"Experimental analysis of deep beam by using BFRP and Bamboo as reinforcement"

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Abstract - *The rapid development in construction industry increasing demand for new innovative material as a part of construction industry. Reinforced concrete deep beams had many useful applications particularly in tall buildings, foundations & offshore structures. Deep beams are often used as structural member in civil engineering works. Generally they are used as load transferring elements such as transfer girders, folded plates & foundation walls. IS 456-2000 page no. 51 clause no. 29.1 said about the deep beam that, the beams with span to depth ratio less than 2.5 for continuous beam as less than 2.0 for simply supported beam is considered as deep beam. Bamboo is available everywhere & widely accepted as construction material. There are so many advantages due to which bamboo becomes more popular rapidly. Till yet we used steel as a reinforcing material in RC element, but steel reinforcement had also some disadvantages such as corrosion & low fire resistance. Due to that researchers are hungry to found out new alternative material. The relatively new development of an FRP composed, fibers of melted basalt rock (BFRP) becomes popular. BFRP is naturally occurring material & hence environment friendly. It has advantages such as light weight, corrosion free, acid resistance, fire resistance etc.*

As a present scenario research carried out on RC deep beams by using BFRP and bamboo yet not found. This study will therefore focus on concrete deep beams reinforced with BFRP & Bamboo. Eighteen specimen of deep beam having a size 700 X 150 X 350 mm were casted. After 28 days they were tested by using UTM of 1000KN under two point loading with two different shear span of 225mm & 275 respectively. Possibility & feasibility of BFRP and bamboo as a reinforcement for deep beams are determine.

Key Words: Deep beam, Baslat fibre Reinforced polymer, BFRP , Bamboo as reinforcement, cost effective construction, corrosion free structural element

1. INTRODUCTION

1.1 Deep beam

Deep beams are often used as structural members in Civil Engineering works. Because of the geometric proportions of deep beams, their strength is usually controlled by shear rather than flexure, if normal amounts of reinforcements are provided. Reinforced concrete (RC) deep beams are generally used as load-transferring elements, such as transfer girders folded plates, and foundation walls. In buildings, a deep beam or transfer girder is used when a lower column on the exterior façade is removed for architectural purposes. In construction, deep beams are widely used in water tanks, underground bunkers, silos, nuclear reactors, etc., where walls act as vertical beams spanning between column supports. Sometimes pile caps are also designed as deep beams. Indian Standard Code IS:456-2000 (page no.51 , clause no.29.1) the beams with span to depth ratios less than 2.5 for continuous span and less than 2.0 for simply supported span are considered as deep beams.

1.2 Bamboo

Bamboo is available everywhere around the world; some regions in the world continue to use bamboo structures to this day. It was found that for steel it is necessary to spend 50 times more energy than for bamboo. In the production of one tone steel two tons of CO_2 is produced. In contrast bamboo plant absorbs CO_2 besides producing oxygen. The tensile strength of bamboo is relatively high and can reach 200-300 MPa; this turns the use of bamboo attractive as substitute of steel, especially when considering the relation between tensile resistance and specific weight of bamboo which is six times greater than for the steel. Tensile strength of bamboo reinforcement is almost the same with steel reinforcement, but bamboo material is not as ductile as steel material. In the recent years, due to an increase in the cost has led to the use of naturally available material for the reinforcement of concrete beams in the rural constructions.

1.2 BFRP

Concrete is the world's most used man-made construction material today. It is relatively cheap and easy to form when cast in India. The most common reinforcing material for Reinforced Concrete (RC) used until now and is still used today is steel. Using steel as reinforcement has numerous advantages; it is strong in tension and has a high modulus of elasticity. The thermal expansion is similar to concrete and it works well with concrete under loading. The production process for steel is very stable and thus the material properties are also very stable, then steel is easy to form and work with. But using steel as reinforcement has also some disadvantages; it can corrode with time and has low fire resistance. The price of steel has also been rising over the last few years. The main challenge for civil & structural engineers is to provide sustainable, environmental friendly and financially feasible structures to the society. Finding new materials that can fulfill these requirements is a must. The relatively new development of an FRP composed of fibers of melted basalt rock (BFRP). Basalt fibers are environmentally friendly and nonhazardous materials as they are produced from volcanic rocks by using single component raw material and drawing fibers from the molten rocks. Basalt is naturally occurring and is one of the most abundant materials on

