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Potential Coconut Coir Fiber as Soil Reinforcement

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Abstract: Coconut coir fibre (CCF) is one of the natural fibres abundantly available in tropical regions and is extracted from coconut fruit's husk. Coconut coir fibre will be used as reinforcement material to reduce waste material and save the environment. This research will evaluate the effect of load on coconut coir fibre's tensile properties using a different diameter a 0.2 mm, 0.3 mm, 0.4 mm, 0.5 mm, and 0.6 mm with the same length of 0.7 mm. The tensile test will be carried out to determine the properties of coconut coir fibre. The research carried out and the conclusions drawn by different researchers in the last few decades are also briefly presented. The ultimate tensile strength value base on the graph has been obtained with 0.2 mm and 0.6mm. The high ultimate tensile strength is 88.30 MPa at 0.6 mm diameter of CCF. It can be concluded the diameter of the CCF will affect the strength of the reinforcement. Coconut fibres reinforced composites have been used as cheap and durable non-structural elements. This review aims to spread awareness of coconut fibres as a construction material in civil engineering.

Keywords: Coir fibre, Tensile test, Tensile strength, Load

1. Introduction

Soil reinforcement is a technique to improve the engineering properties of soil using geo-engineering methods. The main purpose of soil reinforcement is to enhance its stability, to increase its bearing capacity, and also to reduce settlements and lateral deformations. There are a variety of materials used for reinforcing such as steel, concrete, glass, fiber, wood, rubber, aluminium and thermoplastics.

In Malaysia, the number of agricultural waste disposal sites is increasing. New appropriate landfill sites are becoming more difficult because communities are unwilling to accept new landfill sites near their residence, and landfill space for solid waste will decrease [1]. Besides that, to reduce agricultural waste product from the coconut husk, which are burnt during its disposal, will impact the environment, as shown in Figure 1.

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Figure 1: Reduce agricultural waste by the burnt method

This research focuses on coconut fibre material where the fibre was investigated in the laboratory using a tensile testing machine according to ASTM D638 [2]. This research investigates the tensile properties of coconut coir fibre via tensile test, compares the tensile properties of coconut coir fibre by secondary data, and recommends the suitable application of coconut coir fibre as reinforcement. The scope and limitation of the study are shown in Figure 2.

