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Experimental Investigation On Strength Characteristics Of Fibers Reinforced High Performance Concrete

Palthya prasad[1] ,K.Geetha[2], S.Maruthi[3]

[1]M-Tech Student, Department of Civil Engineering, J B Institute of Engineering and Technology,Hyd.

[2,3]Assistant Professor, Department of Civil Engineering, J B Institute of Engineering and Technology,Hyd.

ABSTRACT

Concrete material is an essential requirement for many structural and superstructure construction. Concrete's strength is regarded as a key component because it has a long lifespan that persists even under challenging circumstances. However, the strength of standard concrete is maintained at a certain level. Still more to improve the strength of concrete is improved by producing High Performance Concrete (HPC). HPC is produced by selecting an appropriate proportion of cement, fine aggregate, coarse aggregate and admixtures. HPC's durability and strength are more excellent than ordinary concrete. This is due to the low water to cementitious material ratio and the presence of cementitious materials and chemical admixtures.In this current research paper, to incorporate high performance concrete as sustainable concrete using natural fibers. The choice of admixture has been made considering the concrete’s strength and sustainability targets. M50 grade of fibers reinforced concrete mix is prepared using cement, water, fine aggregate, coarse aggregate and admixtures varying proportion of fibers and subjected to a curing process. After the curing process, the concrete mix's compressive strength, tensile strength and flexural strength are analyzed at 3 days, 7 days, 28 days, 56 days days. Additionally, natural and synthetic fibres are used to analyse the strength of the concrete mixture.

Keywords: High Performance Concrete; fibers reinforced concrete; Compressive strength.

1.0 INTRODUCTION

In this research paper, an attempt has been made to prepare a HPC using the fiber reinforcement. Strength and durability characteristics were analyzed. This chapter covers the basic information about the HPC, concrete materials, and different types of fibers. The design of concrete structures and systems has undergone a paradigm shift with the advent of limit state design philosophy. Similarly, for concrete material, strength alone is no longer a sole criterion to evaluate the fitness of use. An ideal concrete must meet its functional goals during various stages in its lifecycle. The concrete must have good workability during its casting, attain high early strength while maturing, and remain robust and durable for its design life.

2.0 LITRATURE REVIEW

Dingqiang *et al.* (2021) constructed high-performance concrete with fiber volume reinforcement optimized design. The system based on the Andersen model, analyzed the fiber geometry and content, and reported that the hooked steel fiber showed negative results. A D-optimal design to minimize the negative results and used a wet packing density prediction model by hybrid fibers. The wet packing density of fiber was examined using an artificial neural network, and the investigation produced realistic conclusions. Finally, the authors evaluated the analysis results with experimental results of high-performance concrete. Zhang *et al.* (2021) analyzed a high performance concrete's mechanical characteristics and resistance to spalling at high temperatures. Polypropylene and polyethylene fibers of various volume percentages were used in this study. Results showed that 1.5% polyethylene fiber showed severe spalling and no improvement. However, 0.3% polypropylene fiber showed better spalling resistance against 150 °C by forming the micro cracks and increased permeability. Moreover, the varying proportions of polypropylene and polyethylene fiber had a detrimental impact on the tensile qualities of concrete but had no impact on its compressive strength. Liu *et al.* (2021) investigated the impact penetration resistance of high performance concrete using the ceramic ball, steel fiber& geo-polymer reinforcement. Results showed that the usage of ceramic balls improved the impact penetration resistance. Further, the combined effect of ceramic ball and steel fiber showed more resistance to projectile impact. Moreover, numerical simulations were performed to predict the optimal volume percentage of reinforcements and concluded that 20% ceramic ball and 1.5% steel fiber displayed optimal results. Razmi *et al.* (2017) researched the jute fiber reinforced concrete and analyzed the bending performance. Fiber dosages were varied as 1%, 3% & 5% and length was maintained as 20-mm. According to experimental findings, jute fiber reinforced concrete had superior crack resistance. Moreover, compared to plain concrete, the compressive, split tensile, and flexural characteristics of concrete were enhanced. Ibrahim *et al.* (2021) investigated the shear behaviour of a concrete beam reinforced with steel fibers and built of Recycled Concrete Aggregate (RCA). The study was performed experimentally and analyzed through finite element analysis. Beam was prepared to 150 mm × 250 mm × 2000 mm, and two numbers of 12 mm bar at the top and three numbers of 16 mm bar at the bottom were used as reinforcement. Three varieties of RCA were used viz. 0%, 30% & 70% and the steel fiber percentages were varied as 0%, 0.5%, 1% & 1.5%. Four-point bending load was performed on all the concrete beams and the criteria such as load – deflection diagram & failure load were considered to compare shear response of all beams.

3.0 MATERIALS AND METHODS

The materials are tested in the laboratory and get the physical and chemical properties. The high performance concrete was adopted for various tests. The slump cone test was used to determine the workability of concrete, andthe compressive strength, split tensile strength, and flexural strength tests were used to determine the mechanical characteristics of HPC. The best mechanical properties achieved specimens are adopted for water absorption test, modulus of elasticity test, and stress-strain behavior and durability tests also conducted, and resultsare noted. The best durability performed mixes are used to cast reinforced concretebeams and cured, tested using loading frame equipment and the experimental setupand testing procedures explained.