2. LITERATURE REVIEW

Vengatachalapathy.V, Ilangovan R. (2010): Paper on "A study on steel Fibre reinforced concrete deep beams with and without openings". This experimental study deals with the behavior and ultimate strength of steel fiber reinforced concrete (SFRC)deep beams with and without openings in web subjected to two point loading, nine concrete deep beams of dimensions 750mm×350mm×75mm thickness were tested to destruction by applying gradually increased load. Simply supported conditions were maintained for all the concrete deep beams. The percentage of steel fiber was varied from 0 to 1.0.The influence of fiber content in the concrete deep beams has been studied by measuring the deflection of the deep beams and by observing the crack patterns. The investigation also includes the study of steel fiber reinforced concrete deep beams with web reinforcement with and without openings. The ultimate loads obtained by applying the modified Kong and Sharp's formula of deep beams are compared with the experimental values. The above study indicates that the location of openings and the amount of web reinforcement, either in the form of discrete fibers or as continuous reinforcement are the principal parameters that affect the behavior and strength of deep beams. The conclusions can be drawn from the experimental results are obtained. Web openings may be provided in the compression zone of the beams and fiber content of 0.75%by volume may be added to improve the strength of the structure. The openings in the tension zone weaken the beam. Fiber content of 0.75%by volume of the beam improves the ultimate load and the first crack load of the beam. Additional of steel fibers increase the tensile strength of concrete matrix and also increase in the flexural rigidity of the beam.

Anurag Nayak, Arehant S Bajaj, Abhishek Jain, Apoorv Khandelwal, Hirdesh Tiwari, (2011): Carried out study on "Replacement of steel by bamboo Reinforcement" The present paper deals with cost-wise comparison of steel reinforcement with bamboo reinforcement. The utilization of bamboo reinforcement as replacement of steel reinforcement is gaining immense importance today, mainly on account of the improvement in the economical aspect combined with ecological benefits. To study the effect of replacement of steel reinforcement by bamboo reinforcement, designs have been conducted on one way slab of size 3000 x 7000 sq-mm with providing beam of 7000 mm length and 250 x 250 sq-mm. In this paper the designs are done on the basis of shearing and bending. Based on this study of cost vs strength provided results have been discussed in the paper. In this project we have opted advanced bamboo reinforcement technique instead of traditional steel reinforcement. This is a good idea for low cost economical structure. Bamboo reinforcement technique is used for both main and distribution reinforcement as it was same earlier done for steel reinforcement. It is three times cheaper than steel reinforcement technique. It is clear from results that this bamboo reinforcement technique is absolutely cheaper than steel reinforcement technique especially for single story structure.

Satya M Saad, Indrajit Patel, Nandish Pethani (2014): Carried out study on "Basalt fibre reinforced polymer (BFRP): Effective replacement of steel in reinforced concrete" They come to know that concrete structures are usually reinforced because plain concrete has strong limitations to resist tension. One of the familiar reinforcing material is steel; it suits well as reinforcement but has quite well known pros and cons. Fibre Reinforced Polymer (FRP) have over the past years became an interesting choice as a reinforcement for concrete. There are widely researched range and types of FRP namely: Aramid FRP (AFRP), Carbon FRP (CFRP) and Glass FRP (GFRP). FRP shows various advantages out of which few are: high tensile strength, high strength-weight ratio, no corrosion and also light in weight. These many of such benefits suggest the structural designers to research & implement on a large scale the replacement of steel with different FRPs as a choice of reinforcing material for concrete. One of the choices that we have made is Basalt Fibres Reinforced Polymer (BFRP) which is rather a new material to structural design, although it has been known for several decades. They are made from basalt rock, are very light and have tensile strength, over twice as high as steel. Tensile strength of BFRP tendon is about twice the tensile strength of steel reinforcement and elongation of BFRP tendons is much more than of steel. To utilize the high tensile strength of BFRP and prevent cracking of concrete, the tendons could be pre stressed. This paper focuses on the various performance based study of BFRP on reinforced concrete properties where we replaced reinforcing steel with BFRP and extended it as a pre stress reinforcement to achieve few specialties in reinforced concrete elements. .

