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Studying The HPFRCC Beams To Under Cyclic Loading

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Abstract: The fiber used in the concrete to increases the structural integrity of the member. It is one of the emerging techniques used in the construction industry. In this study the effective utilization of High Performance Fiber Reinforced Concrete (HPFRCC) beams has been experimental investigated. The experimental investigation has been conducted on different steel fibers (Hooked, Crimpled and Hybrid) under cyclic loading. The behaviour of HPFRCC beams are compared with the conventional beams. Totally four numbers of specimens were cast with different content of fiber concrete and compared conventional concrete. The fibers are added to the concrete by volume base replacement of concrete. The silica fume and super plasticizers were used to modify the properties of concrete. Single point loading were carried out for all the specimens and the beam specimens were subjected to cyclic loading. The load deflection behaviour of fibers is compared with the conventional concrete. The ultimate load carrying capacity, energy absorption and ductility of hybrid fiber reinforced concrete is higher than the conventional concrete by 5-10%.

Key words: Cyclic loading, ductility, high performance, fiber reinforced concrete, structural integrity

INTRODUCTION

Now a days High performance fiber reinforced concrete is used to improve the strength, stiffness, toughness, ductility and durability in the structural applications. The efficiency of HPFRCC techniques has not been effectively studied and there is less number of studies carried out to evaluate the behaviour. The high performance fiber concrete has gained wider acceptance in the construction industry. This technique is used in construction of tall and high rise buildings, long span bridges, off shore and mega structures. In the past few decades, HPFRCC has been developed based on the structural and durability aspects by the influence of cement properties, mineral admixtures and super plasticizer. High performance concrete is designed and developed to reduce the cost. The admixture used in the concrete reduces the water content which directly reduces the porosity of hydrated cement paste. The steel fiber used in this technique reduces or

Controls the crack and deflection in the concrete. In addition to the steel fiber, HPC makes the concrete extremely ductile and improves the energy absorption capacity. FRC is used to control the cracks in water retaining structures and increases the toughness in the building which reduces the abrasion when compared to other materials. FRC is used in repairs and rehabilitation of marine structures such as concrete pilling and caissons. The high performance of fiber reinforced concrete HPFRCC material consists of steel fibers, silica fume, super plasticizer, reinforcing steel and cement materials. The behaviour of HPFRCC material is studied through an experimental investigation. Totally four beams are cast with one hooked end fiber reinforced concrete beam, second crimpled fiber reinforced concrete beam, third hybrid fiber reinforced concrete beam and finally conventional high performance reinforced concrete beams tested according to the standards. All the beams subjected to cyclic load. The simply supported at both ends with concentrated point loading.

Literature review: Martinola *et al*. (2010) conducted various researches about Reinforced beams with fiber reinforced concrete. The dimensions of the beam were 4.55 m length, 500 mm depth and 300 mm width. In the self leveling mortar the strengthening material is the maximum aggregate size. The result of the study was increasing n the ultimate load by 2.15 times.

Ruano *et al*. (2014) researched about shear retrofitting. The fiber reinforced jacketing looks like an efficient method for shear strengthening of reinforced concrete beams with stirrups. Load bearing capacity depends upon the strength of the beam.

Larbi *et al*. (2006) researched about the flexural behaviour of the beams. Beams mixed with CFRP-steel rebar are able to achieve bending stiffness comparable to the beams reinforced with traditional fitness.

Spadea and Bencardino (1997) conducted experiments to find out the beahviour of fiber reinforced

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concrete beams. The most advantageous situation in which steel fibers are present in 1.2% by volume an increase of 10.15% of ultimate moment. Fiber reinforced concrete proved to be an efficient alternative to the conventional one.

MATERIALS AND METHODS

The materials used for the fabrication of beams specimens. The coarse aggregate used in the mix were 10-12 mm size in the proportion of 40-60% of volume batching. The steel bars of 8 mm reinforcement were used in the experiment which is subjected to high yield tensile strength. The super plasticizers (Cera hyperplast XR-W40) are used in the range of 0.8% of volume of cement. The silica fume is replaced with cement. It is extremely fine with particle size <1 μ and 10% is replaced. The steel fibers (hooked and crimpled) are used separately with a proportion of 30-70% by total volume of fraction 1.5%. M60 grade of concrete is used for the experimental investigation.

