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Role of Bamboo as Reinforcement in Construction of Concrete Members

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***Abstract*— Recently, in the attention in response to global warming issues and sustainable society, the manufacturing using natural materials has become actively. Bamboo, low cost, fast growing, and broad distribution of growth, is expected to contribute significantly to earthquake-resistant construction and seismic retrofit technology in the developing countries. This paper investigates the mechanical properties of bamboo reinforced concrete structure. It compares these experimental results of bamboo reinforced concrete members with the experimental ones of reinforced concrete members, and the mechanical property of the bamboo reinforced concrete members is studied.**

Bamboo's light weight and relative flexibility make it a particularly attractive alternative for residential construction in seismic regions. Compared on a mass-per-volume basis to concrete, steel and wood, bamboo is second to concrete for strength, and ranks first for stiffness. As strong as mild steel with the compression strength of concrete, amazingly, one inch of bamboo can hold up to 7 1/2 tons of weight. This present study is an attempt to implement bamboo construction in Manipur which is regarded as one of the most seismically active regions worldwide.

Keywords*— *Bamboo, Flexural strength, Tensile strength, Mechanical properties, Comparison,

I. INTRODUCTION

Bamboo, which is one of the fastest growing plants, has got a great economic potential. Bamboo has been used in constructions of bridges and houses. Bamboo has low manufacturing costs compared with steel, because it takes less energy to harvest and transport. Therefore bamboo is widely expected to be possible even in countries and regions that have no advanced manufacturing technology and construction techniques.

Species of bamboo change as per topography and climatic conditions. It has good tensile and compression strength. Problems faced in using bamboo as construction material are water absorption and moisture content. To avoid this problems proper seasoning or treatment should be given to bamboo.

The major application of bamboo is for construction and housing. According to study it is estimated that one billion people in the world live in bamboo houses. Bamboos are used as props, foundations, framing, scaffolding flooring, walls, roofs and trusses. Bamboos are tied together to make grid reinforcement and placed in soft clay to solve deformation problems in embankments. In rural parts of India mostly bamboo is used as reinforcement in mud walls.

Bamboo is versatile resource characterized by high strength to weight ratio and ease in working with simple tools. It has a long and well established history as a building material throughout the tropical and sub-tropical regions. culms are a cylindrical shell divided by solid transversal diaphragms at nodes and properties include high strength in the direction parallel to the fibres, which run longitudinally along the length of the Culm, and low strength in a direction perpendicular to the fibres. Bamboo reaches its full growth in just a few months and reaches its maximum mechanical strength in just few years. Some of the positive aspects such as a lightweight design, better flexibility, and toughness due to its thin walls with discretely distributed nodes and its great strength make it a good construction material. Bamboo is used as structural material at construction sites in India, China and other countries as it is a tough, flexible, light weight and low cost material. In nature when bamboo is covered with heavy snow, it will bend until it touches the ground without breaking. This implies that bamboo has greater flexibility than wood.

II. OBJECTIVE

The main objectives of this project are:

a) To compare the tension behavior of steel and bamboo.

b) To determine the flexural strength of singly and doubly reinforced concrete beams.

c) To determine the water absorption capacity of bamboo.

d) To compare the efficiency of bamboo reinforced concrete against conventional concrete and steel reinforced concrete.

III. METHODOLOGY

A. Selection

The following factors should be considered in the selection of bamboo:

i) Use only bamboos showing brown color. This will indicate that the plant is at least 3 to 4 years old.

ii) Select the bamboo having longest length & large diameter.

iii) Never use green, untreated, unseasoned bamboo.

B. preparation

i) Sizing: Larger culms should be split into thin strip of bamboo. Whole culms less than 3/4 inch in diameter can be used without splitting.

ii) Splitting: The bamboos culms should be split by separating the base with a sharp knife and then pulling a dulled blade through the Culm. The dull blade will force the stem to split open; this is most effective and useful than cutting because the bamboos splitting will result in continuous fibers and nearly along a straight section.

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iii) Seasoning: Bamboo should be cut and allowed to sundry to reduce the moisture content for at least three to four weeks before using, also the bamboo culms must be supported at regular interval spacing to reduce buckling and twisting.

iv)Bending: Bamboo culms and bamboo strip can be permanently bent if heat (either dries or wet), with a sharp nozzle is applied to a section and apply pressure to bend. This process can also be used for forming splints into arc, circular shaped stirrups and for putting hooks on reinforcement for additional anchorage.

v) Waterproof Coating**:** Culms should be painted with a waterproof coating to reduce swelling when in contact with concrete. Without some type of water coating, bamboo surface will swell before the concrete has attained sufficient strength to prevent cracking and the member may be damaged, especially if more than 4% bamboo is used as reinforcement. A dip coat of bituminous paint or brush coat is preferable. Native latex, coal tar, bituminous paint, dilute varnish, and water-glass are suitable coatings. In any above cases, only a single thin coating of paint should be applied because thick coating will lubricate the surface and weaken the bond with the concrete.

