Experimental Investigation on Concrete using Bamboo Fibre as Partial Replacement for Course Aggregate in Concrete

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Abstract— Utilization of concrete in almost every civil engineering applications have continued to place high demand on constituent concrete materials. Concrete is an extensively used construction material for its various advantages such as low cost, availability, fire resistance etc. But it cannot be used alone everywhere because of its low tensile strength. So, generally steel is used to reinforce the concrete. But considering high cost of steel, bamboo is one of the suitable replacements of reinforcing bar in concrete for low cost constructions. Bamboo is natural, cheap, widely available and most importantly strong in both tension and compression. To see the effect of bamboo fibre on compressive and flexure strength, bamboo reinforced Concrete cubes have been tested. On comparing the results with plain concrete cubes, strength becomes double in 50 days testing. Further singly and doubly reinforced beam with bamboo sticks have been cast and tested in flexure. It has been found that there is remarkably increase in the flexural strength and Modulus of elasticity of bamboo reinforced beam. First of all cubes, beams and cylinders are casted with traditional methods and later same casted by replacing coarse aggregates with 1%, 2% and 3% bamboo fibres. The behavior of specimens has to be studied and compared with conventional specimens.

Key words: Bamboo Fibre, Aggregate Replacement, Flexural Test, Workability, Compressive Strength, Low Cost Construction

I. INTRODUCTION

BAMBOO is one of the oldest building materials used by mankind. The bamboo culm, or stem, has been made into an extended diversity of products ranging from domestic household products to industrial applications. In Asia, bamboo is quite common for bridges, scaffolding and housing, but it is usually a temporary exterior structural material. In many overly populated regions of the tropics, certain bamboos supply the one suitable material that is sufficiently cheap and plentiful to meet the extensive need for economical housing, with the advancement of science and technology and the good supply of timber, new methods are needed for the processing of bamboo to make it more durable and more usable in terms of building materials.

Concrete is a mixture material composed of coarse granular material (the aggregate or filler) surrounded in a hard matrix of material (the cement or binder) that fills the gap among the aggregate particles and cements them together. The usage of concrete, worldwide, is twice as much as steel, wood, plastics, and aluminum combined. Concrete's use in the modern world is only exceeded by the usage of naturally occurring water. The economy, efficiency, durability, shape retaining ability and rigidity of reinforced concrete make it an amazing material for a wide range of structural applications.

Concrete is widely used for making architectural structures, foundations, brick/block walls, pavements, bridges/overpasses, motorways/roads, runways, parking structures, dams, pools/reservoirs, pipes, footings for gates, fences and poles and even boats. Combining water with a cementitious material forms a cement paste by the process of hydration. The cement paste glues the aggregate together, fills voids within it, and makes it flow more freely.

Aggregate is one of the important constituents which has effect in strength development in the theory that the gaps of coarse aggregate is filled by the fine aggregate and the gaps of fine aggregate is filled by the binding materials. In addition the strength of concrete mainly depends on water/cement ratio, aggregate gradation, and aggregate size and shape, cement quality, mixing time, mixing ratios, curing etc. Concrete must be both strong and workable, a careful balance of the cement to water ratio is required when making concrete. Fine aggregate are basically sands won from the land or the marine environment. Fine aggregates generally consist of natural sand or crushed stone with most particles passing through a 4.75mm sieve. For concrete sand fineness modulus range is 2.3-3.1.

In this experiment it has been observed that coarse aggregates can be replaced with coarse bamboo pieces. Bamboo fibres can also be used as a filler material in concrete in road construction or other ground works such as paver block construction, waist slab and other water retaining structures. Bamboo pieces may also be used with some effectiveness as a partial replacement of inorganic aggregates in concrete applications to decrease the dead weight of structures.

II. MATERIALS USED

PPC approving to IS 1489-1991 part 1 has been used in the experiment. Coarse aggregates of 10 mm and 20 mm size and natural sand confirming to zone III has been used. Bamboo fibres with size of varying length from 2 to 4 cm, breadth from 1 to 2 cm, and thickness of 1 cm is also used as a partial replacement of coarse aggregate at the replacement levels of 0%, 1%, 2% and 3%. The physical properties of all these materials were tested as per IS 383-1970.

Property of Cement used			
	Particulars	Test results	Requirements as per IS:1489; 1991
1.	Standard Consistency	32%	
2.	Setting Time(In Minutes)	32%	
	– Initial – Final	34 484	30 60

3.	Compressive Strength 72 +/- 1hr. (3 days) 168 +/- 2hr. (7 days) 672 +/- 4hr. (28 days)	 30.5 40.3 55.2	 16 (Min) 22 (Min) 33 (Min)
4.	Fineness of cement	12%	

Table 1: Property of Cement used

Physical properties of aggregates used		
Particulars	Specific Gravity	Water Absorption (%)
Coarse Aggregate	2.93	0.9
Fine Aggregates (sand)	2.71	1.20
Bamboo	0.74	22

Table 2: Physical properties of aggregates used

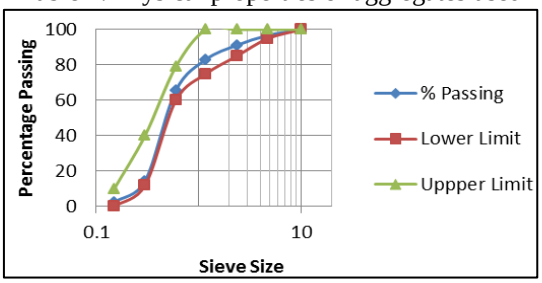

Fig. 1: Grading curve of natural sand

III. Experimental Methodology

Before starting the experiment, mix design of M20 grade is carried out as per IS 10262-2009. The Engineering properties of concrete mixes such as Slump (through cone test) as per 1199-1959, compressive strength test and flexural strength test as per IS 516-1959 and split tensile test as per IS 5816-1999 were carried out.

