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Mechanical Properties of Hybrid Coconut Fiber Reinforced Concrete

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***Abstract*—Engineering properties such as compressive strength, splitting tensile strength of normal concrete (NC), Glass fiber reinforced concrete (GFRC) and hybrid fiber reinforced concrete have been obtained from standard tests and compared. A total of 36 specimens were tested for determining the mechanical properties. The grade of concrete used was M30. The total volume of fibers was fixed as 0.5% of total volume of concrete. Six concrete mixes were selected for study. Which include control mix without fiber (NC), glass fiber reinforced concrete (GFRC) with 0.5% glass fibers, and four hybrid fiber reinforced (HFRC) concrete of glass and coconut fibers with total volume fraction as 0.5%. In general, the addition of fibers improved the mechanical properties. However the increase was found to be nominal in case of compressive strength (29.74%), significant in the case of splitting tensile strength (70%), at 0.35% glass fibers and 0.15% coconut fibers.**

***Keywords*—Concrete, Hybrid fiber reinforced concrete, coconut fibers, Glass fibers, Mechanical properties**

I. INTRODUCTION

Concrete is the most commonly used construction material. Concrete exhibits brittle behavior due to its low tensile strength. The addition of fibers, either short or continuous, changes its brittle behaviour to ductile with significant improvement in tensile strength, tensile strain, toughness and energy absorption capacities. Hybrid Fiber Reinforced Concrete (HFRC) is a combination of different types of fibers, which differ in material properties, remain bonded together when added in concrete and retain their identities and properties. In HFRC, two or more different types of fibers are rationally combined to produce a composite that derives benefits from each of the individual fibers and exhibits a synergistic response. The hybrid combination of metallic and non metallic fibers can offer potential advantages in improving the properties of concrete. The use of different types of fiber in a suitable combination may potentially improve the mechanical properties of concrete and result in synergic performance. Recently studies have been carrying out in the area of hybrid fibers but hybridization with coconut and glass fibers are limited. Hence this area is focused in this study.

I. OBJECTIVES

- To develop the proper mix proportion of M30 grade concrete.
- To study the effect of glass fiber and coconut fiber on the mechanical properties of concrete.
- To study the effect of hybrid fibers on the mechanical properties of concrete and find its optimum.

II. METHODOLOGY

- Materials required for the experiments were procured and their properties were found as per IS codes.
- Mix design of M30 grade concrete was done.
- Specimens for determining mechanical properties with control, concrete and hybrid (glass and coconut) fiber reinforced concrete mix were prepared.
- Optimum combination of fibers contents were obtained from compressive strength and split tensile strength of concrete.

III. EXPERIMENTAL PROGRAMME

The experimentation involves the comparative study of effect of coconut fibers and hybrid (glass and coconut fibers) on compressive and split tensile of M30 grade concrete at 28 days of curing. Six mixes were selected for the study. Which include control mix without fibers (NC), glass fiber reinforced concrete (GFRC) with 0.5% glass fibers and four hybrid fiber reinforced (HFRCC) concrete of coconut and glass fibers with total volume fraction as 0.5%. Designation of mixes is shown in Table-1

Table -1: Mix Designation

Sl No	Designation	Glass fiber (%)	Coconut fiber (%)
1	NC	0	0
2	GFRC	100	0
3	HFRC1	90	10
4	HFRC2	80	20
5	HFRC3	70	30
6	HFRC4	60	40

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IV. MATERIALS AND MIX PROPORTION

A. Cement:

The cement used was ordinary Portland cement 53 grade with a specific gravity 3.12. Initial and final setting time of the cement was 55 min. and 360 min respectively.

B. Fine aggregate:

M sand is used as fine aggregate. Specific gravity and fineness modulus of sand were 2.7 and 3.024 respectively.

C. Coarse aggregate:

Coarse aggregate of maximum size 20 mm from local source was used.

D. A R Glass Fiber:

A R fibers of length 13mm and aspect ratio 875 was used for the study.

E. Coconut fiber:

Locally available coconut fibers of length 300mm was used for the study

F. Superplasticizer:

Naphthalene based superplasticizer Conplast SP-430, supplied by Fosroc Chemical (India) Pvt. Ltd. was used as superplasticizer.

Fig -1 Glass fiber

Fig 2 – Coconut fiber

The mix proportion details are given in Table-2.

