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Utilization of Hybrid Fiber Reinforced Concrete for Beam-Column Joint Analysis

KEYWORDS: Hybridization, Steel Fiber, Polypropylene Fiber, Beam-Column Joint, Shear Strength, Failure pattern.

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ABSTRACT *Concrete is one of the most resourceful and environmental friendly building material. The brittle nature of concrete results in sudden unpredictable failure, by using special hybrid fiber combination of steel and polypropylene fiber whose aspect ratio are 50 and 33 respectively. The main objective of this study is to investigate the effects of hybrid fiber combination (0.50 % of steel and polypropylene fiber) at the beam-column joint of M20 concrete grade. The hybrid combination of 0.50% steel fiber and 0.50% polypropylene fiber have best performance considering the strength , energy dissipation capacity and. Also beam-column joint specimen is tested for shear strength.*

1. Introduction:

Concrete has undergone rapid and phenomenal development in past few years in India. It is most used man made product in the world, but plan concrete has two deficiencies low tensile strength and low strain at fracture. These short coming are generally overcome by reinforcing concrete. Another approach is to replace certain amount of steel reinforcement by fibers to produce fiber reinforced concrete. conventional concrete losses its tensile resistance after formation of cracks. However fiber reinforced concrete can sustain a portion of its resistance following cracking to resist more cycle of load.

The reason for using hybrid fiber is to enhance the properties of concrete by combining the benefits that each particular fiber type can impart. Appropriate combination of fiber with minimum amount of traditional reinforcing bar can lead to synergetic effects. Hybridization of fibers provide a system in which one type of fiber which is stronger and stiffer improves the first crack stress and ultimate strength and second type of fiber which is more flexible and ductile leads to the improved toughness and strain capacity in post cracking zone.

2. Research Objective:

This paper report the experimental study carried out to investigate the behavior of beam-column joint made of hybrid fiber(combination of steel and polypropylene fiber) reinforced concrete. In the present study two set (each sets contain three specimen) were tested under displacement controlled loading. The specimen were designed as per IS456:2000

Sr no.	Type of specimen	Number of specimen	Fiber proportion	
1	Ordinary concrete	1	Nil	
4	Hybrid fiber reinforced concrete	4	Steel	P.P
			0.50	0.50

Table 1: Details of the test specimen

3. Material Properties and Concrete mix:

Properties	Obtained
Specific gravity	2.85
Aggregate impact value	14%
Aggregate crushing value	17.5%

3.1. Cement:

Ordinary Portland Cement of "JP" brand of 53 grade confirming to IS: 12269-1987 was used in present study. The property of cement is shown in Table 2

Properties	Obtained
Specific gravity	3.15
Initial setting time	65 min
Final setting time	175 min
Consistency	30%

Table 2: Properties of Cement

3.2. Fine Aggregate:

Natural sand as per IS: 383-1987 was used.

Source: Sevalia, Gujarat

The properties of Fine aggregate are shown below in Table 3

Properties	Obtained
Specific gravity	2.67
Fineness modulus	2.544
Grading zone	II

Table 3: Properties of Fine Aggregate

3.3 Coarse Aggregate:

Crushed aggregate conforming to IS: 383-1987 was used.

Source: Sevalia, Gujarat

The properties of Coarse aggregate are shown below in Table 4.

20 mm Kapchi and 10 mm Grit were used.

Table 4: Properties of Coarse Aggregate

3.4 Steel Fiber:

Source: Fiber zone, Ahmedabad

The properties of fiber are shown below Table 5.

Product name:	Description
Material	Krampeharex Steel fiber

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Length	25mm ±10%
Diameter	0.5mm
Aspect ratio	50
Tensile strength (N/mm²)	1250-1550 N/mm²

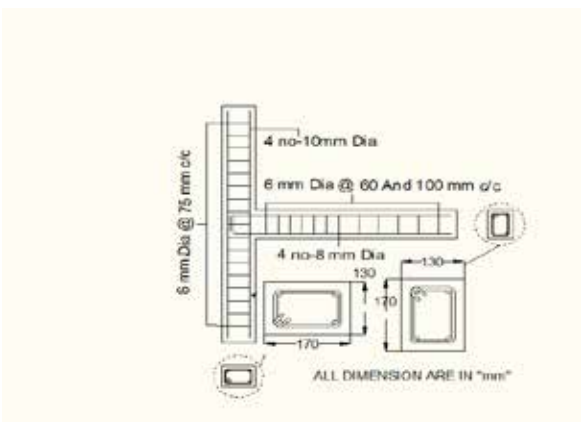
Table 5: Properties of Steel Fiber

3.5 Polypropylene Fiber:
Source: Fiber zone, Ahmedabad

The properties of fiber are shown in Table 6

Product name:	Description
Material	Polymerized - olefin.
Length	12mm ±10%
Diameter	34 (μ)
Aspect ratio	36
Tensile strength (N/mm²)	300-400 N/mm²

Table 6: Properties of Polypropylene fiber



4. Mix Proportions:
All the samples were prepared using design mix. M20 grade of concrete was used for the present investigation. Mix design was done based on I.S 10262-2009. The Table 7 shows mix proportion of concrete (Kg/m3).