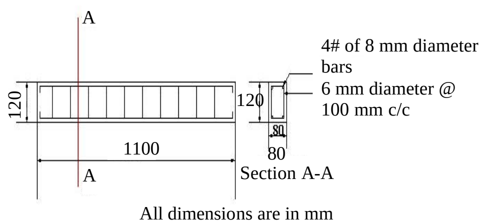

Fig. 1: Schematic diagram of reinforcement

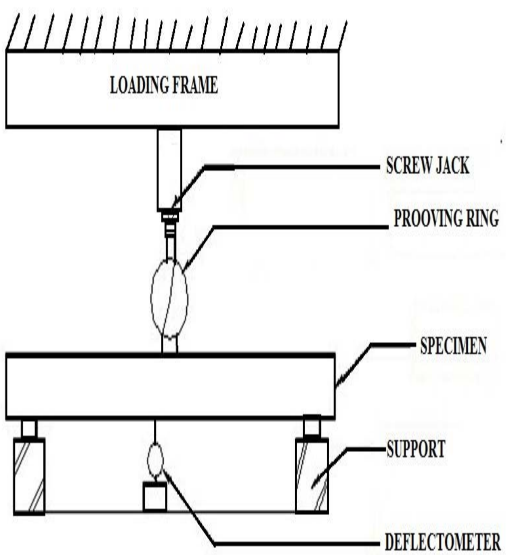

Fig. 2: Schematic experimental setup

Reinforcement details: The beams were cast with the following reinforcement details as shown in the Fig.1.

Experimental setup: The beams specimens were simply supported at both ends (roller and hinge) conditions. The specimens were subjected to central concentrated cyclic loading. Using hydraulic jack the load was applied on the specimen. The load cell and LVDT is used to measure the corresponding load vs deflection on the beam specimen. The LVDT is fixed at the bottom of the beam specimen at the mid-span. The schematic view of experimental test is presented in Fig. 2.

RESULTS AND DISCUSSION

Load deflection behaviour: The beams are subjected to cyclic loading by using screw jack. No of cycles of loading were imposed on the beam till it fails. The deflections are measured at the centre of beam by using deflectometer. In general, the beams subjected to loading will develop crack gradually with increase in load. The initial load at which the crack formed is known as first crack load. Ultimate load is defined as the maximum load at which the beam can withstand its position without any failure. When compared to conventional concrete beams, the fiber reinforced concrete will have maximum load carrying capacity

Stiffness: Stiffness is defined as the load required causing unit deflection of beam. A tangent was drawn for each cycle of the hysteresis curves at a load of P = 0.75 Pu.

Relative energy absorption capacity: When the frame is subjected to cyclic loading such as those witnessed during wind or earth quake loads some energy is absorbed. It is equal to the work done in straining and deforming the structure to the limit of deflection. The relative energy absorption capacities during various load cycles were calculated as the area under the hysteresis loops from the load versus deflection diagram. The cumulative energy absorption capacity of the frame was obtained by adding the energy absorption capacity of the frame during each cycle considered.

Ductilty factor: Ductility is one of the most important parameter to be considered in the design of structures subjected to various loading conditions. It is defined as the ability of a member undergoes inelastic deformations beyond the yield deformations without significant loss in its load carrying capacity. The ductility of a flexural

