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Bamboo Reinforced Concrete Containing Plastic Waste, Brick Masonry Waste and Rice Husk Ash as Aggregates

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Abstract— *This paper aims to demonstrate the flexural strength of bamboo reinforced concrete beam through the use of plastic and other waste aggregate. Three type cement aggregate composition were used to make 15cm x15cm x60cm bamboo reinforced concrete beam specimens. The beams loaded in four points loads and occurred the deflections. The average volume weight was 1670 kg/m3. The average strength of each concrete variation were 5.6 MPa, 5.8 MPa, and 6.2 MPa and the average ultimate loads were 15.6 kN, 16.7 kN, and 17.8 kN. Four bamboo bars 10mmx10mm used as longitudinal reinforcement and small hose clamp installed at the ends of the bars. From these ultimate loads it was seen that bamboo success to resist the stress between 73-83 MPa near the ultimate strength of bamboo130-180 MPa.*

Keywords— *Bamboo, plastic waste, light weight concrete.*

I. Introduction

Bamboo is one of the oldest building materials with many applications in the field of construction, particularly in developing countries. It is strong, cheap, light weight and can often be used without processing or finishing. Similar to timber bamboo is vulnerable to be attacked by environmental agents, insects and moisture. Its durability depends very much on the species, age, right conservation, treatment and environmental attacks.

Bamboo can be dried in air, green house, oven, or by fire. The durability of bamboo depends strongly on the preservative treatment methods in accordance with basic requirements.

Several studies have been carried out on the use of raw bamboo as reinforcing material to replace conventional steel. The use of bamboo as reinforcement in concrete has developed by Ghavani [1], Kharee [2] Dewi [3]. In all the bamboo reinforced beam tests realized up to present, the failure mostly occurred due to tensile slip failure at concrete and bamboo. This is mainly due to imperfect bonding between bamboo and concrete. The action to overcome this was treatment the raw bamboo with various types of coating for reduce water absorption and swelling of bamboo reinforcement.

The bonding between bamboo and concrete caused some slip failure between bamboo bars and concrete. Bonding establishes a shear resistance at the concrete matrix interface with reinforcement. Dewi [4-6] Terai [7]. Studied bonding properties of treated and untreated raw bamboo splits in concrete. and treated this problem by coating and roughness the bars with sands. Lestari [8] add some wood hooks for increase shear resistance of reinforcement bonding. The latest treatment by Muhtar [9] was using hose clamp along reinforcement for reduce slip of the bars.

The concept of using hose clamp at the ends of bamboo reinforcement is the same with the concept of using deformed reinforcement and hook at the ends of steel bars. Hooks should have distributed the tensile force along the bars.

Use of lightweight concrete (LWC), adding cementitious material and using waste has gained much more interest from the researchers in the last few decades. The reasons for such increased interest are its unique advantages over normal weight concrete such as reduction in dead loads. The lightweight materials are those that originally have normal densities and by some procedure its density can be reduced. This procedure consists of taking part of its volume with a much lower density material propose by Astorqui [10] with coefficient of lightening.

Some innovative structural materials to date are obtained by partially replacing one of the major components of concrete with any of the many wastes (industrial, agricultural, construction, etc.) and non-waste materials.

II. Experimental Program

A. Material

In the present work, bamboo, plastic waste, brick waste, and Rice Husk Ash (RHA) were being used on reinforce concrete beam specimens. The bamboo species employed within this study was a 4-year-old Dendrocalamus asper, which was harvested in the Java island in Indonesia and is known locally as Petung Bamboo.

Fig. 1. Beam Materials

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The parameters investigated in the present work are compressive strength, density, crack development pattern and propagation, failure pattern, load–deflection characteristics and the ultimate moment. The materials are shown in Fig. 1.

Three composition of concrete variation were shown in Table 1.

TABLE 1. Concrete Mixture Composition

Type	PC	RHA	WP	WB	PC/vol kg/m^3
A	1	0.1	0.43	0.9	540
B	1	0.1	0.37	0.81	590
C	1	0.1	0.33	0.77	615

B. Specimen and Testing

Beam specimen dimension 15 cm x 15 cm x60 cm loading with span 54 cm shown in Fig. 2.

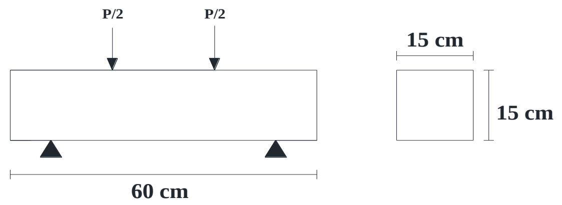

Fig. 2. Beam specimen dimension and loading

III. Results and Discussion

A. Material Testing

The cylinder specimen were tested in compression machine and the results strength of compressive strength and volume weight shown in Table 2.

TABLE 2. Strength and Volume Weight of Concrete

Concrete type	Strength MPa		Volume weight kg/m^3	
A	5.71	5.65	1570	1586
	5.57		1580	
	5.67		1620	
B	5.70	5.83	1630	1650
	5.92		1670	
	5.87		1650	
C	5.98	6.22	1678	1681
	6.31		1685	
	6.18		1680	

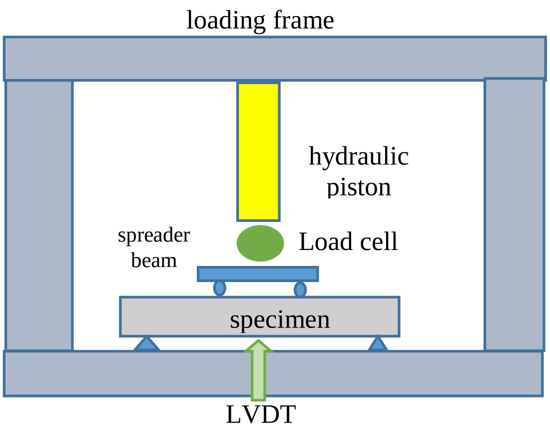

Fig. 3. Loading of beam specimen

B. Beam Testing

The beam testing in reaction frame as shown in Fig. 3. The load induced by hydraulic piston and occurred with load cell. The deflection at the center span occurred by LVDT

The load deflection curve of 9 beams specimen shown in Fig. 4.

