Civil and Environmental Research
ISSN 2224-5790 (Paper) ISSN 2225-0514 (Online)
Vol.9, No.11, 2017

Tensile Strength of Coconut Fiber Waste as an Organic Fiber on Concrete

Jeffrey Andre Delarue
Building Engineering Education Department, Manado State University (UNIMA)
Kampus UNIMA, Tondano 95618, Indonesia

Abstract
Coconut fiber waste as waste material from processed fiber making from coco fiber is generally just thrown away and burned. This waste still has fiber properties in size 5 - 7 cm in diameter ranging from 0.2 to 0.7 mm. This study aims to treat waste so as to obtain fiber that can be utilized as organic fiber in fiber concrete. The fiber diameter used in the study was 0.32 mm, 0.35 mm, 0.37 mm, 0.49 mm and 0.65 mm. Further examined the chemical content and tested tensile strength. The results showed that the chemical content of the fiber, namely hemicellulose 7.46%, cellulose 42.90% and lignin 41.28%. The tensile test result gives an average tensile strength value of 18.2 N with an average tensile stress of 117.46 MPa with a standard deviation of 25.04
Keywords: Coconut fiber waste, tensile strength, organic fiber

1. Introduction

Coconut trees are very common in North Sulawesi Province, so the province is often referred to as "*Nyiur Melambai*" province. Based on the North Sulawesi Provincial Plantation Service data, in 2014 the planting area of coconut trees reached 278,484 ha with production of 282,330 tons. The manifestation of this coconut production is for the manufacture of copra, where the utilization of coconut is dominant in coconut meat, while coconut shell and coconut husks are discarded.

Coconut shells are often used as shell charcoal, handicrafts, mosquito coils and firewood. While coconut husk is processed, either manually or by machine into fiber raw material, and it often called coco fiber or coir. The raw material of coconut fiber can be used as handicraft, such as doormat, sports mat, house floor broom, spring bed mattress, and car seat.

Chandel, *et al*. (2016) states that coir fiber is a natural fiber which is obtained from the husk of coconut. It is the fibrous material found between the hard, internal shell and the outer coat of coconut. Coconut coir has about 48% of lignin which adds strength and elasticity to the cellulose based fiber walls. Since lignin resists bio-degradation, high lignin content also imparts longevity to outdoor applications. Coir fiber nearly takes more than 20 years to decompose. Coco fiber has potential in various forms and methods in applications in various media and forms such as those used for insulation, as a concrete reinforcement component, to provide reinforcement of the soil mass in embankments and foundations, in the manufacture of lightweight cement boards for soundproofing. In addition, for walls, and cement blocks.

The development of science and technology has utilized coco fiber as fiber in the manufacture of concrete. Several previous studies that utilize coco fiber on concrete production included: Mawardi (2006) studying the effect of coco fiber addition on the strength of concrete bending; Miko Eniarti (2010) examines the effect of coco fiber on the improvement of the normal mechanical properties of concrete; Ali, *et al.*(2010) examined the effect of coco fiber on the reinforced concrete beam properties; Abdullah, *et al*. (2011) examined the physical and mechanical behavior as well as the concrete collapse due to the use of coconut fiber, and Madjid Ali (2010) which examined the utilization of coco fiber as a concrete material.

In principle, the addition of fiber to the concrete is an attempt to fix the weakness of the concrete, that is the tensile strength which much smaller than the compressive strength. Tensile strength of concrete ranges from 8 to 15% of its compressive strength (McCormac, 2001). Fiber is added in a random and evenly mixed concrete. This treatment is expected to reduce early cracks due to both loading and heat hydration that contribute directly to the enhancement of the ability of the concrete to support inner forces.

In general, the fibers used in the concrete can be categorized into 2 (two) groups, namely artificial fibers and organic fibers (natural). Artificial fibers such as steel, glass, plastics and carbon, while organic fibers (natural), specifically fibers derived from plants and animals. The process of processing coco fiber into coconut fiber raw material by using the machine produces waste that is still fiber. The waste of coco coir fiber is still very rarely used even just thrown away and burned.