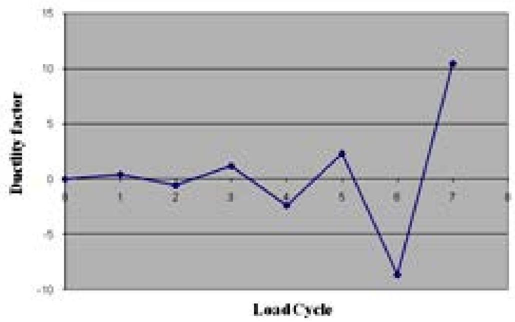

Fig. 3: Variation of ductility factor with load cycle

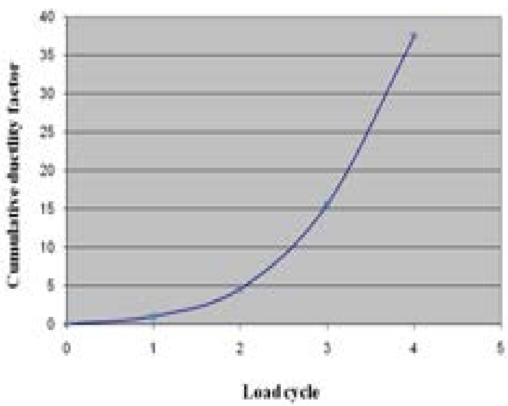

Fig. 4: Variation of cumulative ductility factor with load cycle

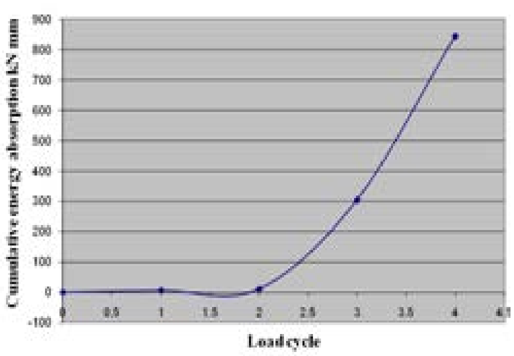

Fig. 5: Variation of cumulative energy absorption with load cycle

member can be obtained from its load-deflection curve. The ratio of maximum deflection at each cycle to the deflection at first yield is known ductility factor.

Behaviour of conventional concrete beam: Figure 3-6 are shown the behaviour of conventional concrete beam.

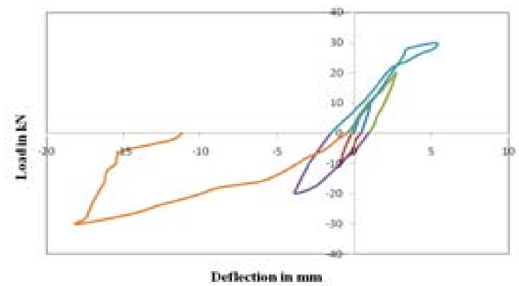

Fig. 6: Loop diagram for HPC beam

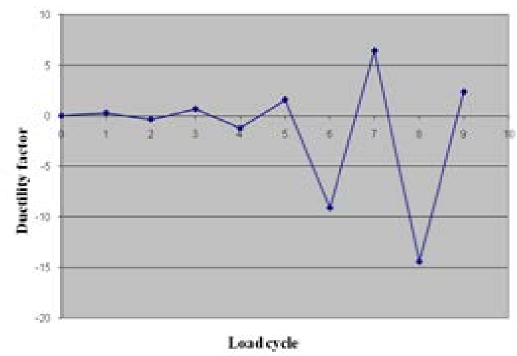

Fig. 7: Variation of ductility factor with load cycle

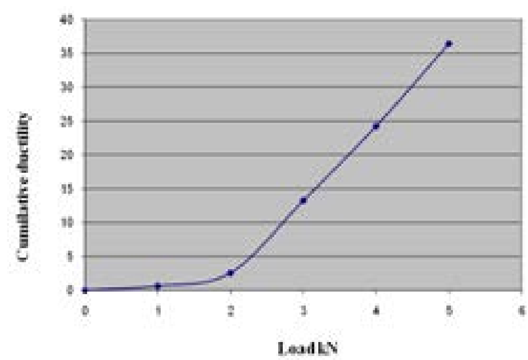

Fig. 8: Variation of cumulative ductility factor with load

Behaviour of hooked end fiber RC beam: Figure 7-10 are shown the behaviour of hooked end fiber RC beam.

Behaviour of crimpled fiber RC beam: Figure 11-15 are shown the behaviour of crimpled fiber RC beam.

Behaviour of hybrid fiber RC beam: Figure 16-18 are shown the behaviour of hybrid fiber RC beam.

Comparison of test result: In this project, the beams are compared with various parameters such as first crack load, ultimate load, cumulative ductility factor and energy

