FLEXURAL BEHAVIOUR OF REINFORCED CONCRETE HOLLOW BEAM WITH POLYPROPYLENE PLASTIC SHEET INFILL

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Abstract - *This paper presents details of the studies carried out on flexural behaviour of simply supported rectangular reinforced concrete hollow beam with polypropylene plastic sheet as infill. Concrete is weak in tension and strong in compression, so steel is provided in the tension zone to take tensile load, so strength of concrete is ignored in tension zone as compare to compression zone. So ideally no concrete is required in tension zone. But this concrete acts as strain or stress transfer media between compression zone and tension zone. However concrete below or near neutral axis is not fully utilised hence that un-utilised concrete may be replaced by any light-weight or waste material. The project include experimental study on flexural behaviour of hollow core infill reinforced concrete beam with polypropylene plastic sheet. The experimental programme consist of casting and testing of reinforced concrete beam of size 1200mm x 200mm x 300mm with and without rectangular hollow core (25%, 35% & 45%) in tension zone. To study the flexural behaviour, all 12 beams are tested after 28 days curing by applying two point loading. The test results of beam shows that as increase in percentage of replacement cause decrease in flexural strength of beam and also as replacement increases, deflection of beam decreases with respect to control beam.*

Key Words: RC hollow beam, Sandwich beams, Hollow core, Flexural behaviour.

1. INTRODUCTION

Concrete is such building material that it is second to water only. Every year millions of structures such as commercial building and residential building are built with reinforced concrete. In such structures billions of reinforced concrete solid beams are used. Lot of literature is available on flexural strength of reinforced concrete solid beam, but regarding hollow beam satisfactory literature is not available.[2] Now a days problem faced by construction industry is acute shortage of raw material. In recent days many researches are going on to find new better and efficient construction material but concrete materials are still preferred because of its beneficial properties such as workability, low cost and fire resistance as well as low maintenance cost. It is formed from mixture of cement, fine aggregate, coarse aggregate and water. Huge exploration of the natural resources for producing concrete affect the environmental conditions and global warning.[6] So there is need to reduce the use of concrete or make a optimum use of concrete. According to behaviour of concrete it is strong in compression and weak in tension. As per assumption is to design the reinforced concrete beam in which contribution of tensile stresses are neglected. The moment of resistance of beam is governed by only compression stress of concrete and the tensile stress of steel reinforcement.[15] The attempt is made to make optimum use concrete by replacing concrete below neutral axis with polypropylene plastic sheet as infill.

Arun Murugesan, Arunachalam Narayan (2017) developed theoretical equations or modified existing equations by taking into account position of hole to determine maximum deflection at pre-cracking and post-cracking of reinforced concrete hollow beam. Author have examined the validity of developed equations with experimental testing.[3]

Dhinesh. N . P. and Satheesh. V. S. (2017) flexural behaviour of hollow core reinforced concrete beam with different core depths. As concrete is weak in tension steel is provided to take tensile load so logically there is no use of concrete so it can be replaced by any light-weight material. The experimental program consist of casting and testing of RC beams of size 1000mm x 150mm x 150mm with hollow core in different zone. To study the flexural behaviour of beams are tested under three point loading.[6]

S. Manikandan and two other author (2015) studied flexure behaviour of reinforced concrete hollow core sandwich beams. The experimental setup includes casting and testing of reinforced concrete beams of size 1500mmx150mmx200mm with and without hollow core in tension zone with different shapes such as circular 75mm diameter and square 70mm are used. Concrete mix of M25 grade is adopted for casting. Hollow core 25% is introduced in tension zone of beam, the flexure behaviour of beam is not changed with respect to flexural strength, deflection and strain measurement of control beam.[15]

Arun Murugesan, Arunachalam Narayan (2016) developed theoretical equations or modified existing equations to determine the first cracking load and ultimate load of beam and validate with experimental testing. In this work author have replaced concrete by PVC pipe in compression zone and tension zone and compared results with each other. Theoretical prediction of first cracking load and ultimate load of RC hollow beam was found to be close to experimental results.[2]

Aswathy S Kumar and Anup Joy (2015) investigated partial replacement of concrete below neutral axis of beam. The specimens are of dimension 200mm x 300mm x

1000mm with an effective span of 800mm. A replaced beam with 4% and 8% of air voids created using polythene balls of 3.5cm diameter respectively. The M30 grade of concrete is used. The zone below the neutral axis is divided into three zones and the two zones adjacent to the neutral axis is replaced The load values and corresponding deflection of solid control beam and beam with replacement at the neutral axis up to a safe load of 220kN. The deflection solid beam is 30.73mm and beam with 4% and 8% air voids created polythene balls 35.16mm and 37.85mm.[4]

2. OBJECTIVE

Main objective the study is to conduct study by replacing some amount of concrete below neutral axis of beam by polypropylene plastic sheet to reduce self-weight of beam.

