International Journal for Research in Engineering Application & Management (IJREAM)
ISSN : 2454-9150 Vol-08, Issue-06, Sep 2022

Flexural Behaviour of Self Compacting Concrete Beam Containing UPVC Hollow Pipe

[1]Manoj Kumar berawa, [2]Mohit Menaria, [3]Dr. Praveen Kumar

[1,2]PG Scholar, Structural Engineering, University College of Engineering, Kota, India.

[3]Professor, Department of Civil Engineering, University College of Engineering, Kota, India.

Abstract: Partial replacement of the concrete below the neutral axis is an idea that can create reduction in weight and savings in materials. An experimental work has been undertaken in the present study on flexural behaviour of concrete beams with hollow cores obtained through inserting UPVC pipes near neutral axis. The work consists of casting and testing of self-compacting concrete beam specimens of size 150mm x 150mm x 700 mm with and without hollow cores. To study the flexural behaviour, these are tested by four points loading. Hollow concrete beam specimens have been casted with 40mm and 63mm diameter UPVC pipe at centre.

Keywords: Hollow Beam, SCC, UPVC, Neutral Axis, Flexural behaviour.

I. INTRODUCTION

Concrete is strong in compression and weak in tension. Stresses in the beams are maximum at the top and bottom and zero at the neutral axis. So strength of concrete lying in and near the neutral axis is not fully utilized. This un-utilized concrete can be eliminated by placing a UPVC pipe instead, hence making the beam hollow near the neutral axis.

Consequently, the required size of other structural members such as columns and foundations that support these beams will be reduced leading to the saving in the construction materials and reducing in dead load. So, it is considered as environment friendly. Further, there is scope for making essential utility services like water supply, sewage, air conditioning ducts, electrical and telephone cables through the longitudinal hollow core of these beams, wherever necessary. The concept of longitudinal hollow core in beams came after the demand of industry due to the improvement of deflection factor; this improvement was associated with increasing awareness of ductility phenomenon. Ductility is an important factor as it ensures large deformation to occur under overload conditions and high ductility enables a concrete segment or a joint to sustain plastic deformations without reduction in stress. Large deflections in structures provide a good warning of failure in the form of tensile cracks prior to complete failure of the beam.

In the present experimental study, hollow pipes have been inserted near neutral axis, with the view that the provision of longitudinal hollow core in beams will result in the reduction of self-weight of beams.

II. REVIEW OF LITERATURE

[1] Nibin Varghese et al (May2016) studied flexural behaviour of reinforced concrete beam with hollow core at various depths. They tested ten beam specimens of size 200 x 300 x 2000mm with hollow Core at depth 120mm, 160mm, 200mm and 240mm from top. The tension zone below the neutral axis was divided into four zones and each zone was replaced with voids created by placing circular PVC pipes of diameter 50mm in zigzag pattern. Considered M30 grade concrete and Fe500 steel with an effective cover of 25mm.They came out with conclusion of presence of hollow PVC pipe instead of concrete in the low stressed zone has caused an increase of 21% in strength of reinforced concrete beams at optimum depth of hollow core was 160 mm from top below the neutral axis. As the depth of hollow core increases the ultimate load decreases.

[2] N Parthiban et al (April 2017) investigated flexural behaviour of reinforced concrete beam with hollow core in shear section. A total of eight beam specimens were casted and tested; two of these specimens were reference beams and the others were replaced with voids created by using PVC pipe of diameter 50mm, 2 nos. of 25mm and 3 nos. of 12mm. All the specimens were of dimension 150mm x 200mm x 1200mm with an effective span of 900mm. they concluded that the optimum depth for providing hollow core was just below the neutral axis. And Presence of hollow PVC pipe instead of concrete in the low stressed zone was caused an increase of 21 percentages in strength of reinforced concrete beams.

[3] Arun M et al (August 2015) studied behaviour and strength of reinforced concrete hollow beams. They tested seventy-five RC hollow beams and eleven solid beams up to failure by symmetrically applied and gradually increased two points loading. RC beams were having a single

 DOI : 10.35291/2454-9150.2022.0426

longitudinal hole of either 25mm or 40mm or 50mm.The diameter and the position of canter of hole were varied. This experimental program indicate that using the concept of transformed section, and by equating the maximum tensile stress to the modulus of rupture value of concrete it is possible to predict the first cracking load which will be safe and close to the actual value. They concluded that the ultimate load carrying capacity of RC hollow beams which will fail by flexural mode can be estimated by adopting rectangular stress block on concrete with an average compressive stress of 3/2rd the cube compressive strength of concrete and by replacing the circular hole by an equivalent square hole where more complicated calculations were involved.

