RESEARCH ARTICLE OPEN ACCESS

STRUCTURAL BEHAVIOUR OF BEAM COLUMN JOINT BY USING STAINLESS STEEL FIBER

I.ABINAYA

M.E. Structural Engineering Student, CMS College of Engineering, Namakkal.

ABSTRACT:
In RC buildings, portions of columnsthat are common to beams at their intersections are called beam-column joints. 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.Under earthquake shaking, the beams adjoining a joint are subjected to moments in the same (clockwise or counterclockwise) direction. Under these moments, the top bars in the beam-column joint are pulled in one direction and the bottom ones in the opposite direction as shown in Fig 1.1. These forces are balanced by bond stress developed between concrete and steel in the joint region. If the column is not wide enough or if the strength of concrete in the joint is low, there is insufficient grip of concrete on the steel bars. In such circumstances, the bar slips inside the joint region, and beams lose their capacity to carry load. Further, under the action of the above pull-push forces at top and bottom ends, joints undergo geometric distortion; one diagonal length of the joint elongates and the other compresses. If the column cross-sectional size is insufficient, the concrete in the joint develops diagonal cracks. Problems of diagonal cracking and crushing of concrete in the joint region can be controlled by two mean, namely providing large column sizesand providing closely spaced closed-loop steel tiesaround column bars in the joint region. The ties hold together the concrete in the joint and also resist shear force, thereby reducing the cracking and crushing of concrete.

1.1 INTRODUCTION

Providing closed-loop ties in the joint requires some extra effort. Indian Standard IS: 13920-1993 recommends continuing the transverse loops around the column bars through the joint region. In practice, this is achieved by preparing the cage of the reinforcement (both longitudinal bars and stirrups) of all beams at a floor level to be prepared on top of the beam formwork of that level and lowered into the cage. However, this may not always be possible particularly when the beams are long and the entire reinforcement cage becomes heavy.The gripping of beam bars in the joint region is improved firstby using columns of reasonably large cross-sectional size. As explained in Earthquake Tip19, the Indian Standard IS:13920-1993 requires building columns in seismic zones III, IV and V to be at least 300mm wide in each direction of the cross-section when they support beams that are longer than 5mor when these columns are taller than 4m between floors (or beams). The American Concrete Institute recommends a column width of at least 20times the diameter of largest longitudinal bar used in adjoining beam.Failures in RC buildings during earthquakes demonstrate that brittle shear failure of beam column joints lead to total collapse. In order to strengthen the weak elements, various retrofit schemes could be designed. Recently, a simplified analytical model for the joint behavior has been proposed as a viable tool for extensive parametrical studies on seismic response of the existing buildings.Thus, the size of the member should accommodate the development length considering the possibility of yield penetration.

1.2 OBJECTIVE

Generally beam column joints are weak in seismic loads and have limited ductility and little resistance to cracking. To overcome the

- deficiency of the conventional concrete, fibers have been added to prevent the concrete from corrosion by using stainless steel fibers.

- To develop a steelfibre Reinforced Concrete with the addition of stainless steel fiber.

- To design a concrete mix using stainless steel fiber reinforced concrete.

2 MATERIALS

2.1 CEMENT

Cement is the most important ingredient in concrete.Ordinary Portland cement (53 grade) conforming to IS: 1489 (Part 1) 1991 was used for casting all the specimens. The choice of brand and type of cement is the most important to produce a good quality of concrete. The type of cement affects the rate of hydration, so that the strength at early ages can be considerably influenced by the particular cement used.

2.2 FINE AGGREGATE

Clean and dry river sand available locally will be used. Sand passing through IS 4.75mm sieve will be used for casting all the specimens.

2.2.1 FOUNDRY SAND

Foundry sand is high quality uniform silica sand that is used to make moulds and cores for ferrous and non-ferrous metals castings. Foundry sand is a bi-product of the casting industry typically comprising uniformly sized sands with various additives and metals associated with the specific casting process. Sand passing through IS 4.75 mm sieve was used for casting all the specimens. Fine aggregate used are confirming to IS 383-1970.

