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Experimental Study on Beam Column Joints by Using Steel Fiber Reinforcement for Cyclic Looading

Bonguluri sudheerbabu, Ch. Srinivas
Department of civil Engineering, DITYA Engineering college, Surampalem, East godavari(dt).
bsbabu142@gmail.com,bongulurisudheerbabu@gmail.com

Abstract: This paper describes the experimental results of ten steel fibre reinforced high performance concrete (SFRHPC) exterior beam-column joints under cyclic loading. The M30, grade concrete used. Volume fraction of the fibres used in this study varied from 0 to 1% with an increment of 0.25%. Joints were tested under positive cyclic loading, and the results were evaluated with respect to strength, ductility and stiffness degradation. Test results indicate that the provision of SFRHPC in beam-column joints enhances the strength, ductility and stiffness, and is one of the possible alternative solutions for reducing the congestion of transverse reinforcement in beam column joints. Also, an attempt has been made to compare the shear strengths of beam-column joints obtained by using the models. As these models are meant for the joints in ordinary concrete, comparison was not found to be satisfactory. The moderoposed by co-workers was modified to account for the presence of high performance concrete. The proposed model was found to compare satisfactorily with the test results.

1. Introduction

Recent earthquakes in different parts of the world have revealed again the importance of design of reinforced concrete structures with high ductility. Strength and ductility of structures depend mainly on proper detailing of the reinforcement in beam-column joints. The flow of forces within a beam-column joint may be interrupted if the shear strength of the joint is not adequately provided. Under seismic excitations, the beam-column joint region is subjected to horizontal and vertical shear forces whose magnitudes are many times higher than those within the adjacent beams and columns. Conventional concrete loses its tensile resistance after the formation of multiple cracks. However, fibre concrete can sustain a portion of its resistance following cracking to resist more cycles of loading. Beam-column joints have a crucial role in the structural integrity of the buildings. For this reason they must be provided with adequate stiffness and strength to sustain the loads transmitted from beam and columns. The formation of plastic hinges in columns must be prevented since it affects the entire structure. For adequate ductility of beam-column joints, use of closely spaced hoops as transverse reinforcement was recommended in the ACI-ASCE Committee 352 report (ACI, 2002). Due to the congestion of reinforcement, casting of beam-column joint will be difficult and will lead to honeycombing in concrete (Kumar et al., 1991).

2. Materials

2.1 CEMENT : Ordinary Portland cement of 53 Grade confirming to IS 12269-1987 was used. The properties of the cement used were

(a) Fineness of cement by Sieve analysis
(b) fineness Index = 3.9 %
(c) Normal consistency = 32 %
(d) Initial setting time = 45Min 30 Secs
(e) Specific gravity=3.15
(f) Compressive strength at an age of 28 days = 38 N/mm

2.2 AGGREGATES

The properties of coarse aggregates and fine aggregates are given below

2.2.1 Coarse aggregate

10 mm maximum size broken granite metal of igneous origin was used. Specific gravity was found to be 2.65.

2.2.2 Fine aggregates

Fine river sand was used. It was dried, sieved and stored. The sand which was used falls under zone second of IS383. The specific gravity was found to be 2.60.

2.2.3 WATER

Clean water, which was free from all impurities, was used for the entire work of concrete preparation and curing

3. Mix Design Procedure

The proportioning of a concrete mixture is based on determining the quantities of the ingredients which, when mixed together and cured properly will produce reasonably workable concrete that has a good finish and achieves the desired strength when hardened. This involves different variables in terms of water to cement ratio, the desired workability measured by slump and cement content and aggregate proportions. The mix is M30 Grade. Mix design is done according to Indian standard recommended method of concrete mix design IS 10262-1982.

