International Journal of Science and Research (IJSR)
ISSN: 2319-7064
SJIF (2022): 7.942

Enhancing Mechanical Properties of Concrete with Glass and Polypropylene Fibers: An Experimental Approach

Abhishek C. Dholi[1], Sachin U. Pagar[2]

[1]PG Student, Department of Civil Engineering, K. C. T. LT. G. N. Sapkal College of Engineering, Nashik
Email: *abhishekdholi17[at]gmail.com*

[2]Professor, Department of Civil Engineering, K. C. T. LT. G. N. Sapkal College of Engineering, Nashik
Email: *pagarsachin2011[at]gmail.com*

Abstract: ***Recent advancements in concrete technology have led to the use of fiber reinforcement. The main purpose of fiber reinforcement is fracture control, not structural reinforcement. By properly combining two or more fiber types, hybrid fiber reinforced concrete has the ability to enhance concrete's overall qualities and produce performance concrete. The purpose of this study is to investigate the compressive and flexural strength of hybrid fiber reinforced concrete, which uses fibers made of polypropylene and Glass. Five M25 grade mixes, one standard control mix, and four hybrid fiber reinforced concrete mixes were made specifically for this purpose. To ascertain the workability of the hybrid fiber reinforced concrete. a compressive and flexural test is conducted to investigate the hybrid fiber reinforced concrete's mechanical characteristics.***

Keywords: Hybrid fiber reinforced concrete, Polypropylene fiber, Glass fiber

1. Introduction

Because concrete has a high compressive strength, it is frequently used in construction in conjunction with deformed steel reinforcing bar, or rebar. Reinforced concrete is made possible by the application of steel reinforcements only in locations where tensile or shear stress is feasible. These concrete types' improved tensile and shear resistance makes them ideal for structural elements. However, in recent years, a number of events, including terrorist acts, have exposed structures to high loading conditions, such as fire and explosions. Reinforced concrete and prestressed concrete constructions work well when stationary but poorly when subjected to heavy loads because concrete is brittle and has a low energy - absorbing capacity. Although the idea of using fibers to reinforce brittle materials is not new, research conducted since the 1960s has led to a contemporary interest in using fibers dispersed randomly to reinforce cement - based materials.

It has been demonstrated that steel fibers improve fracture toughness, ductility, and impact resistance while randomly dispersed polypropylene fibers decrease plastic cracking. The idea of polypropylene fiber concrete has given concrete building a new dimension because fibers can be premixed in a traditional way. There are very few fiber types that can enhance both fresh and hardened concrete's desirable qualities. Combining two or more fiber types is necessary to improve all of the qualities of concrete; this composite is referred to as "hybrid fiber reinforced concrete. "

Types of fibers:
Depending upon the parent material used for manufacturing fibers can be broadly classified as:

1) Metallic fibers (e. g. low carbon steel, stainless steel, galvanized iron, aluminum)
2) Mineral fibers (e. g. asbestos, glass, carbon)
3) Synthetic fibers (polyester, nylon, polypropylene, polyethylene)
4) Natural fibers (bamboo, coir, jute, sisal, wood, sugarcane bagasse)

2. Objectives of Study

The main objective of this study is to compare the compressive and flexural strength of normal concrete and hybrid fiber reinforced concrete with different percentage combination of fibers.

3. Literature Review

Kazemian and Shafei (2023) found that adding artificial fibers to concrete enhances its mechanical characteristics, even with small amounts. The researchers discovered that mixing synthetic fibers such as polypropylene and nylon improves the performance of HFRC more than using just one type of fiber. The research also found that the length - to - width ratio of fibers is important in determining the mechanical characteristics of HFRC, as longer fibers lead to increased strength. The article emphasized the possibility of enhancing concrete's mechanical characteristics with hybrid combinations of synthetic fibers, even with minimal amounts used.

Das (2020) evaluated the use of hybrid fibers in concrete to improve its mechanical and rheological properties. The authors compared the properties of control concrete with HFRC made from steel and coconut fibers in different concentrations. The results showed that HFRC had improved compressive, tensile and flexural strength compared to the control concrete, however, the addition of hybrid fibres reduced the workability of the concrete. The study suggested that the optimum concentration of hybrid fibers is 2 wt% of cement to improve the mechanical properties of HFRC.

