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Experimental Investigation of Flexural Member of Beam Opening in Web by using PVC Pipe

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Abstract - *Now a days, in many construction industry faced by the problem is shortage of raw materials. So, we are the responsibility to reduce the effects of application of concrete materials to environmental impacts. In normally a beam has two zone that is compression zone and tension zone. For compression zone at top and tension zone at bottom of the beam. In compression zone is strong in concrete and tension zone is week in concrete therefore in tension zone some quantity of concrete is removed and inserted PVC pipes at certain diameter. This paper presents the details of flexural behavior of opening in beam for laterally and longitudinally direction. The experimental investigation consist of casting and testing of RC beams of size 1000mm x 200mm x 150mm with and without opening in tension side. Here, beams are tested by one point loading and two point loading. The performance of opening core of beams under flexural strength shows better than conventional solid beam.*

Key Words: Hollow core Reinforced concrete beam, light weight, web opening, flexural behaviour etc.

1. INTRODUCTION

In natural concrete behaviour, it's strong in compression and week in tension. For my assumption to design the R.C beams in tensile stress of concrete to be neglected. So, it reduce alternative use of concrete. In reinforced concrete beam, at above neutral axis has less stressed and at the below neutral axis has serves a shear transmitting media. Here the bond between PVC pipes and concrete layer at the concrete pipe should be very good. In reinforced concrete beams with hollow natural axis shows the stresses in beams are maximum at top and bottom and zero at neutral axis. So, cheap and light weight material is used at the near neutral zone. For this we can saves the cement and also reduces the greenhouse gases emissions and it considered as the environmental friendly.

1.1 Web Opening in beam

Beams with opening near the center stub showed similar crack pattern. Generally, the flexural cracks are appeared ahead of shear crack but this pattern is reversed in beam openings. If opening size is increased, loads that cause diagonal cracks and cracks width will decline.

Moreover, crack width is larger in beams with openings than solid beams and exceed limitations of crack width irrespective of location and size of holes. From this, it becomes quite clear that serviceability of cracks could extremely influenced by openings. For increasing opening sizes and changing their locations from the Centre stub of beam were obviously decreases the ultimate strength of the beams. When the openings were located close to the beam supports to skip failure plane, the ultimate strength decreases when compared with beams without openings by more than ten percent. This resulted from cutting one or more stirrups which decrease capacity to carry considerable amount of applied shear.

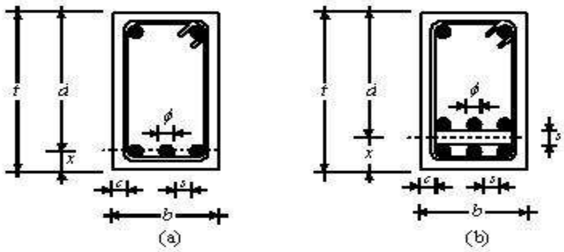

Figure 1: Normal beam detailing and web opening in latteral direction

2. OBJECTIVE OF THE WORK

The main objective is to reduce the usage of concrete and also to introduce new method of reinforced concrete beam by using PVC pipes at below the neutral axis in longitudinal and lateral direction without affecting the geometry of the section.

3. METHODOLOGY

The methodology of project work consist of

(1) Selecting the grade of concrete – M_{30}
(2) Mix design for $M_{30\ grade}$ concrete.
(3) Using this mix proportion RC solid beam and RC hollow beam with neutral and below neutral axis were cast.
(4) By conducting flexural test various effects of these beams were studied.

