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Study of the Effect of Optimized Hybrid Fiber on the Strength Characteristics and Structural Performance of the Concrete

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ABSTRACT

To determine the ideal dosage amount of hybrid fibre in concrete mixtures, the strength properties including cube compressive strength, cylinder compressive strength, split tensile strength, and flexural strength were examined. By casting a beam for every mix proportion, the structural behaviour and structural performance of hybrid fibre reinforced concrete are determined. Compared to control reinforced concrete, the hybrid fibre addition with 0.75% steel fibre and 0.25% PVA fibre shown good strength characteristics and structural behaviour, according to the experimental examination. For hybrid fibre reinforced concrete, the relationship between several parameters in strength characteristics, structural behaviour, and structural performance is derived by regression analysis.

KEYWORDS: *concrete mixtures, hybrid fibre, hybrid fibre reinforced, characteristics*

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I. INTRODUCTION

High strength low carbon steel wire is woven into tiny filaments to create steel fibres. There are numerous cross-sections of steel fibres. They are easily chopped to the appropriate lengths and included into the concrete mixture to produce a homogenous composite concrete mass. It goes without saying that the fibres will be distributed randomly. A material that is isotropic is steel fibre. It enhances the concrete's tensile strength, compressive strength, shear strength, and flexural strength uniformly in all directions when it is added to the mix. Steel fibres are metallic, therefore their inclusion in concrete decreases the slump of the finished product. Plasticizers are thus added to the concrete mix to solve this drawback and improve the workability of the concrete. All admixtures, high range water reducers, hardeners, air entraining agents, curing chemicals, and coatings are compatible with steel fibres. The production method, the geometry, and the form of the cross-sectional area are used to categorise steel fibres. Steel fibres can be classified as cold drawn wire, cut sheet, melt extracted, mill cut, and modified cold drawn wire depending on the manufacturing method. Steel wires can be classified as circular, square, crescent-shaped, etc. based on the shape of the cross-sectional area. Steel fibres are divided into straight steel fibre, crimped steel fibre, hook end steel fibre, and flattened steel fibre based on how they are shaped.

II. Literature review

Lakshmi and Madhavi (2016) incorporated steel fiber and polypropylene fiber in the concrete mix and cast beam specimens and wrapped them with fiber reinforced polymer sheets. The flexural strength was determined. The behaviour of hybrid fiber reinforced concrete beams was studied. The addition of steel fiber reduced the slump value, and hence the dosage of super plasticizer was increased. A combination of steel fiber and polypropylene fiber in the proportions of 80% and 20% respectively imparted higher flexural strength to hybrid fiber reinforced concrete as compared to control concrete. The mode of failure observed was more ductile in nature than that of control concrete.

Manisha and Karjinni (2016) carried out experimental investigation the mechanical properties – strength and workability – of hybrid fiber (steel fiber + polypropylene fiber) reinforced concrete. Alccofine-1203 mineral admixture was added to the concrete mix. It was reported that the addition of hybrid fibers and mineral admixtureAlccofine-1203 influenced the flexural strength and compressive strength of concrete respectively.

Preeti and Titiksh (2016) employed certain innovative hybrid fibers in a self-compacting concrete. The hybrid fibers were produced with a blend of artificial steel fibers and natural banana fibers. It was summarized that an optimum dosage of hybrid fibers increased the overall performance of the self-compacting concrete to a significant level thus promoting that it could be used in congested places. It was found that the flexural performance was increased even during high loads thus endorsing the suitability of hybrid fiber reinforced self-compacting concrete in structures requiring high resistance

Fathima and Ipe (2016) formulated a kind of hybrid fiber consisting of steel fiber, polypropylene fiber, and glass fiber and employed it in the casting of hybrid fiber reinforced concrete column. Load was applied as axial load and cyclic lateral load. From the experimental test results it was learnt that the peak lateral load capacity and ductility ratio of FRC column specimen were increased by 40% and 33% respectively as compared to control concrete specimen.

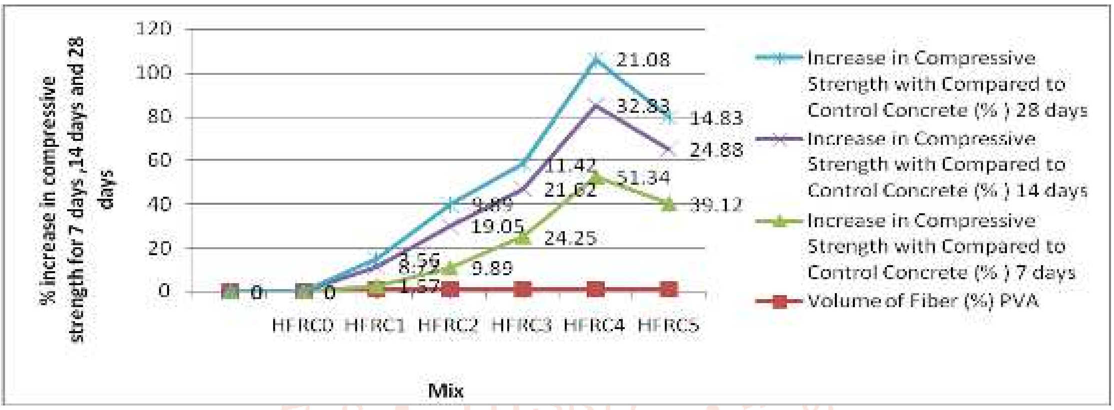
Pooja et al. (2021). This paper gives a review on concrete by adding various types of steel fibre, glass fibre and recron fibre into the concrete and to make comparison of test results. The sudden application of the lateral load demands for a flexible structure which under goes large inelastic deformation 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 according to IS: 13920–1993. RC, SFRC, HFRC-1, and HFRC-2 are the four internal beam column joint specimens in the experimental programme. The load bearing capacity, load–deflection behaviour, stiffness degradation factor, energy dissipation capacity, ductility factor, and cracking properties of internal beam column joints are investigated. Important inferences will be formed based on the experimental results, and the benefit of employing fibres in the beam column joint region will be well proven.

