THE STUDY OF BENDING BEAMS MECHANICAL PROPERTIES WITH MICRO REINFORCEMENT

Andi Yusra1, Lissa Opirina2, Teuku Farizal3
1,2,3) Civil Engineering Department, Fakulty of Technique, University of Teuku Umar
Jl. Alue Peunyareng, Meulaboh 23617

e-mail: andiyusra@utu.ac.id, lissaopirina@utu.ac.id, teukufarizal@utu.ac.id

Abstract: Research on fiber concrete is currently growing very rapidly. The alternative fibers used in the concrete mixture is to use natural fibers. In this study, researchers used bamboo fiber as a substitute for artificial fiber, where bamboo has a good tensile strength. The aim of this study to increase beam strength in sustaining external loads by added bamboo fibers. The content of fiber additional to the concrete mixture was 1.5% of the cement weight. The mix design of concrete using ratio of cement water 0.25. The plasticizer and filler added in the mixture with the content of 2% and 15% cement weight, respectively. Two reinforced concrete beam specimens and 24 concrete cylinder specimens used in the study. Tests carried out of 28 days, and 56 days for cylindrical concrete, while bending test conducted of CBR1 and CBR2 at 28 test life only. In study show that addition 1.5% bamboo fiber to reinforced concrete beams increased the flexural capacity and ductility of the beams.

Keywords: bending capacity, micro reinforcement

1. INTRODUCTION

Fiber material used as the durability of concrete to cracks and for strengthening flexural strength of concrete beams to help improve the performance of reinforced concrete beams. The Generally various types of fibers are used in the concrete mix to achieve the strength and resistance planned. Nowadays, in response to the problem of global warming, manufacturers are trying to use natural materials in the process of making concrete. Bamboo, low cost, fast growing, and a wide distribution of growth, expected to make a significant contribution to earthquake resistant construction and seismic retrofitting technology. The author has studied to understand mechanical properties of bamboo fiber reinforcement concretes members. The results showed that there was an aspect ratio (40). Increasing the fiber weight fraction provides a consistent increase in ductility to optimal content (1.0%) with a suitable fibers aspect ratio of 40. The overall studies have shown that the addition of bamboo fiber in concrete causes an increasing on concrete strength and torsional toughness and tensile stress, however further work is needed to assess the long-term durability of bamboo fibers reinforced concrete, [1].

Use 1% bamboo fibers in the concretes mixture improving in mechanical behavior of concretes. The tensile strength and compressive strengths increased by about 22% and 17% comparing to the strength of the concretes fibers, [2]. The use of 10% powder of limestone increases concrete strength. The study shows results that bam-boo fiber and limestone powder could improve the flow performance of Self Compacting Concrete [3]. Bamboo
fiber can reduce crack width and concrete deflection and increase load-bearing capacity after beam cracking. The amount of fiber affects the performance and strength of concrete. Bamboo fibers can resist the development and spread of fracture, [4]. Use of bamboo fiber by 1% into the concrete mixture increases the compressive strength of concrete by 10% compared to original concretes, [5].

The performance of bamboo fiber concrete 0.1% with the addition of Fly Ash (BFRFAC) showed an increase of 12.44%, the compressive strength of bamboo fiber concrete was 0.2% and 0.30%, decreased compressive strength was 9.33% and 33.03% compared to fiber less concrete, [6]. Bamboo fiber reinforced mortar mixture improving the mechanics behavior of concretes and concrete ability to resist cracking, [7]. The optimal impact resistance of concrete obtained 50% volume / 10 mm, 16.6 times greater than that of neat polyester. Comparing the results of experimental with model of theoretic, size of the destruction area increases. Research shows that bamboo fibers increase the strength of concrete in receiving impact, [8], slender.

This study shows that CFR-HSC has an increase in strength of compressive, tensile strength of tensile and strength bending, compared to HSC. CFR-HSC, which uses a 50 mm length of coconut fiber with a content of 1.5% cement mass, produces optimum strength, [9]. The use of fibers in the concrete mix can improve crack resistance, resistance to impact shock loads, resistance to bending loads, and durability. The advantageous mechanical properties of bamboo fiber, we can use bamboo fiber in rural infrastructure development and increases road durability and increases service life, as well as improve the mechanical performance of concrete, [10].

The results showed that the use of oil palm empty fruit bunches in the concrete mixture could increase the split tensile strength of the concrete [11].