2.3 COARSE AGGREGATE

For making SCC maximum size of aggregate is 12.5mm. The aggregate used is sound free from deleterious materials and hacking crushing strength, at least 1.5 times that of concrete. Crushed stone angular shaped aggregate is used. Ordinary blue granite crushed stone aggregate confirming to IS: 383-1970 was used as a coarse aggregate in concrete.

2.4 WATER

Water is an important ingredient of concrete as it actively participates in chemical reactions with cement to form the hydration products, calcium-silicate-hydrate (C-S-H) gel. The strength of the cement concrete depends mainly from the binding action of the hydrate cement paste gel. Water confirming to the requirements of IS: 456-2000, is found to be suitable for making concrete. It is generally stated that the water used for drinking is fit for making concrete. In this present study, casting and curing of specimens were done with the potable water, i.e., available in the college premises.

2.5 BEHAVIOUR OF EXTERIOR BEAM COLUMN JOINT

The stainless steel shall be Glenium B233, high range water reducing, super plasticizer based on polycarboxylic ether formulation. The product shall have specific gravity of 1.09 and solid contents not less than 30% by weight. Optimum dosage of Glenium B233 should be determined with trial mixes. As a guide, a dosage range of 500ml to 1500ml per 100kg of cementitious material is normally recommended.The forces in a corner joint with a continuous column above the joint can be understood in the same way as that in an exterior joint with respect to the considered direction of loading. Wall type corners form another category of joints wherein the applied moments tend to either close or open the corners. Such joints may also be referred as knee joints or L-joints. The stresses and cracks developed in such a joints are shown in Figure.

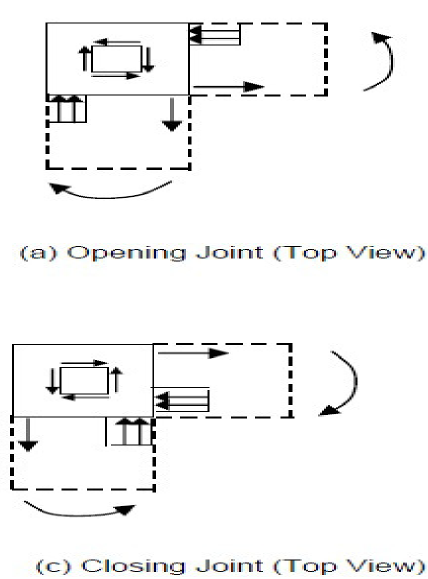


Fig 2.5 Behaviour of corner joint

2.6 FIBRE REINFORCED CONCRETE

Fiber reinforced concrete is a type of concrete that includes fibrous substance that increases its structural strength and cohesion. Fiber reinforced concrete has small distinct fibers that are homogeneously dispersed and oriented haphazardly. Fibers are natural fibres and artificial fibres, namely steel fibers, synthetic fibers, glass fibers, and polyethylene fibers. The characteristics of fiber reinforced concrete are changed by the alteration of quantities of concretes, fiber substances, geometric configuration, dispersal, orientation and concentration of fibres.

2.6.1 PRINCIPLE OF FIBER CONCRETE

Apart from its excellent properties, concrete shows a rather low performance when subjected to tensile stress. Although in constructions pure tensile forces acting on concrete elements are rather scarce, this is not only an academic problem. Even a simple concrete beam under bending conditions has zones with high compressive as well as high tensile stresses. The traditional solution to this problem is reinforced concrete, where reinforcing bars or pre stressed steel bars inside the concrete elements are capable of absorbing the appearing tensile stresses. Another rather recent development is steel fiber.reinforced concrete (FRC). By adding steel fibers while mixing the concrete, a so-called homogeneous reinforcement is created. This does not notably increase the mechanical properties before failure, but governs the post failure behavior. Thus, plain concrete, which is a quasi-brittle material, is turned to the pseudo ductile steel fiber reinforced concrete.After matrix crack initiation, the stresses are absorbed by bridging fibers, and the bending moments are redistributed.

