Behavior of Precast Beam-Column Junction and RC (Cast-in-situ) Beam-Column Junction on Experimental Based Study

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Abstract- - **In this study, we have design a junction of Beam-Column RC and Precast and then applying a different types of load on the junction specimen. Comparison between the load-deflection on both cases, Comparison between the exterior and interior joint with transverse reinforcement details as per IS 13920-1993 and SP16.Comparison between the previous lists of experimental work. The effect of axial load on the behaviour of joint is also considered in this study. That type of experimental work on precast beam-column junction has been never done at the plant of "Precast India Infrastructure Limited". Comparison between the manually work which is done by the code of IS 13920-1993,IS 1893 part 1 – 2002 ,SP 16 and others. Comparison between the chemicals of precast members which is applied in the junction (Fosrok & Ultratech Power Grouting).**

Index Terms- **Precast Beam-Column junction, wooden kiln, static hydraulic machines etc.**

I. INTRODUCTION

In RC frame buildings, portion of column that are common to beams at their intersection are called beam-column joint. In general, the performance of framed structures depends on the individual members such as beam and column when there is only gravity load acting on the structure. But when lateral load acting on the structure then performance of the structure depends not only with the individual member, also with the integrity of the joints. The beam-column joint plays a critical role in ensuring performance of RC frame structures in resisting the design force, particularly induced by earthquake force. In case of design, it is very important to design beam-column joint precisely because the individual member such as a beam or column in case of considerable damage can be strengthened by some methods, but a beam- column joint cannot be strengthened once it form the plastic hinge. Many researches are going around the worldwide to understand the behaviour of beam column joint in a better manner. Moreover, concrete is a material possessing low thermal conductivity and high specific heat capacities.

II. OBJECT & SCOPE OF THE STUDY

A beam-column joint is a very critical zone in reinforced concrete framed structure where the elements intersect in all three directions. Joints ensure continuity of a structure and transfer forces that are present at the ends of the members. We have to design the entire beam-column junction with different types of loading, design with different dimensions like depth of beam, height of column then due to applied load and varies the span of beam with all particular loading condition. Then after all the records of both precast and RC (cast-in-situ) beam-column junction should be designed and analysis as per different software's.

1. Comparison between the performance of RC and Precast beam-column junction by using experimental work (static loading)
2. Comparison between the load-deflection on both cases
3. Comparison between the exterior and interior joint with transverse reinforcement details as per IS 13920-1993 and SP16
4. Comparison between the previous lists of experimental work. The effect of axial load on

the behavior of joint is also considered in this study

5. That type of experimental work on precast beam-column junction has been never done at the plant of "Precast India Infrastructure Limited"
6. Comparison between the manually work which is done by the code of IS 13920-1993,IS 1893 part 1 – 2002 ,SP 16 and others