4. MATERIAL TEST

Table -1: Material Testing Results

TEST	MATERIAL	EQUIBMENTS USED	VALUES
Specific gravity	OPC 53 grade	Le Chatelier flask	3.15
Specific gravity	Fine aggregate (M – sand)	Pycnometer	2.64
Specific gravity	Coarse aggregate (20 mm size)	Wire basket	2.76
Workability	M_{30} grade	Slump cone apparatus	100 mm

5. MIX DESIGN

Table -2: Mix proportion for M_{30} grade of concrete

Cement (Kg/m³)	438.2
Fine aggregate (Kg/m³)	651.5
Coarse aggregate (Kg/m³)	1160
Water (li/m³)	197.2
Water cement ratio	0.45
Mix	1 : 1.49 : 2.65

6. EXPERIMENTAL INVESTIGATION

A. Details of beams

In this research 14 beams were casted at the size of 1000 mm x 200 mm x 150 mm and 50mm dia PVC pipes were used. Two control beam (CB), six beam with hollow core at neutral axis for longitudinal and lateral direction and six beam with hollow core at below neutral axis for longitudinal and lateral direction are cured at 28 days. For longitudinal direction, 3 numbers of 250 mm length PVC pipes placed in Zigzag pattern and lateral direction, 15 numbers of 90mm length placed in Zigzag pattern. All beams are designed as per IS 456 – 2000. In this beam 3 numbers of 12mm dia is used at tension zone and 2 number of 10mm dia is used at compression zone and shear reinforcement 8 mm dia stirrups @ 100mm c/c spacing. Main accepts for this research flexural strength, center span deformation and strain behavior of beam were examined.

Depth of neutral axis can be calculated by considering M_{30} grade concrete and Fe415 steel with an effective cover 25mm.

As per IS 456 – 2000 code,

Depth of neutral axis at limiting value,

$X_{u,max}/d = 0.46$

$X_{u,max} = 0.46 \times 175$

$= 80.5mm$

Tension reinforcement,

$Pt_{lim} = 41.61\ (f_{ck}/f_y)(x_{u,max}/d)$

$Pt_{lim} = 1.38\ \%$

$100A_{st}/b \times d = 1.38$

$A_{st} = 362.25\ mm^2$

Area of steel rft = $3 * (\Pi \times 12^2/4)$

$= 339.29\ mm^2$

Depth of neutral axis,

$X_u = (0.87 \times 415 \times 339.29)/(0.36 \times 30 \times 150)$

$= 75.61\ mm$

Therefore, $X_u < X_{u,max}$

Hence, the section is under reinforced section.

Minimum shear reinforcement 8mm dia @ 100 mm spacing

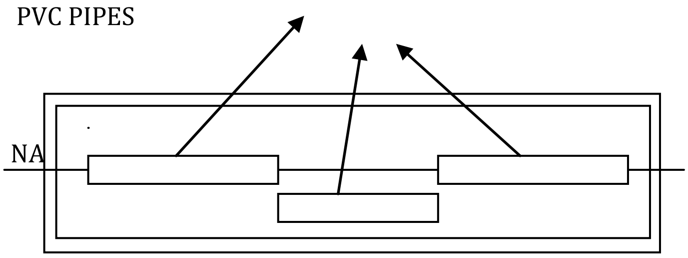

Figure 2: Schematic sectional plan of specimen in longitudinal zigzag position.

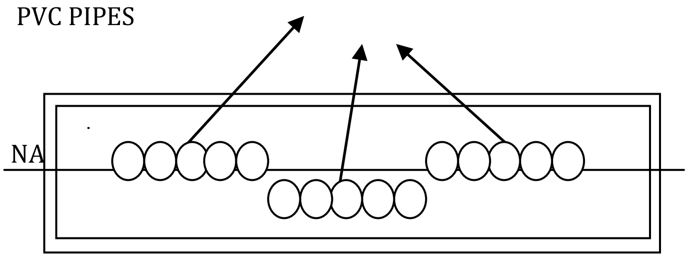

Figure 3: Schematic sectional plan of specimen in lateral zigzag position.

Figure 4: Arrangement of PVC pipes in longitudinal zigzag position.

Figure 5: Arrangement of PVC pipes in longitudinal zigzag position.