2.6.2PROPERTIES OF FIBER REINFORCED CONCRETE

1.Reduces the plastic shrinkage

2.Improves dynamic & static properties

3.Arrests and settles crack

4.Improves durability

5.Resists abrasion & toughness

6.Reduces the thickness of concrete slabs

7.Improves ductility and deformation

2.7 TYPES OF FIBERS

There are various fibers are used in the concrete. Some of them listed below,

1.Steel Fiber

2.Glass Fiber

3.Carbon Fiber

4.Polypropylene Fiber

5.Natural Fiber

6.Basalt Fiber

7.Stainless steel Fiber

1.S

TEEL FIBER

The superior properties of structural properties of SFRC have found it an ideal material for overlays and over slab of roads, pavements, airfields and bridge decks, industrial and other flooring units those subjected to wear and tear, and attack due to chemical effects.

Glass fibers are produced commercially in three basic forms, namely, ravings, strands and woven or chopped strand mat. There are however, two main problems is the use of glass fibers in Portland cement products, namely, the breakage of fibers, and the surface degradation of the glass by the high alkalinity of the hydrated cement paste.

1. **3.CARBON FIBER**

Carbon fibers have high tensile strength and young's modulus, but also a high specific strength compared to steel and glass fibers. Increase in flexural strength, and stiffness are about 214 kg/cm2 and 21420 kg/cm2 respectively for the one percent of fiber.

2. **4.BASALT FIBER**

Basalt is common extrusive volcanic rock formed by decompression melting of the earth's mantle. It contains large crystals in a matrix of quartz. Basalt steel fibers are used to create alternative building material to metal reinforcements like steel and aluminum. Basalt mesh is used the frame work in our panels for structural reinforcements and material integrity.

3. 5.STAINLESS STEEL FIBER

It is defined as a steel alloy with a minimum of 10.5% to 11% chromium content by mass. Stainless steel does not readily corrode, rust or stain with water as ordinary steel does, but despite the name it is not fully stain-proof, most notably under low oxygen, high salinity, or poor circulation environments. It is also called corrosion-resistant steel or CRES.

Chromium produces a thin layer of oxide on the surface of the steel known as the 'passive layer'. This prevents any further corrosion of the surface. Increasing the amount of Chromium gives an increased resistance to corrosion.

Stainless steel also contains varying amounts of Carbon, Silicon and Manganese. Other elements such as Nickel and Molybdenum may be added to impart other useful properties such as enhanced formability and increased corrosion resistance.

2.8 CORROSION

Corrosion is defined as the destruction of material due to chemical reaction with the environment, and also the loss of steel due to the formation of rust. The corrosion of steel reinforcement is the de passivation of steel with reduction in concrete alkalinity through carbonation or due to chloride attack. Most material undergoes corrosion on exposure to natural environments (such as air, water, and soil) or other artificial environments (such as gases, liquids, and moisture).

2.8.1 CORROSION MECHANISM

1.The corrosion process (anodic reaction) of the metal dissolving as ions generates some electrons that are consumed by a secondary process (cathodic reaction). These two processes have to balance their charges.

2.The sites hosting these two processes can be located close to each other on the metal's surface or far apart depending on the circumstances.

3.This simple observation has a major impact in many aspects of corrosion prevention and control, for designing new corrosion monitoring techniques to avoiding the most insidious or localized forms of corrosion.

Corrosion is an electrochemical process involving the flow of charges (electrons and ions). At active sites on the bar, called anodes, iron atoms lose electrons and move into the surrounding concrete as ferrous ions. This process is called a half-cell oxidation reaction, or the anodic reaction, and is represented as:

$$2Fe \rightarrow 2Fe_{2+} + 4e^-$$

4.The electrons remain in the bar and flow to sites called cathodes, where they combine with water and oxygen in the concrete. The reaction at the cathode is called a reduction reaction.

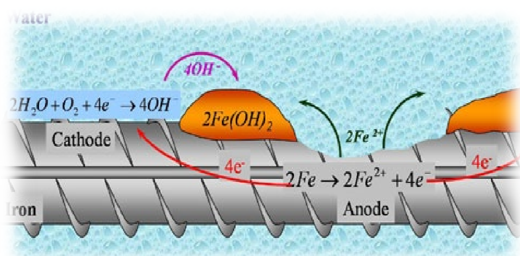


Fig 2.8.1 Corrosion Mechanism

2.9 EXPERIMENTAL INVESTIGATON

An experimental investigation has carried out on the 1/5th model of interior beam column joint with and without fiber under cyclic loading. The details of the investigation are presented in this chapter.