III. METHODOLOGY OF WORK

Problem Statement of Precast Beam-Column junction

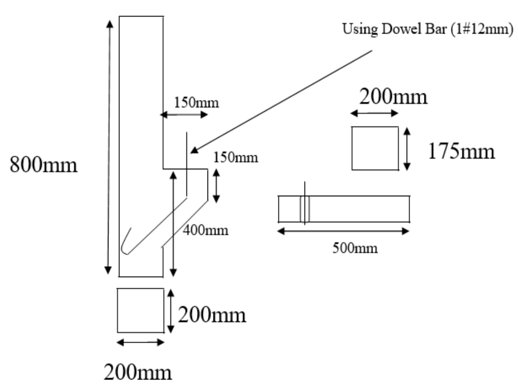

Fig.1 Type1 Precast Beam-Column Junction with dimensions

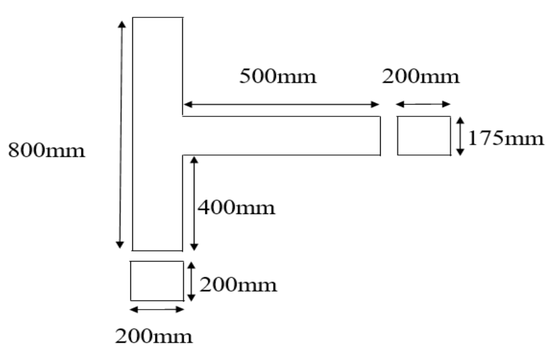

Fig.2 RC Beam-Column Junction with dimensions

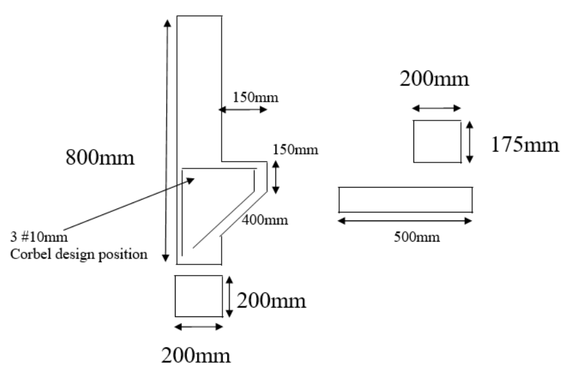

Fig.3 Type2 Precast Beam-Column Junction with dimensions

TECHNICAL WRITING

A. Analysis of cast-in-situ and precast beam-column junction an exterior type 1 junction

Given data

1. Column 800X800mm with a maximum load on the column 6336KN, bar diameter 4-32ϕ and 20-25ϕ
2. Main beam 800X700mm ultimate capacity 237.51 KN/m and tension steel 7 nos. 25mm (3436mm2)
3. Spandrel beam 450X450mm
4. IS 13920 (1993): Ductile detailing of reinforced concrete structures subjected to seismic forces
5. SP 16 (1980): Design Aids for Reinforced Concrete to IS 456:1978

Assume grade of concrete M30 and Fe500, storey height 4620mm, if the joint may experience slow reversal of moment due to wind loads, design the junction :-

Load acting on the members of beam-column junction

Live load – 5 KN/m^2 as per IS 875 part 1,2,3,4 &5

Dead load or superimposed load as per the size of section

Finish load – 1.25 KN/m^2 as per IS 875 part 1,2,3,4 &5

Internal External walls are light weight wall of density 1KN/m^2

Escalator load – 6KN/m^2 as per IS 875 part 1,2,3,4 &5.

Total working load on the column by using manually and software

Column size 800 X 800 mm^2 = W = 6336 KN

Column size 1200 X 800 mm^2 = W = 9300 KN

Column size 1200 X 450 mm^2 = W = 4884 KN

Step 1

Check column moment capacity from interaction dia.

Column 800X800 mm,

Assume % of steel = 2

p/fckbD = 0.33

$Mu/fckbD^2 = 0.067$

$Mu = 1030X10^6$ Nmm

But, column above and below the junction have twice this capacity i.e.

2X1030 = 2060 KNm.

Step 2

Check the stability condition of the column with the capacity of beam

$\Sigma M\ col / \Sigma M\ beam = 8.6$

Desirable capacity for class 1 junction = Fy/ 0.87Fy = 1.15 similar to 1.2.

Step 3

Check anchorage of 25mm bars (beam to column)

$Ldh = 0.27 fy\phi / \sqrt{fck} = 616.18mm$

Length available = 700 – cover – (diameter of the column bar) = 603mm

Anchorage can be made within the core and will give enough development length.

Minimum radius of bend $r = 0.456 fy/fck (1 + 2\phi/a)\ \phi$

Let a = 100mm, ϕ = 25mm, then

r = 285mm.

Step 4

Provide for confinement by minimum transverse steel

Spandrel beam is only on both side: confinement by transverse steel is needed.

S (spacing of tie) =100mm

H (large dimension of core = 370mm

$Ash = 0.18SH\ (Ag/Ak – 1)fck/fy = 67.42\ mm^2$

Provide 10mm (78.54 mm^2) at 100mm spacing with cross ties in both direction.

