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Torsion Behaviour of Beam with Bamboo as Reinforcement and Coconut Shell as Aggregate

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ABSTRACT

Bamboo, which is fast growing grass and eco-friendly and naturally renewable material, is proved to be appropriate for structural applications. The tensile strength of bamboo is quite high and is almost similar to that of steel. This makes bamboo a perfect alternative to steel in tensile loading applications. The intention of the research is to evolve a design using bamboo as one of the chief structural materials, for a safe and durable house. This research investigates and evaluates the results of bamboo reinforced coconut shell concrete beams subjected to torsion and compared with conventional concrete beams and coconut shell concrete beams with steel reinforcement. Twelve beams, three with treated bamboo reinforced coconut shell concrete, three with un-treated bamboo reinforced coconut shell concrete, three with steel reinforced coconut shell concrete and three with conventional concrete were fabricated and tested. Study includes the general cracking characteristics, pre cracking behaviour and analysis, post cracking behaviour and analysis, crack width and stiffness. It was observed that the torsional behaviour of bamboo reinforced coconut shell concrete is comparable to that of conventional concrete.

Keywords

Torsional beams; treated bamboo; reinforcement; coconut shell.

1. INTRODUCTION

Concrete, the essential product in the construction industry has gained lot of importance today. This is because of the development of the infrastructure all around the world. The major constituent in the concrete is the coarse aggregate which is generally a broken stone naturally available on the earth. As the usage concrete is increasing, the usage of aggregate also has increased enormously. This leads to degradation of naturally available rock on the earth. At the same time there was a serious problem with disposal of several wastes which leads to the increase in the pollution. Hence these wastes, if properly utilized can be effective in reducing the pollution. The major disadvantage with the conventional concrete was its density which is around 2500kg/m^3. Thus there a need to reduce the density of the concrete which can be helpful in several ways for the construction industry. This light weight concrete can be achieved by reducing the density of the concrete which can be generally by the replacement of coarse aggregate with several available light weight aggregates. The one such light weight aggregate which is also a waste product is coconut shell. Coconut production was carried out on large scale in India and all around the world. This leaves large quantity of coconut shell waste. Many of the researches have suggested that coconut shell waste can be a suitable material for the replacement of coarse aggregate. Coconut shell aggregate was also proved to be light weight aggregate attaining a density in the range of 1900kg/m^3. Thus light weight concrete can be achieved by replacing the naturally available broken stone aggregate with coconut shell aggregate. This type of replacement can be very much helpful in disposal of wastes and also in the development light weight concrete.

Concrete is generally strong in compression and weak in tension. Hence, usually steel which is good in tension is provided along with concrete to make it equally strong in tension. The production of steel generally requires lot energy and source materials. Thus leading to the pollution. Bamboo, which is a naturally grown tall grass, widely available and cheap material. Bamboo was proved to be equally strong in tension compared to steel. Bamboo is usually weak in compression. Steel is a very heavy material which usually costs more. Bamboo is proved to be a light material with very less cost. There was a lot of research carried out by replacing the steel reinforcement with bamboo in beams and columns with conventional concrete. Studies on the behaviour of bamboo as reinforcement in torsion were very less. Hence a study was made on the behaviour of bamboo in torsion.

An attempt was made in the present study to know the behaviour of the bamboo in torsion along with the aim of making the concrete light weight. Bamboo is generally a water absorbing material; hence a study was also made to know the behaviour of bamboo under treated and un-treated conditions. Generally, as the bamboo absorbs water, to make it suitable for reinforcement they were soaked in water for 24hr. prior to casting. Another way of making the bamboo suitable for reinforcement was tried by applying epoxy coating over the bamboo and allowing it to dry. The epoxy coated bamboo was sand coated to increase the bond properties of the bamboo when placed inside the concrete. This study was made to know the behaviour of bamboo under treated and un-treated conditions in comparison with the conventional steel reinforcement with conventional concrete and light weight concrete.

