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Experimental Study on Behavior of Steel Fiber Reinforced High Strength Concrete Beam-Column Joint

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Abstract:- **Beam column joint is an important component of a reinforced concrete moment resisting frame and should be designed and detailed properly, especially when the frame is subjected to earthquake loading. In the present study, a five bay seven storey RCC moment resisting frame for a general building has been analyses and designed in STAAD Pro as per IS 1893-2002 code procedures and detailed as SP-66 (ACI) recommendations. An Exterior beam column joint has been modeled to a scale of 1/3rd from the prototype and the model has been subjected to cyclic loading to find its behavior during earthquake**

This project work is on the study of the structural behavior beam column joint using fibre reinforced high strength concrete elements. The influence of fibre content on the structural characteristics of fibre reinforced specimens having different fibre-volume fractions will be investigated. The fibres are incorporated with the fraction of 0.25 to 1.75%. The experimental program consists of four exterior beam column joint specimens namely SBC1, SBC2, SBC3 and SBC4 and conventional beam column joint specimen namely BC.The Exterior beam – column joints are examined in terms of load carrying capacity, Load-deflection behavior, stiffness degradation factor, Ductility factor and cracking characteristics. The results of exterior beam column joints were compared with different volume fractions of beam column joint and graph, bar chart has been developed.

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, ductility and stiffness. A volume fraction of beam column joint and graph, bar chart has been developed.

Key words:- Steel fiber, beam-column joint, Load-deflection behavior, stiffness degradation factor, Ductility factor.

1 GENERAL:

Structures on the earth are generally subjected to static and dynamic Loads. Static loads are constant with time while dynamic loads are time-varying. In general the majority of civil engineering structures are designed with the assumption that all applied loads are static.

1.1 INTRODUCTION

The easy availability, low cost and higher stiffness make reinforced cement concrete (RCC) the most widely used construction material. Well designed and well constructed RCC is suitable for most structures in earthquake-prone areas. The minimum concrete strength recommended for earthquake-resistant building structures is 20N/mm2.The grade of the steel used is limited to Fe-415 grade.

In RC buildings, portions of columns that are common to beams at their intersections are called beam-column joints. When forces larger than these are applied during earthquakes, joints are severely damaged. Repairing damaged joints is difficult, and so damage must be avoided.

The strengthening of joints is necessary due to

i. Poor detailing of reinforcement,
ii. deficient constituents materials and inadequate anchorage length of bars,
iii. Improper confinement of joint region,
iv. changes in current design detailing,
v. Variation of loads due to frequency of earthquakes and hence alteration of earthquake zones. The shear failure of beam column joints is the primary cause of collapse of many non-seismically designed framed buildings due to earthquake forces.

1.2 BEHAVIOUR OF BEAM-COLUMN JOINT:

The functional requirement of a joint, which is the zone of intersection of beams and columns, is to enable the adjoining members to develop and sustain their ultimate capacity. The demand on this finite size element is always severe especially under seismic loading. The joint should have adequate strength and stiffness to resist the internal force by the framing members. The joint is defined as the portion of the column within the depth of the deepest beam that frame into the column1.in a moment resisting frame, three type of joints can be identified viz. interior joint, exterior and corner joint (Fig.3.1). When three beams frame into the vertical force of a column, the joint is called as exterior joint.

1.3 MATERIALS

The concrete used for the construction of all specimens consists of the following materials.

1.3.1 Cement

Cement used for the specimen was Ultratech OPC Cement. The cement used was in standard gunny bags and transferred to latter to air tight steel drums to avoid deterioration of the quality. The specification gravity of cement was determined as per IS 576- 1964 and found to be 3.15.

1.3.2 Silica fume

Silica fume a by- product in the Silicon and Ferrosilicon industry was used as a mineral admixture in concrete mixes. It contains large proportions of silicon-di-oxide (SiO_2) which is about 90% of silica fume constituents. The fineness in silica fume in terms of specific surface area may be around 20000m^2/kg when compare with 300-400 m^2/kg for OPC. A typical silica fume having an average diameter about 0.1 microns. Silica fume is added as partial replacement of cement at 8.5% by weight of cement in order to get high strength concrete.

1.3.3 Water

The potable water available in our campus is used for mixing and curing of concrete.

1.3.4 Fine aggregate

The fine aggregate used for the entire specimen in river sand. The fine aggregate used for casting was sieved through IS 4.75 mm sieve. The specific gravity of fine aggregate used for concrete was determined and found to be 2.40.

