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BAMBOO REINFORCED CONCRETE CONSTRUCTION

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ABSTRACT
Strength of structure is the major part which is often observed before construction of any engineering structure. Bamboo is used in many construction purposes like housings, scaffolding etc., and also provides a good strength both tensile and compressive. It can be used as a reinforcement in walls and ground slabs while replacing plain cement concrete with reinforced one. As it doesn't provide the same strength as that of steel but, when compared with plain cement concrete it provides more strength as that of Plain Cement Concrete individual. While construction of walls brickwork can be replaced with reinforced work. Material for reinforcement can be used as bamboo which is available cheaper than the reinforcement material i.e. Steel. This will result into the modification of walls, slabs and floors of plain cement concrete.

Keywords:
Bamboo reinforced, Modification of walls, Plain cement concrete.

INTRODUCTION

Bamboo is a material which has high compressive strength and low weight and has been one of the most useful building material for support of concrete, especially in the locations where it is found in abundance. Material used for construction of concrete should have all the essential properties which would make it withstands structure active load. As we know that bamboo is a natural occurring material and has many species, different properties like size, shape, textures etc., and would be having different strength for every species. So it's essential to know which species is best or not. The purpose of using bamboo as a reinforcement is to strengthen walls and ground floors more than it was earlier in an economical way instead of using steel as a reinforcement which is quite expensive. Due to typical rhizome-dependent system, bamboos are also one of the fastest-growing plants in the world and their growth is as faster as three times than most other species of plants. They are renewable and extremely adaptable resource with multi-purpose usage. Among many uses of bamboo, Housing is one of the major area applications especially in the wake of residential shortages around the globe. [1]

Bamboo has been used as a construction material in many areas for centuries and till now the same construction is still live. Bamboo was given recent consideration for use as reinforcement in soil-cement pavement slabs in which the slabs behave in elastically even under light loads. For this case ultimate load analysis was shown to be more economical and suitable for use. [2]

As we all know that the steel demand is increasing day by day to use it as a reinforcement material with concrete in most of the developing countries. It is sure that the day will come soon when the production of steel would be less and demand would be more and it's going to be very difficult to fulfil the demand of steel as per requirement. Hence it is essential to have an alternative solution before we face any major trouble in future. It's not possible to provide the same strength as that of steel but still there would be more some extra strength than that of non-reinforced construction. This construction is not for the purpose of construction of reinforced structures as that of steel but it's constructed for providing strength in walls slabs and ground floors by using reinforcement as a bamboo with plain

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cement concrete.

Background

Bamboo is by its origin an orthotropic material. It possesses fibers within it. It gains high strength along the fibers and low strength in the transverse direction. The bamboo has a structure of a composite material with cellulose fibers aligned across the length. It has high thick fibers near to the outer length of the bamboo, which is the main reason why they resist huge wind forces.Figure-1 shows a schematic diagram of a bamboo sample. The node that is seen in the bamboo are represented by n. It is subjected to a lateral load 'P' causing a maximum moment at the support. It forms a cantilever arrangement. [3]

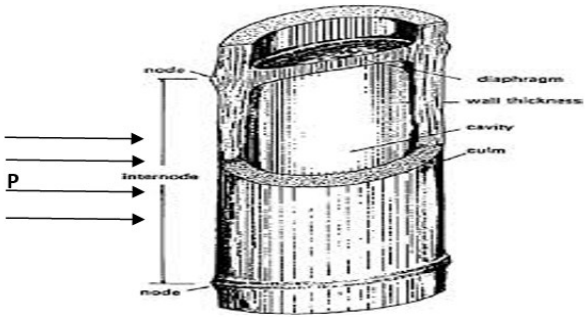

Fig. 1: Schematic diagram of bamboo

There were several experiments which were performed on universal testing machine under axial loading. The laminae were positioned carefully at the center of the cross-head with its end faces exactly perpendicular to the longitudinal axis to get accurate results. The load vs displacement plots were obtained for the provided lamina specimen from the computerized chart recorder with the help of software called test pert software inbuilt in machine which automatically plot a graph. From the software tensile failure strength and its young`s modulus were recorded automatically for the laminae along the length of bamboo selected from outer, middle and inner region of cross section of culms. Using recorded data from the software, graphs were plotted and prepared for variation of tensile failure stress and young modulus. Similarly, tensile tests were performed on Universal Testing Machine at a crosshead speed of 2 mm/min for this test specimens were prepared. Test specimen was mounted in a properly aligned test frame.The stress-strain curves were generated from the same software for the specimen. To increase the strength of walls with the economical material and to make it earthquake resistant. During the time of earthquake, the wall which is simply made up of concrete has no safety during that time. Whereas our motive is to provide such a building which is economical, strengthen and have the properties to face the most critical situations which other materials hae.