3. METHODOLOGY

This project work consist of casting and testing of reinforced concrete beam with and without hollow core. Concrete mix is used for casting of beam is of grade of M20 and concrete mix is designed as per IS : 10262 2009. Reinforcing steel used for beam is of grade Fe 500. Design of reinforced concrete beam is done as per IS : 456 2000. Casting of hollow beam is done by putting polypropylene plastic sheet in reinforcement cage below neutral axis and the same cage is kept in wooden formwork for concrete pouring. Beams are cured by water for 28 days and testing of beam is conducted on loading frame using two point load test.

4. MATERIALS

4.1 Concrete

The concrete mix of M20 used for casting of beam was made from ordinary Portland cement grade 53, fine aggregate (natural river sand) and coarse aggregate of size 20mm

4.1.1 Mix Proportion

Cement : Fine Aggregate : Coarse Aggregate : Water
1 : 1.69 : 2.93 : 0.5

4.1.2 Material Test

Test	Material	Value Obtained
Specific Gravity	Ordinary Portland Cement Grade 53	3.15
Specific Gravity	Fine Aggregate	2.60
Specific Gravity	Coarse Aggregate	2.75
Water Absorption	Coarse Aggregate	0.5%
Water Absorption	Fine Aggregate	1.04%
Workability	Concrete	120mm

Table No. 1 Material Test

4.2 Polypropylene Plastic Sheet

Polypropylene plastic sheet is light-weight material having density between 0.7-0.9gm/cc and thickness of 2mm with corrugations hence it can be used below neutral axis of beam to make the section light weight. (Figure-1)

Figure No. 1 Polypropylene Plastic Sheet.

4.3 Reinforcing Steel

Fe 500 grade steel is used as reinforcing steel in beam. Bottom steel is of 12mm diameter, anchor bar of 8mm diameter and 6mm # bar used as stirrups provided at 100mm c/c.

5. EXPERIMENTAL INVESTIGATION

5.1 Experimental Programme

The experimental work consist of casting and testing of twelve beams of size 200mm x 300mm x 1200mm out of which three are control beam (CB), three beam are with 25% replacement (B1), three beam are with 35% replacement (B2) and three beam are with 45% replacement below neutral axis by polypropylene plastic sheet (B3).

The beam is designed as under reinforced section as per IS: 456: 2000. Beam is reinforced with 2-12mm #bar at bottom, 2-8mm # bar at top and 6mm # stirrups at 100mm c/c. All the beam tested under two-point loading test. The main aspect of test was to study the flexural behaviour of beam.

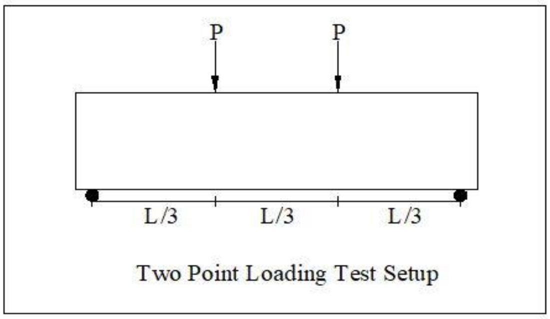

Figure No. 2 Experimental Program

5.2 Test Procedure

It includes testing of beam under loading frame of capacity 1000 KN also it gives flexural strength of beam and deflection of beam. Deflection of beam is measured by dial gauges. Study of flexural behaviour of beam is done by two-point loading test using hydraulic jack attached to loading frame, effective span of beam is achieved by using support of hot rolled joist bar. Failure of beam is studied or observed in proper manner and noted down the results. The loading was stopped when beam is just near to collapse. Deflection of beam is measured at specific interval of load for the plot of load vs deflection graph. Propagation of crack is observed carefully and observation were noted clearly and crack pattern is identified.

6. RESULTS AND DISCUSSION

6.1 Load Carrying Capacity

Ultimate load carrying capacity of beam is determined by two-point loading test. All the readings are recorded carefully. First crack load is recorded carefully for all twelve beams with and without replacement for comparison with control beam as shown in figure-3

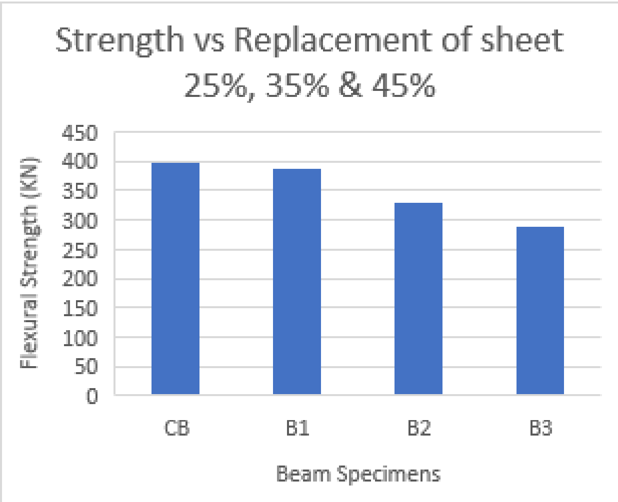

Figure No. 3 Beam Specimen vs Flexural Strength.

