EXPERIMENTAL STUDY ON INTERNAL STRENGTHENING OF RC BEAM WITH TRANSVERSE SQUARE OPENING IN CENTRE OF L/3 ZONE

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Abstract - *Three types of beams are made, first beam is solid beam called control beam, another one is hollow square opening beam without internal strengthening, and third one is hollow square opening with internal strengthening. The ultimate load and deflection are investigate experimentally, and compare solid beam, hollow without internal strengthening beam, and hollow with internal strengthening beam with each other. A size of beam is (150*200*1700) mm. The openings of the beams are classified based on their size and shape of the beam. A portion of square opening is 0.4D (80mm) in L/3 zone, and it will be hollow in one side of the beam. Solid beam is compared with hollow square opening beam without inter strengthening, the un-strengthened beam is decreases 12.5% its strength. Solid beam is compared with hollow square opening beam with inter strengthening, the strengthened beam is increases 11.10% its strength. Hollow without inter strengthening beam is compared with inter strengthening beam, the strengthened beam is increases 22.22% its strength.*

Key Words: Solid (Control) beam, Strengthened beam, Un-Strengthened beam.

1. INTRODUCTION

Specialists are planned the structures in light of wellbeing and serviceability contemplations, yet they additionally needs to consider the useful necessities in light of the utilization to which the structure is expected. While outlining multi story building or a force plant structure, the customary auxiliary framing comprises of bars and braces with strong networks. These indications gives pipelines such a kind uses like water supply, power, sewage, PC system, phone and air containing channels required for acceptable working for which the structure is set up. All the time, the administration engineer who is on the scene long after the basic erection has been totally required to alter aerating and cooling conduits set up. The procurement of web opening in shaft has turned into a worthy designing practice, and taking out the likelihood of administration specialist cutting gaps accordingly in suitable areas. Going conduits through these transverse openings in the floor pillars prompts a dead space lessening and result in a more minimized configuration.

1.1 AIM OF THE STUDY

1. Comparison between the solid beam and hollow square beam.

2. To compare the beam having large square opening, with internal strengthening techniques of beam and without internal strengthening.

1.2 CLASSIFICATION OF OPENINGS

1. Based on Shape of Openings

2. Based on Geometry of Openings

2. METHODOLOGY

All beams were tested under two point flexural loading applied at one third loading span points, so to have a pure-bending or moment region of middle of the beam. The beam was placed at the center of the loading frame lying on the same line as per required effective span of 1.7m. The load was distributed at two points by means of rigid distribution of beams and rollers. Dial gauge placed just below the point loads and center of the beam. Before loading zero is the initial reading all gauges were noted. For every increment of load the readings of dial gauge and load reading in loading frame were recorded, and the load at corresponding crack was noted. After the crack pattern and failure of beam was pointed. Test duration of each beam was 2 hours.

2.1 PARAMETERS USED

Grade of concrete	M25
Type of cement	OPC43

F_y	415 N/mm2
Dia of bars	8mm & 10mm
Size hollow section	0.4D
Mix proportion	1:1.35:2.38
	438:628:1107
Water-cement ratio	0.45
Slump value	85mm
Compressive Strength	36.44N/mm^2
Curing period	28days
Loading method	2 point load

Table -1: Parameters Used

2.2 INSTRUMENTS USED

2.2.1 DIAL GAUGE

The deflection was measured utilizing the dial gage having the attractive base. Minimal number of dial gage is 0.01mm.

2.2.2 LOADING FRAME

A loading frame of 25tonnes limit introduced in the research facility was utilized for testing the beam examples.

Fig -1: Loading Frame

3. RESULTS AND DISCUSSION

3.1 SOLID BEAM (B1)

SL NO	LOAD (psi)	LOAD (KN)	DEFLECTION (mm)			CRACKS
			D_1	D_2	D_3	
1	100	20.68	40	60	40	
2	150	31.02	120	155	120	
3	180	37.23	150	220	150	1
4	200	41.36	170	280	170	2
5	250	51.70	230	340	230	
6	280	57.91	350	415	350	3
7	300	62.05	410	470	410	
8	330	68.25	550	630	550	4,5
9	350	72.39	730	800	730	6
10	400	82.73	820	910	820	