3. OBJECTIVES

- The main aim of this investigation is to examine the possibility and feasibility of BFRP and bamboo as reinforcement for deep beam.
- To evaluate the ultimate load carrying capacity of deep beams reinforced with BFRP and bamboo as reinforcement.
- To study the cracking characteristics and shear behavior of RC deep beams.
- To study the effectiveness of BFRP and bamboo as reinforcement in resisting shear failure.

- To compare the experimental results of BFRP, bamboo and steel reinforced deep beams.

4. METHODOLOGY

In order to accomplish the objectives, the project work has been divided into five major parts. They are:

- Collection of required data to carry out the analysis from the journals, technical, magazines, reference books and web source.
- Casting of deep beam with two different sizes for analysis of parameters.
- Preparation of deep beams with three number of specimen of each material.
- Comparison to be made between this analysis to know the possibility and feasibility.
- From the results of analysis the final conclusions will drawn.

5. MATERIALS AND EXPERIMENTAL PROCEDURE

To attain objectives, materials were collected from various sources. Material accumulation is the fundamental and vital role in any research work. However, the material that is utilized as a part of a work should not make any harm to the environment. To find out the goal of this examination, the experimental work was completed on eighteen deep beams. The source of the materials utilized for experimental work of the RC deep beam and testing strategies are given in the upcoming article.

5.1 Concrete

The concrete used for casting was prepared in the testing laboratory using a hand mix method of concrete. The concrete was (M25 Grade) with mix proportion adopted was (1:2.01:3.48) with water /cement ratio of 0.50. The material proportions per cubic meter of concrete:

1) 1332.47 kg/m^3 of coarse aggregate (maximum size 20mm)

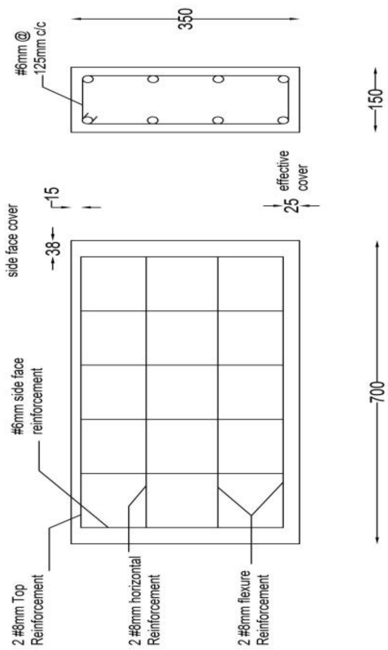
2) 770 kg/m3 of natural river sand (sp.gr =2.66)

3) 383 kg/m^3 of ordinary port land cement (43 grades)

4) 191.5 liters of water

5.2 Details of beam specimen

While reviewing literature of deep beam come to knew that the beam size is 700X150X350 mm. Accorded to the IS (10086-1982) & IS (516-1959) minimum size of specimen for beam mould is 700X150X150mm. There is no specified mould size was found in Indian standard codes, hence select the deep beam size as 700X150X350 mm which satisfies provision of IS (10086-1982) & IS (516-1959).At the same it satisfies IS 456-2000 clause no. 29.1 regarding deep beam.



5.3 Preparation of beam specimens

After all the collection of material next step was go through the specimen making from the collected material. The details of Specimen making is enlisted below.

