Phaseoloides seeds can be planted directly on the ground or even on the slope without using container so that it is more similar to an actual situation when applied on site.
- b. Coir mat can be designed with different opening size such as 10 mm, 20 mm and 30 mm.
- c. Prepare soil sample at different water contents.
- d. Conduct the Tensile Strength Test to identify the strength of coir mat and roots.
- e. Safe precautions should be practised before conducting Direct Shear Test to prevent soil from disturbed.

## ACKNOWLEDGMENT

The authors gratefully acknowledge the Universiti Tun Hussein Onn Malaysia for the financial support to this research. The authors also would like to thank the anonymous reviewers for their valuable comments and suggestions to improve the quality of the paper.

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