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Experimental Investigation on Internal Strengthening of RC Beam with Transverse Circular Opening in Centre of L/3 Zone

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ABSTRACT: The reason for providing the transverse circular opening in the floor beams to make possible the Passage of utility pipes and service ducts results not only in a more systematic layout of Pipes and ducts, it also translates into extensive economic savings in the construction of a multi-storey building. To investigate the problem of openings in beams, experimental investigation has been carried out. In this project, we have provided a circular opening at the L/3 zone of the beam and we have considered three beams first is the Normal solid RC beam, second is the RC beam providing transverse circular opening without strengthening reinforcement and third is the RC beam providing transverse circular opening with strengthened reinforcement. In this work, we considered a beam of dimensions 1700*150*200mm.and provided a transverse circular opening of dia 80mm in beam at L/3 zone using Grade of concrete used is M30.By the experimental investigation on the RC beam providing transverse circular opening with strengthened reinforcement gives up to 30-35% of more strength when compare to RC beam providing transverse circular opening without strengthening reinforcement.

KEYWORDS: Web opening, RC beam, flexural strength, deflection, M30.

I. INTRODUCTION

The transverse opening in the webs of beams in buildings are necessary for the passage of service ducts and piping in order to minimize the story height and to attain economy. The web openings of the beam result in the decrease of flexural, shear strengths, flexural stiffness and the increase of the deflection. Although many investigations have been conducted on reinforced concrete and structural steel beams with Opening at different zone in beam. It has been practiced that pipes and ducts are usually hanged below the floor beams and covered by a suspended ceiling for its aesthetic purposes. These openings can be of different shapes and sizes as circular, square or rectangular etc.Normally for aesthetical appearance, circular opening is fine when compared to square, rectangular etc., the below shows a circular hallow beam in a building,

Sudden change in the dimension of cross section of the beam leaded to high stress concentration at the corners of opening that may lead to cracking unacceptable from aesthetic and durability viewpoints. Many experimental investigations have been carried out on shear zone, support zone and at mid of the span of the beam but now we are making an experimental investigation on the L/3 span on the beam. In this RC beam, we have provided a circular opening of size of diameter 0.4 times the depth of the beam. We are providing the circular opening at one side of L/3 span of the beam .L/3 span is the point were the loading is applied over the portion of RC beam. We have considered a RC beam dimensions of breadth of 150mm,depth of 200mm and length of span 1.7m.At side of the L/3 span of RC beam a circular opening is provided and at another side there is no opening provided.

II.OBJECTIVES

- M30 Grade of concrete
- DIMENSIONS OF THE BEAM: 1.7 m length of beam with breadth 150mm and 200mm depth.
- POSITION OF OPENING PROVIDED: At L/3 span of the beam at one side providing 80 mm diameter opening in the RC beam.
- LOADING CONDITION: Two Point Loading.

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III. MATERIALS AND METHODOLOGY

Cement: In this present work Ultratech cement of 43 grade ordinary Portland cement was used for casting cubes and cylinder for all concrete mixes. The cement is uniform colour i.e. grey with a light greenish shade and was free from any hard lumps. The various testes conducted on cement are standard consistency, initial and final setting time, specific gravity, fineness and compressive strength. Testing of cement was done as per IS: 8112-1989. The specific and composition limits of Portland cement..

Fine Aggregate (FA): The locally available river sand conforming to grading zone III of table 4 of IS 383-1970 has been used as fine aggregate. The tested as been carried out as per IS: 383-1970.

Coarse Aggregate (CA): Locally available crushed granite coarse aggregate has been used. It is necessary to know the specific gravity and water absorption of aggregate in order to determine the mix proportions of the concrete. Accordingly, tests have been carried out as per the procedure given in IS 2386 (PART 3)-1963 and result presented in the **Table 2**. The present work having maximum size 20mm coarse aggregate used. In this work,we have provided 60% of 12-20mm size and 40% of 6.75-12mm size coarse aggregate.

Reinforcement Detail: Un-tensioned high yield strength deformed bars of size of dia 10mm are used at tension zone & 8mm dia bar used at compression zone & also stirrups. As per IS 1786-2000, to determine yield strength & ultimate strength of the revealed that the materials confines to IS standards.

Methodology: To compare the beams ultimate strength between Normal solid RC beam ,RC beam providing transverse circular opening without strengthening reinforcement & RC beam providing transverse circular opening with 45° bent up reinforcement as strengthening reinforcement.

To compare the beams behavior over transverse opening provide at the L/3 zone of the beam.

Scope of this present experimental investigation involving of testing of three RC beams and each beam of three specimens are constructed.

- One solid beam without opening is considered as Normal solid RC beam (B1).
- One beam with circular opening without strengthening (B2).
- One beam with circular opening with strengthening (B3).

