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A Study on "Srength and Behaviour of Exterior Beam-Column joint by using SCC and SFRSCC"

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Abstract— The beam-column joint is one of the most critical section in the design and construction of the structure. The beam column joint subjected to cyclic loading require great care in detailing. Diagonal tension cracking is one of the main causes of failure of joint. The satisfactory performance of a beam column joint depends strongly on the lateral confinement of joint. The present study deals with the non-conventional reinforcement detailing of the beam column joint that provides inclined bars on the two faces of the joint core.The performance of beam column joint has been a research topic for many years. The anchorage length requirements for beam and column bars, the provision of transverse reinforcement, the design and detailing of the joint are the main issues. Several researches have reported their test results using SFRC in framed beam column joints. All these tests have shown the effectiveness of using steel fibers to increase the joint strength, ductility and the energy absorption capacity. Provision of high percentage of hoops leads to congestion of steel leading to construction difficulties. This difficulties can be removed by using self compacting concrete (SCC).

Index Terms— SCC, Steel Fibre, Cyclic loading, Beam-Column Joint, Cement, Fine Aggregate and Coarse Aggregate

1 INTRODUCTION

Amages in reinforced concrete structures are mainly attributed to shear force due to the inadequate detailing of reinforcement and the lack of transverse steel and confinement of concrete in structural elements. Typical failures are brittle in nature, demonstrating inadequate capacity to dissipate and absorbs inelastic energy. The beam-column joints that are subjected to reverse cyclic loading require great care in detailing. Diagonal tension cracking is one of the main causes of failure of joint. The satisfactory performance of a beam column joints depends strongly on the lateral confinement of joint. The present study deals with the non-conventional reinforcement detailing in the beam-column joint by providing inclined bars on the 2 faces of the joint core, which leads to reduction in compaction and construction difficulties due to congestion of reinforcement in the joint region. The performance of beam column joint seismic conditions has been a research topic for many years. The anchorage length requirements for beam and column bars, the provision of transverse reinforcement, the design and detailing of the beams are the main issues.

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Normal Conventional concrete has been widely used as a construction material throughout the world because of the advantages of mould ability, durability, resistance to fire and energy efficiency. However the major deficiencies in conventional concrete are it's poor tensile strength, low ductility, dimensional stability etc. Hence in order to improve the tensile properties, several new material have been developed in the recent past such as high performance concrete, high performance fiber reinforcement concrete, polymer modified concrete etc. Recently, Self compaction of fresh concrete has been recognized as a means to improve the quality and constructability of concrete infrastructure. The self compacting properties are generally achieved by high deformability of fresh concrete mix, good resistance against segregation and low slump loss. The Steel fiber reinforcement is used to increase the tensile properties in Self compacting concrete.

Concept of self compacting concrete:-

Self compacting concrete is a fluid mixture, which is suitable for placing in difficult condition and in structures with congested reinforcement without vibration. It is characterized by high powder content. The resulting concrete has an excellent surface finish. When large quantity of heavy reinforcement is to be placed in a reinforced concrete member, It is difficult to insure that formwork gets completely filled with concrete, Which is fully compacted without voids and honeycombs.

Concept of Steel fiber reinforced self-compacting concrete:-

Beam column joint is one of the most vulnerable areas in the case of reinforced concrete framed structure. The congestion of steel reinforcement in the joints often leads to poor inadequate strength and ductility of the joint. One of the possible methods of overcoming this problem is by making use of self-compacting concrete in place of usual concretes. Also from the literature it is noted that addition of steel fibers to cementitious materials improves many of the engineering properties like tensile and flexural strength, Energy absorption capacity and ductility and fracture toughness. Considering this, an attempt has been made to study the effect of steel fibers on the strength and behaviour of self-compacting concrete beam – column joints.

2 RELEVANCE/MOTIVATION

In the design and construction of structures, one of the areas is the beam column joint. In these areas, a high percentage of transverse hoops in the core of the joint are needed in order to meet the requirements of strength, stiffness and ductility factor under cyclic inelastic flexure loading. Typical failures are brittle in nature, demonstrating inadequate capacity to dissipate and absorbs inelastic energy.

The beam-column joint subjected to cyclic loading require great care in detailing. Diagonal tension cracking is one of the main causes of failure of joint. The satisfactory beam-column joint depends strongly on the lateral confinement of joint. Several researches have reported their test results using SFRC in framed beam-column joint. All these tests have shown the effectiveness of using steel fiber to increase the joint strength, ductility and energy absorption capacity. Provision of high percentage of hoops leads to congestion of steel leading to construction difficulties. This difficulties can be removed by using Self Compacting Concrete (SCC).

3 SCOPE/OBJECTIVES

- To develop Self compacting concrete satisfying the requirements of the fresh and hardened state.
- To obtain a mix design for steel fiber reinforced self compacting concrete.
- To study the behaviour of structural elements such as beam-column joints made of SFRSCC.
- To find the new way for the confinement of joint core by providing cross inclined bars.
- To develop Steel Fiber reinforcement SCC and compare the same with plain SCC.
- To evaluate the behaviour of beam column joint made up of SCC and SFRSCC under cyclic loading.

4 MATERIALS REQUIRED FOR SCC AND SFRSCC

The basic ingredients used in Self-compacting concrete mixes are practically the same as those used in the ordinary concrete. Following are the important materials used in SCC and SFRSCC.