1.3.5 Coarse aggregate

The coarse aggregate used in the mixes are hard blue granite stones form quarries around Thirisoolam. Reduced 12mm size aggregate was stored in separate dust proof containers. The aggregates retained on 4.75mm are used for specimen. The specific gravity of aggregate was determined and found to be 2.74.

1.3.6 Reinforcement steel

The main reinforcement used for the specimen was HYSD (Fe 415) bar of diameter 12mm. the lateral tie and shear reinforcement was HYSD (Fe 415) bar 6mm. IS specification was used to manufacture the test result.

1.3.7 Steel fiber

The steel fibers used are Duraflex hooked end steel fibers, supplied by Kasthuri metal composites (P) Ltd, Amaravati, Mumbai. The properties of the fiber are shown in table4.2 and show the view of the fiber.

2. OBJECTIVES AND SCOPE

2.1 OBJECTIVES

To study the behavior of exterior beam column joint designed and detailed as per IS13920 with and without fiber.

To investigate the load –deflection characteristics, ductility factor, load carrying capacity and stiffness characteristics of sub assemblies of fiber reinforced high strength concrete beam column joint under cyclic loads through experimental study.

To compare the behavior of all the specimens with the effect of steel fiber in the beam column joint under cyclic loads and also to compare the various parameters like stiffness, ductility and load carrying capacity.

2.2 NEED FOR THE STUDY

A Beam–column joint becomes structurally less efficient when subjected to large lateral loads, such as a strong wind, earthquake, or explosion. A high percentage of transverse hoops in the core of joint are needed in order to meet the requirement of strength, stiffness and ductility under cyclic loading. Provision of high percentage of hoops to causes congestion of steel leading to construction difficulties like honey combs, etc.

In the past two decade, efforts to develop more efficient structural system with better resistance against earthquake load. Since a great potential is available in the beam –column joint, also to meet construction difficulties without changing the properties, the fiber reinforced high strength concrete have been included for strength, stiffness and ductility.

3. EXPERIMENTAL INVESTIGATION

3.1 GENERAL

An experimental investigation has carried out on the 1/3rd model of exterior beam column joint with and without fiber under cyclic loading. The details of the investigation are presented in this chapter.

3.2 ANALYSIS & DESIGN

Seven storey RCC framed structure building has been modeled in staad pro with Dead load, Imposed load and Lateral loading analysis has done and Column has designed as per staad output and Beam designed with IN-House spread sheet. The Specimen taken from Exterior Beam-Column Joint.

3.2.1 Properties of steel fiber

S.NO	**Technical Data**	**Details**
1.	Length	35mm
2.	Diameter	0.60mm
3.	Aspect ratio	58.33
4.	Modulus of elasticity	210000 Mpa
5.	Tensile strength	1100Mpa
6.	Specific gravity	7.8 g/cc

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3.2.2 MIX PROPORTION FOR ALL SPECIMEN

Specimen	*SBC1*	*SBC2*	***SBC3***	***SB***
Cement kg	***25.3***	***25.3***	***25.3***	***25.3***
Silica fumes kg	***2.350***	***2.350***	***2.350***	***2.350***
F.A kg	***32.0***	***32.0***	***32.0***	***32.0***
C.A kg	***56.0***	***56.0***	***56.0***	***56.0***
Water lit	***8.6***	***8.6***	***8.6***	***8.6***
HRWR lit	***0.35***	***0.35***	***0.35***	***0.35***
steel fiber	***.25***	***.75***	***1.25***	***1.75***
Steel fiber kg	***1.05***	***3.15***	***5.25***	***7.35***

3.2.3 REINFORCEMENT DETAILS IN CODE ACI FOR PROTOTYPE
For beam:
Size:450x600mm,
Main reinforcment:
8nos .12mm dia (Ae=900mm^2)
Shear reinforcement:
8mm dia at 300mm c/c
For Column:
Size:450x600mm
Main reinforcment:
20nos .12mm dia (Ae=2260mm^2)
Shear bars:8mm dia @300mm c/c

IN CODE ACI FOR 1/3rd MODEL
For beam:
Size:150x200mm
Main reinforcment:
4nos .12mm dia (Ae=452mm^2)
Shear reinforcement:
6mm dia at 100mm c/c
For Column:
Size:150x200mm
Main reinforcment:
6nos .12mm dia (Ae=678mm^2)
Shear bars: 6mm dia at 100mm c/c