Figure 6: Casted specimen in longitudinal and horizontal zigzag position

B.Test procedure

The flexural strength of the testing specimen were tested by 100T loading frame and also dial gauge were used for determining the deflection of the beam. In this research, one point and two point loading were used to test the specimen. The behaviour of the beams was observed from the beginning to failure of the specimen. The first crack appearance, the development and the propagation of cracks due to the increase of load were noted. After that the loading was continued at the initial cracks and was stopped when the specimen was just on the verge of collapse.Here load was applied by hydraulic jack. Then the values of load applied and the deflection of specimen were noted directly and also plot the graph between load and deflection which is taken as the output. The applied load increased up to the breaking point or till the failure of the specimen.

Figure 7: Experimental set up of beam in one point loading

7. EXPERIMENTAL RESULTS

A. Load carrying capacity.

The comparison of the results between the solid control beam and the beam with PVC pipes below and at the neutral axis as shown in fig. and fig. In this research the specimens were denoted as solid control beam (CB_1 and CB_2), beam with hollow neutral axis at longitudinal zigzag position (BLO_1), and beam with hollow below neutral axis at the depth of 100 mm in longitudinal zigzag position (BLO_2), beam with hollow below neutral axis at the depth of 125 mm in longitudinal zigzag position (BLO_3) and beam with hollow neutral axis at lateral zigzag position (BLA_1), and beam with hollow below neutral axis at the depth of 100 mm in lateral zigzag position (BLA_2), beam with hollow below neutral axis at the depth of 125 mm in lateral zigzag position (BLA_3)

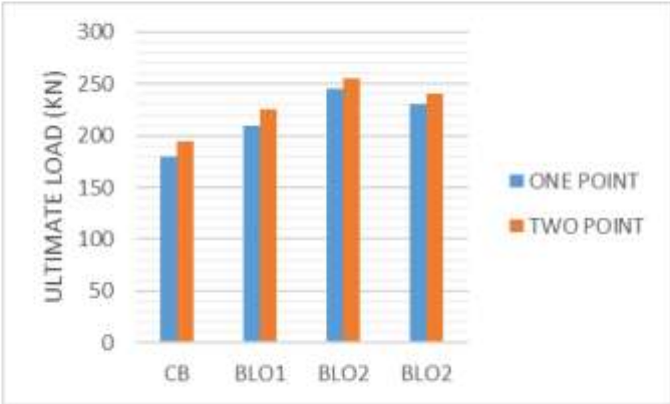

Chart 1: Ultimate load of beam in longitudinal zigzag position

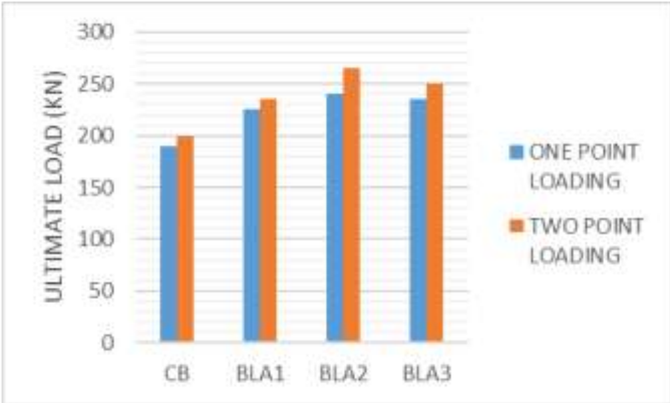

Chart 2: Ultimate load of beam in lateral zigzag position

B. Load and Deflection

When the load increases the deflection of beam begins. The corresponding deflection of CB ,beam with hollow neutral axis and the load up to a safe 150 KN given in Table 3 and Table 4.

Table -3: Load and deflection of beam for one point load.