This research was a research developed on coco coir fiber as fiber in concrete done by previous researchers. The development was to use coco fiber waste material. This research intends to examine the properties of coco fiber waste material. The result of this research was expected that coco coir fiber waste can be used as organic fiber in concrete.

This research was aimed to get the chemical content from coco coir fiber waste and get the tensile strength of coco coir fiber waste in relation as organic fiber in concrete

2. Material and Method

2.1. Chemical Content

The Van Soest method is used to estimate the fiber content in the plant or plant product and its fractions into specific groups based on its engagement with anion or detergent cation (detergent method). The concept behind the detergent fiber analysis is that plant cells can be divided into less cell walls (contains hemicellulose, cellulose and lignin) and cell contents (contains starch, sugars, and organic acids). Van Soest (1982) separated two components of plant fiber successfully by use of two detergents: a neutral detergent (Na-lauryl sulfate, EDTA, pH =7.0) and an acid detergent (cetyl trimethyl ammonium bromide in 1 N H2SO4) (Mc Donald, *et al*., 2010)

Neutral Detergent Fiber (NDF) is a fiber that contains a structural type of carbohydrate, consisting of: Hemicellulose + Cellulose + Lignin, while Acid Detergent Fiber (ADF), containing Cellulose + Lignin

Procedure of Analysis

Procedure for NDF determination (Neutral detergent fiber)

1. Grind the air dried sample to pass 1 mm screen.
2. Weigh in a crucible 1 g of grinded sample with 1 mg approximation.
3. Add 100 ml of neutral detergent solution at room temperature into crucible with 0.5 g of sodium sulfite and some drops of n-octanol.
4. Heat to boiling and reflux 60 minutes from onset of boiling.
5. Filter and wash 3 times with boiling water, then twice with cold acetone.
6. Dry 8 hours at 105 °C and let cool in a desiccator.
7. Weigh.
8. Calculate neutral detergent fiber: NDF % = (weight of crucible + weight of residue) - weight of crucible / weight of sample x 100. Neutral detergent solubles: NDS % = 100 - NDF %.
9. Ash in a muffle at 550 °C 2 hours and let cool in a desiccator.
10. Weigh.
11. Calculate ash insoluble in neutral detergent: loss on ashing / weight of sample x 100.

Procedure for ADF determination (Acid detergent fiber)

1. Grind the air dried sample to pass 1 mm screen.
2. Weigh in a crucible 1 g of grinded sample with 1 mg approximation.
3. Add 100 ml of acid detergent solution at room temperature and some drops of n-octanol.
4. Heat to boiling and reflux 60 minutes from onset of boiling.
5. Filter and wash 3 times with boiling water, then twice with cold acetone.
6. Dry 8 hours at 105 °C and let cool in a desiccator.
7. Weigh.
8. Calculate acid detergent fiber: ADF % = (weight of crucible + weight of residue) - weight of crucible / weight of sample x 100.
9. Ash in a muffle at 550 °C 2 hours and let cool in a desiccator.
10. Weigh.
11. Calculate ash insoluble in acid detergent: loss on ashing / weight of sample x 100.

2.2. Tensile Test

In conducting the tensile test, samples were made in five (5) specimens based on diameter (mm) with the following categories : 0.29 mm; 0.35 mm; 0.37 mm; 0.65 mm; and 0.49 mm (no grip)

The testing was done with the testing load 1000 kg

Figure 1 and figure 2 show the preparation of material and tools.

