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FLEXURAL BEHAVIOUR OF FIBER REINFORCED HOLLOW SQUARE BEAM

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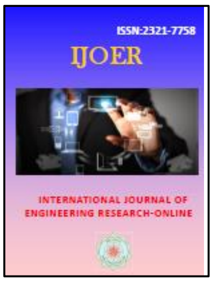


ABSTRACT

Nowadays research efforts are continuously looking for new, better and efficient construction material and method. In recent days the problem faced by the construction industry is acute shortage of raw materials.. Partial replacement of the concrete below the neutral axis is an idea that can create reduction in weight and savings in materials. This research focuses on structural material optimization by introducing hollow core using PVC pipe in tension zone of RC beams.

Experimental testing under single point flexural load of AR glass fiber reinforced hollow square beam section indicates a strong influence of flexural on a ultimate failure mechanism of the beam. These is an inexpensive way of adding compressive strength to the concrete which may give better result when added to the combination of fiber5cubes and 5cylinders and 3 beams were casted and the result of compressive strength and split tensile strength and flexural strength were found. The experimental program consists of casting and testing of RC beams of size 1000mm x150mm x150 mm with and without hollow core in tension zone. The test result indicates that the addition of AR glass fiber may have a beneficial effect on mechanism properties such as compressive strength and split tensile test on concrete. The paper briefly reviews all the above points referred.

Keywords: Compressive strength, split tensile strength, hollow concrete beam, AR glass fiber, flexural strength.

I.INTRODUCTION

A. GENERAL

Concrete materials are still a dominant material for construction due to its advantages such as workability, low cost and fire resistance as well as its low maintenance cost. It is formed from a hardened mixture of cement, fine aggregate, coarse aggregate, water and some admixture. Massive exploration of the natural resources for producing concrete affect to the environment condition and global warning. We have responsibility to reduce the effect of the application of concrete materials to environmental impact. The concrete should be used as efficient as possible. Nowadays researches efforts are continuously looking for new, better and efficient construction method. Various theories related to the analysis of structural elements reduced the self-weight of element for a given load-carrying capacity. Structural material optimization can reduce the dead load which reduce the contribution of seismic effect in high rise structures and also very good at the vibration dampers and heat isolation.

According to the natural behaviour of the concrete, it is strong in compression and weak in tension. Our assumption to design the R.C beams is the contribution of tensile stress of the concrete is neglected. The flexural capacity (MR) of the beam is influenced only by compression stresses of the concrete and the tensile stress of the steel reinforcement. Efficient use the concrete materials can be done by replacing the concrete in and near the neutral axis. However, in RC beams strength of concrete lying in and near the neutral axis is not fully utilized. So this un-utilized concrete is removed by placing a PVC pipe instead, hence making the beam hollow at the neutral axis. This is an alternative to reduce the use of concrete. The concrete just above neutral axis is less stressed whereas the concrete below the neutral axis serves as a shear transmitting media. The bond between PVC pipe and concrete layers at the pipe concrete interface should essentially be very good. It should be ensured that no slip will occur between the two layers. Experimental work is carried on the reinforced concrete beams with hollow neutral axis, with the view that the stresses in the beams are maximum at the top and bottom and zero at the neutral axis. So a cheap and light material can be used near the neutral zone. Sustainability can be achieved by replacing the partially used concrete. By saving concrete, we can save cement, which reduces the greenhouse gases emissions. So it is considered as environment friendly. According to various literature review it is observed that there is a problem related to the depth and continuity of hollow core. So this paper is an attempt to study flexural behaviour of reinforced concrete beam with hollow core at various depths under four point loading. This aims to obtain an efficient and optimum depth and pattern for the provision of hollow core.

Glass fiber also called fiberglass. It is material made from extremely fine fibres of glass Fiberglass is a lightweight, extremely strong, and robust material. Although strength properties are somewhat lower than carbon fiber and it is less stiff, the material is typically far less brittle, and the raw materials are much less expensive. Its bulk strength and weight properties are also very favourable when compared to metals, and it can be easily formed using molding processes. Glass is the oldest, and most familiar, performance fiber. Fibers have been manufactured from glass since the 1930s.