Load (KN)	Deflection (mm)			
	CB_1	**BLO_1**	**BLO_2**	**BLO_3**
10	0.22	0.18	0.16	0.19
20	0.29	0.21	0.19	0.27
30	0.45	0.41	0.28	0.79
40	0.58	0.55	0.34	0.90
50	0.69	0.63	0.46	1.11
60	0.74	0.69	0.55	1.34
70	0.95	0.88	0.69	1.45
80	1.15	0.99	0.78	1.69
90	1.28	1.10	0.95	1.88
100	1.58	1.29	1.18	2.19
110	1.79	1.49	1.37	2.55
120	2.37	1.84	1.79	2.98
130	2.88	2.19	2.00	3.09
140	3.18	2.53	2.38	3.75
150	3.88	2.97	2.74	3.98

Table -4: Load and deflection of beam for two point loading.

Load (KN)	Deflection (mm)			
	CB_1	**BLO_1**	**BLO_2**	**BLO_3**
10	0.19	0.11	0.11	0.15
20	0.29	0.22	0.14	0.3
30	0.41	0.39	0.18	0.75
40	0.52	0.45	0.24	0.89
50	0.64	0.53	0.36	1.1
60	0.7	0.67	0.45	1.24
70	0.85	0.82	0.59	1.35
80	1.10	0.91	0.71	1.65
90	1.25	1.00	0.89	1.85
100	1.52	1.21	1.1	2.10
110	1.76	1.39	1.32	2.45
120	2.30	1.78	1.69	2.88
130	2.78	2.10	1.98	3.06
140	3.12	2.43	2.18	3.45
150	3.68	2.78	2.54	3.89

C.Saving of concrete and self-weight reduction.

Concrete is one of the most important building material. For construction site, huge amount of concrete wastage can occurs. Material cost is a main component in the total cost of the product varying from 25 to 70 % therefore, in order to the cost control, it is necessary to pay the maximum attention for controlling material cost especially through the abnormal losses.

In this research, dimension of beam is 1000 mm x 200 mm x 150 mm and PVC pipes length 250mm and dia 50mm for longitudinal zigzag direction and PVC pipes length 90mm and dia 50mm for lateral zigzag direction,

By calculating the volume, we know the % of reduction in concrete volume.

Volume of specimen (beam) V_1 = 1000 x 200 x150

= 3×10^7 mm^3

Volume of PVC pipe $V_2 = \Pi r^2 l$

= $3.14 \times 25^2 \times 250 \times 3$

= 1471875 mm^3

% Reduction in concrete (longitudinal) = [(V2/V1)] x 100

= 5 %

Self-weight reduction,

All structural and architectural components shall have dead load weight and also self-weight which are permanent in nature. If we reduce the volume of concrete then self-weight of the beam also get reduced.

Unit weight of concrete = 25 KN/m^3

Weight of 1 m^3 concrete = 2500 kg.

Volume of specimen (beam) V_1 = 1 x 0.2x0.15

= 0.03 m^3

Weight of beam, W_1 = 2500 x 0.03

= 75 kg

Consider, PVC pipe dimension

Volume of PVC pipe $V_2 = \Pi r^2 l$

= $3.14 \times 0.025^2 \times 0.75$

= 1.4×10^{-5} m^3

Weight of concrete saved, $W_2 = 1.4 \times 10^{-5} \times 2500$

= 0.036 kg

Weight of hollow core beam = 74.964 kg

For small beam, self – weight reduction is also small. When assuming large beam, weight reduction will be larger.

8. CONCLUSIONS

In this experimental research for web opening RC beams and test result obtained.

1. Flexural behaviour of the RC beam with web opening is similar to the conventional RC beam.
2. The optimum depth of web opening at the below neutral axis is 100mm (from top).
3. The strength were increased in RC beam for web opening in lateral zigzag direction when compared to longitudinal zigzag direction.
4. As comparing with one point loading test, the two point loading test is better.
5. Economy and reduction of weight of specimens is depends on the % of replacement of concrete. The concrete saving will be more effective as the length and depth increases.
6. Web opening reinforced concrete beam can be used for sustainable and environment friendly construction work and its saves concrete which reduces the emission of CO_2 during the production of cement.

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