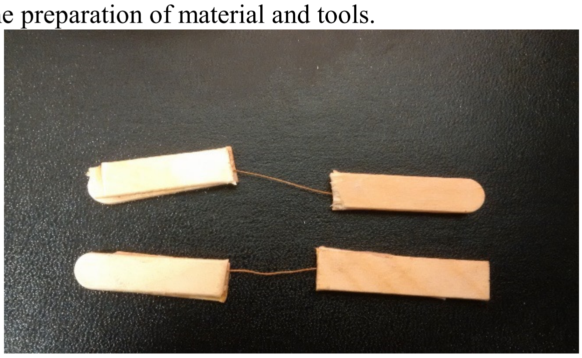


Figure 1. Specimen Sample

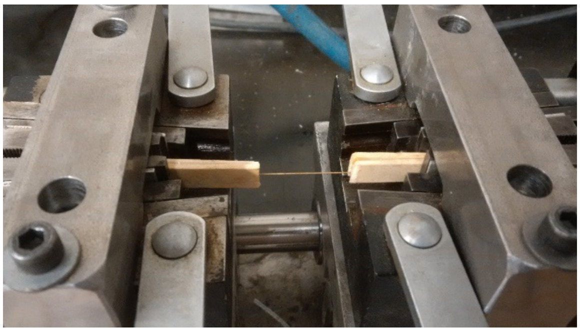


Figure 2. Specimen on the experimental tensile test with grip

3. Result and Discussion

3.1. Chemical Content

Figure 3 shows that coconut fiber coir waste is predominantly composed of hemicellulose, cellulose and lignin.

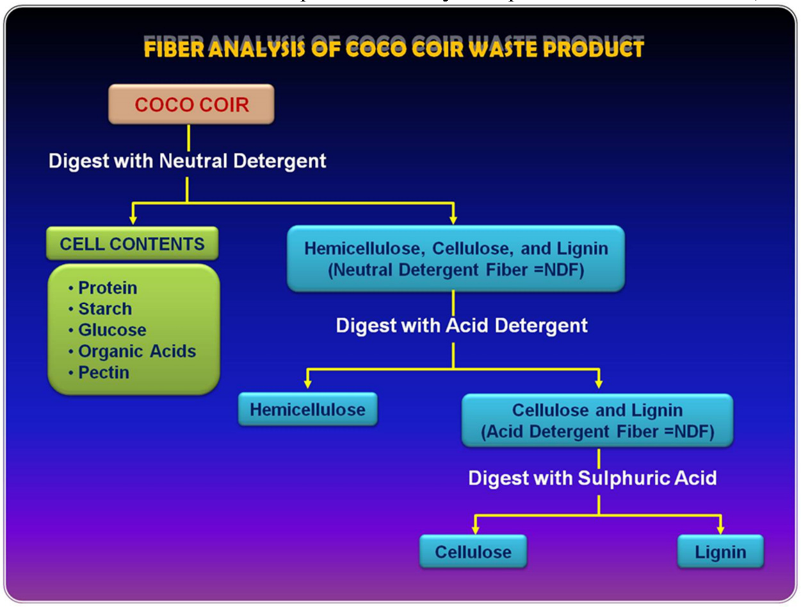


Figure 3. Procedure to Analysis Chemical Content of Coco Choir Waste Product

The result shows that chemical content of waste coconut fiber: hemicellulose 7,46%, cellulose 42,90% and lignin 41,28%

Some researchers found that chemical content of coconut fiber were showed on table 1.

Table 1. Chemical Content of Coconut Fiber

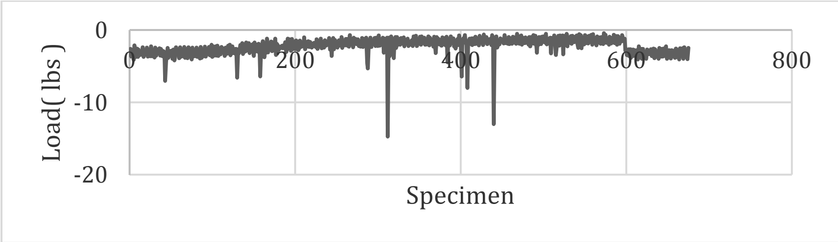
Hemi-cellulose (%)	Cellulose (%)	Lignin (%)	References
31,1	33,2	20,5	Ramakrishna,et al (2005)
15 – 28	35 – 60	20-48	Agopyan, et al (2005)
16,6	68,9	32,1	Asasutjarit, et al (2007)
-	43	45	Satyanarayana, et al (1990)
0,15 – 0,25	36 – 43	41 - 45	Corradini, et al (2006)

Reference: Ali M (2010)