Stipulations for proportioning

a) Grade designation : M 30

b) Type of cement : OPC 53 grade

c) Maximum nominal size of aggregate: 12.5 mm

d) Minimum cement content : 320 kg/m^3

e) Maximum water-cement ratio : 0.45

f) Exposure condition : severe

g) Type of aggregate : crushed angular aggregate

h) Maximum cement content : 450 kg/m^3

i) Chemical admixture type : nil

Mix ratio

Cement Kg/m^3	**Fine Aggregates Kg/m^3**	**Coarse Aggregate kg/m^3**	**Water l/m^3**
450	502.2	1135.49	202.5
1	1.12	2.52	0.45

TESTING OF CONVENTIONAL BEAM-COLUMN JOINT M1

Position of Load cell	**Load (Ton)**	**Cycle III Loading**
Load cell at Top	0	0
	0.2	35.25
	0.4	56.35
	0.6	72.35
	0.8	82.5
	1	90.25
	1.2	107..65
	1.4	113.64
	1.6	135.15
Load cell at Bottom	0	0
	0.2	12.64
	0.4	19.54
	0.6	26.35
	0.8	32.65
	1	41.21
	1.2	50.64
	1.4	59.64
	1.6	68.56

4. Results and Conclusions

4.1.RESULTS OF TESTING OF BEAM-COLUMN JOINTS

The observations from the testing of Beam column joint are given in Appendix B of this report. The observations were processed and graph plotted between the load and deflections. The hysteretic Curves of the specimen have been plotted. The Energy dissipation capacity of Beam Column joints with various hybrid steel fibres.

4.1.2 Test Results of beam-column joint (M1)

From the experiment it has been found that the first crack was formed at a load of 0.6 tonne. The ultimate load that for normal concrete can carry was 1.6 tonne. The hysteretic Curves of the specimen have been plotted in Fig.5.1 respectively.

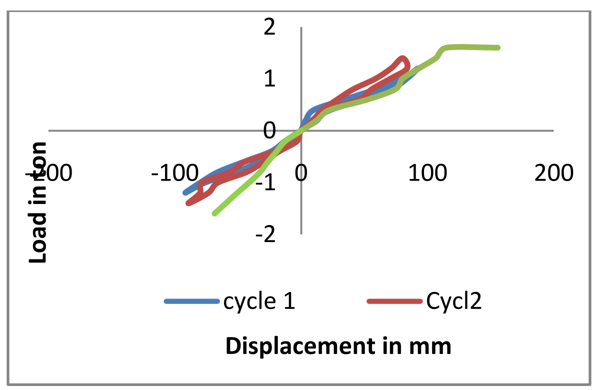

Fig 4.1 Cyclic Load - Deflection Curve for beam-column joint (M1)

The energy dissipation are calculated from the load - deflection curve is found to be 41.837kN/m.

4.2.2 Test Results of beam-column joint (M2)

From the experiment it has been found that the first crack was formed at a load of 0.8 tonne. The ultimate load for ductile detailing can carry was 1.9 tonne. The hysteretic Curves of the specimen have been plotted in Fig.s 5.2 respectively.

4.2.3 Test Results of beam-column joint (M5)

From the experiment it has been found that the first crack was formed at a load of 1.4 tonne. The ultimate load for hybrid

(CR+HE) can carry was 2.4 tonne. The hysteretic Curves of the specimen have been plotted in Fig.s 5.3 respectively.

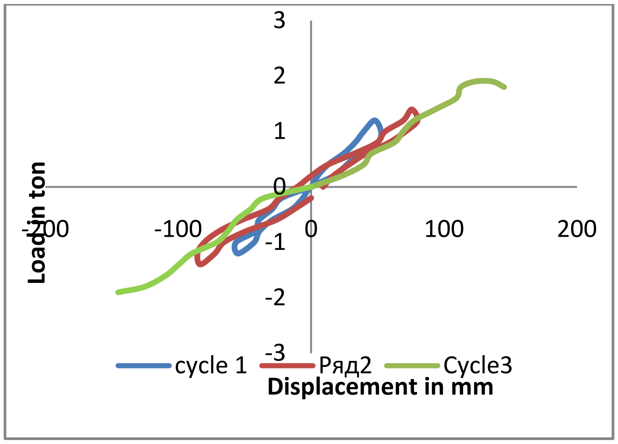

Fig 4.2 Cyclic Load - Deflection Curve for beam-column joint (M2)

The energy dissipation are calculated from the load - deflection curve is found to be 73.97kN/m.