[4] Jain Joy (2014) et al studied effect of reinforced concrete beam with hollow neutral axis. They tested nine specimens of size 150x230x980mm with an effective span of 800mm.All the beams were subjected to 4-point flexural test in UTM. They concluded behaviour of reinforced concrete beams with hollow neutral axis was similar to that of conventional reinforced concrete beams. Presence of hollow PVC pipe instead of concrete in the low stressed zone has not caused significant reduction in strength of reinforced concrete beams. It has been observed that the replacement of concrete by hollow pipe in reinforced concrete beams does not require any extra labour or time. Economy and reduction of weight in beams depends on the percentage replacement of concrete.

[5] Dhinesh, N.P et al (March 2017) studied flexural behaviour of hollow square beam. They tested eight beams in the size 150 x 150 x 1000mm out of which two beams were hollow with core depth 34mm from near the compression zone, two beams were hollow with core depth at 75mm from centroid axis; two were beams with hollow core at depth 116mm from tension zone, two were beams with hollow core at depth 75mm and 116mm from centroid and tension zone. They found that the ultimate load carrying capacity of the beam is high in tensile zone of hollow core when compared to other zones of hollow core. The strain values are optimum depth of hollow core is 116 mm from tension zone.

III. Objective of the Work

The objectives are to Partial replacement of the concrete below the neutral axis and observe the flexural behaviour, ductility ratio and energy ratio of self-compacting concrete beam with containing UPVC hollow pipe.

IV. Experimental Investigation

In this study, total 18 specimens were casted. All the specimens were size of 150mm x 150mm x 700mm. All materials and strength of samples were tested at materials testing lab of UCE, RTU, Kota.

Table-1: Shows the details of beam specimens.

Specimen	Length	Width (mm)	Height (mm)	Days of Testing	Diameter of UPVC Pipe
CB1	700	150	150	28	-
CB2	700	150	150	28	-
CB3	700	150	150	28	-
CB4	700	150	150	90	-
CB5	700	150	150	90	-
CB6	700	150	150	90	-
HBA1	700	150	150	28	40 mm
HBA2	700	150	150	28	40 mm
HBA3	700	150	150	28	40 mm
HBA4	700	150	150	90	40 mm
HBA5	700	150	150	90	40 mm
HBA6	700	150	150	90	40 mm
HBC1	700	150	150	28	63 mm
HBC2	700	150	150	28	63 mm
HBC3	700	150	150	28	63 mm
HBC4	700	150	150	90	63 mm
HBC5	700	150	150	90	63 mm
HBC6	700	150	150	90	63 mm

Here 'CB' represents for control beam, 'HBA' represents hollow beam with 40 mm diameter UPVC pipe and 'HBC' represents hollow beam with 63 mm diameter UPVC pipe.

V. Test Procedure

Test was performed as per IS 516:1959 to find out the flexural strength of concrete after 28 days and 90 days curing of concrete. At the time of testing, specimen removed from curing, surface water was wiped off by the cloth and any projecting fines removed.

The tests for flexural strength of beam specimens were performed on a Flexural Strength Testing Machine of capacity 100 KN. The loading was applied continuously without a jerk load. Displacements were measured continuously by dial gauge positioned at the top platen of FTM.

Fig. 1: Arrangement of Dial gauge with FTM

 DOI : 10.35291/2454-9150.2022.0426

VI. EXPERIMENTAL RESULTS AND DISCUSSION

Table-2: Moment of resistance, Average Ultimate load at 28 days

S. No.	Type of Beam	LOAD(KN)	Moment of resistance (KN-m)
1.	Control Beam	20	2
2.	Hollow beam with 40 mm pipe	25.33	2.52
3.	Hollow beam with 63 mm pipe	18.66	1.84

Table-3: Moment of resistance, Average Ultimate load at 90 days

S. No.	Type of Beam	LOAD(KN)	Moment of resistance (KN-m)
1.	Control Beam	27.5	2.75
2.	Hollow beam with 40 mm pipe	36	3.64
3.	Hollow beam with 63 mm pipe	24.67	2.43