AR Roving and AR Chopped Strand are used for the production of GRC products and also for renders, crack control in in-situ concrete, to improve the toughness of precast concrete and to reinforce lime-based plasters. High-quality alkali-resistant glass fiber containing a high percentage of zirconium (ZrO_2), which enhances its resistance to alkali in cement composites Can be used as an asbestos replacement Available in a variety of strand lengths and sizing to meet specific applications and processing requirements Excellent workability characteristics Large stocks of roving and chopped strand are available for immediate dispatch from our UK warehouse to Europe and the rest of the world. AR Glass fiber is essential for GRC because of its resistance to the high alkalinity levels in cement. The fibres add strength and flexibility to the concrete resulting in a strong yet light-weight end product. The alkali resistance of Glass fiber depends principally on the content of Zirconia (ZrO_2) in the glass. The AR Glass fiber supplied by Fiber Technologies has a minimum zirconia content of19%, the highest of any commercially available glass fiber. Alkali Resistant Glass Fiber is a recent introduction in making fibrous concrete. Glass fiber which is originally used in conjunction with cement was found to be affected by alkaline condition of cement. Therefore Cem-Fil (2002) alkali resistant glass fiber has been developed and used. GRCA (2006). The paper presents an experimental investigation on the use of Cem-Fil ARC14 306 HD and dual mixed fibres. The alkaline resistant glass fibers with locally available materials.

B.CONCRETE SAVING AND SELF-WEIGHT REDUCTION

Concrete is one of the most versatile building material. In construction industries huge wastage in concrete occurs. Material cost is a main component in the total cost of the product varying from 25 to 70%. Therefore, in order to control the cost, it is necessary to pay maximum attention for controlling material cost especially through abnormal losses. It should be made sure that the right quantities of materials are consumed with less wastage. This issue can be minimized by avoiding concrete in the neutral axis without bearing significant strength. Saving of concrete can be efficiently achieved with increase in length and depth of the beam. Therefore it can be effectively utilized during the construction of plinth beams, raft foundation, piers and similar other works.

C.LABOUR REDUCTION

Labours are one of the major resources in construction industries. Construction labour is most dis organized in India. Direct labour cost is also a part of the prime cost. It is clearly evident from the study that the total volume saving in concrete is directly proportional to the percentage reduction in labour. Concreting works in construction industry is labour intensive. When the volume of concreting works reduces, the need for labour also get decreased simultaneously, which in turn minimize the production cost.

D. COST REDUCTION

In current days of competition, it is significant amount of concrete without bearing any strength loss. This saving in material cost is more effectively utilized when considering large depth and length of beam or in similar other works, where abnormal loss of concrete occurs. This can be compared to a chain reaction because as the volume of concrete decreases, the material cost reduces which decreases the labour cost, which in turn minimizes the construction cost.

E.APPLICATIONS OF HOLLOW CONCRETE BEAM

From the evaluation of the results, it was observed that the areas of application of the experimental reinforced beamwith hollow neutral axis include various fields of construction where abnormal losses in concrete occurs. The wastage of concrete can be minimized by adopting this technique of hollow neutral axis of low stress zone without any strength loss. The fields of application are:

- Plinth beams
- Raft foundations
- Piers
- Similar other works

II. LITERATURE REVIEW

SAEED AHMED AL-SHEIKH[1]The test results, it could be concluded that the ultimate load carrying capacity of the RC beam at shear zone with opening was maximum reduction but at flexure zone, it showed minimum reduction. All the tested beams were rectangular in cross-section having the dimensions width (b) of 120 mm, height (H) of 250 mm with effective depth (d) of 220 mm. The overall length (L) is 2000 mm and M30 grade of concrete is used. The Comparison between the square opening of 80mm in height and the rectangular opening of same height. The test results showed that providing an opening, a rectangular opening caused reduction in ultimate load about 3-4% more than square opening.