The hollow tubular structure has high resistance against wind forces when it is in natural habitat. Working on the weak points of bamboo and bringing up an innovation of bamboo as a reinforcement and replacing plain walls of concrete, would be a great alternative.

Hence it is essential to have an alternative that is worth compared to steel. Bamboo is found in abundant, they are resilient and hence these can face the demand as a reinforcing material and become an ideal replacement for steel. Bamboo reinforced concrete construction follows same design, mix proportions and construction techniques as used for steel reinforced. Just steel reinforcement is replaced with bamboo reinforcement.

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Fig. 2: Universal Testing Machine

Properties of bamboo reinforcement, mix proportion of concrete, design and construction technique with bamboo reinforced concrete will be discussed. The major requirement of bamboo when used in reinforcement is the concern for water absorption which is the main requirement. From various studies the water absorption among different species were found. Among which Dendrocalamusgiganteus, known simply as DG and Bambusa vulgaris hard, BVS are the ones which absorbed less water than that of others. The rate of water absorption can also be reduced by certain treatment processes. [9]

MATERIAL SELECTION

Method of selection of bamboo for reinforcement is done on various factors like size, color, age, diameter & most importantly species. All these factors are explained below:

- Color – bamboo with evident brown color should be chosen for perfection.
- Age – Brown color also shows the age of bamboo to be at least 3 years.
- Diameter – Use the one with long large culms.
- Harvesting – Do not use the bamboo which are cut either during spring or summer seasons.
- Species – As there are more than 10000 species of bamboo, the material with good properties should be selected as the reinforcement with concrete like Dendrocalamus, Phyllostachys, Guadua etc.

Properties of preparation material for use

Sizing: Generally, splint culms are more desirable than whole culms as reinforcement. Larger culms should be split into splints approximately 3/4 inch wide. Whole culms less than 3/4 inch in diameter can be used without splitting. This can be done easily with the sharp knife as the base can be cut and rest can be done with dull blade. [4]

- Selection: The bamboo should be allowed to dry and season for three to four weeks before using after cut.
- Bending: Bending is the major problem in bamboo, it can also have bent up permanently if heat, either dry or wet, is applied while applying pressure. This procedure can be used for forming splints into C-shaped stirrups and for putting hooks on reinforcement for additional anchorage. [6][7]
- Durability: As, being a natural product make it more exposed to environmental agents and insects. A remedy against this is to undergo bamboo curing.

The curing of bamboo can be done either by:

1. Curing on spot
2. Immersion process
3. By heating
4. Smoke Curing

To make penetration undergo in the right way treatment in case of bamboo must be done in dry state. Taking care of durability factor, the preservation treatment should be carefully done on the bamboo and should also have no chemical

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composition effect. The treatment should last itself, without being washed away under high water conditions (if any).

METHODOLOGY

Concrete mix proportions for bamboo reinforced concrete

As we know that, in concrete mix proportion water-cement ratio plays an important role in strength and durability of reinforced concrete. Bamboo being a natural building material has the property to absorb water. It also causes swelling of bamboo. Thus, for the appropriate result of strength and durability, concrete mix proportion for bamboo reinforced concrete must have water-cement ratio as low as possible. [9]

To minimize cracks caused by swelling of bamboo concrete used should be of high early-strength. The mix design of concrete can be as per the strength requirement for structure, as per structural design. Since use of reinforcement has no effect on compressive strength requirement of concrete, bamboo reinforced concrete mix proportion can be used as same as steel reinforced concrete mix design

Placement of bamboo

Bamboo reinforcement placed should be at least 1-1/2 inches not less than this from the face of the concrete surfaceas shown in figure 4. The top and bottom of the stems should be alternated in every row and the nodes or collars, should be staggered in case of whole culms. This will insure a fairly uniform cross section of the bamboo throughout the length of the member, and the wedging effect obtained at the nodes will materially increase the bond between concrete and bamboo.

The clear spacing between bamboo rods or splints should not be less than the maximum size aggregate plus 1/4 inch. Reinforcement should be evenly spaced and lashed together on short sticks placed at right angles to the main reinforcement. When more than one layer is required, the layers should also be tied together. Ties should be made with wire in major members. For secondary members, ties can also be made with vegetation strips.

Bamboo culms must be carefully tied down before placing the concrete. It should be placed at a distance of 3-4 feet to enable the settlement of placement of concrete. In flexural members continuous, one-half to two-thirds of the bottom longitudinal reinforcement should be bent up near the supports. This is especially recommended in members continuous over several supports. [5][3] Additional diagonal tension reinforcement in the form of stirrups must be used close to the supports. To make vertical stirrups we mostly use wire or packing; they can also be improvised from split sections of bamboo bent into U-shape, and tied securely to both bottom longitudinal reinforcement and bent-up reinforcement. Spacing of the stirrups should not be more than 6 inches.

