第V部門
連続繊維補強コンクリート（材料）
2023年9月15日(金) 16:50 〜 18:10 V-8 (広島大 東広島キャンパス総合科学部講義棟 K２０９)

[V-760] Mechanical Properties of Palm-Fiber-Reinforced Cementitious Composites (palm-FRCC)

*selamawit Fthanegest Abrha[1], Kanakubo Toshiyuki[1] （1. University of Tsukuba）

キーワード：Natural Fiber, Palm Fiber, Palm-FRCC, Ecological material, SEM, Bending test

In this research, the mechanical properties of palm fiber and palm-FRCC were studied. The palm fiber was prepared by cutting a palm rope with a 10mm shredder. The density of the fiber was measured by Archimedes’ principle. A scanning electron microscope (SEM) was used to observe the surface configuration and measure the diameter of the fiber. A four-point bending test was carried out for specimens without fiber and specimens with palm fiber. The maximum bending moment and curvature at the maximum bending moment for specimens without fiber and with fiber are 0.300kNm, 0.290kNm, and 0.021 1/m, 0.001 1/m respectively.

Mechanical Properties of Palm-Fiber-Reinforced Cementitious Composites (palm-FRCC)

筑波大学　学生会員　○ Abrha Selamawit Fthanegest
筑波大学　正会員　Toshiyuki Kanakubo

1. INTRODUCTION

Natural fibers are fibrous materials obtained from natural sources. Natural fibers can be classified as plant fibers or cellulose-based fibers, animal fibers or protein-based fibers, and mineral fibers.[1] The demand for ecological materials and their properties such as biodegradability, low density, and inexpensiveness led to the application of plant fibers as alternatives to synthetic fibers. This research is conducted to study the mechanical properties of fiber-reinforced cementitious composites with palm fiber. The palm fiber used in this research was prepared by cutting a palm rope around 10mm in length.

2. DENSITY AND DIAMETER MEASUREMENT

2.1 Density

Fiber density was calculated using the Archimedes principle. This principle states that the volume of liquid displaced is equal to the volume of an object completely immersed in liquid. The braided palm fibers were sampled before cutting and the dry weight at room temperature was measured. The sample was soaked in water for 22 hours and the wet weight was measured after squeezing. The sample was then immersed in a full glass funnel and the mass of water displaced was measured as the fiber volume. Density calculation methods and results are shown in Fig. 1 and Table 1. The average density is 0.723g/cm³.

2.2 Diameter and morphology using SEM

Scanning electron microscope (SEM) was used to observe the fiber configuration and measure the diameter. All the samples have a cylindrical shape as shown in Fig. 2a. Fig. 2b shows the wax and impurities on the surface and Fig. 2c shows the array of bulges which are silica bodies embedding circular holes. In Fig. 2d, the silica is removed leaving an empty hole that may facilitate the mechanical interlocking of the fiber and the matrix. Fig. 3 shows the distribution of fiber diameters, with an average fiber diameter of 171μm.

Table 1 Density of fiber

Sample	Wet weight (g)	Dry weight (g)	Volume (cm^3)	Density (g/cm^3)
1	23.3	14.9	17.9	0.832
2	31.1	16.5	24.9	0.663
3	29.0	16.6	23.9	0.695
4	32.2	16.7	26.7	0.625
5	28.3	17.5	21.9	0.799
Avg.	28.8	16.4	23.1	0.723