All these beams are tested under the two point loading condition to fail these beams and the ultimate load of each beam is recorded. Deflections of these beams are recorded at three different zones. One at the middle of span ,one at the transverse opening provide at the L/3 zone & last at the L/3 zone were the transverse opening is not provided. These beams deflections are recorded by the mechanical dial gauges for incremental loading over the beam.

Experimental investigation involves the comparison of the normal solid RC beam, RC beam providing transverse circular opening without strengthening reinforcement & RC beam providing transverse circular opening with 45° bent up reinforcement as strengthening reinforcement

3.1BASED ON THE SIZE OF OPENING

When comes to size of the opening, many experimental investigations have been carried out. We have taken 0.4H of opening is the effective opening to be provided to beam. In the below fig, we have provided a80mm of circular opening in the beam.

3.2BEAM VARIABLE PARAMETERS

There are three different beams considered in this experimental investigation

- Normal solid RC beam.
- RC beam providing transverse circular opening without strengthening reinforcement.
- RC beam providing transverse circular opening with 45° bent up reinforcement as strengthening reinforcement

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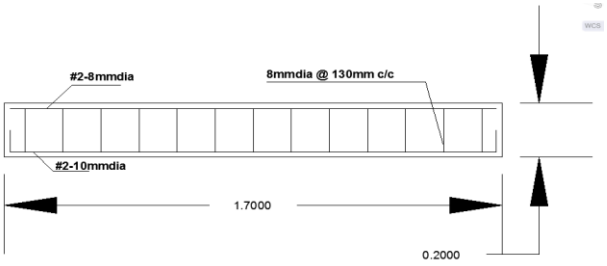

FIG 1: NORMAL SOLID RC BEAM WITHOUT STRENGTHENING REINFORCEMENT.

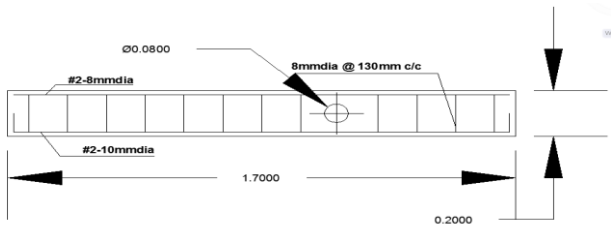

FIG 2:RC BEAM PROVIDING TRANSVERSE CIRCULAR OPENING

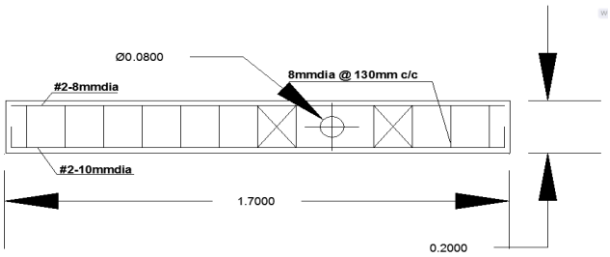

FIG 3:RCBEAM PROVIDING TRANSVERSE CIRCULAR OPENING WITH 45° BENT UP REINFORCEMENT AS STRENGTHENING REINFORCEMENT

IV.EXPERIMENTAL PROGRAMME

In the present experimental work was carried out with the Comparison of solid normal reinforced beam, un strengthened reinforced hallow circular reinforced beam & strengthened beam having reinforcement at 45° bent up over the hallow circular reinforced beam. All tests were conducted on the rectangular cross section beam of dimensions 150mm width &200mm depth & overall length of 1700mm. The length of the opening for the beam (0.40 times of depth) is 80mm. The opening located in L/3 zone of the beam at one end. Each beam of 3 samples was casted & tested.flexural strength on these beams are carried out under two point loading condition.

V. RESULTS AND DISCUSSIONS

Experimental investigations were carried out on three variety of RC beam. These three beams were tested to compare the behaviours. B1Normal solid RC beam is beam reinforcements as per design criteria.B2 RC beam providing transverse circular opening without strengthening reinforcement in this a single stirrup is removed to provide circular transverse opening so, that the RC beam provide serviceability.B3 RC beam providing transverse circular opening with 45° bent up reinforcement as strengthening reinforcement .In this beam extra strengthening reinforcement is provided to compare to B2 beam .Comparison of these three beams are tested and studied the behaviour .

Deflection is the very important serviceability limit to satisfy the design of RC structures. Clause no. 23.2 of the IS 456-2000 recommends the l/d less than or equal to 20.Here the simply supported and a two point loading condition is taken into the account for tests. The deflections on the mid of the span and on the both the l/3 zone are recorded at various incremental loading respectively of each beam. The deflections of Normal solid RC beam,RC beam providing transverse circular opening without strengthening reinforcement &RC beam providing transverse circular opening with 45° bent up reinforcement as strengthening reinforcement are taken with respect to loadings are recorded.