C. Concrete Mix Proportions

The same mix designs can be used as would normally be used with steel reinforced concrete. Concrete slump should be as low as workability will allow. Excess water causes swelling of the bamboo. High early-strength cement is preferred to minimize cracks caused by swelling of bamboo when seasoned bamboo cannot be waterproofed

D. Casting And Determination of Strength of Concrete

Compressive Strength Test and Splitting Tensile Strength Test were conducted for cylindrical concrete specimen. Flexural strength test was conducted for beam. Tensile Strength Test was conducted for Bamboo Stick in UTM machine.

E. Comparison of Strength of Steel and Bamboo

The strength of bamboo is greater than most timber products which are advantageous, but it is approximately half the tensile strength of steel. Bamboo is easily accessible as it grows in almost every tropical and subtropical region; this lowers the cost of construction and increases the strength of the buildings that would otherwise be unreinforced.

IV. PRELIMINARY INVESTIGATION

Various tests are conducted on materials used for mixing to determine the strength variation of concrete and the properties of materials.

SAND

Table 1: Physical properties of sand

PROPERTIES	TEST RESULTS
Apparent specific gravity	2.6
Effective size in microns	180µ
Uniformity coefficient	3.5
Fineness modulus	3.71

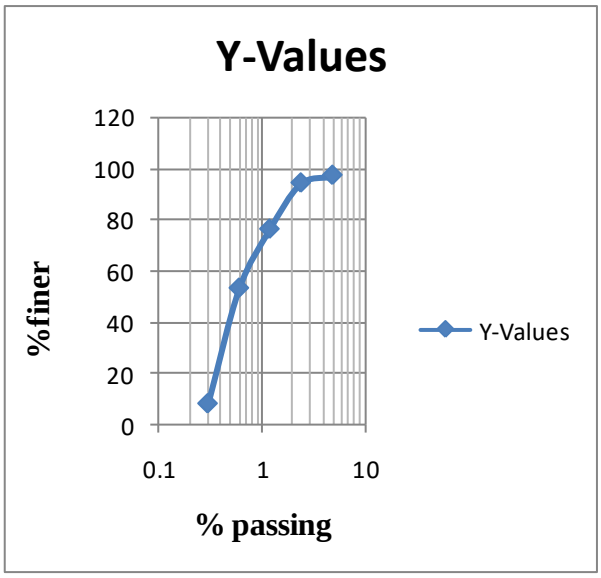

Fig.1: Distribution curve of fine aggregate

CEMENT

Table 2: Physical properties of cement

SL. NO.	PROPERTIES	TEST RESULTS	IS SPECIFICATIONS
1	Specific gravity	2.92	-
2	Standard consistency (%)	30	-
3	Fineness (%)	5.2	<10
4	Initial setting time (minutes)	60	>30
5	Final setting time (minutes)	300	<600

COURSE AGGREGATE

Table 3: Physical properties of course aggregate

PROPERTIES	TEST RESULTS
Apparent specific gravity	2.6
Effective size in microns	10µ
Uniformity coefficient	1.7
Fineness modulus	3.9

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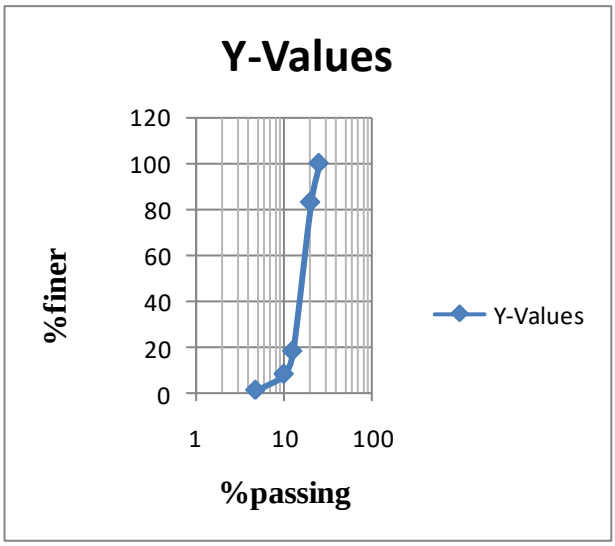

Fig.2: Distribution curve of coarse aggregate

TENSION TEST

To determine the yield load and ultimate load on the bamboo

(i) Mark a 40 cm length on the bamboo.