SOJI SOMAN, ANIMA.P [2]Air voids were created using polyethylene balls and PVC pipes. Dimension of all the specimens are 150mm x 200mm x 1250mm and M25 grade of concrete is used.The neutral axis by using plastic balls of 3.7cm and PVC pipe of 3.8cm diameter.Specimens with partial replacement of 4%, 8% & 16% below neutral axis. It test result that partial replacement up to a range of 8% can be done and beyond that replacement leads to a decrease in the load carrying capacity.

L.F.A. BERNARDO, S.M.R. LOPES(Mar 2004)[3] The beams were 3 m long with a 0.12X0.27 m cross section. The longitudinal tensile reinforcement, hot-rolled ribbed steel bars were used with commercial diameters varying between 12 and 20 mm. The experimental values studied of the parameters needed for the calculation of the ductility's index of the test beams. The yielding deflection (dy) 0-2% and the ultimate deflection (du) 0-5% increase the various diameter bar. The 16and 20mm rebar used to load and deflection is increased

III.METHODOLOGY

A. AIM OF THE INVESTIGATION

The main aim of the thesis is to study the flexural behavior of Fiber Reinforced Hollow Concrete Square Beam.

B.OBJECTIVES OF THE INVESTIGATION

- To study the flexural behaviour of hollow fiber reinforced concrete beam in different hollow size.
- To find the various no shear zone with respect to neutral axis and cross section.

C. MATERIALS REQUIRED FOR THE STUDY

The materials used for Fiber Reinforced Concrete are selected from those by the conventional concrete industry. Typical materials used for Fiber Reinforced Concrete are coarse aggregate, fine aggregate, cement, steel and fiber. Fiber Reinforced Concrete can be designed and constructed using a broad range of normal concreting materials, and that this is essential for Fiber Reinforced Concrete to gain popularity.

D. Cement

The 33 grade ordinary Portland cement has been chosen because of its greater fineness which would have effective hydration and also secondary hydration. The ordinary Portland cement which conforms to IS 12269 -1987 is used for making concrete. The cement was of uniform colour i.e. grey with a light greenish shade and was free from any hard lumps.

Table: 1 Properties of 33 grade OPC

S.No	Characteristics	Value
1	Grade	OPC 33
2	Specific Gravity	3.15
3	Compressive strength	33 N/mm^2
	672± 4h	(min)
4	Initial setting time	30 mins
5	Final setting time	600 mins

E. Fine Aggregate

Table: 2 Properties of Fine Aggregate

Test particulars	Result obtained
Specific gravity	2.6
Fineness modulus	2.25
Size	Passing through 4.75 mm sieve

F. Coarse aggregate

Machine crushed well graded angular granite aggregate of nominal size 20mm from local source are used. It is free from impurities such as dust, clay and organic matter.

Table: 3 Properties of Coarse Aggregate

Test particulars	Result obtained
Specific gravity	2.6
Flakiness index	4.35
Elongation index	3.64 percentage

G. Water

The water used for mixing and curing shall be clean and free injurious amounts of oils, acids, alkalis, salts, sugar, organic material or other substances that may be deleterious to concrete or steel. However the water is conformed to IS-2000.

H. Reinforcing Steel

The longitudinal steel reinforcement was provided using Fe415 steel rods and shear stirrups were provided using steel rods. The proof stresses of the reinforcement are 0.2 %. Steel reinforcement tensile strength was determine according to IS code. Two tensile tests were made for each bar diameter longitudinal tensile reinforcement (8mm), longitudinal compression reinforcement (8mm) and stirrups bars (6mm).