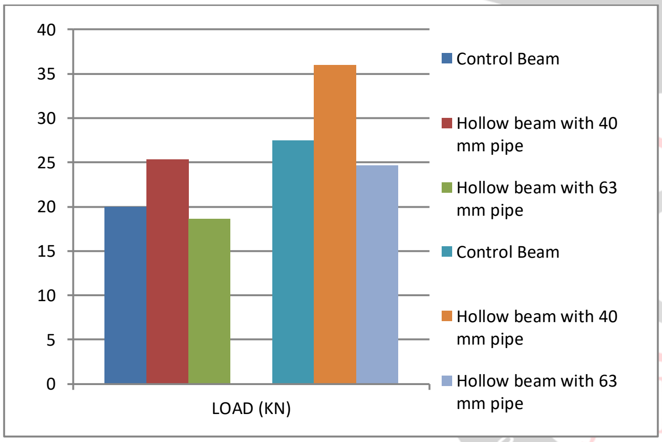

Fig. 2: Variation of Ultimate Load at 28 and 90 Days

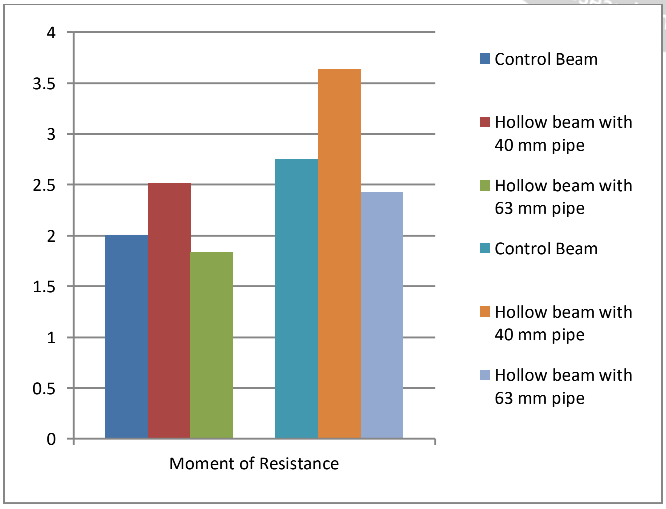

Fig. 3: Variation of Moment of Resistance at 28 and 90 Days

A. Comparison of ductility ratio between hollow and solid specimens.

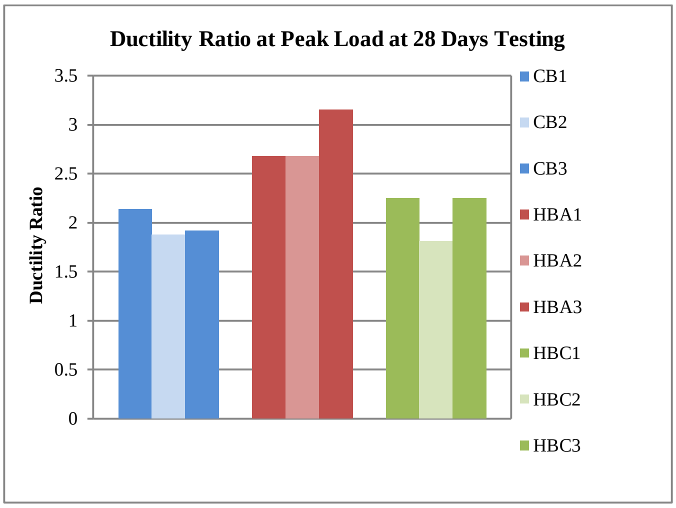

Fig. 4: Ductility Ratios at Peak Load with Control and Hollow Specimen

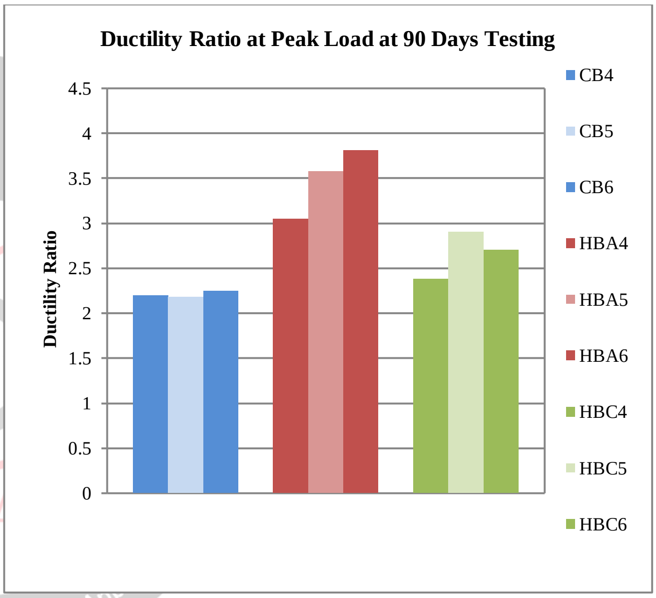

Fig. 5: Ductility Ratios at Peak Load with Control and Hollow Specimen

B. Comparison of energy ratio between hollow and solid specimens.

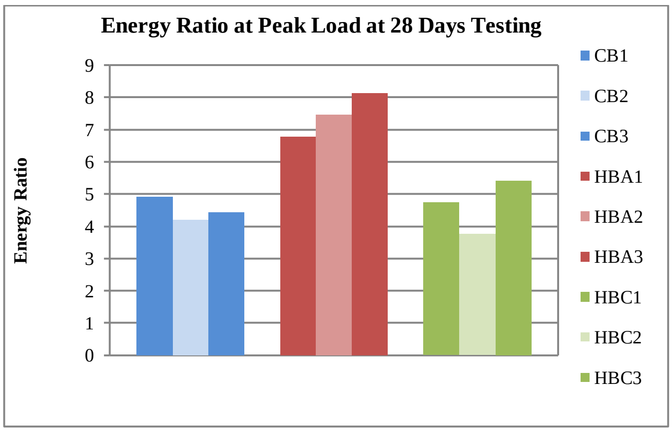

Fig. 6: Energy Ratios at Peak Load with Control and Hollow Specimen

 DOI : 10.35291/2454-9150.2022.0426

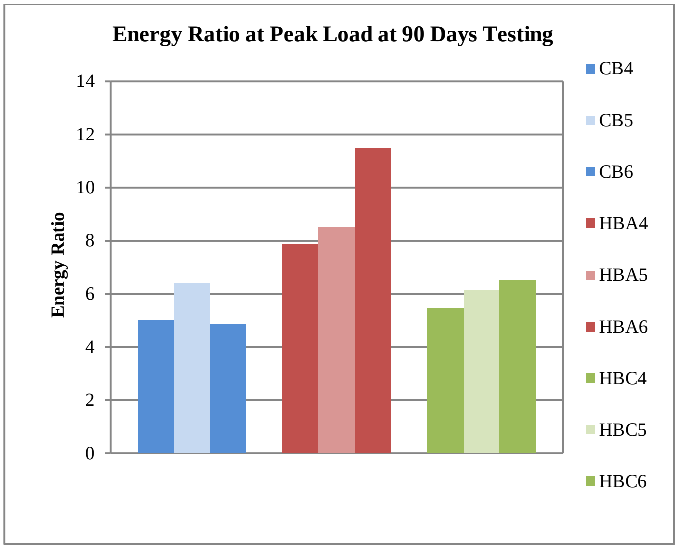

Fig. 7: Energy Ratios at Peak Load with Control and Hollow Specimen

Following points are observed from Figures 4 & 5:

1. It is observed that ductility ratios, at peak load point, are more in hollow beam with 40 mm diameter pipe than control beam.
2. It is also observed that only among the two diameters of pipes- 40 mm and 63 mm, the value of the ductility ratio obtained is higher with 40 mm pipe

Following points are observed from Figures 6 and 7:

1. It is observed that energy ratios, at peak load point, are more in hollow beam with 40 mm diameter pipe than control beam.
2. It is also observed that only among the two diameters of pipes- 40 mm and 63 mm; the value of the energy ratio obtained is higher with 40 mm pipe.