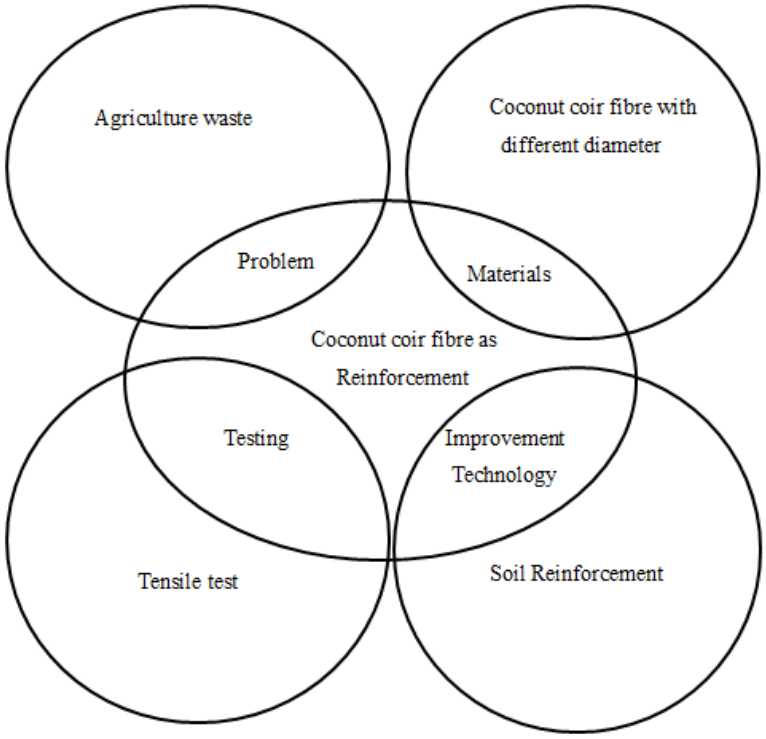

Figure 2: Limitation and Scope of Study

However, many kinds of research have been done using different agricultural waste types such as rice husk, palm oil waste, sawdust and pineapple leaves in the construction area [3]. These materials are found to be sustainable and environmentally friendly raw materials for use in construction. Agricultural waste materials such as ash coconut coir fibre will reduce construction costs and reduce the environmental hazards caused by its careless disposal. The application of coconut coir fibre includes soil drying, a soil amendment to enhance subgrade support capacities for pavements, additional material in concrete boards application, reinforced corrugated slabs, plastering and cement sand mortar [4-6].

2. Materials and Methods

Agricultural wastes are defined as the residues from the growing and processing of raw agricultural products such as fruits, vegetables, meat, poultry, dairy products, and crops [3-4]. They are the non-product outputs of production and processing of agricultural products that may contain material that can benefit man but whose economic values are less than the cost of collection, transportation, and processing for beneficially used [5-6].

2.1 Coconut Coir Fibre

Coconut fibre is extracted from the outer shell of a coconut and belongs to the group of stiff structural fibres. The common name, scientific name and plant family of coconut fibre is coir, cocos nucifera and arecaceae (palm) [7]. There are two types of coconut fibres, a brown fibre extracted from matured coconuts and white fibres extracted from immature coconuts. Brown fibres are thick, strong and have high abrasion resistance. White fibres are smoother and more refined, but also weaker. Coconut fibres are commercially available in three forms, namely bristle (long fibres), mattress (relatively short) and decorticated (mixed fibres) [7]. These different types of fibres have different uses depending upon the requirement. In engineering, brown fibres are mostly used. The main advantage of using coconut coir in improving soil subgrade strength is that they are cheap, locally available, and eco-friendly. In this study, the coconut coir is extracted mainly from the green nut. Coir or coconut fibre belongs to the group of stiff structural Fibres. The coir fibre is elastic enough to twist without breaking, and it holds a curl as though permanently waved. The inclusion of fibres had a significant influence on the engineering behaviour of coir mixtures in Figure 3.

Figure 3: Coconut tree, Coconut and Coir Fibre [5]

2.2 Methodology

Flow chart acts as an indicator in the planning proposed for the early stage of the project or used to identify the progress of work. Flow chart of the methodology, as shown in Figure 4.