3.3 CASTING AND CURING

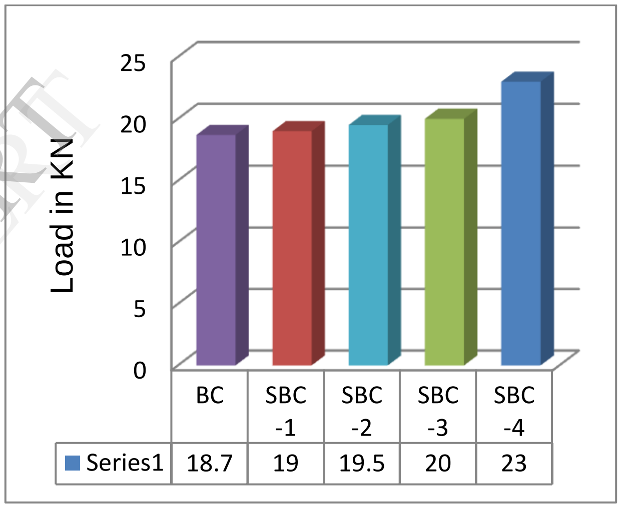
The reinforcement cages were placed in the mould and cover between cages and from provided was 20mm. M60 grade concrete mix designed 1:1.6:2.03 and water cement ratio 0.32 with HRWR. Cement mortar block pieces were used as cover blocks. Silica fume were 8.5% used for replacing of cement. HRWR were 1.25% used for replacing of water.

3.4 TESTING

Each specimen was tested under cyclic loading in the structural laboratory. The column of the test assembly was placed in a loading frame. The column was centered accurately using plumb bob to avoid eccentricity.

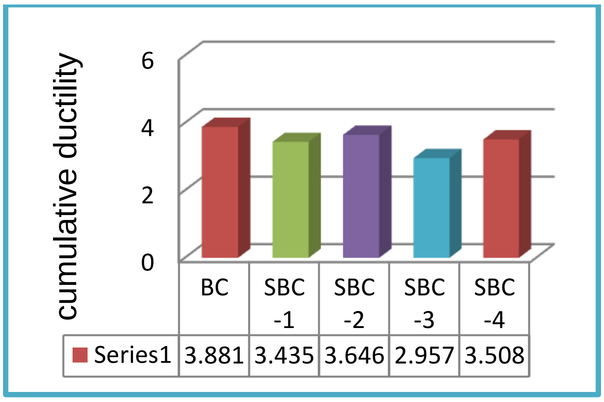
3.5 BEHAVIOR OF BEAM COLUMN

Load carrying capacity of beam column joint

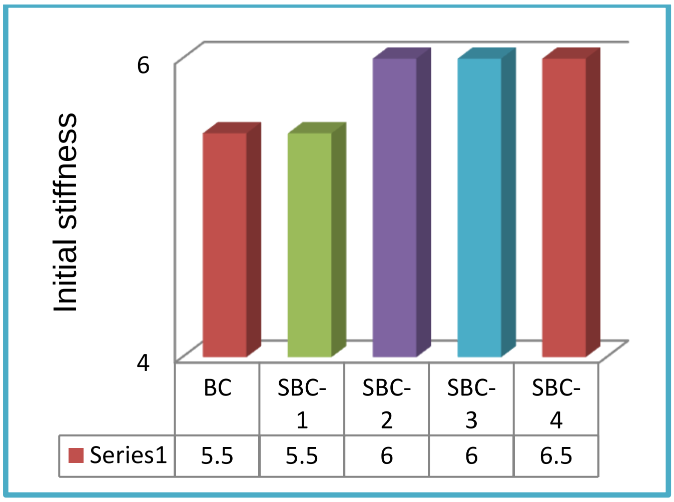


Comparison of Load carrying capacity of specimens BC, SBC-1, SBC-2, SBC-3 and SBC-4

Cumulative ductility factor



Initial Stiffness



Comparison of Result

S.NO	1	2	3
Parameters of the specimen	Load carrying capacity in KN	Cumulative ductility factor	Initial stiffness in KN/mm
BC	18.7	3.881	4
SBC-1	19	3.435	5.5
SBC-2	19.5	3.646	6
SBC-3	20	2.957	6
SBC-4	23	3.508	6.5

4. SUMMARY AND CONCLUSIONS

In this thesis, four number of Fiber reinforced high strength concrete specimens and one number of conventional specimens tested under cyclic loading and has concluded that the effective application of steel fibers in the beam column joint concrete mix results, significantly improved joint behavior under seismic loading, in particular with an increased ductility and stiffness than conventional 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, ductility and stiffness. 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 fibres influence the behavior of beam column joint by increasing the ductility characteristics and initial stiffness.

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