I. A R Glass Fiber

Cem-Fil ARC14 306HDglass fiber is used. The properties are shown in Table 4

Table 4 Properties of Glass Fiber Cem-Fil ARC 14 306 HD

Fiber	AR GLASS FIBER
Density((t/m^3)	2.6
Elastic modulus(GPa)	73
Tensile strength(MPa)	1700
Density(micron)	14
Length(mm)	12
No.of fibers(million/kg)	212
Aspect ratio	0.857

Fig: 1 A R Glass Fiber

J. MIX DESIGN

- water - 191.6 ltr
- cement - 383kg/m^3
- fine aggregate - 546kg/m^3
- coarse aggregate -1188kg/m^3
- A R Glass fiber - 25 kg/m^3 (1.2%)
- ratio - 1:1.425:3.1

K.Mould

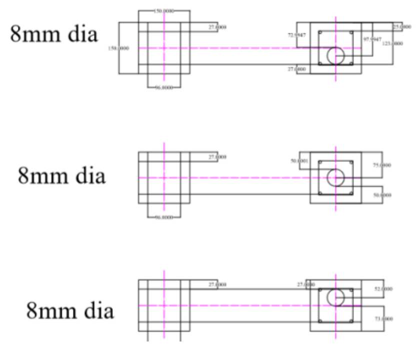
The beam mould is made of steel. The inside dimension of the mould are 150 mm wide 150 mm deep and 1000 mm long. The mould was cleaned and mould oil is applied to avoid adhesion of concrete for easy removal.

L.Casting

The actual quantity of materials were weighed and kept ready before mixing. The moulds were kept ready on table vibrator with reinforcement placed in position with cooler blocks.

The aggregate are mixed by concrete mixer and filled in the mould by three layers and compacted well by table vibrator each time for 10 seconds. After 24 hours, the beam and companion specimens were removed from the moulds and placed in curing tank for curing.

Fig: 2 Schematic cross sectional view of beam specimens



IV.RESULTS AND DISCUSSION

A. COMPRESSIVE STRENGTH TEST

Table: 5 Compressive Strength Test Results

S.NO	CURING DAYS	COMPRESSIVE STRENGTH (N/mm^2)
1	7	19.82
2	14	21.9
3	28	23.4

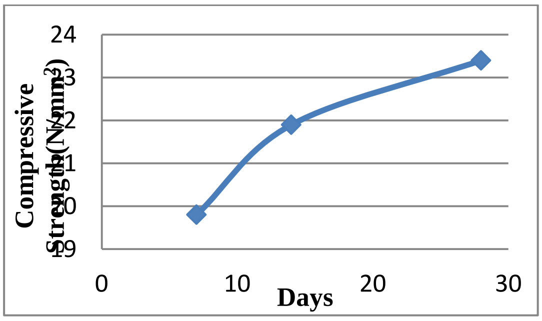


Fig: 3 Graphical Representation of Compressive Strength

B.SPLIT TENSILE STRENGTH TEST

. Table: 6 Split Tensile Test Results

S.NO	CURING DAYS	TENSILE STRENGTH(N/mm^2)
1	7	1.57
2	14	1.68
3	28	1.79

C. FLEXURE TEST

The test specimens were (150mmx150mm size and 1m long) tested as was fitted in center of the beam specimens. A set of 6 "demec" points was placed on the side of the specimen to allow measuring the strain versus load during the test. Demec points were centered on the centerline of the specimens as shown in Fig 4.5. The testing is setup as shown in Fig 4.6. The specimen is mounted on beam testing frame of 50 ton capacity. The beams are simply supported over a span 1200mm, and subjected to two concentrate loads placed symmetrically on the span. A Linear Variable Data Transformers (LVDT) was placed under the specimen at the center to measure the deflection versus load. Load was applied by a Hydraulic Power pack system attached with jacks. The strains are recorded demec point by using demec gauge. An Automatic Data Acquisition system with PC Interface is used to collect the data from load cell and LVDT during test. At the time of testing, the specimen was painted with white cement to facilitate the visual crack detection during testing process. Cracks were traced throughout the sides of the specimen and then marked with color markers. The first cracking load of each specimen was recorded. The load was increases until complete failure of the specimen was reached.