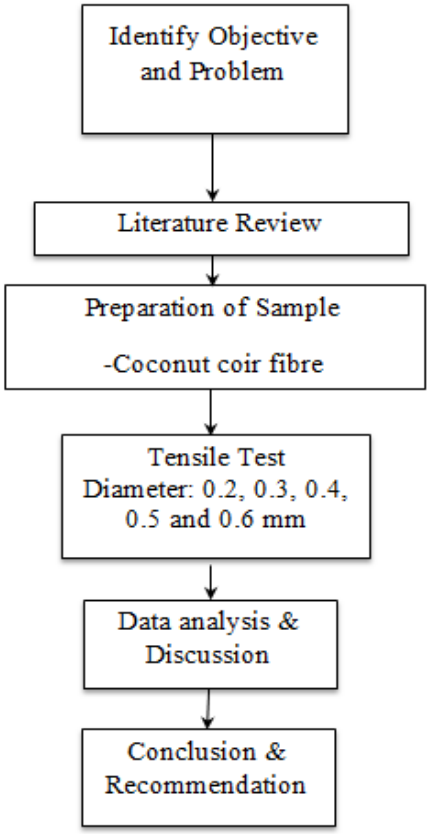

Figure 4: Flowchart of Research Methodology

2.3 Preparation of Sample

The raw materials that will be used for the project are fibre from coconut husk. Coir is obtained from the coconut that has ripened and fallen from the tree. The ripe coconut then is husked immediately to remove the fruit from the seed. The husk is then undergoing a process, which is the curing process. The husk is buried in pits dug along riverbanks for at least six (6) months to naturally promote microbes' action. This process is done to decompose partially to separate coir fibres and residue called coir pith. The CCF is dried for coir fiber at 70 ^{0}C to 80 ^{0}C using the oven for 24 hours to get rid of moisture in the fibre [8-9]. The diameter of coconut coir fibre used is 0.2 mm, 0.3 mm, 0.4 mm, 0.5mm and 0.6 mm, and the length is 0.7 mm. The diameter and length of coconut coir fibre will be measured using an electronic vernier caliper and ruler, as shown in Figure 5. The selection and cutting must be made carefully to produce accurate test results.

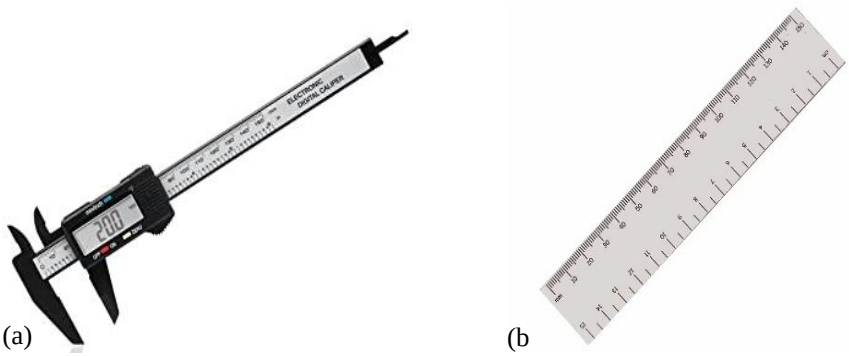

Figure 5: Vanier Caliper (a) and Ruler (b)

2.4 Tensile Test

The tensile test is used to measure the tensile strength of a material. It is the measurement of a material up to which extent it can bare the loads. It is the ability to resist the loads without failure. Coconut coir fibre (CCF) will separate to five different diameters 0.2 mm, 0.3 mm, 0.4 mm, 0.5 mm and 0.6 mm with the same length 0.7 mm, as shown in Table 1. The test carried out using ASTM D638 [2] as shown in Figure 6, with speeds of 10.0 mm/min. The result of testing will calculate automatically by the software, and the graph stress-strain generate in a computer.

Table 1: Diameter of samples with the same length

Diameter(mm)	Length (mm)
0.2	0.7
0.3	0.7
0.4	0.7
0.5	0.7
0.6	0.7

Figure 6: Tensile Test

The young modulus, yield strength, ultimate tensile and fracture determined from graph stress-strain while the young modulus can be calculated by using Eq 1 [2].

$$\text{Young Modulus, E, } = \frac{\text{Stress}}{\text{Strain}} \qquad \textit{Eq.1}$$

3. Results and Discussion

This test was conducted with different load with 9 N, 23 N, 11 N, 17 N and 27 N. The extension versus load data was obtained from the 5 different diameters of specimen coconut fibres as per shown in Figure 7.