Table -2: Result of Beam1

Fig -2: Testing of Beam1

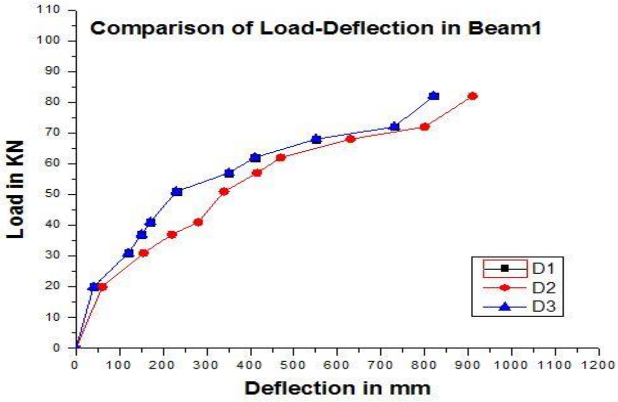

Chart -1: Comparison of Load-Deflection in Beam1

For solid beam (B1), the first crack was flexural crack was observed at the position of the maximum bending moment between the two concentrated loads at a load of 37.23KN. The increment of load is increase the flexural cracks was observed, at the end beam was failed at flexural mode. Beam is fail at the ultimate load of 82.73KN.

3.2 INTERNAL UN-STRENGTHENING BEAM (B2)

SL NO	LOAD (psi)	LOAD (KN)	DEFLECTION (mm)			CRACKS
			D_1	D_2	D_3	
1	100	20.68	45	55	70	
2	150	31.02	110	115	130	1
3	200	41.36	150	180	210	
4	220	45.50	180	210	240	2,3
5	250	51.70	235	260	290	
6	280	57.91	360	385	410	4
7	300	62.05	430	470	530	5
8	315	65.14	480	530	610	6
9	350	72.39	760	820	910	

Table -3: Result of Beam2

Fig -3: Testing of Beam2

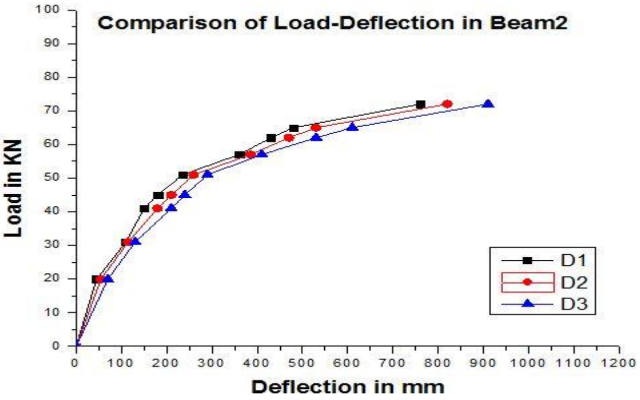

Chart -2: Comparison of Load-Deflection in Beam2

In This beam crack pattern and failure mode of the un-strengthening beam with square opening in L/3 zone is (B2). The first crack was observed at 31.02KN, and first crack was observed at below the square opening. The applied load increase and resultant the crack pattern was appeared at opening first then appears at flexural zone and shear crack are also observed. The ultimate load of the beam is observed about 72.39KN. It will decrease in strength have been observed compared to solid beam due to presence of opening in shear zone.

3.3 INTERNAL STRENGTHENING BEAM (B3)

SL NO	LOAD (psi)	LOAD (KN)	DEFLECTION (mm)			CRACKS
			D_1	D_2	D_3	
1	100	20.68	60	45	25	
2	150	31.02	155	130	110	

3	200	41.36	220	180	150	1
4	230	47.56	270	230	210	2
5	250	51.70	340	315	280	
6	270	55.84	405	365	330	3
7	300	62.05	480	430	390	
8	340	70.32	550	500	460	4
9	350	72.40	585	540	510	
10	400	82.73	720	650	590	5
11	425	91.00	815	730	660	6
12	450	93.08	970	800	720	

Table -4: Result of Beam3

Fig -4: Testing of Beam3

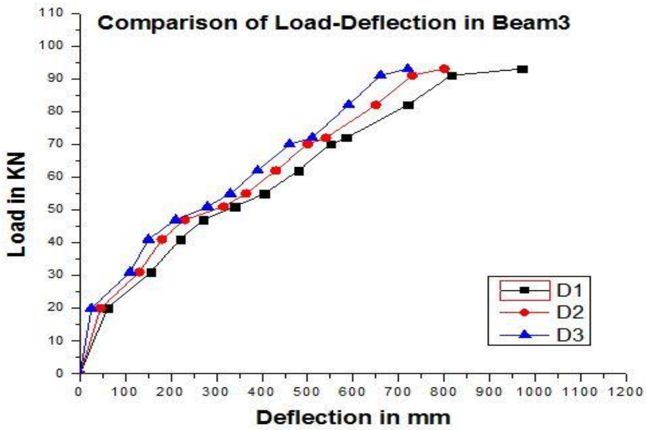

Chart -3: Comparison of Load-Deflection in Beam3

It should be noted that the cracking behavior of the strengthening hollow square beam B3 is opposite of beam B2, and similar to beam B1. In this beam the first crack was developed in 41.36KN. The ultimate load of this beam is 93.08KN. There is some flexural cracks are observed and few shear cracks also obtained. Cracks are developed only in one side of shear zone but there is no cracks in opening side and it gives more strength.