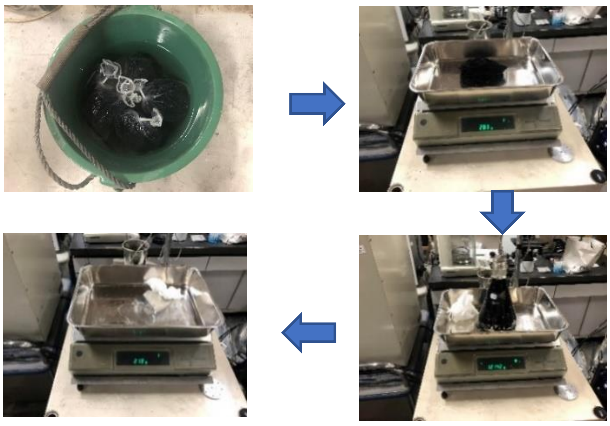

Fig. 1 Measurement of fiber volume

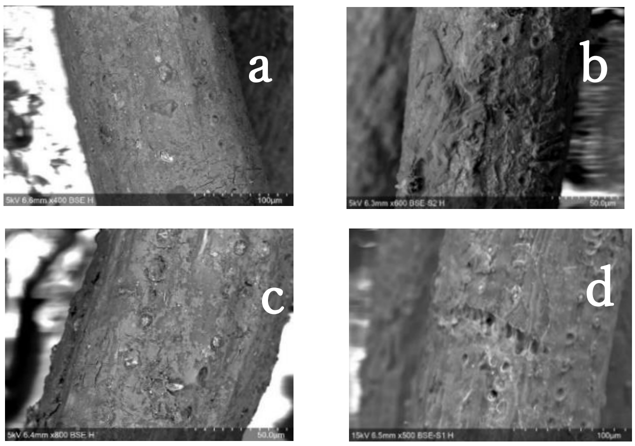

Fig. 2 Surface observation

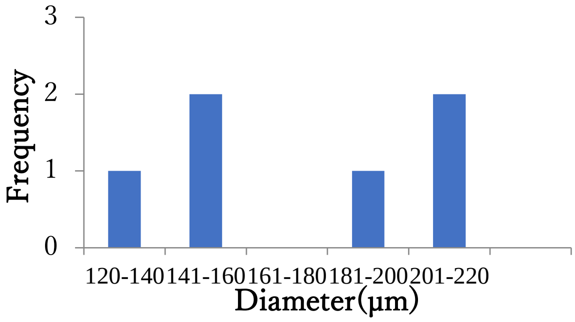

Fig. 3 Fiber diameter distribution

Keywords　Natural fiber, Palm fiber, Palm-FRCC, Ecological material, SEM, Bending test
連絡先　〒305-8573　茨城県つくば市天王台 1-1-1　筑波大学　TEL 029-853-5045

3. BENDING TEST OF PALM-FRCC

3.1 Test outline

Table 2 shows the mixture proportion and Fig. 4 shows the palm fiber used in FRCC. The fiber volume fraction (V_f) was set to 3%. The specimen was a prism with a cross-section of 100mm×100mm and a length of 400mm. Three specimens each, for mortar(N) and with 3% fiber volume fraction(P3%), were prepared and a four-point bending test with a pure bending length of 100 mm using a 500kN universal testing machine was carried out. Table 3 shows the compression test results using ϕ100-200mm cylinder test pieces for specimens without fiber and specimens with a fiber volume fraction of 3%.

3.2 Specimen status after loading

Fig. 5 shows the cross-section of specimens after loading. The fibers are distributed evenly throughout the cross-section. Cross-sectional fracture surfaces show that most of the fibers are pulled out of the matrix, indicating the crack-bridging characteristics of the fiber.

3.3 Load-deflection relationship

Fig. 6 shows the relationship between the load and deflection at midspan. Specimens without fiber showed brittle behavior, while specimens with fiber exhibited ductile behavior due to the crack-bridging ability of the palm fiber. The deflection at the maximum load for specimens without fiber and with fiber is 0.028mm and 0.013mm respectively.

3.4 Moment-curvature relationship

Fig. 7 shows the moment-curvature relationship for all the specimens. Specimens with fiber exhibited similar results since the fibers were evenly distributed throughout the matrix. The maximum bending moment and curvature at the maximum bending moment for specimens without fiber and with fiber is 0.300kNm, 0.290kNm and 0.021 1/m, 0.001 1/m.

4. CONCLUSION

Palm fibers were evenly distributed throughout the matrix cross-section in all specimens. Addition of palm fiber to the matrix enhanced the material property from brittle to ductile. Most of the fibers were not ruptured but rather pulled out, indicating the crack-bridging ability of the palm fiber. Considering the crack-bridging ability of the fiber, it can be recognized that by increasing the fiber volume fraction a deflection hardening property can be obtained.

Table 2 Mixture proportion

Unit weight (kg/m^3)					Fiber (kg) (3%)
Water	Cement	Sand	Fly ash	Super-plasticizer	
380	484	484	484	6	21.69

Fig. 4 Palm fiber

Table 3 Compressive strength and Elastic Modulus

Specimen	Compressive strength (MPa)	Elastic modulus (GPa)
N	26.0	12.5
P 3%	25.2	11.8

Fig. 5 Specimens after loading

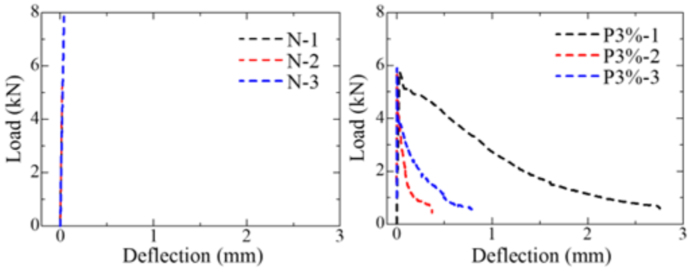

Fig. 6 Load-deflection relationship

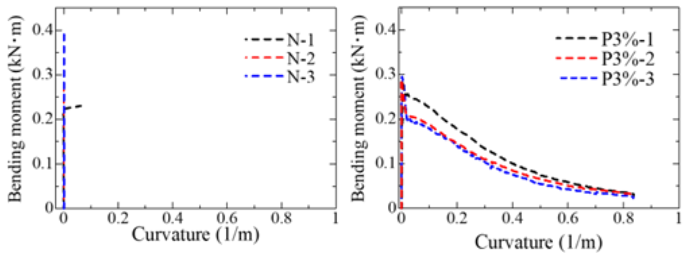

Fig. 7 Moment-curvature relationship

REFERENCE

[1] Valeria Laverde, et al. Use of vegetable fibers as reinforcements in cement-matrix composite materials: A review, Construction and Building Materials, Vol. 340, 127729, 2022