A total of 96 specimens were casted (24 specimens of 0%, 1%, 2%, and 3% bamboo pieces having 12 cubes, 6 cylinders and 6 beams). The cube test carried at 7, 14, 28 and 50 days, flexural test and tensile test at 28 and 50 days.

S. No.	Mix		Ingredient (Kg/m^3)			
	Bamboo cuttings percentage	Cement	Fine Aggregate	Coarse Aggregate	Bamboo cuttings weight	Water (In Kg)
M 20 mix design of Concrete						
1	0%	59.4	97.62	230.38	0	32.64
2	1%	59.4	97.62	228	2.30	32.64
3	2%	59.4	97.62	225.7	4.6	32.64
4	3%	59.4	97.62	223.5	7	32.64

Table 3: Experimental Methodology

IV. Results and Observations

A. *Compressive Strength Test Result*

Bamboo cuttings waste	Compressive strength (N/mm^2) for M20			
	7 days	14 days	28 days	50 days
0%	18.8	19.2	22.4	26.5
1%	16	20.4	25.5	27.8
2%	17.2	17.5	24	29.4
3%	17.5	20.6	27.1	29.5

Table 4: Compressive Strength Test Result

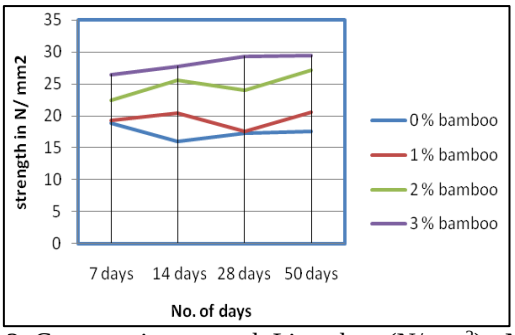

Fig. 2: Compressive strength Line chart (N/mm^2) - M20

B. *Slump Cone Test*

Bamboo cuttings waste	Slump(in mm)
M20	
0%	80
1%	50
2%	30
3%	15

Table 3: Slump Cone Test

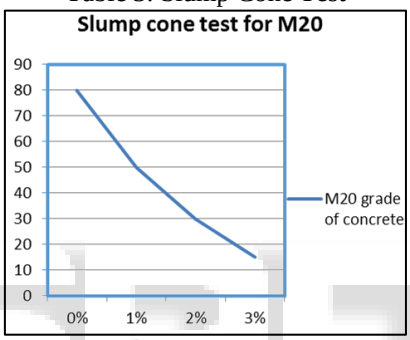

Fig. 3: Slump Cone Test

C. *Flexural Test Result and Analysis*

Bamboo Cutting Percentage	Flexural Strength Test	
M20		
	28 days	50 days
0%	2.95	3.21
1%	1.32	1.30
2%	1.28	1.36
3%	1.24	1.32

Table 4: Flexural Strength Test

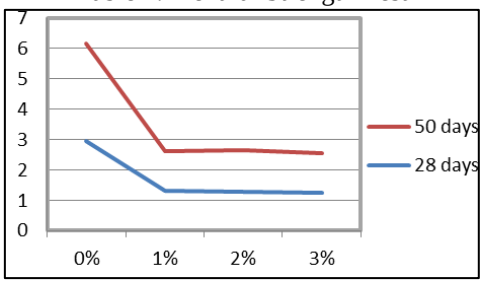

Fig. 4: Flexural strength Test results line chart

D. *Tensile Test Results*

Bamboo cutting percentage	Tensile strength test	
	28 days	50 days
0%	2.19	2.33
1%	1.96	2.43
2%	1.65	1.73
3%	1.56	1.70

Table 5: Tensile test results

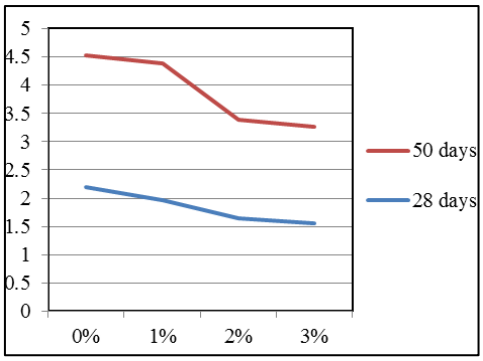

Fig. 5: Tensile strength test results in line chart

V. CONCLUSIONS

All these tests are performed in the laboratory of Gargi College, Bhopal Based on the results of the experimental investigation, following conclusions could be drawn as follows:

1) With the increase in bamboo percentage, earlier achievement of compressive strength occurred but at the end of 50 days there is not much percentage increase. This indicates towards the earlier strength gain of concrete due to replacement of bamboo.
2) Slump results shows that there is decrease in workability with increase in bamboo percentage. This workability can be increased by the use of plasticizers
3) Flexural strength deceases up to 50 percent with simply one percent of bamboo and then decrease with slow rate. This shows that the concrete having replaced coarse aggregate with bamboo pieces are weak in taking bending moment. So it's not recommended for upper floors.
4) Tensile strength line chart also show a gradual decrease in the tensile strength

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