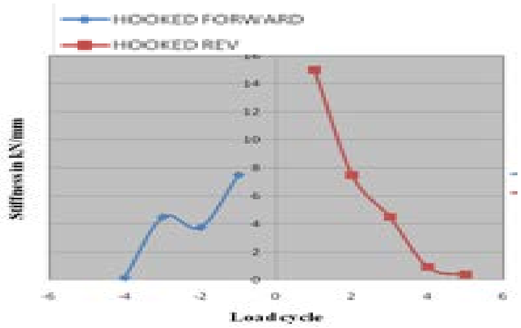

Fig. 9: Variation of stiffness with load cycle

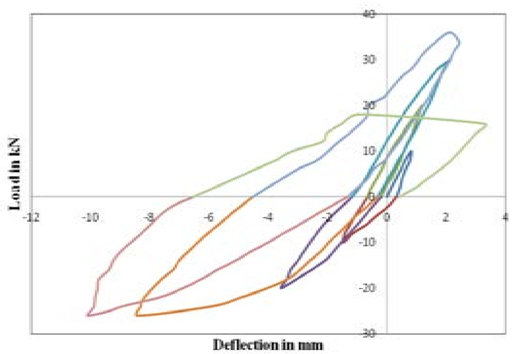

Fig. 10: Loop diagram for hooked end fibre beam

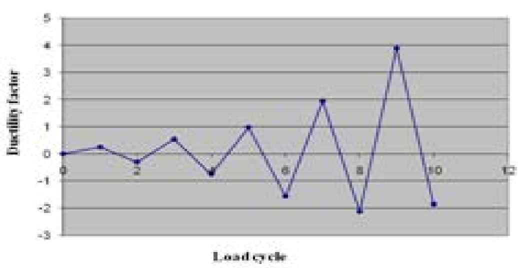

Fig. 11: Variation of ductility factor with load cycle

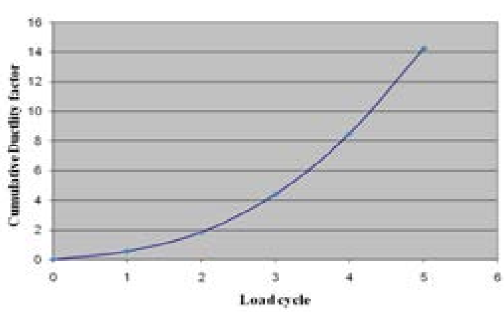

Fig. 12: Variation of cumulative ductility factor with load

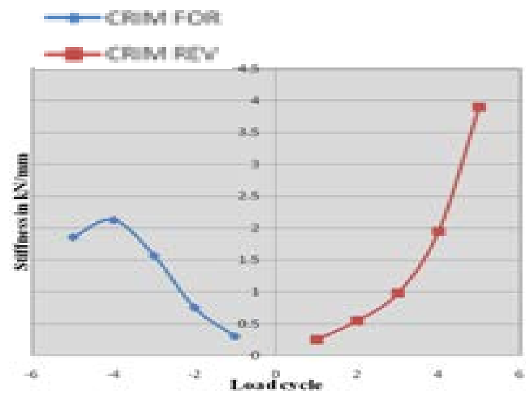

Fig. 13: Variation of stiffness with load cycle

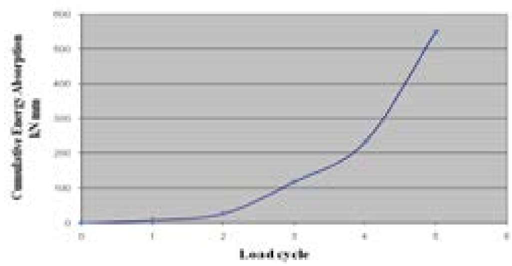

Fig. 14: Variation of energy absorption with load cycle

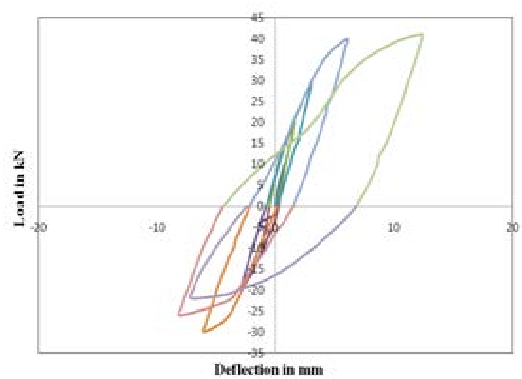

Fig. 15: Loop diagram for crimpled beam

Table 1: Comparison of test result

Parameter	HPC	H	C	H+C
First Crack Load(kN)	12	15	13.5	18
Ultimate Crack Load(kN)	22.5	27	30.25	32.25
Stiffness (kN/mm)	3.74	4.19	2.24	4.89
Ductility Factor	14.68	36.42	16.48	76.1155
Energy absorption(kN mm)	550	1213	844.5	1312.5

absorption. The different parameters of conventional RC beam, hooked end, crimpled and hybrid fiber reinforced concrete beam were shown in Table 1.