2. METHODOLOGY

A total number of twelve beams were cast to know the behaviour of bamboo in torsion. The details of the specimens were as below.

a) Beams with conventional concrete and steel reinforcement.
b) Beams with coconut shell concrete and steel reinforcement.
c) Beams with coconut shell concrete and un-treated bamboo.
d) Beams with coconut shell concrete and treated bamboo.

3. MATERIALS

Cement of grade 53 was used in this study. River sand passing through 4.75mm IS sieve was used as fine aggregate. Crushed stone aggregate passing through 12.5mm IS sieve was used as coarse aggregate.

Coconut shell waste which was crushed and passing through 12.5mm IS sieve was used in replacement to coarse aggregate.

Bamboo of species SP-dera which was cut into four parts diametrically and sized to approximately 20mm was used.

Figure 1. Coconut Shell.

Figure 2. Treated Bamboo Specimens with Winding.

4. EXPERIMENTAL WORK

Three beams were cast with conventional concrete and steel reinforcement with the mix proportion of 1:2.22:3.66 with w/c ratio of 0.55.

Three beams were cast with coconut shell concrete and steel reinforcement with the mix proportion of 1:1.47:0.65 with w/c ratio of 0.42.

Three beams were cast with coconut shell concrete and un-treated bamboo.

Three beams were cast with coconut shell concrete and treated bamboo.

All the specimens were de-moulded after 24hr. of casting and cured for 28 days after which tested under torsion loading.

Figure 3. Prepared Reinforcement with Bamboo

The reinforcement provided in the beams was 3nos 12mm diameter steel bars in the tension zone and 2nos 12mm diameter bars in the compression zone, stirrups of 8mm diameter bars were provided at a spacing of 150mm c/c. The reinforcement details were shown in the figure 4.

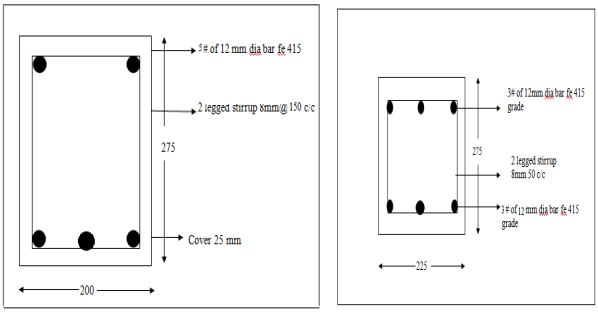

Figure 4. Reinforcement details

5. RESULTS AND DISCUSSIONS

Specimens were tested by using a setup consisting of 40T loading frame, 50T capacity hydraulic jack and 40T capacity proving ring. The testing setup was shown in figure 5. Two deflectometers were used to measure the twist. Torsional loading is given to the beam using an ISMB section. Crack patterns and crack widths were measured using visual observations and brennels microscope of least count 0.01mm.

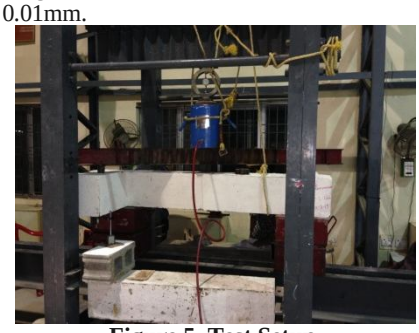

Figure 5. Test Setup

The beam to be tested was lifted using a hydraulic crane of capacity 2T and kept inside the loading platform of the frame where the steel saddles were made ready by placing 12mm mild steel bars in between the saddles and also by applying grease to carry the beams on both edges to allow the twist when torque is applied. An Indian Standard Medium Beam was placed diagonally over the two cantilever portions of the beam to transfer the torque equally to the two legs. A hydraulic jack was placed over the ISMB section at the middle over which a proving ring was placed. The jack and the proving ring was adjusted to the middle of the

beam using a plum bob.

The torque vs twist for all the four types of specimens were shown in figure 6. Performance of treated and untreated bamboo under torsional loading was shown in the figure 7.