Prototype specimen having beam dimension of 240 x 350mm including slab thickness and column dimension of 300 x 500mm. For experimental model, the dimension of beam was 120 x 170mm without slab

S.No	Description	Cement	FA	CA	V.RATIO (%)	W/C
1	RC	1bag	1.61	2.62	-	.45
2	SFRC	1bag	1.61	2.62	1	.45
3	SFRC	1bag	1.61	2.62	1	.45
4	SSFRC	1bag	1.61	2.62	1	.45

thickness and beam length of 450mm and that column size was 120 x 230mm.Height of the column was 700mm and length of beam is 450mm.The dimension of specimen were shown in table 4.1

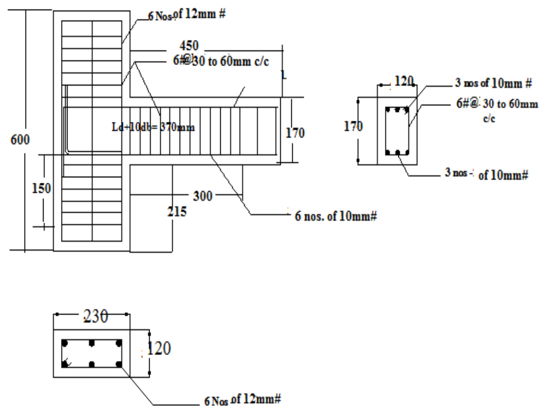
The experimental program consisted of four interior beam column specimens, namely, conventional, steel fibre reinforced concrete (0.5%), steel fibre reinforced concrete specimen (1%), and stainless fibre reinforced concrete specimen (1%). Specimen conventional represented a control specimen, detailed as per IS: 13920-1993 recommendations. Specimen SFRC (0.5%), SFRC (1%)and SSFRC (1%) were strengthen by fibers (steel fibre, stainless steel fibre)at beam column joint and detailed as per IS: 13920 recommendation.

Fig 2.7 Steel fibre

Table: 2.7.1: **Properties of steel**

3.MIX DESIGN

3.1 REINFORCEMENT DETAILS



4. GENERAL

In this chapter the test results of Marsh cone test, workability and strength studies are discussed and its influence on various constituents of SCC. And deals with the result and discussions of the experimental investigation carried out to study the mechanical properties of hybrid concrete. The basic strength properties namely compressive strength, split tensile strength and flexural strength were studied

4.1 COMPRESSIVE STRENGTH TEST

S.No	Technical Data	Details
1.	Length	38mm
2.	Diameter	0.50mm
3.	Aspect ratio	60
4.	Modulus of elasticity	210000 Mpa
5.	Tensile strength	966 - 1242Mpa

TABLE 5.1 MARSH CONE TEST RESULTS WITH DIFFERENT STEEL

SP% BY CEMENT	TIME IN SEC (T) STEEL1	TIME IN SEC (T) STEEL 2

0.1	168	175
0.3	77.30	83
0.5	50.38	58.23
0.7	38.54	47.12
0.8	38.57	41.03
0.9	38.61	40.67
1	39.31	**39.96**

5.2 SPLIT TENSILE TEST

TABLE 5.2 SPLIT TENSILE STRENGTH RESULTS

SL. NO.	MIX PROPORTIONS	SPLIT TENSILE STRENGTH		
		7-DAYS	14-DAYS	28-DAYS
1	SCC-0	2.33	3.18	4.6
2	SCC-1	2.55	3.61	4.8
3	SCC-2	2.02	2.9	4.35
4	SCC-3	1.91	2.86	4.14