Fig: 4 Setup of Specimen

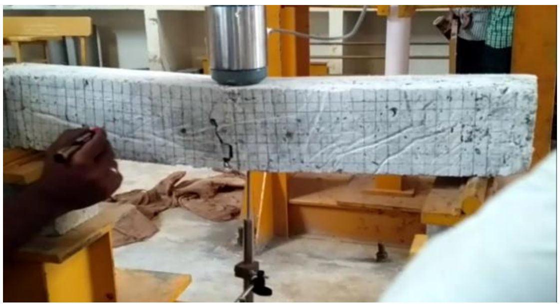


Fig: 5. Test of Specimen

Finally ultimate load at which the beam specimens was failed also measured and these readings are summarized in below Tables.

D. Load Carrying Capacity

Ultimate strength of beams under four point test was confirmed through recording the maximum load indicated by LVDT, but the cracking load was specified with developing the first crack on the concrete. It was found that the load carrying capacity of all partially replaced beams are more than that of solid control beam section. The result of beam with replacement below the neutral axis. beams with hollow core at depth 27mm from top as B1, beams with hollow core at depth 50 mm as B2, and beams with hollow core at depth 72mm as B3.

Experimental Readings of Beams

REFERENCE BEAM
UPPER HOLE = 27 mm
FIRST CRACK LOAD = 26kN
ULTIMATE LOAD = 30.6 kN

TABLE 7.LOAD-DEFLECTION TABLE FOR REFERENCE BEAM

S.NO	LOAD (kN)	DEFLECTION (mm)
1	0	0.1
2	9.1	0.5
3	8.2	1
4	16.5	1.1
5	18.6	2.1
6	22.1	2.2
7	25.9	3.2
8	25.9	3.4
9	30.6	4.3

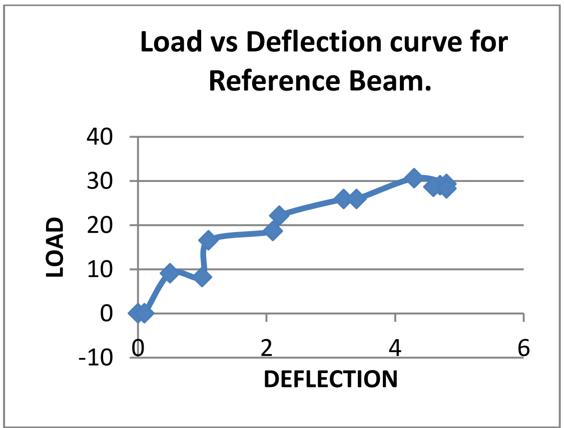


Fig: 5 Load vs Deflection curve for Reference Beam.

REFERENCE BEAM
MIDDLE HOLE = 50 mm
FIRST CRACK LOAD = 28 kN
ULTIMATE LOAD = 32 kN

TABLE 8.LOAD-DEFLECTION TABLE FOR REFERENCE BEAM

S.NO	LOAD (kN)	DEFLECTION (mm)
1	1.4	0.1
2	10.4	0.4
3	16.6	1
5	16.3	1.6
6	16	1.4
7	19.5	1.6
8	26.7	2.6
9	27.8	3.6
10	27.2	3.7
11	27.2	3.4
12	31.6	3.9
13	32	4.9
14	31	5.8
15	31.2	5.8
16	30.7	5.7