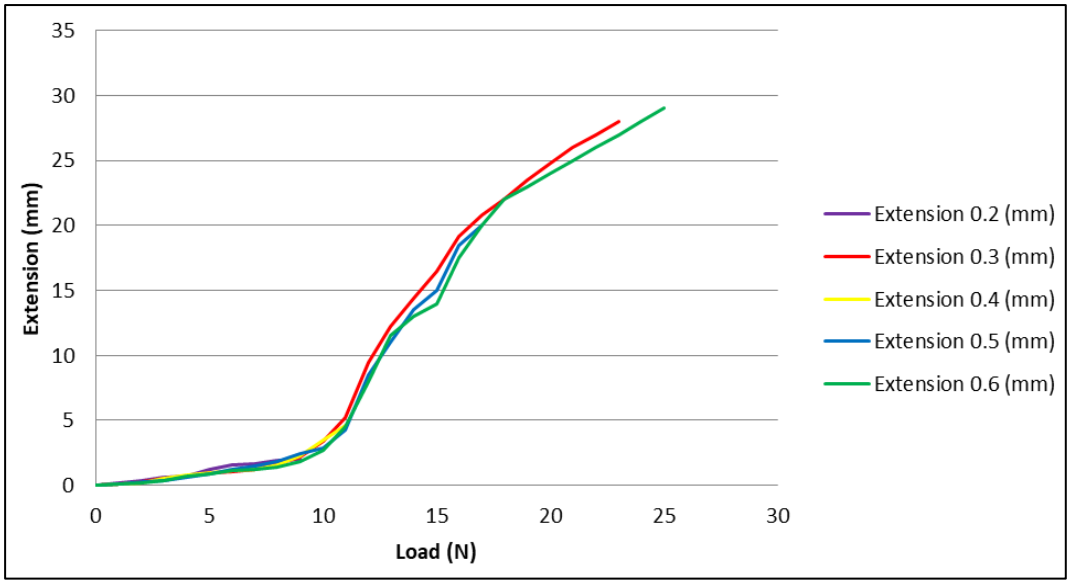

Figure 7: Extension versus load curves

Figure 7 shows the extension, and the load are calculated at the ultimate break of coconut coir fibre. According to Figure 7, the higher extension is obtained at diameter 0.6 mm. While the stress versus strain of the 5 different diameter specimen coconut fibres are displayed in Figure 8. The data from the graph were taken along on the stress-strain graph of each fibre specimen to calculate the value of young modulus, yield strength, ultimate tensile strength, and fracture also obtained from the figure and tabulated below in the stress versus strain graph.