Material	Quantity(Kg/m3)
Cement	330
Fine Aggregate	709.5
Coarse Aggregate	1221
Water	181.5
W/C ratio	0.55

Table 7: mix proportion of concrete

5. Experimental Investigation:
The specimen was designed for seismic load according to Indian standard. The dimension of column and beam section is 170mm x 130mm. The reinforcement details of the beam-column joint specimen are shown in fig-2. The main reinforcement provided in the beam are 8mm dia bars. The stirrups are of 6mm dia, spaced at 60mm c/c up to 2d distance and 100mm c/c in rest of length. The longitudinal reinforcement in column are 10mm dia . The stirrups are of 6mm dia spaced at 75mm c/c.

Fig :2 Reinforcement detailing of specimen

6. Test setup:
Each specimen was tested under static loading in the loading frame. The general arrangement of the experiment setup is shown in fig-3. The test was done with displacement control and specimen was subjected to displacement up to failure. By using proving ring the load was precisely recorded and the beam displacement was recorded using dial gauge.

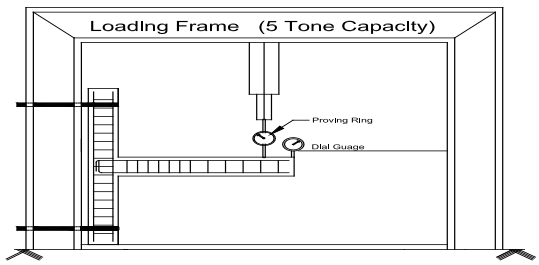


Fig :3 Schematic Diagram of Static Loading Test set-up

Fig :4 Testing of specimen

6.1 Load and Deflection measurements:
At a distance of 900 mm from the column face load was applied at beam through the hand operated screw jack. The proving ring was placed between loading point and screw jack and used to measure the applied beam forced.

7.0 Results
Ultimate load
Table 3 shows the ultimate load for the specimens. Figure 4 and Figure 5 shows the load-deflection curve of the specimens. From this figure it is evident that the specimen has maximum ultimate load of 11.62 KN. It is 3.75 KN higher than the specimen cast without fiber.

Specimen	Ultimate load.	Deflection at peak load	Compressive strength
OC.	7.88 KN	25 mm	26.3 N/mm²
H.F.C	11.62KN	45 mm	31.7 N/mm²

Table :7 Ultimate Load, Maximum Deflection at failure and Energy Dissipation Capacity

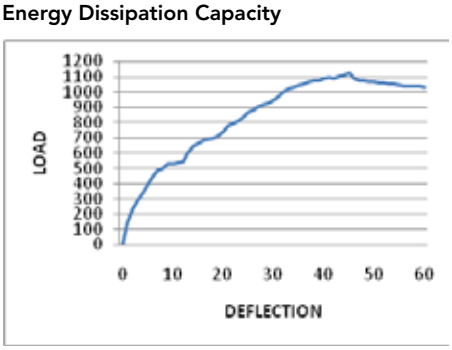


Fig :5 Load-deflection curve of hybrid specimen

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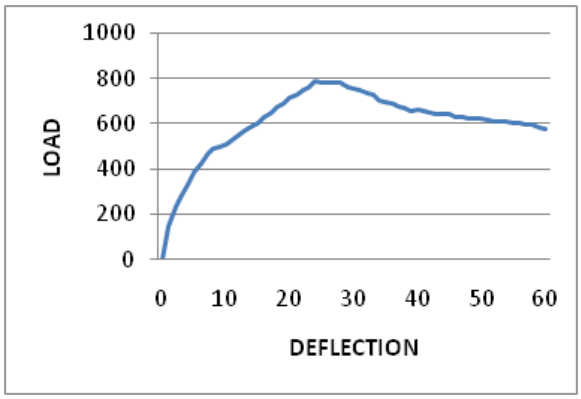

Fig :6 Load-deflection curve of ordinary specimen

8.0 conclusions

1. Hybrid fiber reinforced concrete joints have high ductility as compared to ordinary concrete joints
2. The hybrid fiber reinforced concrete joints undergo large displacements without developing wider cracks when compared to ordinary concrete joints.
3. The fibers are effective in resisting deformation at all stages of loading from first crack to failure.
4. It is possible to reduce the congestion of steel reinforcement in beam-column joint by replacing part of ties in columns by steel and synthetic fibers and thereby reducing the cost of construction.
5. The specimen-B which was formed by using hybrid fiber reinforced concrete, consisting of 0.5% of steel fiber and 0.5% of polypropylene fiber exhibited excellent strength, energy dissipation capacity and damage tolerance. It also has minor joint damage.

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