3.4 COMPARISON OF DIFFERENT DEFLECTION VALUES WITH LOAD

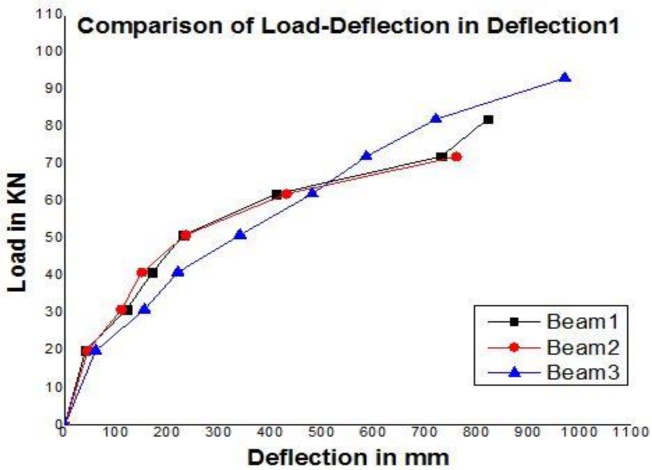

Chart -4: Comparison of Load-Deflection in Deflection1

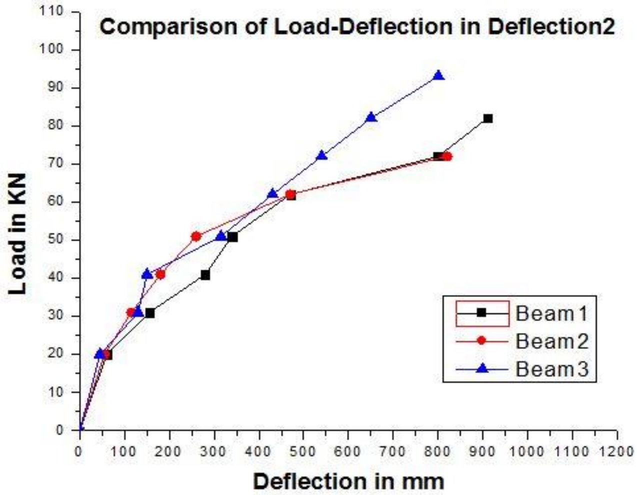

Chart -5: Comparison of Load-Deflection in Deflection2

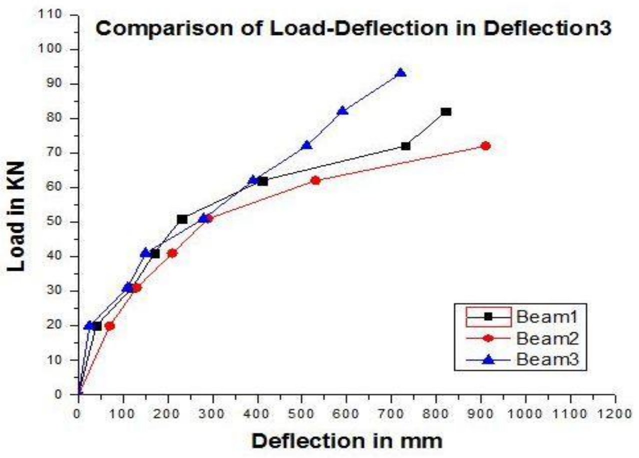

Chart -6: Comparison of Load-Deflection in Deflection3

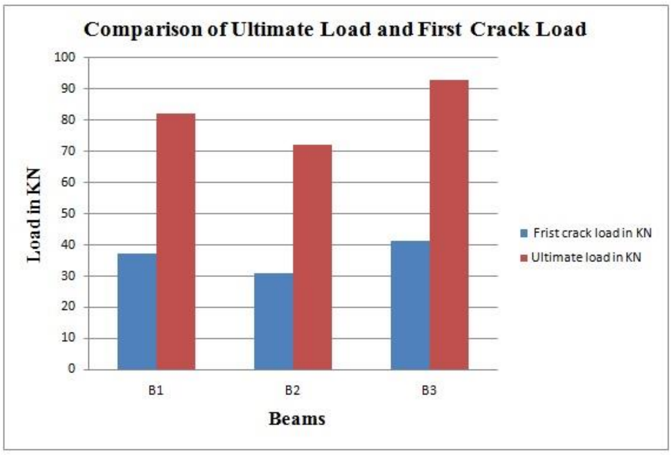

Chart -7: Comparison of Ultimate Load and First Crack Load

4. THEORETICAL EVALUTION

4.1 BEAM CALCULATION

Yield strain of F_e 415 = $f_y/1.15*E_s + 0.002$

E_{sc} = 415/1.15*.002 = 0.0038

Ast = 257.58 mm^2

Mu = 0.87*fy*Ast*d*(1-Ast*fy/b*d*fck

Mu = 13.62 KN-m

Mu = W*L/3 = 27.25 KN

P = 2* W = 54.50 KN

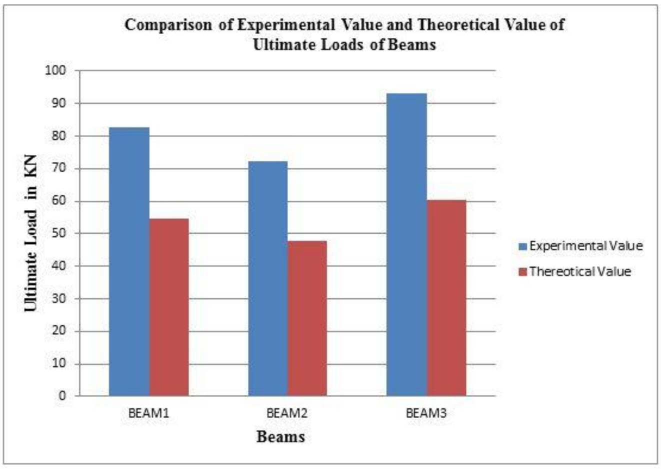

Chart -8: Comparison of Experimental Value and Theoretical Values of Ultimate Loads of Beams

5. CONCLUSIONS

1) When solid beam (control beam) of ultimate load (82.73KN) is compared with hollow square opening beam without inter strengthening of ultimate load (72.39KN) in L/3 zone. The un-strengthened beam is decreases 12.5% of the ultimate strength.
2) When solid beam (control beam) of ultimate load (82.73KN) is compared with hollow square opening beam with inter strengthening of ultimate load (93.07KN) in L/3 zone. The strengthened beam is increases up to 11.10% of the ultimate strength.
3) When hollow square opening beam with inter strengthening of ultimate load (93.07KN) in L/3 zone is compared with without inter strengthening beam of ultimate load (72.39KN) in L/3 zone. The strengthened beam is increases up to 22.22% of the ultimate strength.