VII. OBSERVATION

Table-3: Summary of Effect of using Hollow Pipe in Beams placed near Neutral axis

S. No.	Properties	Nibin Varghese et al.(1) using PVC Pipe	N Parthiban et al. (2) using PVC Pipe	Present Study Using UPVC Pipe
1.	Increase in ultimate load	21%	21%	40mm ϕ, 34% ↑ 63mm ϕ, 8% ↓
2.	Deflection	Reduces	Reduces	Reduces
3.	Increase in Ductility Ratio	-	-	40mm ϕ, 47% 63mm ϕ, 6%
4.	Increase in Energy Ratio	-	-	40mm ϕ, 65% 63mm ϕ, 3%

VIII. CONCLUSIONS

Based on experimental test results, due to insertion of hollow pipes near neutral axis in the beam specimens, the following conclusions are drawn:

1. The moment of resistance of the hollow beam having 40 mm diameter UPVC pipe gets increased by 32%.
2. The ultimate load of hollow beam having 40 mm diameter UPVC pipe gets increased by 34%.
3. The ductility ratio of hollow beam having 40 mm diameter UPVC pipe gets increased by 40% to 60%, .
4. The energy ratio of hollow beam having 40 mm diameter UPVC pipe gets increased by 50% to 70% due to the pipe.
5. The self-weight of the hollow beam having 40 mm diameter UPVC pipe at neutral axis gets decreased by 8%.
6. The magnitude of ductility ratio and energy ratio are found to increase with age.

REFERENCES

[1] Nibin Varghese, Anup Joy (May 2016) "Flexural behaviour of reinforced concrete beam with hollow core at various depth" International Journal of Science and Research (IJSR), Vol.5, PP: 741-746

[2] N Parthiban, Dr M Neelamegam (Apr -2017) "Flexural behaviour of reinforced concrete beam with hollow core in shear section" International Research Journal of Engineering and Technology (IRJET), Volume: 04, 2395 -0056.

[3] Arun M (August 2015) "Studied behaviour and strength of reinforced concrete hollow beams." Shodhganga Inflibnet jspui Anna University August 2015.

[4] Jain Joy, Rajesh Rajeev (2014) "Effect of reinforced concrete beam with hollow neutral axis" International Journal for Scientific Research & Development IJSRD, page 341, Vol. 2, Issue 10.

[5] Dhinesh.N.P, Satheesh.V.S (March 2017) "Flexural behaviour of hollow square beam" International Journal of Scientific Engineering and Applied Science (IJSEAS) Volume-3, ISSN: 2395-3470.

[6] G. Hemalatha and W.Godwin Jesudhason(2013), "Experimental investigation on beams partial replacement below the neutral axis", International Journal of Civil and Structural Engineering Research, Vol. 2, January.

[7] B S Karthik, H.Eramma & Madhukaran (2014) "Behaviour of concrete grade variation in tension and compression zones of RCC beams" International Journal of Advanced Technology in Engineering and

 DOI : 10.35291/2454-9150.2022.0426

Science, Volume No.02, Issue No. 07, page 2348 – 7550330.

[8] S.Manikandan, S.Dharmar, S.Robertravi (2015) "Experimental study on flexural behaviour of reinforced concrete hollow core sandwich beams" International Journal of Advance Research In Science And Engineering, IJARSE, page-937,Vol. No.4, Special Issue (01), March 2015 ISSN-2319-8354.

[9] Aswathy S Kumar, Anup Joy (2015)"Experimental investigation on partial replacement of concrete below neutral axis of beam", International Journal of Science and Research (IJSR)", volume 4, Issue 8, August.

[10] IS 10262-2009 –"Concrete mix proportion guidelines"-Bureau of Indian standards – New Delhi.

[11] IS 456-2000 –"Plain and Reinforced concrete code of practice"-Bureau of Indian standards – New Delhi.

[12] Ahmad Jabbar Hussain Alshimmeri, Hadi Nasir Ghadhban Al-Maliki (Jul 2014) "Structural behaviour of reinforced concrete hollow beams under partial uniformly distributed load" International Journal of Engineering, Vol.20, PP:130-145.

[13] Er.Ima Mathew, Er.Sneha M.Varghese (September 2016) "Experimental study on partial replacement of concrete in and below neutral axis of beam" IJIRT, Volume 3 Issue 4, ISSN: 2349-6002.

[14] IS 4985-2008- "Manual for Certification of Unplasticised PVC Pipes for Potable Water Supplies" Bureau of Indian standards – New Delhi.

 DOI : 10.35291/2454-9150.2022.0426