5.3.1 Preparation of beam specimens

Firstly I did the binding of reinforcement that is steel, BFRP & bamboo as per our design. While binding of reinforcement I came to knew that Bamboo and BFRP should not be used for vertical reinforcement. I was used Steel as vertical reinforcement in all specimen. Horizontal reinforcement & flexural reinforcement were replaced with Bamboo & BFRP. In the sequence of procedure first thing which is carried out was cutting of appropriate length of reinforcement. Later that vertical & shear reinforcement were made. Then cage was bind properly with the help of binding wire.

5.3.2 Casting of Deep Beams Specimens

Six wooden moulds of the same dimensions were fabricated for casting the deep beam specimens to be tested in this study. The moulds were properly cleaned and greased for easy de-moulding after casting. The concrete required for casting was prepared using a concrete hand mix. Before pouring concrete, the reinforcement cages were placed inside the mould with suitable sized cover. The concrete was properly compacted. All the beams were cast to the same dimensions of 350 mm depth, 150 mm width and 700 mm overall length.

Placing of the cage in the mould

Beam cast

5.4 Experimental Set-up for Deep Beams Testing

The testing of deep beams in this work was carried out using a 1000 kN Universal Testing Machine (UTM) that was available at the institution for conducting the experiments. All the deep beam specimens were designed to be of the maximum possible dimensions that the UTM can support during testing. Due to capacity constraints and also due to constraints in increasing the overall depth of the specimen, the loading and support points of the beam were decided on the basis of the maximum available support span. The two point load was applied with shear span of 225mm & 275mm respectively.

Applying a load on deep beam

Shear failure and cracks on deep beam for Steel & BFRP

Flexure failure shows in Bamboo reinforced deep beam

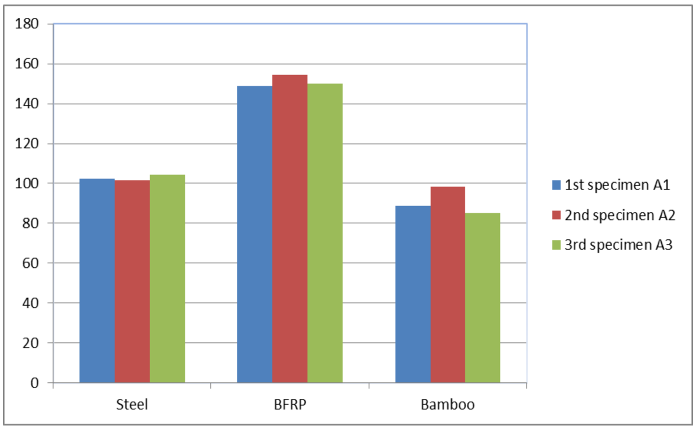
Data acquisition on UTM for deep beam

6. RESULTS

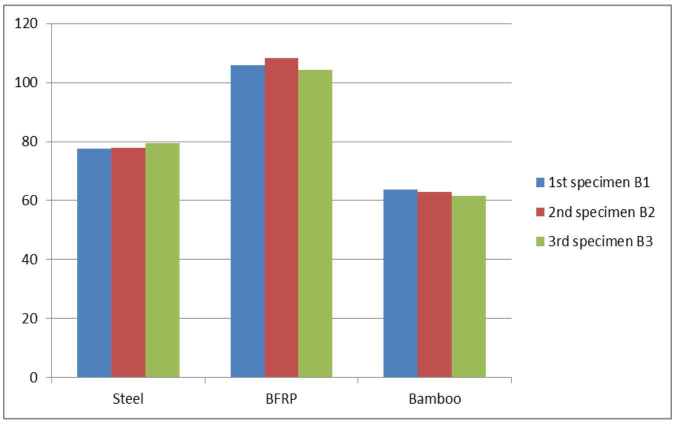
All the 18 number of deep beams were tested at UTM machine with capacity of 1000KN and following data were obtained.