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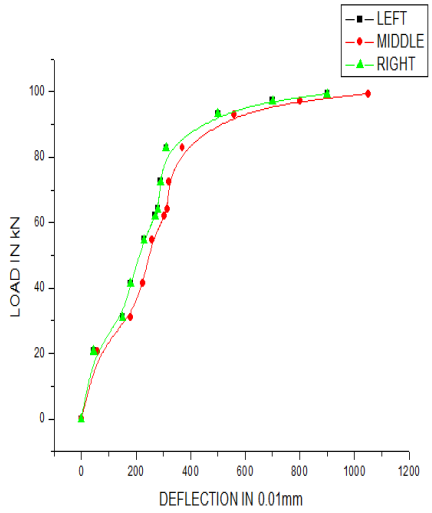
LOAD VERSES DEFLECTIONS OF B1 BEAM



In this above graph, we can see the deflection is more in the middle of span than compare to other both l/3 zone. For solid normal beam B1, the first flexural crack was appeared at the flexural zone at both side of two point loading at a load of 62.40KN. Further increase of applied load crack appears at the middle of the span .This crack increases its size and thus it fails in flexure at a load of 99.30KN.

FIG 4:LOAD V/S DEFLECTION RELATION OF B1 BEAM

TABLE 1:LOAD V/S DEFLECTION FOR B1 BEAM

LOAD IN KN	DEFLECTION IN 0.01 mm		
	LEFT OF L/3 ZONE	MID OF SPAN	RIGHT OF L/3 ZONE
0	0	0	0
20.68	45	60	45
31.02	150	180	150
41.36	180	225	180
54.70	230	260	230
62.05	270	305	270
64.12	280	315	280
72.4	290	320	290
82.74	310	370	310
93.10	500	560	500
97.22	700	800	700
99.30	900	1050	900

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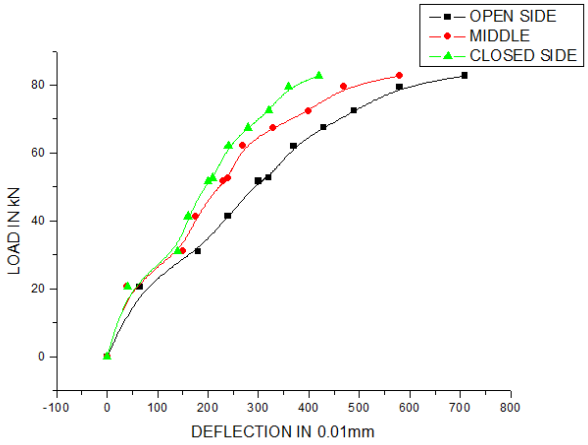
LOAD VERSES DEFLECTIONS OF B2 BEAM



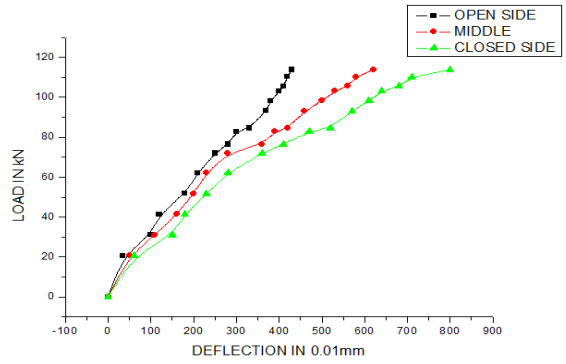
In this above graph, we can see the deflection is more in the transverse opened in l/3 zone and less deflection at the closed solid l/3 zone. For RC beam providing transverse circular opening without strengthening reinforcement B2, the first flexural crack was appeared at the flexural zone at solid closed side of l/3 zone 70.32KN. Further increase of applied load crack appears at the circular opening of l/3 zone .This crack increases its size and thus it fails at the circular opening at l/3 zone at a load of 82.74KN.

FIG 5:LOAD V/S DEFLECTION RELATION OF B2 BEAM

TABLE 2:LOAD V/S DEFLECTION RELATION FOR B2

LOAD IN KN	DEFLECTION IN 0.01 mm		
	OPENED SIDE OF L/3 ZONE	MID OF SPAN	CLOSED SIDE OF L/3 ZONE
0	0	0	0
20.68	65	40	40
31.02	180	150	140
41.36	240	175	160
51.70	300	230	200
52.65	320	240	210
62.05	370	269	240
67.50	430	330	280
72.40	490	400	320
79.50	580	470	360
82.74	710	580	420

LOAD VERSES DEFLECTIONS OF B3 BEAM



In this above graph, we can see the that deflection is more in the transverse opened in l/3 zone and less deflection at the closed solid l/3 zone .RC beam with transverse circular opening with 45° bent up reinforcement as strengthening reinforcement ,the first flexural crack was appeared at the flexural zone at solid closed side of l/3 zone 76.40KN.Further increase of applied load, This crack increases its size and thus it fails at the closed solid side at l/3 zone at a load of 113.80KN.