Table 1 Properties of 53 grade OPC

Sl.No	Test particulars	Result obtained	Requirements as per IS:8112-1989
1	Specific gravity	3.15	3.10 minimum-3.15 maximum
2	Normal consistency (%)	31	30 minimum -35 maximum
3	Initial setting time	29 minutes	30minutes
4	Final setting time	540 minutes	600 minutes
5	Compressive strength (MPa)		
	a) 3 days	26	23
	b) 7 days	37	35
	c) 28 days	55	53

Fine Aggregate

A 4.75 mm sieve characterises fine aggregates as those that pass through but are held at a 0.075 mm sieve. The fine aggregate employed inthe current investigation was river sand to Zone-II, which complies withIS: 383-2016. It was verified to be devoid of silt, clay, and natural dust, as well as clean and inert. Its physical attributes are listed in Table 3.2. The specific gravity test, fineness modulus test, bulk density test, and water absorption physical properties tests are conducted soil mechanics laboratory. Class F fly ash characteristics are listed in Table 3.3.

Table 2 Properties of fine aggregate

Sl. No	Properties	Fine Aggregate (FA)
1	Specific Gravity	2.67
2	Bulk density	1.74 gm/cc
3	Water Absorption	0.40 %
4	Fineness Modulus	2.79

Table 3 Class F fly ash characteristics

S.No	Class F fly ash Characteristics	Description
1	Composition	Low calcium oxide (<10% CaO); high SiO_2, Al_2O_3, Fe_2O_3.
2	Pozzolanic Activity	Moderate to high pozzolanic
3	Color	Light grey or tan
4	Particle Size	Finer particles compared to Class C fly ash
5	Specific Surface Area	Typically higher specific surface area
6	Water Demand	Typically higher specific surface area
7	Setting Time	May extend setting time; careful mix design required
8	Strength Development	Contributes to long-term strength; slower early strength
9	Durability	Improves resistance to sulfate attack
10	Alkali-Silica Reaction	Generally less prone to ASR; site-specific considerations

3.1High Performance Fiber Reinforced Concrete Mix Proportions

In this study, flyash and coir pith ash are used in replacement of cement as mineral admixtures. Mineral admixtures substituted 10% of the cement. The concrete also included 0.5%, 1%, 1.5%, and 2% of the weight of cement in the form of coir fiber, kenaf fiber, and polypropylene fiber, respectively. Hybrid fiber is a term used to describe the adding of two and three fibers to concrete. The mix percentage for high-performance fiber reinforced concrete shown in Table 3.

Table 4 HPFRC mix proportions

Mix	entkg/m^3	FA kg/m^3	CHA kg/m^3	Sand(kg/m^3	CA(kg/ m^3)	SP(Lit/ m^3)	Coir %
M1	478	0	0	653	1333	4.8	0
M2	430	48	0	653	1333	4.8	0
M3	430	0	48	653	1333	4.8	0
M4	430	24	24	653	1333	4.8	0
M5	430	36	12	653	1333	4.8	0
M6	430	12	36	653	1333	4.8	0
M7	430	24	24	653	1333	4.8	0.5
M8	430	24	24	653	1333	4.8	0
M9	430	24	24	653	1333	4.8	0
M10	430	24	24	653	1333	4.8	1
M11	430	24	24	653	1333	4.8	0
M12	430	24	24	653	1333	4.8	0
M13	430	24	24	653	1333	4.8	1.5
M14	430	24	24	653	1333	4.8	0
M15	430	24	24	653	1333	4.8	0

Using cubes, the compressive strength of concrete was evaluated at 3 days, 7 days, 28 days, 56 days, and 90 days. The test was performed on a 150mm x 150mm x 150mm cube in accordance with IS: 516-1959.

(a) (b)

Figure 3.8 (a) Cube specimen demoulding and (b) Cube failure mode

CONCLUSIONS:

For hybrid fibre reinforced materials, the mechanical properties including compressive strength, split tensile strength, flexural strength, stiffness, ductility, and modulus of elasticity are analysed (HPC). While compared to conventional concrete, the slump flow of concrete of M4 is high due to the presence of fly ash and coir pith ash. While mixing natural fiber with concrete, the water absorption level slightly increases compared to polypropylene. While the addition of superplasticizer enhances the flow characteristics without displaying indications of segregation, leakage, and shrinkage. Incorporating fiber with different proportions to produce hybrid fiber concrete is taken for the experimental investigation. The percentage of fiber incorporated (Coir, kenaf and polypropylene) with 0.5, 0.75 1, 1.5, 2 % by the weight of cement is taken. Cube specimen of 150x150x150 mm is cast and tested for compressive strength with and without fiber proportion as given in the mix proportion tabulation.

While adding the hybrid fiber, due to the tensile nature of the fiber, improves the flexural behaviour and reduces the crack width and ductility behaviour of concrete. The specimen with natural fiber results in reduced deflection compared to the nominal mix proportion and synthetic fiber. Somewhat hybrid fiber based concrete results in better compressive strength and the minor water absorption behaviour of concrete, which decreases the formation of pore volume after curing concrete.