The hardness of palm oil blast furnace slag contributed to this increase, which has wearing value not much different than split, i.e., 4.7% compared with 6.7%. Utilization of fly ash did not contribute to the increase of shear capacity as well, although its compressive strength enhanced when compared to PBHSC [12].

The palm oil clinkers as a substitute for silica fume in high quality reinforced concrete is effectively used to increase concrete ductility [13].

It was found that there is good agreement between the flexural strength for HSFRC beams predicted by the proposed formulae and the experimental result reported in the literature, while the predicted flexural strengths as computed by ACI committee (544) were very conservative [14].

It was observed that the short discrete fibers could significantly improve the shear behaviour of reinforced SCC slender beams and beams incorporating 1% steel fiber addition could achieve a 128% increase in shear capacity over that of the reference beam without fibers [15].

2. MATERIALS AND METHODS

The CBSRF concrete beams are those that use bamboo as micro reinforcement, shows in Figure 1, while concrete Beams that do not use bamboo reinforcement coded as CBRSR concrete blocks. The concrete beams used are designed with a width = 15 cm, height = 30 cm and length = 220 cm.

![Figure 1. Specimens of Reinforced Concrete Beams](image)

| Specimen code | Dimension | Reinforcement |
|---------------|-----------|---------------|
| CBR1          | 15 x 30 x 220 | 2D16 4D16 D12 - 100 |
| CBR2          | 15 x 30 x 220 | 2D16 4D16 D12 - 100 |

Table 1 describes the tensile reinforced, Stress Reinforced and shear reinforcement used in concrete beams.

Figure 2 shows a concrete beams (CBR) setting up for bending test. Figure 3 is about the implementation settings for the beam flexural strength test with the maximum loading capability of the testing machine is 50 tons. Furthermore, Figure 3 describes the implementation of the beam bending test until the beam is destroyed, with the results obtained, namely the value of

---

- 81
the maximum loading, deformation, ductility, strain and crack pattern of beams concretes.

**Figure 2. Beams bending test**

**Figure 3. Conducting of Beams bending test**

### 3. RESULTS AND DISCUSSION

#### Strength concrete

Table 2 and Table 3 shown results of the strength of concrete strength test in 28 testing life. Happened difference in the performance concrete. The result for non-fiber concrete, the strength values are 58.770 MPa (average), compared concrete with added 1.5% bamboo fiber has strength value is 54.427 MPa (average), decreasing compressive strength because added 1.5% on cylin-der concrete compressive strength.

#### Tabel 2. Performance Strength of CBR1

| Code | Loads (N) | Section Area (mm) | Compressive Strength (MPa) |
|------|-----------|-------------------|---------------------------|
| BU1  | 1,100,000 | 17,778            | 61.875                    |
| BU2  | 1,080,000 | 17,896            | 60.349                    |
| BU3  | 1,040,000 | 18,086            | 57.502                    |

#### The Relationship Load-deformation of Concrete Beams

Based on Figure 4 and Figure 5, shows the deformation maximum of CBR2 at transducer 5 are 18.700 mm at transducer 3 and transducer 4 are 12.130 mm and 3.760 mm with 27.000 tons maximum load. The result obtained the deflection maximum happened was greater than deformation in theory, with maximum value is 18.700 mm. The condition of CBR1, where first crack area, concrete beam experience of initial crack at load 6.76 ton, and then deformation in transducer 5 obtained 0.112 cm, in transducer 3 - 4 obtained 0.612 cm, then 0.590 cm. The first fracture formation, shows the use of concrete beams (CBR1) can increase the acting loads that form the first fracture in the beams of concrete. In transition area, bending reinforced starting to melt. The value of loading-deflecting at melt area, it seen at loading 245.2 KN, with deformation 1.078 cm, 1.570 cm and 1.859 mm, at transducer five, three and four. The Fig. 6 shown the deformation at transducer 5 obtained 1.847 cm, transducer 3 and 4 obtained 1.883 cm and 2.015 cm, and then load greater obtained 260.000 KN. The resulted shows deformation ensued is more than the deformation in theoretical to maximum deformation is 8.939 mm.