FIG 6: LOAD V/S DEFLECTION RELATION OF B3 BEAM

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TABLE 3:LOAD V/S DEFLECTION RELATION OF B3 BEAM

LOAD IN KN	DEFLECTION IN 0.01 mm		
	OPENED SIDE OF L/3 ZONE	MID OF SPAN	CLOSED SIDE OF L/3 ZONE
0	0	0	0
20.68	35	50	60
31.02	100	110	150
41.36	120	160	180
51.70	180	200	230
62.05	210	230	280
72.02	250	280	360
76.40	280	360	410
82.74	300	390	470
84.60	330	420	520
93.10	370	460	570
98.20	380	500	610
103	400	530	640
105.56	410	560	680
110.20	420	580	710
113.80	430	620	800

COMPARISON OF LOAD V/S DEFLECTIONOF BEAMS AT RESPECTIVE PORITIONS

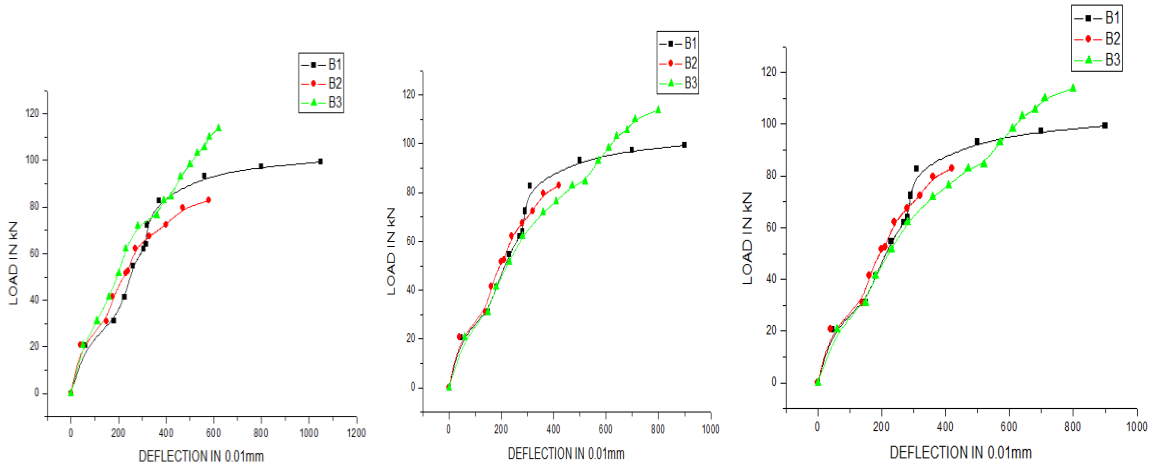

FIG 7:LOAD V/S DEFLECTIONOF BEAMS AT RESPECTIVE PORITIONS

The above three graph are at the opened portion of the beam,mid span of the beam and at the closed portion of the beam. Form this all above graphs, we can conclude that the lesser deflection in transverse beam can be achieved by the internal strengthening of reinforcements in the RC beams .From graph, we can see that the B3 beam gives the higher value deflection at higher ultimate load failure on the closed side of RC beam.B3 beam gives the lesser

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deflection at higher value of ultimate load. There are no much changes in the middle of span for all these beams. From graph ,there is greater variation of values in opened L/3 zone

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VI.CONCLUSION

In circular beam, B2 without the internal strengthening, the ultimate load decreases by nearly 15-20% to that of the solid RC normal beam B1.B3 with internal strengthening, the ultimate load is increased by nearly 14% to that to that solid RC normal beam B1.By the experimental investigation the first cracks in initial stage appears in the B1 solid RC normal beam .From this we can conclude the hallow section resists the cracks at initial stages.RC beam with transverse circular opening with 45° bent up reinforcement as strengthening reinforcement, ultimate load can be increases by 30-35 % than the RC beam providing transverse circular opening without strengthening reinforcement.By providing transverse circular opening with 45° bent up reinforcement as strengthening reinforcement, we can reduce the deflection by 40% then that of transverse circular opening without strengthening reinforcement in beam.By providing extra reinforcement over the RC hallow section can increase the ultimate load and reduce the deflection in structures.

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