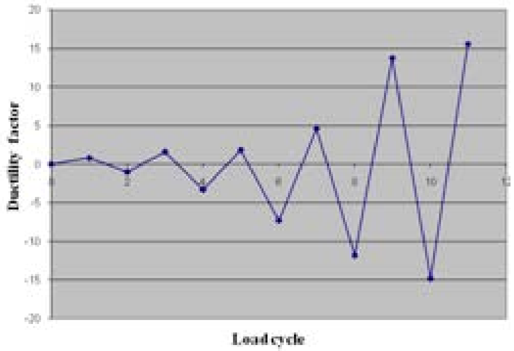

Fig. 16: Variation of ductility factor with load cycle

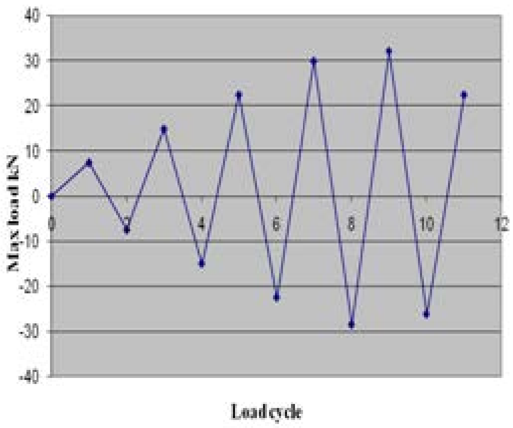

Fig. 17: Load sequence diagram

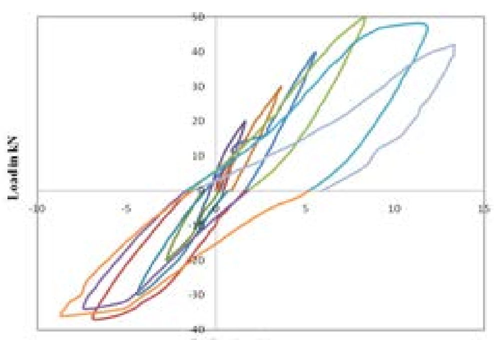

Fig. 18: Loop diagram for hybrid beam

Comparison of first crack load: The first crack load for the conventional RC beam, hooked end, crimpled and hybrid fiber reinforced concrete beam were 12, 13.5, 15 and 18 kN, respectively. The first crack load for the hybrid fiber reinforced concrete beam was 1.5 times greater than The graphical representation for the comparison of first crack load for different types of beam is shown in Fig. 19.

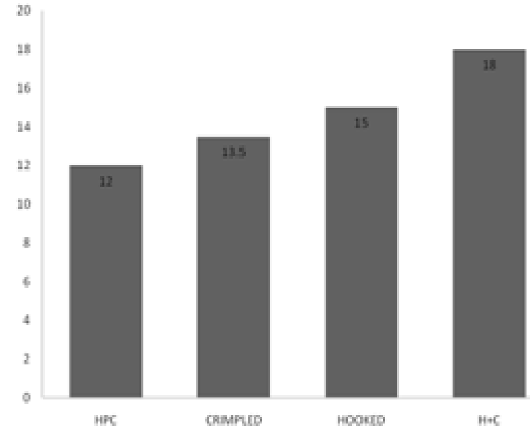

Fig. 19: Crack load for different beam

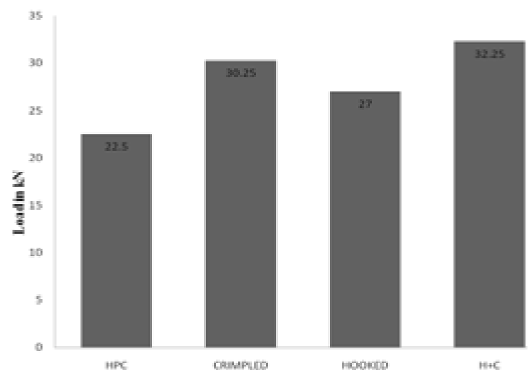

Fig. 20: Comparison of ultimate load for different beam

Comparison of ultimate load: The ultimate load carrying capacity of the conventional RC beam, hooked end, crimpled and hybrid fiber reinforced concrete beam were 22.5, 30.75, 27 and 32.25 kN, respectively. The ultimate load for the hybrid fiber reinforced concrete beam was 1.45 times greater than conventional RC beam. The graphical representation for the comparison of ultimate load for different beam is shown in Fig. 20.