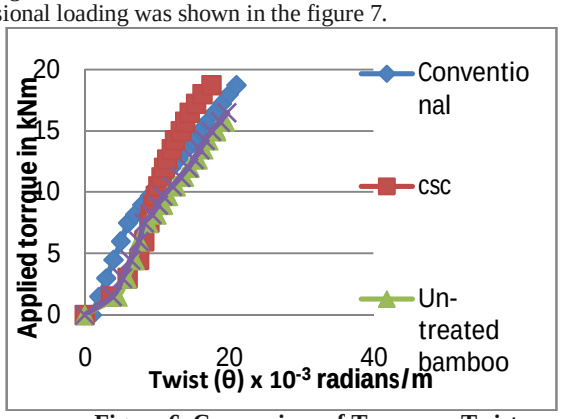

Figure 6. Comparison of Torque vs Twist

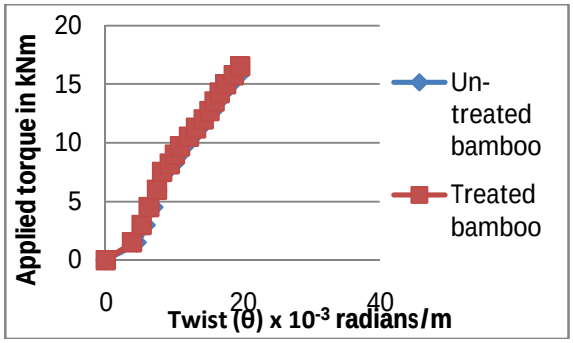

Figure 7. Comparison of Torque vs Twist for Treated and Untreated Bamboo

Up to the cracking, all the types of specimens were elastic and all the torsion was resisted by the concrete itself. From this it can be noted that up to the cracking both the conventional and coconut shell concrete were elastic. After the cracking, it can be seen from the graphs that the torque vs twist relationship is non linear. Cracks were formed at 45^0 with the horizontal, which helps us to decide that the loading is purely torsion and not accompanied by any bending or shear effects. The ultimate load carrying capacity of all the specimens were nearly equal and vary very little. The specimens with bamboo reinforcement have less ultimate load carrying capacity compared to the conventional steel reinforcement. Loading was given at intervals of 1T up to the cracking stage later which the interval was reduced to 0.5T.

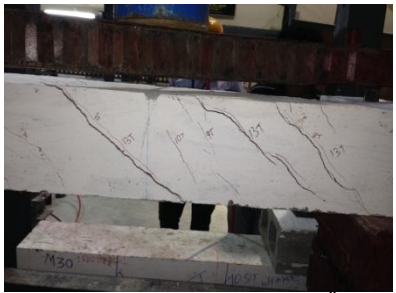

Figure 8. Tested Specimen with 45^0 Cracks

Figure 9. Measurement of Crack Width

Table 1. Torque at Initial and Final Cracking

Specimens	Initial		Final	
	Torque kNm	Crack (mm)	Ultimate torque kNm	Crack (mm)
conventional	7.5	0.01	18.75	5.5
CSC	7.5	0.02	18.75	6.2
CSC with untreated bamboo	8.2	0.08	15.75	6.5
CSC with treated bamboo	9	0.06	16.5	5.8

6. CONCLUSIONS

- The behaviour of both conventional and coconut shell concrete before cracking was elastic.
- Cracks were formed and propagated at nearly 45^0 with the horizontal which is useful in deciding the loading as purely torsional.
- The ultimate load carrying capacity of the conventional concrete and coconut shell concrete with steel reinforcement was about 12.5T.
- The ultimate load carrying capacity of the coconut shell concrete with un-treated bamboo and treated bamboo is 10.5T and 11T respectively.
- The stiffness of the beams with conventional concrete and coconut shell concrete was almost similar.
- The stiffness of the beams with coconut shell concrete and treated bamboo has higher stiffness compared to the untreated bamboo.
- The stiffness of the beams with steel reinforcement is higher than the stiffness of the beams with bamboo reinforcement.
- Formation of initial crack was at lesser load for steel reinforcement compared to the bamboo reinforcement.
- The crack widths of the initial crack for the bamboo reinforced specimens were higher than the steel reinforced specimens.
- The crack width of the final crack for the bamboo reinforced specimens and steel reinforced specimens were almost same.

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