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Experimental Investigations on Beam- Column Joint with Fibers under Cyclic Loading

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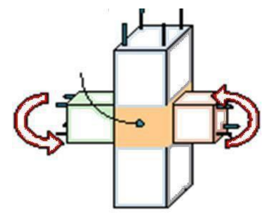
Abstract— Beam-column joint plays a main role in withstanding the horizontal and vertical shear forces under seismic excitation. The magnitudes of Beam-Column joints will be higher than other structure parts. The detailing work in Beam-Column joints have to be done carefully. If it is not done carefully then the joint will become weak link and the structure leads to fail. To prevent this detailing work should be done by following several codes. For better seismic performance ductile detailing should be done under IS 13920-1993.The beam column joint should be having high percentage of transverse hoop reinforcement in order to meet the required strength, toughness, stiffness, ductility, under cyclic loading. High percentage transverse hoop detailing is hard to execute in site. For relaxation of this difficulty steel fibers are introduced as reinforcement in some volumetric fractions and the hoop detailing can be reduced. The steel fibers will fulfils the required strength. In this project one control Beam- column joint of M-60 grade concrete with hoop reinforcement detailed as per IS 13920 and one control beam without Hoop reinforcement as per ACI-318 has been made. Then four types of Beam-Column joint specimens with volume fraction of steel fibers in 0.25%, 0.5%, 0.75%, 1% has been made. The specimens with steel fibers will not be having hoop reinforcement. The several specimens have been tested under cyclic loading and their performance has been compared.

Index Terms—Beam-Column joint, Fibers under cyclic loading & M60 grade concrete with hoop reinforcement.

I. INTRODUCTION

In RC buildings, portions of columns that are common to beams at their intersections are called beam-column joints (Figure 1.1). Since their constituent materials have limited strengths, the joints have limited force carrying capacity. When forces larger than these are applied during earthquakes, joints are severely damaged. Repairing damaged joints is difficult and so damage must be avoided. Thus, beam- column joints must be designed to resist earthquake effects.



According to Park and Paulay (1975) the essential requirements for the satisfactory performance of a joint in a reinforced concrete structure can be summed up as follows:

1. A joint should exhibit a service load performance equal to that of the members it joins.
2. A joint should possess a strength that corresponds to at least the most adverse load combinations that the adjoining members can possibly sustain, several times if necessary.
3. The strength of the joint should not govern the strength of the structure and its behavior should not impede the development of the full strength of the adjoining member.
4. Ease of construction and access for placement and compacting concrete are the prominent issues of joint design.

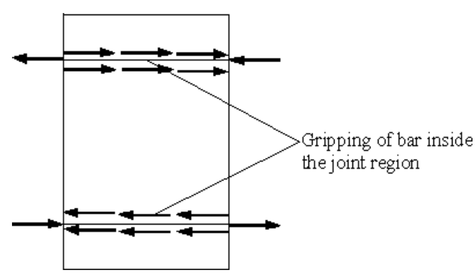


Fig 1.2: Earthquake behavior at joints (Pull-push Forces on Joints)

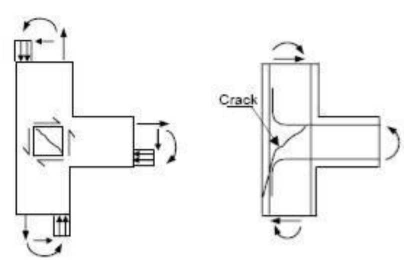


Fig 1.3a: Forces acting at joint (Poor Reinforcement)

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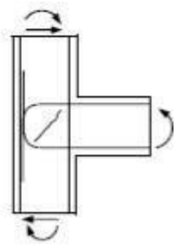

Fig 1.3b: Forces acting at joint (Satisfactory Reinforcement)

Damage Pattern of RC Beam Column Connections:

Designing beam–column joints is considered to be a complex and challenging task for structural engineers, and careful design of joints in RC frame structures is crucial to the safety of the structure. Although the size of the joint is controlled by the size of the frame members, joints are subjected to a different set of loads from those used in designing beams and columns.

The two major failure modes for the failure at joints are (a) joint shear failure and (b) end anchorage failure. A typical example of a beam–column joint failure during the 1999 Turkey earthquake is shown in figure.

Fig. 1.4 Beam-Column joint failures

II. EXPERIMENTAL STUDY

The experimental study consists of casting of fourteen large scale continuous (two-span) rectangular reinforced concrete beams. All the beams weak in flexure are casted and tested to failure.

The materials used for casting of beam-column joint samples are coarse aggregate, fine aggregate, steel fiber, silica fume and super plasticizer (High Range Water Reducer) are as shown below.

Fig. 1.5 Steel fiber

Fig. 1.6 Silica fume

Fig. 1.7 GLENIUM B233 (High Range Water Reducers)

Specimen Details

The specimens has been casted on mix 2 which is having 9% silica fume replacement and 1.75% replacement of HRWR.

Six numbers of Beam-Column joint Specimen has been casted with a dimension of Beam (800X200x150) column (1000x200X150) having 0.054m^3 volume.

The control specimen has been casted with Hoop reinforcement as per IS 13920 and without hoop reinforcement as per ACI 311and the other specimens has been casted without Hoop reinforcement.