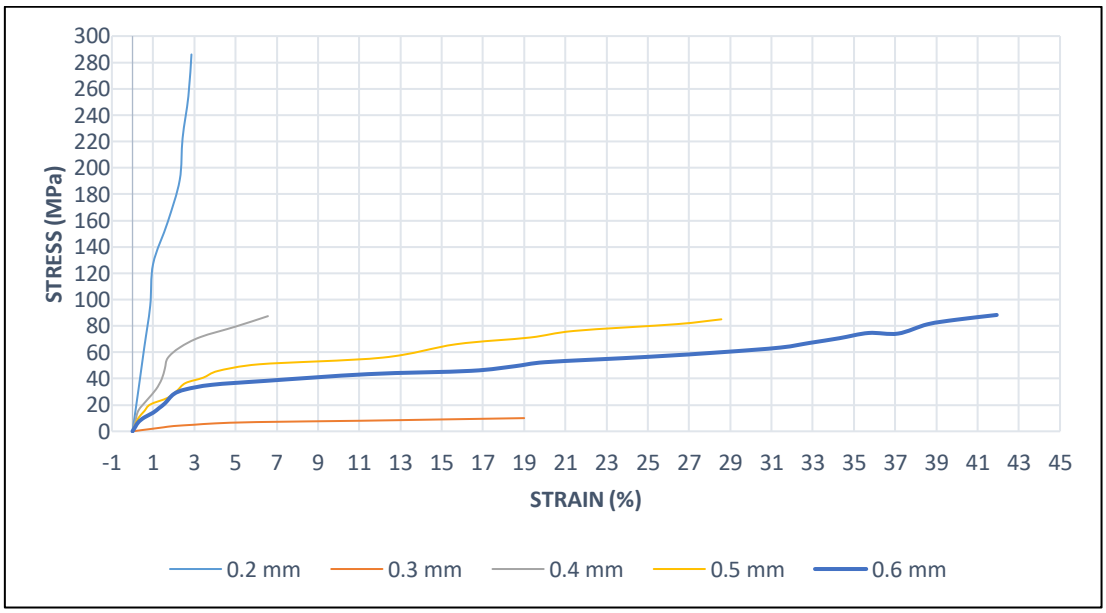

Figure 8: Relationship of the tress versus Strain of coconut coir fibre

Figure 8 above shows the stress and strain graph trend that indicates five different diameters of 0.2 mm, 0.3 mm, 0.4 mm, 0.5 mm, and 0.6 mm with the same length of 0.7 mm. The load will calculate at coconut coir fibre break with 0.2 mm at 9N, 0.3 mm at 23 N, 0.4 mm at 11 N, 0.5 mm at 17 N and 0.6 mm at 27 N. Figure 8 shows that the value of higher stress at 0.2 mm with 286.08 MPa and the lowest at 0.3 mm with 23 MPa. The result of strain also the higher at point 0.2 mm with 2.86 % and the lowest at 0.6 mm with 41.91 %. The value of strain also increases base on the load obtain. From the graph, we can conclude the diameter of coconut coir fibre will affect the result of stress-strain.

Table 2: Properties of coconut coir fibre with different diameters

Diameter (mm)	Young Modulus (GPa)	Yield Strength (MPa)	Ultimate Tensile Strength (MPa)	Fracture
0.2	0.010	158.93	28.61	36
0.3	0.012	169.53	12.85	92
0.4	0.026	55.63	26.60	44
0.5	0.003	55.94	86.45	68
0.6	0.002	31.79	88.30	108

Table 2 shows that coconut coir fibre properties with different diameter and the value of young modulus, yield strength, ultimate tensile strength, and fracture to find out the suitable diameter for reinforcement material. The young modulus of the coconut coir fibre was obtained at all diameters with different values. The value of coconut coir fibre shows the highest value, which is 0.026 GPa compare the lowest with 0.6 mm with 0.002 GPa. Furthermore, from the table's result, the 0.6 diameter shows the high ultime tensile strength and fracture, which can conclude the higher diameter is suitable for reinforcement material. The diameter of the CCF will affect the strength of the reinforcement. The higher diameter of the coconut coir fibre is very suitable to use as reinforcement material base on the graph obtain that it can accept the high of the load.

4. Conclusion

This study work was carried out to evaluate coconut fiber's parameter and verify the results obtained by using a tensile test. From the result, we can conclude that the presence of coir fiber as reinforcement material will have an impact in the engineering field. However, the experimental work was carried out on different diameter fiber specimens and applied with different. Conclude, the diameter coconut fiber less effective for strength and the result not much different from another diameter of 0.6 mm shows the high ultimate tensile strength at 88.30 MPa. Compared to the previous study, the result of coconut coir fiber properties also affects diameter and length; the data obtained with the high diameter and less of the length obtain more high ultimate tensile strength [8].

This research can be concluded, coconut coir fiber suitable as reinforcement material and also as a new alternative to building material. For the reinforcement material, the coconut coir fiber has the potential to be used as replacement sand in the sand brick mix. It also can be applied in small construction and suitable for non-load bearing as plastering and board application.

This project, not a new project, and many researchers have study about coconut coir fiber that use a chemical treatment to obtain the new strength. However, this project can give an idea for more in-depth analysis in the future. It is a hope that the coconut coir fiber or another fiber will be acknowledged by the community of construction engineers as reinforcement material, providing another research into developing other new product based on the idea of the new materials and give benefits to the public by giving them a cheaper product in ensuring maintain their living standard.

For future analysis, research methodology needs to improvise mainly on matrix preparation. As the coir fiber is volume consuming, making the matrix preparation harder, a new preparation method needs to be developed. Since the fibers are very light and delicate, high precision is really needed during the experimental work. Coconut coir fiber diameter is minimal; accuracy must be done to get the right diameter, which will affect the result. Care should be taken when the retting process is carried out. Use the shorter length to provide the high strength of coconut coir fiber.

It is recommended for those who intend to further this research to perform other properties testing to determine the prospect properties that values such as using a chemical to treat coconut coir fiber, heat

resistance test and water absorption test. From this testing, we can develop suitable products that serve specifically according to the optimum properties of this material.

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