(ii) The specimen is fitted in the lower cross head first in a way that they project by about 10 mm downwards from the clamping jaw. At that stage specimen can be put from below through the clamping jaws, opened with the hand wheel.

(iii) Before the specimen is clamped in the upper cross head the load measuring gauge must be selected within the shift rod. Then switch on the hydraulic system.

(iv) The control current illuminated key, regulate the delivery with hand wheel and lift the suspension gear hydraulically.

(v) Adjust the reading pointer to the scale reading zero with the adjusting button and bring the dummy pointer in contact with the main pointer.

(vi) The clamping jaws in the upper cross head are opened with the hand wheel and arrested in the opened position with the clamping lever.

(vii) Now the lower cross head with the already attached specimen is lifted towards the upper cross head using control current key until the upper edge of the specimen nearly coincide with the upper edge of the opened clamping jaw.

(viii) The clamping lever is released causing the clamping jaws to close themselves around the specimen.

(ix) Switch on the hydraulic system and adjust the delivery with the hand wheel. After that the load is being applied.

(x) Note down the yield load, ultimate load and breaking load.

Fig.3: Tension test

V. MIX DESIGN

Table 4: Quantity of materials

SL NO	COMPONENTS	QUANTITY
1	Cement	395.745kg/m3
2	Fine aggregate	689.63kg/m3
3	Coarse aggregate	1118.93kg/m3
4	Water-Cement ratio	.47
5	Ratio	1: 1.74 :2.83 :0.47

VI. EXPERIMENTAL PROCESS

The calculated quantities of materials were used to prepare test specimen.

A Materials Required

Ordinary Portland cement, M sand, Coarse aggregate passing through 20 mm sieve, 8mm diameter bamboo and reinforcement.

Fig.4: Bamboo and steel

Fig.5: M Sand

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Fig.6: Coarse Aggregate

B Apparatus

The apparatus used for the test are Flexural Strength Testing Machine, Weighing balance, Tamping Rod.

Fig.7: Flexural Strength Testing Machine

C Preparation of Specimen

Size of specimen: 500mm x 100mm x 100mm
Mix: M30 (design mix)

Fig.8: Mixing

Thorough mixing of the material was done for the production of uniform concrete. Then ensure that the mass become homogenous, uniform in colour and consistency. The concrete was mixed by hand mixing, that is the cement and fine aggregate were mixed on the water tight non absorbents flat form until the mixture was thoroughly blended and was uniform colour then add the coarse aggregate and mixed cement and sand until the coarse aggregate is uniformly distributed throughout the batch. After that water was added and mixed until the concrete appear to be homogeneous and of desired consistency. Two samples were prepared for each beam for 28 days. Two samples were prepared with two bamboo of 8mm diameter placed at 1cm above the base of the mould with centre to centre spacing 6cm and clear cover of 2cm on both sides. The same procedure is adopted in case of reinforced beam. Then a combination of both bamboo and reinforcement is made.

Sampling

In sampling we prepared 16 samples. Before sampling the mould was cleaned and oil was applied. Each side of the mould was tightened and ensured the sides were water title. Then concrete was filled in the mould in layers approximately 5cm thick. Compacted each layer not less than 25 strokes per layer using a tamping rod. At last leveled the top surface and smoothen it with a trowel.

Fig.9: concrete beam with 2 steel

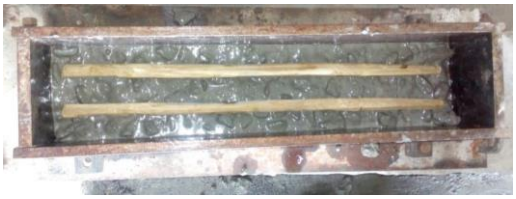

Fig.10: concrete beam with 2 bamboo

Fig.11: concrete beam with bamboo and steel

Fig.12: concrete beam with 2 bamboo and steel

D Curing

The water curing is the best method of curing as it satisfy all the requirement of curing, namely promotion of hydration, elimination of shrinkage and absorption of the heat of hydration. The test specimen were stored in moist air for 24hr and after this period the specimens are marked and removed from the mould and kept submerged in clean fresh water for 28 days.