Table-2 Mix Proportion

Materials	Quantity (kg/m^3)
Cement	437.8
Fine aggregate	694.412
Coarse aggregate	1021.98
Water	197

V. CASTING OF SPECIMEN

For the preparation of test specimens, cement M sand, coarse aggregate, and admixture were used. Firstly mixing of dry materials was done in a drum type mixer. Super plasticizer was mixed with water and was then added to the dry materials. The required quantities of coconut and glass fibers were taken according to the volume fraction and these fibers were added during mixing. Workability of fresh concrete was checked using a standard slump cone. The freshly mixed concrete was poured layer by layer, into standard cubes of size 150mm for compressive strength test, 150 x 300 mm cylinders for splitting tensile test. Total number of layers was three. Each layer was compacted by giving 25 strokes per layer with standard tamping bar. The top surface was levelled using a smooth trowel after compaction. For each mix cubes and cylinders were cast. Each specimen was tested after 28 days of curing.

VI. TEST METHODS

The compressive strength tests were carried on concrete cubes as per IS 516:1959 (reaffirmed 2013). The cubes were loaded in the compression testing machine of 1000kN capacity until failure. The splitting tensile tests, were carried on cylinders in accordance with IS 5816: 1999 (reaffirmed 2013) and was split along its length in the Universal testing machine of 600kN capacity

VII. RESULTS AND DISCUSSION

A. Slump Test

Here slump test were carried out for finding the workability of hybrid coconut fiber reinforced concrete for each mix. Slump values obtained for different mixes are shown in Table-3. The workability of coconut fiber reinforced concrete was decreased while adding fibers and hence Conplast SP430 was used as a super plasticizer for maintaining workability.

From Table-3 it is clear that the addition of fibers decreases the workability. Among all the six mixes the slump value for 0.5% GFRC is obtained as the minimum. On hybridizing by replacing the glass fibers with coconut fiber there will be an increase in workability were observed.

Sl No	Designation	Slump Value (mm)	Degree of workability
1	NC	60	Medium
2	GFRC	58	Medium
3	HFRC1	53	Medium
4	HFRC2	57	Medium
5	HFRC3	59	Medium
6	HFRC4	58	Medium

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However for HFRGPC4 (0.3% Glass fiber + 0.2% coconut fiber) a little decrease in slump value was observed. This may be due to the balling effect of fibers at higher volume fractions.

B. Compressive strength

Table-4 gives the average values of test results of compressive strength. From Table-3 it can be noted that all the fiber reinforced concrete shows improvement in the compressive strength. HFRC (0.35% glass fibre+0.15% coconut fiber) shows the maximum increase and is about 29.74% of NC.

Table-3 Compressive Strength

MIX DESIGNATION	COMPRESSIVE STRENGTH (N/mm^2)		
	3 DAYS	7 DAYS	28 DAYS
NC	12.52	24.71	33.03
GFRC	14.56	31.64	36.12
HFRC 1	18.85	33.52	37.25
HFRC 2	19.23	36.25	39.56
HFRC 3	22.56	39.16	42.87
HFRC 4	20.36	35.12	40.36

C. Split Tensile Strength

Splitting tensile test on concrete cylinder is a method to determine the tensile strength of concrete. The test results are given in Table-4

Table-4 Split Tensile Strength

Mix Designation	Split Tensile Strength (N/mm^2)		Percentage Increases
	7 Days	28 Days	
NC	1.52	2.19	-
GFRC	3.00	3.12	42.46%
HFRC 1	3.32	3.87	76.62%
HFRC 2	3.42	3.89	77.71%
HFRC 3	3.50	4.01	83.10%
HFRC 4	3.12	3.65S	66.89%

It is clear from Table-4 that addition of fibers has a significant effect on split tensile strength. HFRC3 gives the maximum value of split tensile strength and which is more than that of GFRC.

VIII. CONCLUSION

Based on the investigation of the mechanical properties of mono and hybrid fiber reinforced concrete, following conclusions were arrived at

- The addition of fibers decreases the workability. Among all the six mixes the slump value for 0.5% GFRC is obtained as the minimum.
- The compressive strength of NC is obtained as 33.33 N/mm2. Maximum compressive strength is obtained for HFRC3 with 0.3% glass and 0.15% coconut fiber with 29.74% increase than NC.
- The split tensile strength of NC is obtained as 2.19 N/mm^2... The maximum split tensile strength was obtained for HFRC3 which is 70% more than that of NC.

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