The specimens without Hoop reinforcement has been casted with adding some percentage of steel fibre

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Detailing of Reinforcement:
The Beam-Column joint reinforcement details

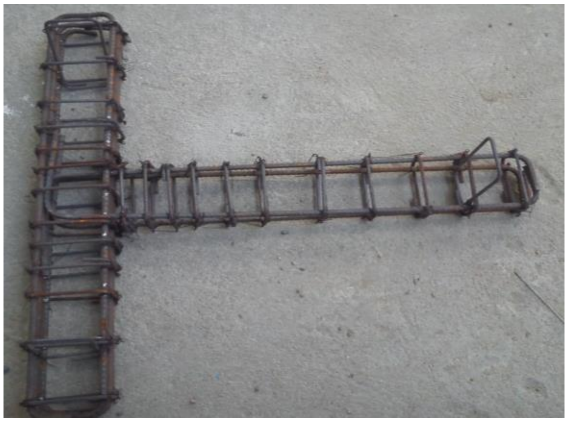

Fig. 1.8: Detailing of reinforcement (Beam-Column joint)

Table. 1 Reinforcement details of Beam and Column

Specimen Reinforcement details
For beam: Size:150x200mm Main reinforcement:
2nos .12mm dia (Ae=200mm2)
Top reinforcement: 2 nos. 12 mm dia (Ae=200mm2) Shear
reinforcement:
6mm dia at 100mm c/c(up to 800mm from column face)
Confinement:
Provide 6mm diameter at 50mm c/c (up to 400mm from column face)
For column :
Size :120x 230mm Longitudinal reinforcement :
4 nos. 12 mm dia (Ae=452mm2) Later ties :
6 mm dia meter at 100 mm c/c Confinement:
6mm dia at 50mm c/c (up to 400mm from beam face)
Provide 6mm dia at 150mm c/c (remaining length)

Fig. 1.9 Form work of Beam-Column joint

Fig. 2.0 Casting of Beam-Column joint.

Fig. 2.1 Curing of sample

IV. EXPERIMENTAL RESULTS

Testing Procedure
The testing of cubes, cylinders and beam-column specimens have been done after 28 days of curing. The following tests were performed in the present research work:
1. Stress strain behavior of concrete by conducting compression test on cylinder
2. Compression test on concrete cubes.
3. Cyclic load test on beam-column joint

Compressive Strength Test
Compressive strength measurements are primarily concerned in testing the strength of concrete. Cube specimens were tested using the 2000 kN capacity Automatic

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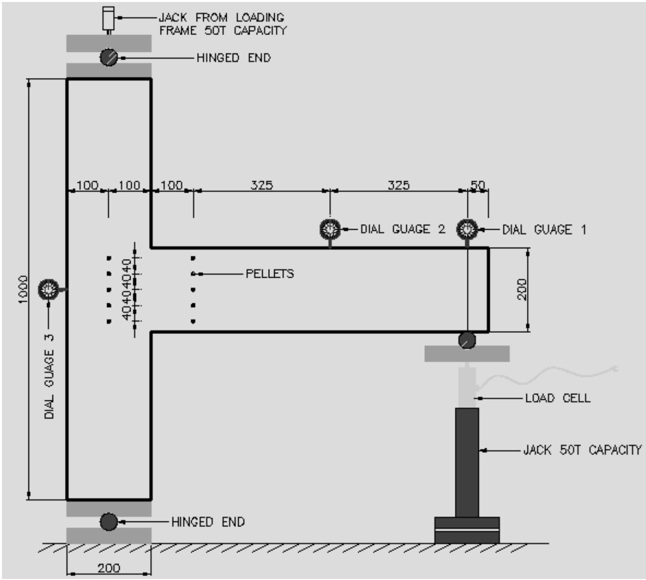

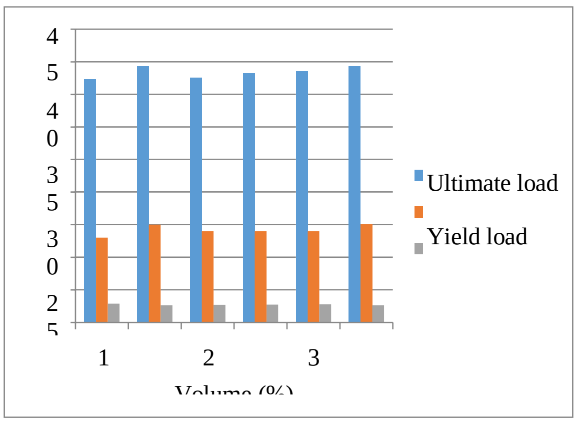

Fig. 2.2 Experimental setup

Table 2.1: Compressive Strength test for Control cylinders of Specimen

Specimen	Cylinder 1	Cylinder 2	Avg. Strength
ASC	61.54	63.22	62.38
ASCH	62.54	68.25	65.39
A1	68.26	64.13	66.19
A2	65.42	65.12	66.27
A3	61.74	66.17	63.95
A4	60.21	63.12	61.66

Table 2.2: Performance Comparison of Specimens

Specimen Name	Yield load (KN)	Ultimate Load (KN)	Deflection Ductility
ASC	13	37.26	2.86
ASCH	15	39.28	2.61
A4	14	37.54	2.68
A3	14	38.24	2.73
A2	14	38.56	2.75
A1	15	39.32	2.62

Fig 2.3 Comparison of Ultimate Load, Yield Load, and Deflection Ductility

V. CONCLUSION

In this thesis, four number of Fiber reinforced high strength concrete specimens and two number of control specimen (with and without Hoop reinforcement) tested under cyclic loading and has concluded that the effective application of steel fibers in the beam column joint concrete mix results in significantly improved joint behavior under seismic loading, in particular with an increased ductility and ultimate load than control specimen.

- The experimental specimens of beam column joints having increasing in percentage of Steel fiber with same geometrical and mechanical properties.
- It is clearly shown that an increase in fibers percentage leads to increased load carrying capacity and ductility.
- This permits to reduce the anchorage value of reinforcement in the joint region, hence limiting steel congestion in joints.
- In general, it is concluded that the effect of adding steel fibers influence the behavior of beam column joint by increasing the ductility characteristics and initial ultimate load and load carrying capacity.

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