Step 5

Check for shear in column (type 1 joint)

Design shear in column = 1.2Moment of beam / storey height = 61.690 KN

$\upsilon = 0.096 N/mm^2$

(for type 2 joint, we will use a factor 1.4)

Assume half as tension steel (2/2) = 1% as per IS 456 Table 19

Allowed $\tau c = 0.66\ N/mm^2$

Hence Column safe in shear

IV. EXPERIMENTAL WORK

The prototype of the exterior beam-column joint was scaled down to its one-fourth size. The dimensions and reinforcement details of the test assemblages are shown in Figures and in Table 1. The specimens in were detailed as per IS 13920 (BIS, 1993). All the two specimens were tested under constant axial load with cyclic load at the end of the beam. One of the specimens is RC beam column junction and another one is precast beam column junction.

Fig.3 Casted Specimen of RC Beam-Column Junction with Grade of M30

TEST SETUP

The joint assemblages were subjected to the axial load and reverse cyclic loading. The specimens were tested in an upright position and the reverse cyclic loading was applied statically at the end of the beam. One end of the column was given an external hinge support that was fastened to the strong reaction floor, and the other end was laterally restrained by a roller support. A schematic drawing of the setup is shown in Figure below. The experimental setup at the laboratory is shown in Figure below.

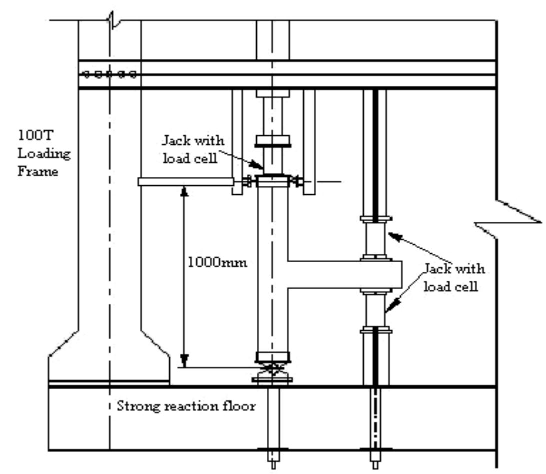

Fig.4 Specimen Setup

CODES OF PRACTISE

Number of codes that are used for design and analysis of Transmission tower, for that study, refer following IS codes-

- IS 13920 (1993): Ductile detailing of reinforced concrete structures subjected to seismic forces
- IS 456:2000: Plain and Reinforced Concrete - Code of Practice [CED 2: Cement and Concrete]
- IS 800 (2007): General Construction In Steel - Code of Practice [CED 7: Structural Engineering and structural sections]
- IS 875 Parts-I -Code of Practice for Design Dead Loads,
- IS 875 Parts-III -Code of Practice for Design Wind Loads.
- IS 1893(part1): 2002 Criteria for Earthquake Resistant Design of Structures,
- SP 16 (1980): Design Aids for Reinforced Concrete to IS 456:2000

V. RESULTS AND DISCUSSION

Analytical and Experimental Verification

All junction are design as per IS 13920 (1993): Ductile detailing of reinforced concrete structures subjected to seismic forces, IS 456-2000 and IS 800-2007

Taking seismic moment – (E) - 120 KN-m

Seismic design shear – ($V_{E)}$ – 80 KN

Grade M30 & Fe 500

Factored B.M (KN-m)	Factored shear force (KN)	Depth required (mm)	Check for shear (τu)
500.1	216	518.10	-
130.05	180.36	264.2	0.97
282.03	238.5	323.73	0.19
237.51	210	267.79	0.39
249.9	216	366.42	1.17
284.76	278.25	400	0.33
2175	421.344	355.6	0.82

S.No.	Size of beam in (mm)	Length (m)	Total factored load (kN/m)
1	450 × 450	20.6	18.37
2	450 × 450	7.4	32
3	650× 1950	9.5	40.5
4	800 × 700	10	31.87
5	450 × 450	10	33.37
6	450 × 1870	7.5	40.5
7	800 × 700	10	43.5