#### Tabel 3. Performance Strength of CBR2

| Code | Loads (N) | Section Area (mm) | Compressive Strength (MPa) |
|------|-----------|-------------------|---------------------------|
| BU1  | 1,029,910 | 18,146            | 55.680                    |
| BU2  | 948,330   | 17,908            | 51.590                    |
| BU3  | 989,120   | 17,437            | 55.650                    |

Note :
- BU1, BU2 and BU3 is sample test using 1.5% bamboo fiber
Stirrup Loads–Strains of Beams
Based on Figure 6 and Figure 7 shows the condition on CBSRF beams, the yield strain on shear reinforcement 1 and shear 2 is 0.000 \( \mu \varepsilon \) and 7,790 \( \mu \varepsilon \) with a maximum load of 27 ton. The loads–strain relationship of stirrups for CBRS, strain of recording at 3,460 \( \mu \varepsilon \) and 1,335 \( \mu \varepsilon \), in loads maximum is 26 tons.

Tensile Steel Loads–Strains of Beams
Based on Figure 8 and Figure 9 seen that the yield strain on CBR2, the tensile reinforcement is 132,500 \( \mu \varepsilon \) at maximum load of 27 tons, an then the relation-ship load–strain of tensile steel for CBR1, in condi-tion the melting strain at tensile reinforced obtained 105.90 \( \mu \varepsilon \) at load maximum is 26 tons. The study, shown the beam condition has post-yield de-
formation is good.

The Relationship Load–strain of concrete beams
Figure 10 and Figure 11 shows CBR2 beams has strain to 231.460 \( \mu \varepsilon \) at a maximum load of 27 ton, small-er than the maximum load at the maximum deflec-tion that occurs. It can be seen that the strain in the graph below remains linear, Compare to CBR1 beams has load–strain of concrete beams rela-
thions that the concrete strain obtained 2845 \( \mu \varepsilon \) with loads maximum is 26 tons.

Ductility and Defection of CBR1 – CBR2 Beams
Figure 13 and Figure 14 shows CBR1 beams has the yield deflection (\( \Delta y \)) 10.780 mm and the ultimate deflec-tion (\( \Delta u \)) 18.700 mm, meanwhile CBR2 beam ob-tained yield deflection (\( \Delta y \)) of 10.260 mm and ulti-
mate deflection (\( \Delta u \)) of 18.700 mm, this condition shows the CBR2 beam is more ductile than the CBR1 beam. The value of ductility shows in Table 6. The CBR2 beams values ductility is 1.823, com-pare with The CBR1 beams has values ductility is 1.713. The highest ductility value found in the CBR2 beam, this indicates the added of
bamboo fi-ber increased performance of concrete beams.

Cracks and patterns of destruction

Due to the given load, the initial crack occurred in load of 5.310 tons with deformation 1.030 mm. In line with the added load, apart from the extension of the cracks at the first crack, it followed by the emergence of a number of new cracks in the flexural and shear areas. Cracked and broken pattern of CBSRF beam, the test object experienced bending failure. This is in accordance with the beam planning, namely the ratio of the theoretical ratio between the shear of capacity to bending is 2.705. The patterns of fracture occurred in concrete beam seen in Figure 13 and Figure 14.
The Fig. 15 and 16 shows initial crack occurred at load of 6.76 tons with a deformation of 1.12 mm. In line added load, apart from the extension of the cracks at the first crack, it followed by the emergence of a number of new cracks in the flexural and shear areas. Cracked and broken pattern of CBSR, the test object experienced bending failure. This is in accordance with the beam planning, namely the ratio of the theoretical ratio between the shear of capacity to bending is 2.705 tons.

4. CONCLUSION

The study results and data processing that carried out, conclusions as follows:
The maximum deformation is 18.700 mm with ultimate loads of 27 tons on (CBSRF) concrete beams. The Initial farcture occurred in load 5.310 tons with deformation of 1.030 mm. Ductility in (cbserf) concrete beams by yield deflection $(\Delta y)$ of 10.780 mm and ultimate deflection $(\Delta u)$ of 18.700 mm of 1.823. The concrete beams (CBSR) has a maximum load 26. tons. The maximum deformation values is 18.470 mm with ultimate loads is 26 tons. The Initial farcture to ensue at 6.76 ton, with deformation 1.12 mm. The concrete beams (CBSR) obtained values ductility is 1.713.

5. REFERENCE

[1] S. Kavitha and T. F. Kala, “Effectiveness of bamboo fiber as an strength enhancer in concrete Effectiveness of Bamboo Fiber as a Strength Enhancer in Concrete,” Int. J. Earth Sci. Eng., vol. 9, no. June 2016, pp. 1–6, 2016, [Online]. Available: www.cafetinnova.org.