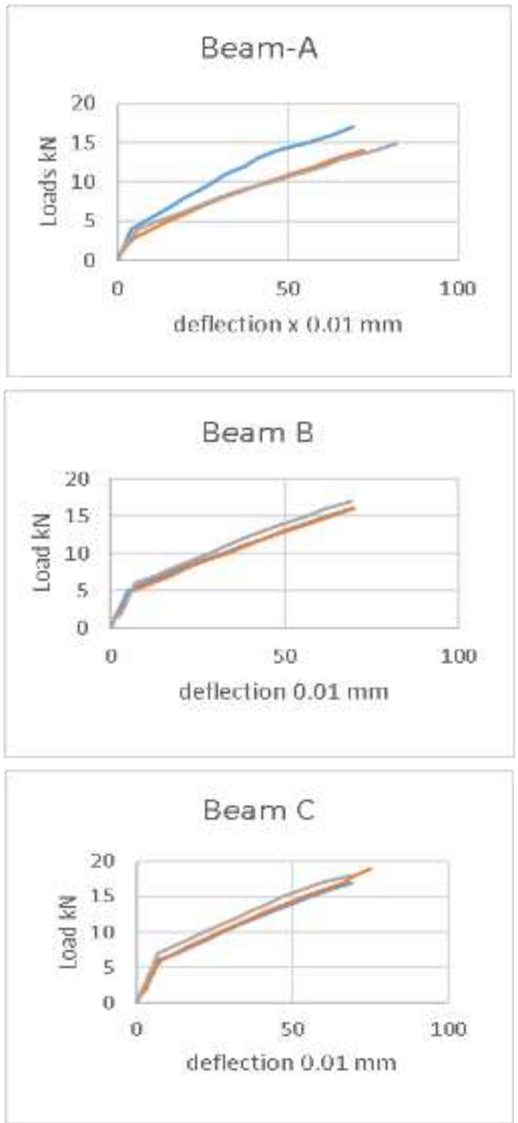

Fig. 4. Load and Deflection Curve

From the maximum loads, then the maximum moment on the beam, maximum tensile force, and maximum tensile stress on bamboo reinforcement obtain as shown in Table 3.

TABLE 3. Maximum Loads and Stress

Beam	P kN	Mn kN	T kN	Tensile Stress MPa
A	15.8	147	14.7	73.5
	15.4	143	14.3	71.5
	15.6	145	14.5	72.5
B	16.2	150	15	75
	16.1	149	14.9	74.5
	16.3	151	15.1	75.5
C	17.8	165	16.5	83
	17.7	164	16.4	82
	17.7	164	16.4	82

From the load deflection record, in elastic range, it had countable the stiffness of each sample beam type as shown in Table 4.

TABLE 4. Stiffness in Elastic Range

Beam	P kN	Deflection mm	EI kN mm^2	E GPa
A	4	0.067	235480	0.55
B	4	0.046	342981	0.81
C	4	0.044	358572	0.84

Sample of crack pattern for three beam type are shown in Fig. 5.

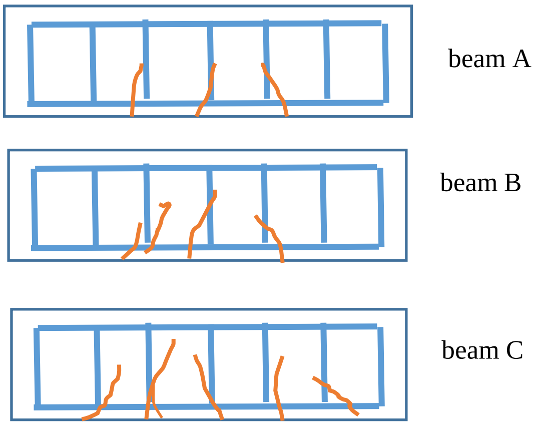

Fig. 5. Crack Pattern of Beam Sample

IV. CONCLUSION AND RECOMMENDATION

Providing bamboo reinforcement in light weight and low strength concrete remarkably similar to normal reinforce concrete with steel reinforcement.

The use of plastic waste aggregate and brick coarse aggregate reduce the volume weight until 1650 kg/m3 compare to 2200 kg/m3 for normal concrete. The cement usage per volume in this light weight concrete about 600 kg/m3 is higher than the normal concrete 400 kg/m^3.

The elastic modular for this light weight concrete 0.80 GPa is lower than normal concrete 15 GPa.

The use of hose clamp can increase the effectiveness of bamboo strength. The average stress was 80 MPa compare to the strength 120-180 MPa, while the previous researcher [1], [2] only reaches the stress 50-60 MPa because low bonding resistance.

The difference of ultimate loads and the crack pattern in difference concrete type explained the influence of concrete strength to the beam capacity.

Because the compressive strength of the concrete is low, the concrete should not be used for heavy load. If this lightweight concrete will be used for structural concrete, it is recommended to consider the use of stronger concrete in the compression area.

The plastic waste use in present work is combination of flat and round granules. This caused increase in cement usage. To reduce the cement usage, it is recommended only use some rounds plastic waste granules.

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