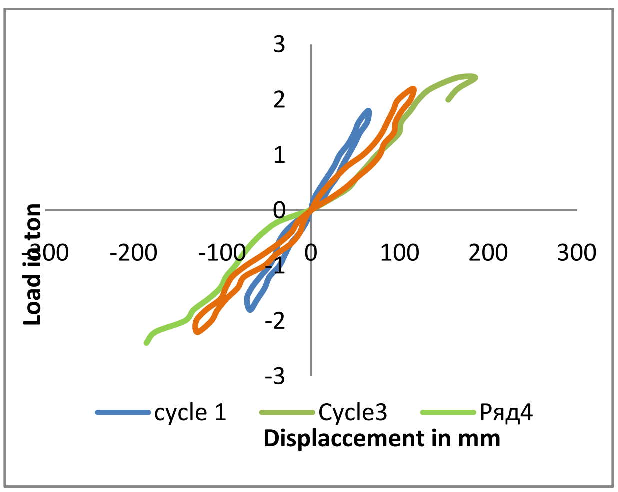

Fig 4.3 Cyclic Load - Deflection Curve for beam-column joint (M5)

The energy dissipation are calculated from the load - deflection curve is found to be 116.97 kN/m.

4.2.4 Test Results of beam-column joint (M8)

From the experiment it has been found that the first crack was formed at a load of 0.9 tonne. The ultimate load for hybrid (HE+HE) can carry was 2 tonne. The hysteretic Curves of the specimen have been plotted in Fig.s 5.4 respectively.

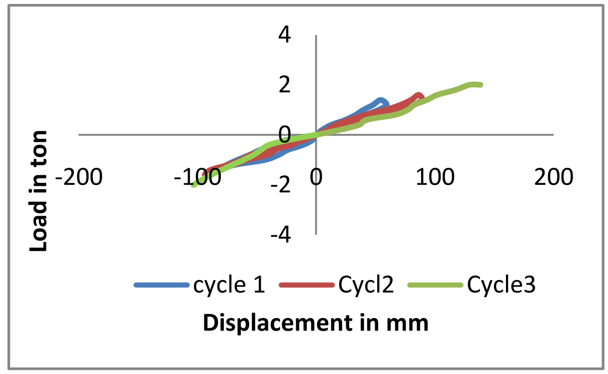

Fig 4.4 Cyclic Load - Deflection Curve for beam-column joint (M8)

The energy dissipation are calculated from the load - deflection curve is found to be 92.711kN/m.

4.3 DISCUSSIONS:

From the experiments carried out, it is observed that the use of Hybrid Steel Fibers increases the Strength energy dissipation, The increases cumulative energy dissipation is 28.3 % for non-ductile and 31.6 % for ductile reinforced concrete beam column joint strengthen by Hybrid Steelfibers.

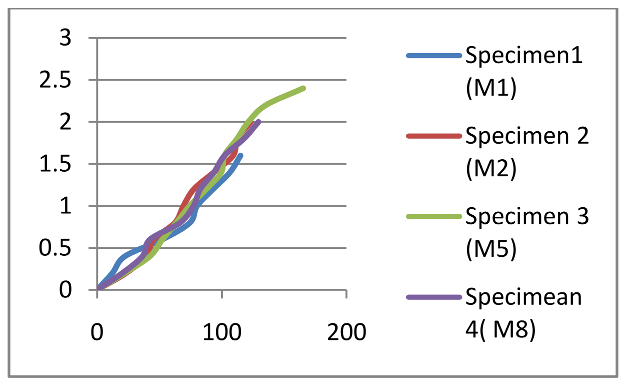

Fig 4.5 Comparison of Cyclic Load - Deflection Curve for beam-column joint

5. Conclusions

The behavior of beam column joints were studied in the present work and it has been concluded that

Based on the behavior of joints under the loads, it is concluded that the use of hybrid steel fibers gives us optimum value for exterior joints

The interaction between ultimate loads and degree of confinement are not linear. This has to be further investigated.

The Hybrid Steel fibers can be efficiently used for seismic reinforced beam column joint.

The deficiency in cumulative energy dissipation in the case of non ductile reinforced beam column joint can be made good by Hybrid Steel fibers strengthening.

The increase in cumulative energy dissipation is 28.3 percent for non ductile and 31.6 percent for ductile reinforced concrete beam column joint strengthened by Hybrid Steel fibers.

Much of experimental investigation is needed in the direction of establishing a relationship between confinement reinforcement's volume and the regionof extent to which this provided on the stiffness and ultimate load characteristics of joints.

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