[2] R. E. Marrero, H. L. Soto, F. R. Benitez, C. Medina, and O. M. Suarez, “Study of high-strength concrete reinforced with bamboo fibers,” Adv. Mater. - TechConnect Briefs 2017, vol. 2, pp. 301–304, 2017.

[3] O. M. Ofuyatan, A. G. Adeniyi, D. Ijie, J. O. Ighalo, and J. Oluwafemi, “Development of high-performance self compacting concrete using eggshell powder and blast furnace slag as partial cement replacement,” Constr. Build. Mater., vol. 256, 2020, doi: 10.1016/j.conbuildmat.2020.119403.

[4] S. M. Dewi, M. N. Wijaya, and N. C. Remayanti, “The use of bamboo fiber in reinforced concrete beam to reduce crack,” AIP Conf. Proc., vol. 1887, 2017, doi: 10.1063/1.5003486.

[5] D. K. Gupta and R. C. Singh, “An
Experimental Evaluation of Compressive Strength and Flexural Strength of Bamboo Fiber Reinforced Concrete,” *Carbon N. Y.*, vol. 1, no. 3500, p. 200, 2018.

[6] H. Eshetu Aweke and T. Alemu Mohammed, “The Mechanical Properties of Fly Ash Concrete Reinforced with Bamboo Fibers,” *Am. J. Constr. Build. Mater.*, vol. 4, no. 1, p. 22, 2020, doi: 10.11648/j.ajcbm.20200401.14.

[7] M. Maier, A. Javadian, N. Saeidi, C. Unluer, H. K. Taylor, and C. P. Ostertag, “Mechanical properties and flexural behavior of sustainable bamboo fiber-reinforced mortar,” *Appl. Sci.*, vol. 10, no. 18, 2020, doi: 10.3390/APP10186587.

[8] K. J. Wong, K. O. Low, and H. A. Israr, “Impact resistance of short bamboo fibre reinforced polyester concretes,” *Proc. Inst. Mech. Eng. Part L J. Mater. Des. Appl.*, vol. 231, no. 8, pp. 683–692, 2017, doi: 10.1177/1464420715609789.

[9] J. Pitroda, H. Pankhaniya, and S. Agravat, “A Critical Review on Innovative Utilization of Bamboo in Rural Road Construction,” *Int. J. Constr. Res. Civ. Eng.*, vol. 2, no. 4, pp. 27–32, 2016, doi: 10.20431/2454-8693.0204004.

[10] A. Bentur and S. Mindess, “Applications of fibre reinforced concrete,” *Fibre Reinf. Cem. Compos.*, vol. 17, no. 11, pp. 578–614, 2020, doi: 10.1201/9781482267747-23.

[11] Satwarnirat, “Pengaruh Penambahan Serat Tandan Kosong Kelapa Sawit Terhadap Kuat Teken dan Kuat Tarik Belah Beton,” *Poli Rekayasa*, vol. 1, no. 1, pp. 1–8, 2005.

[12] T. B. Aulia, Muttaqin, M. Afifuddin, M. Zaki, and S. Merriza, “Shear Capacity Analysis of High-Strength Reinforced Concrete Beams using Geopolymer Flyash and Palm Oil Blast Furnace Slag as Additives and Aggregate Substitution,” *IOP Conf. Ser. Mater. Sci. Eng.*, vol. 434, no. 1, pp. 0–9, 2018, doi: 10.1088/1757-899X/434/1/012199.

[13] A. Yusra, Triwulan, L. Opirina, M. Ikhsan, and M. Safriani, “The Flexural Capacity Study of High Strength Reinforced Concrete Beams Used Palm Oil Clinkers as Additives,” *J. Phys. Conf. Ser.*, vol. 1625, no. 1, pp. 4–13, 2020, doi: 10.1088/1742-6596/1625/1/012010.

[14] F. B. A. Beshara, I. G. Shaaban, and T. S. Mustafa, “Nominal Flexural Strength of High Strength Fiber Reinforced Concrete Beams,” *Arab. J. Sci. Eng.*, vol. 37, no. 2, pp. 291–301, 2012, doi: 10.1007/s13369-012-0172-y.

[15] T. Greenough and M. Nehdi, “Shear behavior of fiber-reinforced self-consolidating concrete slender beams,” *ACI Mater. J.*, vol. 105, no. 5, pp. 468–477, 2008, doi: 10.14359/19976.