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. Also, an effort was made to compare the shear strength of HTGPC beam-column connections with existing equations from the literature. As the available models did not match the actual test results, a method was performed to obtain the shear strength of HTGPC beam-column connections. The developed equation was found to compare convincingly with the experimental test results.

III. Cube Compressive Strength

Table 1 Cube Compressive Strength Activity Index of Hybrid Fiber Reinforced Concrete

Sr. No	Mix Identification	Volume of Fiber (%)		Compressive Strength with Compared to Control Concrete in N/mm2			Activity Index		
		Steel Fiber	PVA Fiber	7 days	14 days	28 days	7 days	14 days	28 days
1	HFRC0	0	0	24.863	34.425	38.25	1	1	1
2	HFRC1	0 .00	1	25.253	37.427	39.6117	1.0157	1.0872	1.0356
3	HFRC2	0.25	0.75	27.321	40.983	42.0329	1.0989	1.1905	1.07145
4	HFRC3	0.5	0.5	30.892	41.868	42.6182	1.2425	1.2162	1.1142
5	HFRC4	0.75	0.25	37.627	45.727	46.3131	1.5134	1.3283	1.2108
6	HFRC5	1	0	34.589	42.99	43.9225	1.3912	1.2759	1.1483

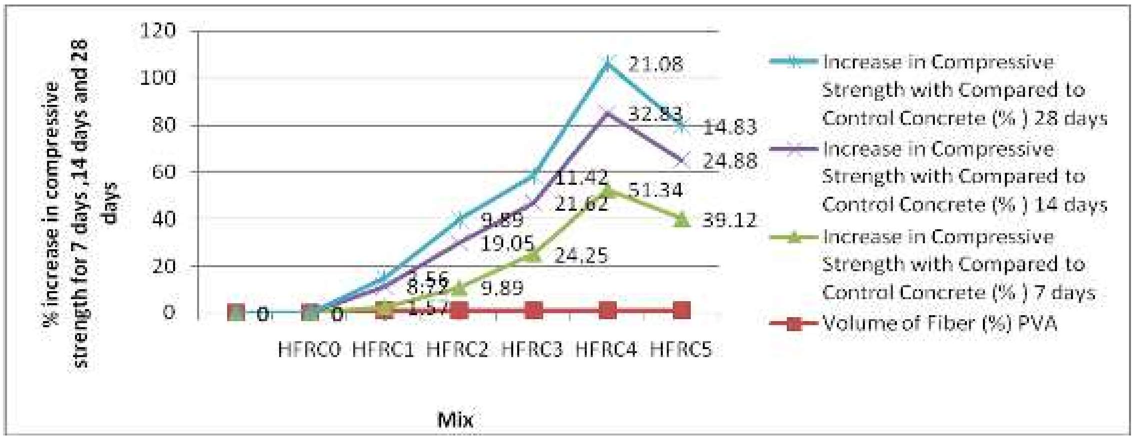


Graph 1 Activity index for Development of Cube Compressive Strength of Control Concrete and Hybrid Fiber Reinforced Concrete at the Age of 7, 14, and 28 days

The increase in cube compressive strength of HFRC mixes expressed in percentage as compared to that of control concrete mix is presented in Table 1.The percentage increase in cube compressive strength is more in respect of HFRC 4 produced with the addition of 0.75% steel fiber and 0.25% PVA fiber.

Table 2 Percentage Increase in Cube Compressive Strength of Hybrid Fiber Reinforced Concrete Compared to Control Concrete

Sl. No.	Mix Identification	Volume of Fiber (%)		Increase in Compressive Strength with Compared to Control Concrete (%)		
		Steel Fiber	PVA Fiber	7 days	14 days	28 days
1	HFRC0	0.00	0.00	0.00	0.00	0.00
2	HFRC1	0.00	1.00	1.57	8.72	3.56
3	HFRC2	0.25	0.75	9.89	19.05	9.89
4	HFRC3	0.50	0.50	24.25	21.62	11.42
5	HFRC4	0.75	0.25	51.34	32.83	21.08
6	HFRC5	1.00	0.00	39.12	24.88	14.83



Graph 2 % increase Cube Compressive Strength of Control Concrete and Hybrid Fiber Reinforced Concrete at the Age of 7, 14, and 28 days

IV. Conclusion

Based on the above study following conclusions can be made:

- 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).

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