Comparison of cumulative ductility factor: Ductility is defined as the ability of a member undergoes inelastic deformations beyond the yield deformations without significant loss in its load carrying capacity. The ratio of ultimate deflection to the deflection at first yield is known was ductility factor. In this experiment, hybrid reinforced concrete beam will give maximum ductility when compare to conventional concrete beam. The comparison of cumulative ductility factor for different types of beam is shown in Fig. 21.

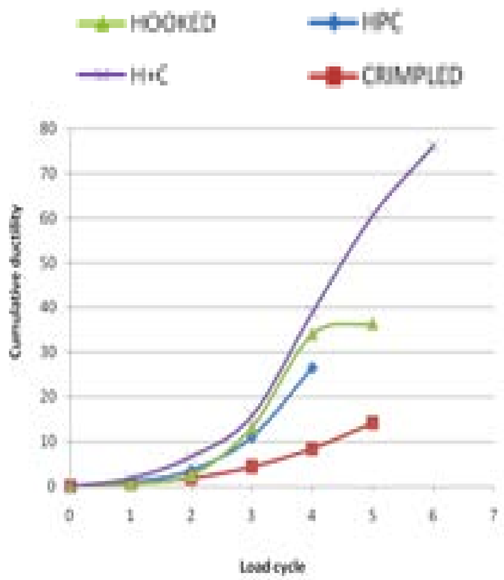

Fig. 21: Comparison of cumulative ductility factor for different types of beam conventional RC beam.

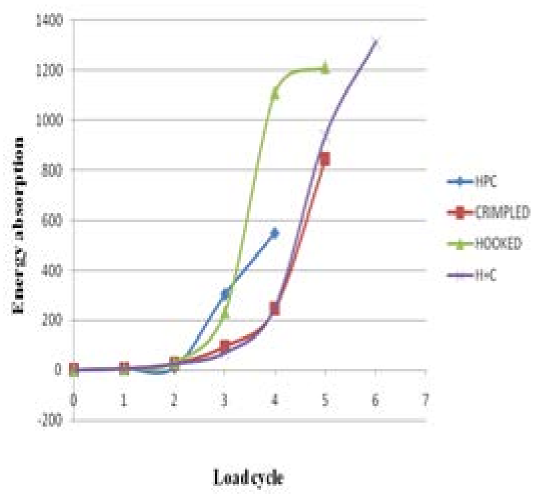

Fig. 22: Comparison of energy absorption for various beam

Comparison of energy absorbtion: The cumulative energy absorption capacity of the frame was obtained by adding the energy absorption capacity of the frame during each cycle considered in this experiment, the hybrid fiber reinforced concrete beam will give maximum energy absorption when compare to other conventional beam. The comparisons of energy absorption for various beams are shown in Fig. 22.

Fig. 23: Testing of beam

Fig. 24: Tested beam

Mode of failure: As the load increases, the number of cracks or crack width increases for each beam. The presence of fiber inside the beam will resist the crack development by forming a bridging across the crack.ie the fibers act as crack arresting material. The pictorial representation for the mode of failure for each beam is shown in Fig. 23 and 24.

CONCLUSION

The experimental investigation is carried out to study the behaviour of high performance fibre reinforced concrete beam such as hooked end, crimpled, hybrid fiber reinforced concrete beam and conventional high performance reinforced concrete beam, subjected to cyclic loading. The test results are compared with that of the conventional high performance reinforced concrete beam. It based on study parameters such as first crack load, ultimate load, cumulative ductility factor and energy absorption, we compare all the beams with that of conventional concrete beam The following observation has been inferred from the experimental programme:

- The ultimate load for the hybrid fiber reinforced concrete beam was 1.45 times greater than that of conventional RC beam
- The first crack load for the hybrid fiber reinforced concrete beam was 1.5 times greater than conventional RC beam

- The ultimate load for hybrid, crimpled and hooked end beams are about 43.33, 36.6 and 20%, respectively more than that of conventional RC beam
- The first crack load for hybrid, crimpled and hooked end beams are about 50, 12.5 and 25%, respectively more than that of conventional beam
- The ductility value of hybrid fiber RC beam is about 5.18 times than that of conventional RC beam and 2.48 times than that of hooked end RC beams
- The energy absorption of hybrid fiber RC beam is about 2.38 times than that of conventional RC beam and 1.53 times than that of crimpled RC beams
- In general the presence of steel fibers increases both ductility and energy absorption capacity which is required for earthquake poof zones
- Moreover, the presence of hybrid fiber results in higher load carrying capacity apart from enhanced ductility and energy absorption

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