The stirrups are 6mm diameter bars at 30mm c/c for distance of 2d, i.e. 300mm from the face of the column and at 60mm c/c for remaining length of the beam. The longitudinal reinforcement provided in the column was 10 No's of 8mm diameter bars distributed along the two side of column. The column confinements are 6mm diameter bars at 30mm c/c for a distance of 150mm from the face of the column and at 60mm c/c for remaining length of the column.In this method, the concrete is placed by free-falling from the top of the shaft to the bottom and is typically used for dry shaft or dry cased shaft construction only. The importance with this method is that the concrete must be directed to free-fall down the center of the cage and not make contact with the cage or shaft walls. The specifications will often specify the maximum distance concrete may free-fall. It is the most sophisticated method particularly suitable for limited space or when a large quantity of concrete is to be poured without cold joints. Pumping of concrete can be done @ 8 to 70 cubic meters per hour up to a horizontal distance of 300 meter and vertical distance of 90 meter. Pipe dia is generally 8 to 20 cm and it is made of steel., plastic or aluminum. The workability for pumped concrete should have a minimum of 40 to 100 mm of slump or 0.90 to 0.95 compacting factor. At delivery point the workability.

6.1 DISCUSSION

From studies it is found out that interaction between two fibres causes increase in 28 day compressive strength, flexural strength and split tensile strength. Single fibre reinforced concrete has lesser values of the same. Use of fibres cause reduction in workability. In order to maintain a constant slump, super plasticizer dosage has to be increased. Increase in synthetic fiber percentage causes formation of lumps in concrete which in turn reduces the strength of concrete.

CONCLUSION

7.1 GENERAL

Being a pumped concrete, the slump at the time of production should be in the range of 150 - 175 mm so that the same can be placed with in 90 minutes at a slump ranging from 90 - 120 mm.This chapter deals with the conclusion arrived from experimental investigation on hybrid fibre reinforced concrete and future investigation works.

7.2 CONCLUSION

Based on the experiment the following conclusion is drawn within the limitation of test results.

- From the above experiment work, it's concluded that when the coarse aggregate content is reduced better flow in SCC can be achieved due to the less blocking effect.
- In this study it has been found that with increase in super plasticizer dosage the workability is increased. So that the required slump value can be obtained thus full filling the criteria of EFNARC.
- The split tensile strength improved with increasing fibre percentage. Fibre combination with MIX 3 showed higher split tensile strength than other combinations.
- From this study work, it's concluded that foundry sand both show higher strength values compared to normal mix.
- From this study work, it's concluded that foundry sand can be used as a partial replacement in concrete.
- Comparison of predicted and experimental values for compressive strength split tensile strength and flexural strength were done. Only marginal variations were found.
- This helps to reduce the cost of construction and also reduce the dumping of waste materials from industries.
- It also reduces the pollution of environment, land to an extent.
- This type of SCC can be used for shortcrete works in concreting vertical walls of tanks.

REFERENCES

1. M. S. Shetty "Concrete Technology: Theory and Practice", Revised Edition (2005), S. Chand and Company Ltd.

2. EFNARC, European guidelines for self-compacting concrete, specification, production and use (May 2005).

3. ASTM C 494, (1992), "Standard Specifications for Chemical Admixtures for Concrete" Annual Book of American Society for Testing Materials Standards.

4. IS: 456-2000 "Plain and reinforced concrete – code of practice" (Third Edition), Bureau of Indian Standards, New Delhi, India.

5. IS 10262-1982. Concrete Mix Proportionating – guidelines. Bureau of Indian Standards, New Delhi.

6. Khuram Rashid1 , Prof. Dr. Muhammad Akram Tahir2 , Sana Nazir3, (2014), "*Evaluation of Concrete Compressive Strength by incorporating Used Foundry Sand*"American Journal of Engineering Research (AJER) e-ISSN : 2320-0847 p-ISSN : 2320-0936 Volume-03, Issue-02, pp-109-116.

7. Dushyant R. Bhimani, Jayesh Kumar Pitroda, Jaydev J. Bhavsar, (2013)"*Effect of Used Foundry SandandPozzocrete Partial Replacement with Fine Aggregate and Cement in Concrete*" International Journal of Innovative Technology and Exploring Engineering (IJITEE) ISSN: 2278-3075, Volume-2, Issue-4, March 2013.