4.1 Cement

In this experimental study, Ordinary Portland Cement of 53 grade is used. The cement that is being used in this project complies with the requirements of the I.S. code. The percentage of fines is less than 10% and the compressive strength of mortar cubes after 28 days curing has been found to be of the required value. The properties of cement are used in experiments are shown in given below -

- Specific gravity of Cement = 3.15
- Initial Setting Time of Cement = 160 min.
- Final Setting Time of Cement = 370 min.
- Percentage of Fines = 4.122%
- Normal consistency of Cement = 30%
- Compressive strength at 28 days = 53.67 Mpa

4.2 Fine Aggregate

River sand passing through 4.75 mm I.S. sieve confirming to grading zone III of IS:383-1970 is used. The properties of fine aggregate are given below-

- Fineness modulus of fine aggregate = 2.163
- Specific gravity of fine aggregate = 2.64
- Dry rodded bulk density of fine aggregate = 1590 Kg/m3
- Bulk density of loose fine aggregate = 1482 Kg/m3

4.3 Coarse Aggregate

The aggregate consist of crushed stone coarse aggregate of a maximum size of 16 mm. The properties of coarse aggregate are given below-

- Fineness modulus of coarse aggregate = 7.24
- Specific gravity of coarse aggregate = 2.78
- Dry rodded bulk density of coarse aggregate = 1600 Kg/m3
- Bulk density of loose coarse aggregate = 1494 Kg/m3

4.4 Fly ash

Fly ash is used in mix because it has cementitious property and acting as a filler material. It is important to increase the amount of pastry in SCC because it is an agent to carry the aggregates. The Fly ash is used is of residue from the combustion of pulverized coal collected by mechanical separators from the fuel gases of thermal plants.

4.5 Steel Fibre

The hooked steel fibre having diameter 0.8 mm and length 60 mm were used for the present study. The steel fibre are used in concrete to increase the tensile strength and reduces the amount of cracks. A 0.5% of volume fraction is used to obtain SFRSCC. From the experiments done by some investigators, it can be seen that the optimum volume fraction is 0.5%. Beyond this limit, there is in fact a reduction in the load carrying capacity of the beams. The strength and ductility of fibre reinforced SCC specimen was found to be a maximum in the case of specimen with volume fraction 0.5%.

4.6 Water

Potable water which satisfy drinking standards was used for the concrete mixing and curing.

4.7 Super Plasticizer

The super plasticizer was used to obtain the required workability. Super plasticizer is essential for the creation of SCC. The job of Super Plasticizer is to impart a high degree of flow ability and deformability, however the high dosages generally associate with SCC can lead to a high degree of segregation. Conplast SP 430 is utilized in this project, which is a product of FOSROC Company. Following table shows properties given by manufacturer –

- Specific gravity = 1.222
- Chloride content = Less than 0.05%
- Air entrainment = Less than 1%

5 Design of Beam_Column Joint

In Beam-column joint, the column was reinforced with 4 numbers of 10 mm diameter and the beam was provided with an equal amount of reinforcement of 2 numbers of 10 mm diameter bars at top and bottom. 6 mm diameter M.S. bars are used for transverse ties in column and stirrups in beams. The reinforcement details are shown in figure below-

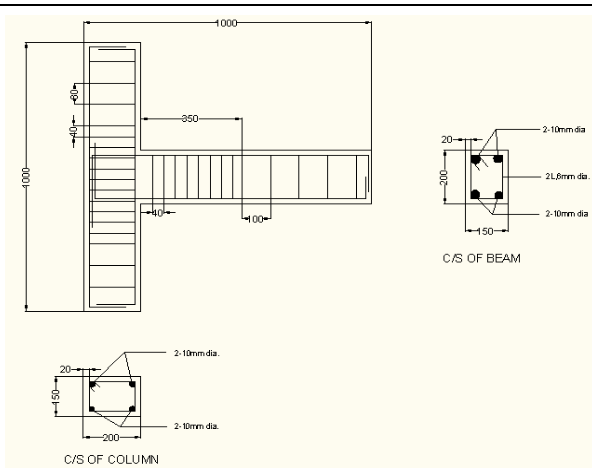

Fig.1. Shows details of specimen and reinforcement as per I.S. 13920:1993

All the specimens were tested in a Universal Testing Machine. The specimen was mounted in a vertical position. A constant axial load equal to 20% of the theoretical axial load capacity of the column was applied to keep the column in vertical position. A hydraulic jack was used to apply the load at the free end of the beam. The increment of loading selected was 1 KN. The beam was then loaded gradually up to 1KN, then unloaded to zero load and reloaded to the next increment of load and this pattern of loading was continued for each increment until failure. Other instrumentation used during test was Linear Variable Differential Transducers to record the curvature of the beam near joint.

7 Experimental Set Up

The test set up is shown schematically as below. The joint assemblages are subjected to axial load and reverse cyclic load. A constant column axial load is applied by means of hydraulic jack mounted vertically to the loading frame to simulate the gravity load on the column. One end of the column is given an external hinge support and other end is laterally restrained by a roller support to get moment free rotation at both ends. The test is load controlled and the specimen is subjected to an increasing cyclic load up to the failure.

Fig.2. Shows Experimental Set Up

8 CONCLUSION

The following conclusions are based on experimental study –

- All the specimens are failed by developing cracks at the interface between beam and column.
- In the beam column joint region of the specimens to improve the ductility by using cross inclined bars.
- To improve the strength and ductility of the joint by addition of steel fibres in the SCC.
- Deflection and curvature at peak load of SCC are significantly increased with increase of fibre content.
- By addition of steel fibre in the joint, the ultimate load carrying capacity was increased.

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