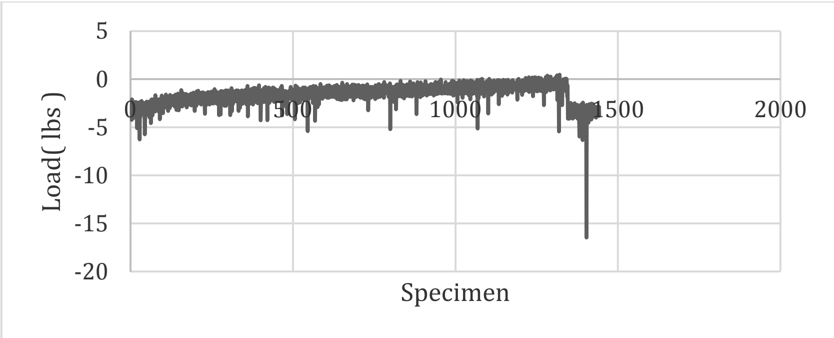
The chemicals content of coco coir fiber waste found in this research were not significantly different from coconut fiber content reported by others previous researchers

3.2. Tensile Test

Graph 1 to 2 and table 2 show the result of tensile test



Graph 1. Tensile Test Specimen Diameter 0,37 mm



Graph 2. Tensile Test Specimen Diameter 0,49 mm (without grip)

Table 2 Tensile strength of the waste coconut fiber

Specimen	Diameter	Peak Load (lb)	Load (N)	Tensile Strength (MPa)
1	0,29	2,676	11,90	148,01
2	0,35	2.619	11,65	121,09
3	0,37	2.566	11,41	106,16
4	0,65	9.716	43,22	130,24
5	0,49	3.469	15,43	81,83
		Average	**18,72**	**117,46**
	Std	**25,04**		

Some researcher found that tensile strength of coconut fiber was showed on table 3

Table 3. The tensile strength of coconut fiber from some researchers

Tensile Strength (MPa)	Reference
15 – 327	Ramakrishna
107	Agopyan
69,3	Paramasivan
50,9	Ramakrishna
142±36	Li et al
108 – 252	Toledo
137±11	Munawar
500	Rao
175	Fernandez
174	Reis
100 – 130	Aggarwal
106 – 175	Satyanarayana

References: Ali M (2010)

The results show that the tensile strength of coco coir fiber waste in this experiment were not significantly different from the tensile strength of coconut fiber found by others previous researchers

4. Conclusion

It is concluded that coco coir fiber waste can be used as coconut fiber substitution on concrete mixture. It is recommended for testing on concrete using the strength of 20-25 MPa concrete strength.

Acknowledgements

The author thanks Dr. Ramon Ferry Tumiwa, MM for his assistance and editing that substantially improved the content of this article.

References

[1] Ali M. 2010. Coconut Fibre – A Versatile Material And Its Application in Engineering. http://www.claisse.info/Proceeding.htm
[2] Ali M., Liu A., Sou H., and Chouw N. 2010. Effect Of Fiber Content On Dynamic Properties Of Choir Fiber Reinforced Concrete Beams. NZEE Conference
[3] Chandel, A., Maurya, R. and U. Kumar. 2016. A Conspectus on Serviceability of Coir Fibers in Civil Engineering. Journal of Scientific and Research Publications, *Vol. 6: 1.*
[4] E. Miko. 2010. Pengaruh Pemanfaatan Serat Serabut Kelapa Terhadap Perbaikan Sifat Mekanik Beton Normal. Spektrum Sipil, ISSN 1858-4896. Volume 1, No.1 hal : 19 – 28
[5] Mawardi. 2006. Tinjauan Pengaruh Penambahan Serat Sabut Kelapa Pada Kuat Lentur Beton. Media Infotama, Volume 1 No.2 Bulan 2 Tahun 2006 hal : 22
[6] McCormac, J.C. 2004. Desain Beton Bertulang. Edisi Kelima. Penerbit Erlangga. Jakarta
[7] McDonald, P., Edwards, R.A., Greehalgh, J.F.D., Morgan, C.A., Sinclair, L.A. and R.G. Wilkinson. 2010. ANIMAL NUTRITION. 7^{th} Ed. Prentice Hall. Pearson. London, New York, San Francisco, Sydney, Amsterdam
[8] Van Soest. P. J., 1982. Nutritional Ecology of the Ruminant. Commstock Publishing Associates. A devision of Cornell University Press. Ithaca and London.