Results/ remarks	Safe/unsafe
-	Unsafe
$Vu< 0.25\sqrt{f_{ck}}$	Safe
$Vu< 0.25\sqrt{f_{ck}}$	Safe
$Vu< 0.25\sqrt{f_{ck}}$	Safe
$Vu< 0.25\sqrt{f_{ck}}$	Safe
$Vu< 0.25\sqrt{f_{ck}}$	Safe
$Vu< 0.25\sqrt{f_{ck}}$	Safe

TABLE IParticulars results in Beam intersect all junctions

VI. CONCLUSIONS

Experimental investigations were carried out on two types of simple mechanical concrete beam-column connections subjected to reverse cyclic loading. The results were then compared with the performance of a reference monolithic beam-column connection. The types of precast concrete connections considered for the present study are (i) Dowel Bar and (ii) The bar of beam merge into the column. The parameters considered for the present study are load carrying capacity, energy dissipation and ductility. The summary of the observations are as follows

1. When we compare to the precast specimen 1 and specimen 2 so the results is Sample with Dowel bar is have a greater capacity compare to another one when we applied a load on the column and the end of the column.
2. One more thing should be occurred in the junction that maximum failure of chances when we applied a load on the junction is top and bottom of the column for both specimen.
3. On comparison of both the precast specimens, specimen RC performed much better than the specimen PC-DW. Also, it is observed that the precast specimen, PC-DWCL exhibited satisfactory behaviour in comparison with the monolithic specimen ML.
4. The proposed connection PC-DWCL is a simple dry connection that can be used for the construction of low rise moment resisting frames.
5. Considering the energy dissipation, the specimen RC performed better than the specimen PC-DW and dissipated 10.71% higher energy than specimen PC-DW. The energy dissipation of specimen PC-DWCL is about 16.52% lesser than the monolithic specimen ML.

6. The specimen RC has better ductility than that of specimen PC-DW and monolithic specimen ML. About 38.04% and 16.56% increase in ductility had been observed for PC-DWCL compared to specimen PC-DW and specimen ML respectively.
7. The load carrying capacity of the connection with Type 1 and Type 2 exhibited 40% and 25% greater load carrying capacity than the specimen with dowel bar PC-DW in the positive and negative direction respectively. This is due to the additional stiffness developed due to the presence of cleat angle. Compared to the monolithic specimen ML, the specimen RC exhibited lesser load carrying capacity. The variation is 29.32% and 25.79% in the positive and negative direction respectively.

Stability condition ∑Mcol / ∑Mbeam	Shear in column N/mm	Shear capacity at junction KN (Vu)	Check shear capacity at junction KN (Vn)
7.3	0.11	3374	4278
4.2	0.29	1876	41407
2.0	0.24	1148	2678.5
8.6	0.096	1666	3209

S.No.	Size of column in mm	Joint type	BM KN-m
1	800 × 800	Exterior	1030
2	1200 × 800	Interior	2304
3	1200 × 450	Exterior	488.4
4	800 × 800	Exterior	1030

Results /remarks	Safe or unsafe
Vu<Vn	Safe
Vu<Vn	Safe
Vu<Vn	Safe
Vu<Vn	Safe

M-R calculation of RC and Precast Junctions

S. No.	Load (KN)	Deflection	Longitudinal Length	M-R Calculation
Specimen 1	390 (C)	1.55	800mm	1.24
Specimen 1	80 (B)	7.55	500mm	3.775
Specimen 2	80 (C)	2.55	800mm	2.04
Specimen 2	50 (B)	4.50	500mm	2.25
Specimen 2	420(C)	1.75	800mm	1.4
Specimen 2	80(B)	7.05	500mm	3.525

TABLE II Particulars results in RC and precast Beam-column junction's

The cracks patterns observed at the time of testing within ±2mm in the junction of RC when applied a load on the top of the column and end of the beam (Jack 1 has 1000KN and Jack 500KN)

The cracks observed at the top of the column within ±2.5mm

Fig.5 Cracks Investigation of RC Beam-Column Junction

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