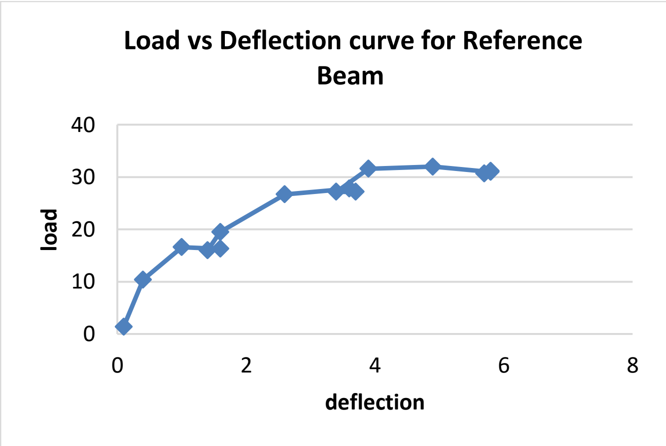


Fig: 6 Load vs Deflection curve for Reference Beam

REFERENCE BEAM
LOWER HOLE = 72mm
FIRST CRACK LOAD = 30.6 kN
ULTIMATE LOAD = 33.8 kN

TABLE 9.LOAD-DEFLECTION TABLE FOR REFERENCE BEAM

S.NO	LOAD (kN	DEFLECTION (mm)
1	0	0
2	8.2	0.4
3	7.4	1.1
4	7.4	1
5	20	2.2
6	18.7	2.4
7	27	3
8	26.1	3.5
9	29.3	3.6
10	30.6	4.8
11	30.1	4.8
12	30.6	4.8
13	32.8	5.6
14	31.4	6.2
15	31.2	6.1
16	33.8	6.5
17	32.2	7.4

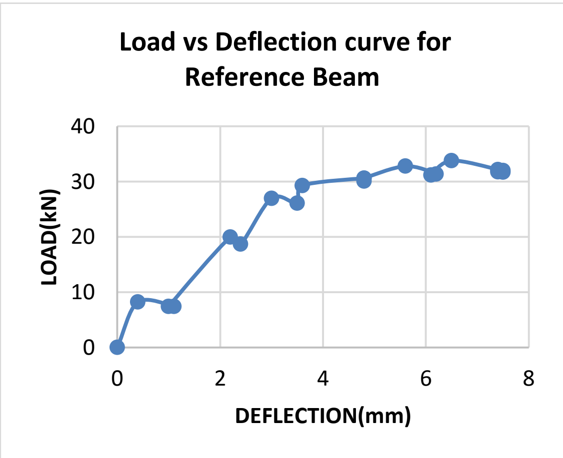


Fig: 7.Load vs Deflection curve for Reference Beam

E. Load Vs. Deflection Graph

As the load increases the deflection of the beam begins. Load will be directly proportional to deflection. The load values and corresponding deflection beam with replacement at the neutral axis upto a safe load of 33,8 kN is given in Table 7,8 and 9.As per the test result it is observed that all partially replaced beams show less deflection than control beam at the safe load.

F. Ultimate Load Vs. Depth of Hollow core

As the depth of hollow core increases the ultimate load decreases. Also by the increase of core depth deflection increases. It can be observed from Figure 9. So the optimum depth for providing hollow core is just below the neutral axis (here it is 72mm).

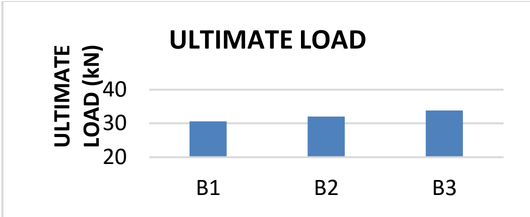


Fig: 8.Ultimate load of beams

G.THEORETICAL LOAD CALCULATION

Depth of neutral axis 27 mm

Moment of resistance 4.134 kN.m

The total load carrying capacity 16.54 kN

V. CONCLUSION

Based on the experimental study conducted on hollow core A R GLASS FIBER RC beams and test result obtained, the following conclusion from the experimental investigation:

- It is found that the ultimate load carrying capacity of the beam is high in tensile zone of hollow core when compared to compression zone of hollow core.
- First crack was observed at 80-90% of the ultimate load.
- Actual experimental results are match with the theoretical calculations as per IS code.
- The hollow core can be used as Duct.

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