Fig.13: Curing tank

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E Testing

Fig.14: Testing of concrete beam with 2 bamboo and steel

Flexural strength is one measure of the tensile strength of concrete. It is a measure of a reinforced concrete beam or slab to resist failure in bending.10cm x 10cm x 50cm sized specimen is used.

Flexural strength, $F_b = PL/bd^2$

VII. RESULT AND DISCUSSION

A WATER ABSORPTION TEST ON BAMBOO

Table 5 Observations on water absorption test on bamboo stick

Sl No.	Weight of dry specimen M_1 (kg)	Weight of wet specimen M_2(kg)	% of water absorption	Average % of water absorption
1	0.3	0.3425	14.17	16.49
2	0.28	0.3375	20.57	
3	0.312	0.3579	14.73	

Inference

The obtained value of average water absorption is 16.49%. According to IS specification the average water absorption shall not be more than 20% by weight up to class 125. Therefore the given bamboo belongs to class 125.

B TENSION TEST

Table 6 Observations on tension test on bamboo

Size of sample	Tensile strength N/mm^2	
	Steel	Bamboo
8 mm	245	22
10 mm	289	30

Table 7: Observations of sample 1 on flexural strength test on single reinforced beam

Sl No	Specimen	Breaking load(KN)	Flexural strength(N/mm^2)
1	B_S	25	10
2	B_S& B_B	23	9.2
3	B_B	13	5.2
4	B_N	9.2	3.68

Table 8: Observations of sample 2 flexural strength test on single reinforced beam

Sl No	Specimen	Breaking load(KN)	Flexural strength(N/mm^2)
1	B_S	23	9.2
2	B_S& B_B	22	8.8
3	B_B	9	3.6
4	B_N	7.4	2.96

Table 9: Observations on of sample 2 flexural strength test on double reinforced beam

Sl No	Specimen	Breaking load(KN)	Flexural strength(N/mm^2)
1	B_S	28	11.2
2	B_S& B_B	27	10.8
3	B_B	17	6.8
4	B_N	6.2	2.48

Table 10: Observations on of sample 2 flexural strength test on double reinforced beam

Sl No	Specimen	Breaking load(KN)	Flexural strength(N/mm^2)
1	B_S	28	11.2
2	B_S& B_B	26	10.4
3	B_B	18	7.2
4	B_N	7	2.8

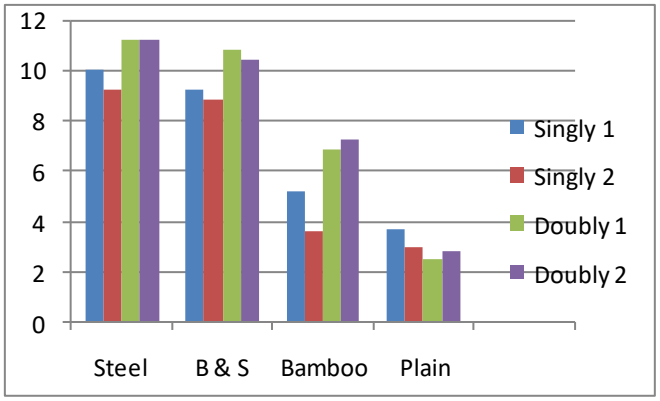

Fig.15: Comparison of Flexural Strength

V111. CONCLUSION

In this project we have opted advanced bamboo reinforcement instead of traditional steel reinforcement .This is good idea for low cost economical structure. It was also found that flexural strength of beam reinforced with bamboo is slightly equal to the steel reinforced beam.

The tensile test result shows that bamboo has a very poor tensile property and may cause brittle failure when loaded. This is a huge disadvantage of using bamboo as a structural member in building construction. But can be used for partition walls, ceilings, roofs and other areas of lightweight engineering construction that is not heavy load bearing.

The positive attributes of Bamboo are listed, supporting its environment-friendly nature. But there are some negative attributes of Bamboo were also given, focusing on its tendency

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to absorb water. Of those, the bonding between the Bamboo and concrete is considered the biggest problem due to absorption of water and smooth wall of the Bamboo Culm. Also there is a need for the development of a simple design code for the application of Bamboo as a Construction material. Several Researches are on going to overcome these problems. Many new techniques are being developed which may make bamboo the best constructional material in future. It has wide scope in Low Cost Constructions. We conclude that in case of singly reinforced beam the flexural strength of bamboo is 4% lower than that of steel. In case of doubly reinforced beam the flexural strength of bamboo is 4.1% lower than that of steel.

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