International Journal of Trend in Scientific Research and Development (IJTSRD)
Volume 6 Issue 5, July-August 2022 Available Online: www.ijtsrd.com e-ISSN: 2456 – 6470

Effect of Hybrid Fiber Reinforcement on the Structural Behaviour of Beam and Beam – Column Joint

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ABSTRACT

As the fibers are distributed randomly, the strength properties of concrete are improved in all directions. A normal concrete matrix is infirm. When it is reinforced with individual fibers uniformly distributed across the whole concrete mass, it becomes strengthened; the fiber reinforced concrete mass behaves as a composite material with properties significantly different from that of normal concrete. Kinds of fibers that are commonly used in fiber Reinforced concrete are polypropylene-, nylon-, polyester-, glass-, carbon-, and steel-fibers. Application of each kind of fiber is wide-ranging. Suitable kind of fiber has to be selected for incorporation in fiber reinforced concrete to get maximum benefits. Using a single type of fiber may improve the properties of fiber reinforced concrete to a limited level only.

KEYWORDS: *Reinforced, concrete, polypropylene, nylon, polyester*

How to cite this paper: Sumit Kumar | Deeksha Shrotriya "Effect of Hybrid Fiber Reinforcement on the Structural Behaviour of Beam and Beam – Column Joint" Published in International Journal of Trend in Scientific Research and Development (ijtsrd), ISSN: 2456-6470, Volume-6 | Issue-5, August 2022, pp.1337-1339, URL: www.ijtsrd.com/papers/ijtsrd50633.pdf

IJTSRD50633

INTRODUCTION

Concrete is a popular material used in civil engineering constructions. It is well recognized that concrete shows strong resistance to compressive stress while it becomes weak under tensile stress. When a concrete member gets loaded, even at minimal loads, cracks tend to develop indicating the concrete's low tensile strength. Further under dynamic loading the cracks become widened and trigger the occurrence of failure and consequently affect the ductility property of the concrete structural member. This characteristic weakness of concrete can be overcome by providing certain reinforcement like incorporation of single type fiber in the concrete matrix. Such kind of concrete is named as Fiber Reinforced Concrete (FRC). Employing single type fiber as secondary reinforcement to the concrete will add less value to the concrete.

To address this constraint, hybrid fibers are utilized to realize balanced improvement in the performance of concrete. Hybrid fiber is a composite of two or more kinds of fibers rationally combined so as to produce synergic response and provide substantial benefits. Synergy of hybrid fiber is the sum total of potential energy derived from the individual types of fiber. Concrete prepared with the incorporation of two or more kinds of fiber blended as secondary reinforcement is commonly known as Hybrid Fiber Reinforced Concrete (HFRC).

Pooja et al. (2021). This paper gives a review on concrete by adding various types of steel fibre, glass fibre and recron fibre into the concrete and to make comparison of test results. The sudden application of the lateral load demands for a flexible structure which under goes large inelastic deformation during the load. One of the techniques to achieve the ductile structure by adding fibre in the concrete. The addition of the fibre can considerably improve the strength and ductility of structural components, resulting in a considerable energy absorption capacity. In this thesis, an experimental examination of the behaviour of internal beam-column joints under seismic circumstances is given ccording to IS: 13920–1993.

RC, SFRC, HFRC-1, and HFRC-2 are the four internal beam column joint specimens in the experimental programme.

Kumar et al. (2022) Beam–column joints are extremely vulnerable to lateral and vertical loads in reinforced concrete (RC) structures. This insufficiency in joint performance can lead to the failure of the whole structure in the event of unforeseen seismic and wind loads. This experimental work was conducted to study the behaviour of ternary blend geopolymer concrete (TGPC) beam-column joints with the addition of hybrid fibres, viz., steel and polypropylene fibres, under reverse cyclic loads. Nine RC beam-column joints were prepared and tested under reverse cyclic loading to recreate the conditions during an earthquake. M55 grade TGPC was designed and used in this present study. The primary parameters studied in this experimental investigation were the volume fractions of steel fibres (0.5% and 1.0%) and polypropylene fibres, viz., 0.1 to 0.25%, with an increment of 0.05%. In this study, the properties of hybrid fibre-reinforced ternary blend geopolymer concrete (HTGPC) beam-column joints, such as their ductility, energy absorption capacity, initial crack load and peak load carrying capacity, were investigated. The test results imply that the hybridisation of fibres effectively enhances the joint performance of TGPC.

METHODOLOGY

The physical properties of the materials used in the preparation of concrete mix for casting beam and beam-column joint specimens are discussed in detail in the following sections.

For the present experimental work Ordinary Portland Cement (OPC) of 53 grade conforming to IS: 12269 - 1987 was used. The properties of cement were determined through conducting tests as per the procedures prescribed in the Indian Standards Code IS: 4031 – 1988. The test results of cement are presented in Table 3.1.

Table 1 Physical Properties of 53 Grade Cement

Sl. No.	Test Particulars	Results Obtained
1	Fineness (%)	5
2	Initial setting time (min)	45
3	Final setting time (min)	390
4	Compressive strength at the age of 28 days(MPa)	54.06
5	Specific gravity	3.12

Control concrete HFRC 0 was prepared without adding fibers. Concrete mix HFRC 1 was formulated with the addition of 0% steel fiber and 1% PVA fiber by volume of concrete. HFRC 2 was produced with the addition of 0.25% steel fiber and 0.75% PVA fiber, by volume of concrete. HFRC 3, HFRC 4, and HFRC 5 were made with the addition of 0.5% steel fiber and 0.5% PVA fiber, 0.75% steel fiber and 0.25% PVA fiber, and 1% steel fiber and 0% PVA fiber respectively.

Table 2 Mix Identification and Proportion of Hybrid Fibers

Mix Identification	Proportion of Hybrid Fibers	
	Steel Fiber (%)	PVA Fiber (%)
HFRC 0	0.00	0.00
HFRC 1	0.00	1.00
HFRC 2	0.25	0.75
HFRC 3	0.50	0.50
HFRC 4	0.75	0.25
HFRC 5	1.00	0.00

CONCLUSION

Hybrid Fiber Reinforced Concrete by the addition of hybrid fibers for 1% volume fraction with mix proportion of 0.75% Steel fiber and 0.25% PVA fiber by volume of concrete gives highest strength at all ages.

The cube compressive strength is increased by 21.08% and cylinder compressive strength is increased by 19.05% for hybrid fiber combination at 0.75% steel fiber and 0.25% PVA fiber by the volume of concrete when compared to control concrete.

There is significant increase in the split tensile strength of HFRC mixes. At the age of 28 days, the split tensile strength of HFRC 4 mix having 0.75% steel fiber and 0.25% PVA fiber increases by 34.07%, as compared to control concrete mix (HFRC 0).

HFRC mixes show improvement in the flexural strength. The flexural strength of HFRC 4 mix (0.75% steel fiber and 0.25% PVA fiber) at the age of 28 days is 1.31 times higher

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