Methods of working on Bamboo

To use a bamboo as a reinforcement we need to work on its desired shape, its bending and appropriate length to be used for different works.

So talking more about few factors as:

- Shape of Bamboo
  As we know that the shape of bamboo is circular, but to make it use for various purposes sometimes we make then grow in square shape by placing a container around its all sides to take up the same growth. So that they can acquire the same shape.
- Bending of Bamboo
  Although bamboo is very hard to bend it normally but for acquiring shape we need to bend it. And for doing so we firstly, have to heat it at the temperature of about 150°C and after doing so only in freshly cut bamboo it can be bent up easily. Bamboo will not retain its shape immediately. It will be retaining its shape after drying off and cooling.

Test Procedure

The procedure of the test is as follows:

1. Read the design concept of making concrete for appropriate mixture.
2. Mix a concrete in a plate and tie the bamboos in square shape as that of slab or beam mentioned in figure 2(a), 2(b).
3. Tie bamboos with steel bars and place it easily in the beam casting mold of size 100mm x100mm x 500mm.

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4. Place the mixture of concrete in the beam mold and use vibrator to remove voids (if any).
5. Place the mold for curing.
6. Leave it for number of days like 7 days, 28 days for curing. After this check the strength of cube and reinforcement in UTM.
7. Software of UTM will provide the graph between Load Vs Displacement.

Fig. 1: Testing of bamboo reinforced beam

Fig.2: Failure by Compression in Bamboo Reinforced Beam

RESULTS AND DISCUSSIONS

After completion of testing of cube and bamboo reinforcement the result comes out from the software tell us the compression and tensile strength of the material. Figure 6 shows the graph between Load Vs Displacement. The final compression force comes out when the cube or beam comes to its final stage and a crack start developing on them. At the same moment maximum force is observed. Table 1 shows the maximum displacement and compressive strength after 28 days.

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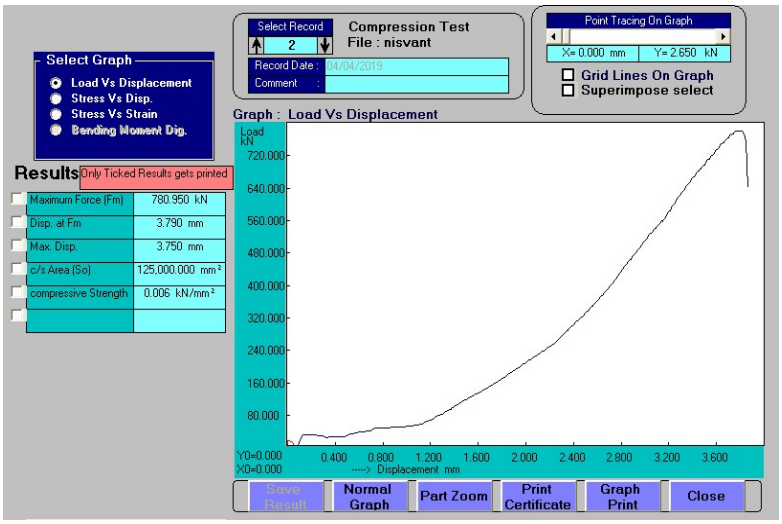

Fig.3: Compressive Test Report on Reinforced Beam

Table 1: Mechanical Properties of Reinforced Beam

Max. Force (Fm)	780.95 KN
Displacement at Fm	3.790 mm
Max. displacement	3.750 mm
c/s Area (So)	125000.00 mm2
Compressive strength	.006 KN/mm2

CONCLUSION

As I've studied the several reports on testing of bamboo as well as steel for their comparison and checking their compressive and tensile strength and to check out their different properties for use of better material in construction. [8][9] In which several samples of bamboos and high & mild steel bars were taken of different sizes. The tensile test result indicates that bamboo unlike steel has a very poor tensile property and undergoes brittle failure when loaded. This is a huge disadvantage of using bamboo as a structural member in building construction. So this is very large drawback of not using bamboo as a main reinforcement in civil engineering works and structures. Therefore, the study concludes that due to minimal breakage force of bamboo, steel is selected as a main reinforcement with concrete. But, bamboo can be used for partition walls, ceilings, roofs and other areas of lightweight engineering construction that is not heavy loadbearing.

Also, the plain concrete cement is less strong than that of bamboo reinforcement concrete. Bamboo being rich in production and economical in some areas it's a better option to adopt it as a reinforcement material than that of using plain cement concrete construction. It provides approximately 3-4 times more strength than that of plain cement concrete. On later stage it can also be replaced with steel in some parts of the structure like walls, ground surface to make building cheaper with reinforcement.

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