6.2 Load vs Deflection

As the load increases beam start to deflect. Load is directly proportional to deflection of beam. Deflection of beam is measured for specific interval of load and recorded carefully and plot of load vs deflection is drawn.

Load in KN	Deflection in mm			
	CB	B1	B2	B3
30	0.45	0	0.25	0.2
50	0.49	0	0.55	0.3
70	0.58	0	0.68	0.36
90	0.70	0.2	0.78	0.39
110	0.80	0.25	0.9	0.45
130	0.88	0.4	0.97	0.49
150	0.93	0.60	1.03	0.51
170	0.99	0.72	1.08	0.55
190	1.1	0.84	1.11	0.56
210	1.18	0.93	1.14	0.62
230	1.25	1.05	1.19	0.69
250	1.3	1.15	1.24	0.74
270	1.45	1.28	1.28	0.78
290	1.59	1.38	1.35	0.83
310	1.62	1.45	1.45	-
330	1.75	1.57	1.57	-
350	1.90	1.58	-	-
370	1.99	1.65	-	-
390	2.20	1.74	-	-
400	2.32	-	-	-

Table No. 2 Load vs Deflection

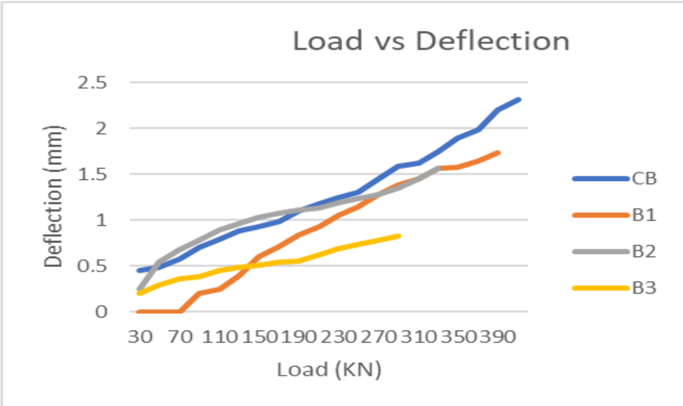

Figure No. 4 Load vs Deflection chart.

6.3 Crack Pattern

Experimental results shows that initially all beams were uncracked. When loading is reached to rupture strength, specimen started to crack. First crack was observed in region of bending moment and then after in region of shear. Same crack pattern is observed in all twelve specimen. The failure observed in all twelve specimen is flexure shear failure. (Figure-4)

Figure No. 4 Crack Pattern of Beam.

6.4 Self-weight Reduction

Concrete is a such building material that it is second to water only. Every year millions of structures such as commercial building and residential buildings are built with reinforced concrete. In such structures billions of RC solid beams are used.[2] Massive exploration of the natural resources for producing concrete affect the environmental conditions and global warning.[7]

As stress diagram of reinforced concrete shows that in tension zone of beam, all the tensile load is taken by steel only hence concrete present intension zone doesn't take any load so that concrete can be replaced by any light weight material so that it will reduce dead weight of beam and section becomes light-weight. Reduction in dead weight of beam will effect in required cross-sectional area for column, footing will be less and optimum use concrete will be made construction industry.

Self-weight of beam is reduced because concrete below neutral axis is replaced by light weight material which is having density less than density of concrete. Percentage reduction in weight of beam for 25% replacement is 11.72 %, for 35% replacement 16.65% and for 45% replacement is 21.31%

7. CONCLUSIONS

In this experimental work comparative study was made on flexural behavior of reinforced concrete solid beam and reinforced concrete hollow beam with replacement of 25%, 35% & 45% below neutral axis by Polypropylene Plastic sheet. The design of beam is done as per IS:456 2000. The replacement 25%, 35% & 45% of concrete below neutral axis with Polypropylene Plastic sheet is done by keeping same cross section of beam and same amount of longitudinal & transverse steel. The same M20 grade of concrete is adopted.

1. Flexural behaviour of reinforced concrete hollow beam is same as control beam.
2. Presence of infill material below neutral axis of beam cause significant change in flexural strength of beam.
3. A flexural strength of beam with 25%, 35% and 45% replacement below neutral axis gives 2.5% , 17.5 % and 27.5% decrease in strength of beam respectively as compared to control beam.
4. Experimental results shows that, as replacement of concrete below neutral axis increases deflection of beam decreases as compared to control beam.
5. A beam with 25%, 35% and 45% replacement below neutral axis gives 11.72%, 16.65% and 21.31% decrease in self-weight of beam respectively as compared to control beam.

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