4) Solid beam's ultimate load is 82.73KN, and it deflect 820mm at left side of L/3 zone, deflect 910mm at center of beam, and deflect 820mm at right side of L/3 zone. But un-strengthened beam's ultimate load is 72.39KN, and it deflect 760mm at left side of L/3 zone, deflect 820mm at center of beam, and deflect 910mm at right side of L/3 zone (hollow portion). At 72.39KN deflection of the un-strengthened beam is increases to solid beam in all zones.
5) Solid beam's ultimate load is 82.73KN, and it deflect 820mm at left side of L/3 zone, deflect 910mm at center of beam, and deflect 820mm at right side of L/3 zone. But the strengthened beam's ultimate load is 93.07KN, and it deflect 970mm at left side of L/3 zone, deflect 800mm at center of beam, and deflect

720mm at right side of L/3 zone (hollow portion). At 82.73KN deflection of solid beam is increases to strengthened beam in all zones.

6) Un-strengthened beam's ultimate load is 72.39KN, and it deflect 760mm at left side of L/3 zone, deflect 820mm at center of beam, and deflect 910mm at right side of L/3 zone (hollow portion). But the strengthened beam's ultimate load is 93.07KN, and it deflect 970mm at left side of L/3 zone, deflect 800mm at center of beam, and deflect 720mm at right side of L/3 zone (hollow portion). At 72.39KN deflection of un-strengthened beam is increases to strengthened beam in all zones.

Here theoretical values of beams are compared with experimental values of the beam.

1) Theoretical values of solid beams is 54.50 KN, and experimental values of solid beam 83.73 KN. Experimental values of solid beam is increases 34.90%.
2) Theoretical values of un-strengthened beams is 47.68 KN, and experimental values of un-strengthened beam 72.39 KN. Experimental values of un-strengthened beam is increases 34.13%.
3) Theoretical values of strengthened beams is 60.50 KN, and experimental values of strengthened beam 93.07 KN. Experimental values of strengthened beam is increases 34.99%.

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