Mehul and Patel (2013) investigated the impact of using different ratios of polypropylene fibers on the high strength concrete properties. The grade of M40 concrete mixture with the amounts of 0.5%, 1%, and 1.5% of polypropylene fibers. Experimental work was carried out by cast concrete specimens and tested at different age levels to find its impact on the tensile or flexural and compressive strength. Also, the fiber impact on plastic shrinkage cracking is considered.

Thirumurugan and Sivakumar (2013) used polypropylene fibers in concrete and studied the workability and mechanical properties. They concluded that the polypropylene fibers decrease the workability of concrete (segregation problems) but it can be overcome by the adding of "high range water reducing Admixtures". Compressive, split tensile, and flexural strength was increased with the addition of polypropylene fibers.

Bentur and Mindess (2006) concluded that hybrid steel fibers with a combination of short and long fiber enhanced the toughness and ductility of the concrete. This improvement was because short fibers in the mixture tie the micro - cracks and this resulted in enhancing the flexural or tensile strength of the composite. Meanwhile, the long fibers minimized the propagating of macro cracks and meaningfully improve the toughness and ductility of the pavement.

4. Materials

a) ***Cement:*** The Ordinary Portland Cement of 53 grade conforming to IS: 12269 - 1987 is used.

b) ***Fine Aggregate:*** The fine aggregate type used in the study was Natural sand.

c) ***Coarse Aggregate:*** Coarse aggregate are the crushed stone is used for making concrete.

d) ***Glass fibers:*** GFRC offers unique benefits over traditional concrete, from added durability to design flexibility.

Figure: Glass fibers

e) ***Polypropylene fibers:*** Polypropylene fiber was first used to reinforce concrete in the 1960s. It was first suggested as an admixture to concrete in 1965 for the construction of blast resistant buildings for the US Corps of Engineers.

Figure: Polypropylene Fibers

f) **Casting:** Casting programme consists of Preparation of moulds as per IS 10086: 1982, preparation of materials, weighing of materials and casting of cubes. Mixing, compacting and curing of concrete done according to IS 516: 1959.

Concrete mix is were prepared as per design mix and for each mix following specimens of both conventional and hybrid fiber reinforced concretes were casted.

Cubes of size 150mm X 150mm X150mm. Beams of size 150mm X 150mm X 700mm

Table 1: Proportion of Glass fibers and Polypropylene fibers

Specimen Designation	Steel fibers by weight of cement (%)	Polypropylene fibers by weight of cement (%)
NM	0	0
HFRC G0.5 PP0.5	0.5	0.5
HFRC G0.6 PP0.4	0.6	0.4
HFRC G0.7 PP0.3	0.7	0.3
HFRC G0.8 PP0.2	0.8	0.2

g) **Testings:** Compressive strength test on cube specimens and flexural strength test on beam specimens.

5. Results

Table 2: Compressive and Flexural Strength Results

Specimen Designation	Steel fibers by weight of cement (%)	Polypropylene fibers by weight of cement (%)	Compressive strength (Mpa)		Flexural strength (Mpa)
			(7Days)	(28Days)	(28Days)
NM	0	0	20.60	31.40	7.64
HFRC G0.5 PP0.5	0.5	0.5	22.20	35.35	8.26
HFRC G0.6 PP0.4	0.6	0.4	25.30	40.60	9.10
HFRC G0.7 PP0.3	0.7	0.3	27.20	43.45	9.52
HFRC G0.8 PP0.2	0.8	0.2	30.40	48.55	9.82

0% 10% 20% 30%

6. Conclusions

1) As we increase the percentage of Glass fibers compressive strength of concrete goes on increasing.
2) As we increase the percentage of Glass fibers Flexural strength of concrete goes on increasing.
3) Concrete with 0.8% addition of Glass fibers and 0.2% addition of polypropylene fibers shows good mechanical properties (Compressive Strength and Flexural).
4) As the Glass fiber percentage increases workability Decreases.

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