Material	Designation of sample	Load Carried (KN)	Deflection (mm)	Avg. load (KN)
Steel	SA1	102.45	4.54	102.8
	SA2	101.65	3.74	
	SA3	104.3	4.63	
	SB1	77.6	3.45	78.33
	SB2	77.9	4.12	
	SB3	79.5	4.24	
BFRP	BA1	148.65	4.21	150.93
	BA2	154.3	4.01	
	BA3	149.85	4.11	
	BB1	105.9	2.95	106.21
	BB2	108.4	2.96	
	BB3	104.35	3.5	
Bamboo	bA1	88.7	7.18	90.81
	bA2	98.55	7.38	
	bA3	85.2	7.02	
	bB1	63.65	6.36	62.8
	bB2	63.05	6.64	
	bB3	61.7	6.31	

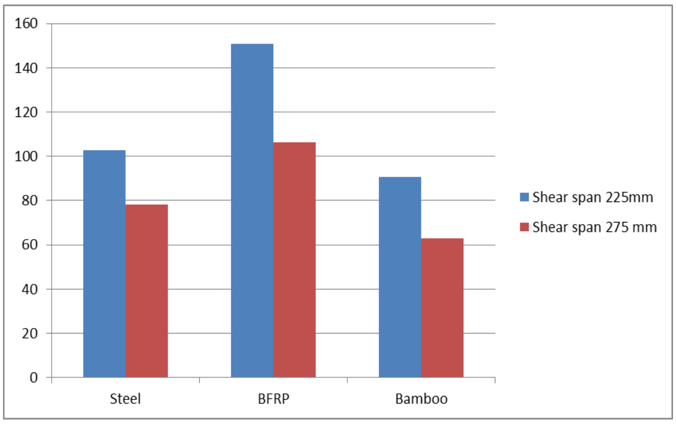
5.1 General Result



Graph 5.1 Load carried when shear span 225mm



Graph 5.2 Load carried when shear span 275mm



Graph 5.3 Avg. Maximum Load carried by each material with different span

7. CONCLUSIONS

From the data received after all the secession of test carried out on deep beam with different material such as steel, BFRP & bamboo from that following conclusion are drawn.

1. All deep beams were failed in shear rather than flexure excepting bamboo. Bamboo is fail in flexure.
2. The strength of the beam with 275mm shear span is less than the strength of beam with shear span of 225mm, hence strength of deep beam are inversely proportional to the shear span of constant depth of deep beam.
3. All the beam had low deflection because no failure shown in flexure other than bamboo.
4. The beams with BFRP shows considerable high strength as compare to steel and bamboo.
5. BFRP shows 46.82% higher strength as compare to steel & 66.23% higher strength as compare to Bamboo with shear span of 225mm.

6. BFRP with shear span of 275mm shows 35.60% higher strength as compare to steel & 69.13 % higher strength as compare to Bamboo.

7. The entire beam shows the diagonal cracks from the point load to end support except bamboo.

8. The BFRP had number of advantages as it is corrosion free material hence can be used as reinforcement in deep beam.

9. Bamboo failed quickly in flexure as compare to steel but where low importance of work with no long life required we can adopt the bamboo as reinforcement for deep beam.

10. When we compare with cost the BFRP is not suitable comparatively steel for deep beam but when it becomes locally available material then it becomes cheap and cost effective.

11. When we compare with other parameters the Bamboo is not suitable due to its number of limitation.

12. This study is firstly carried out with BFRP and bamboo as reinforcement for deep beam hence provide base for further study.

8. FUTURE SCOPE OF PRESENT STUDY

Future scope for this study is summarized below so that researcher may get attention for the future study.

1. The data which is attained after the experimental work provide a base for any future study related with deep beam and bamboo and BFRP.

2. The Inclined bar of BFRP, Steel and bamboo to be test to know capacity in resist the shear load.

3. The durability of Bamboo reinforcement can be determined for deep beam.

4. BFRP sheets can be used to determine the possibility and feasibility of material in deep beam.

5. Experimental work can be work out on hybrid beam of Steel, Bamboo and BFRP.

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BIOGRAPHIES

He is an excellent academic person and PG student with intend in Research work. Working on number of projects which is related with structural engineering.

He is Research scholar having more than 31 years teaching experience. Published number of research paper, guided number of research project and PG, UG student.