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Study of Strength Properties of Hybrid Fiber Sisal/Polypropylene Reinforced Concrete using PPC

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Abstract*: The study focuses on the Compressive and Flexure strength performance of the blended concrete using Sisal and Polypropylene fiber at different percentage as a replacement of PPC. The cement in concrete was replaced accordingly with the percentage of 0.5%, 1% 1.5 and 2% of Sisal and 0.4%, 0.8% and 1.2% of Polypropylene fiber were added by weight of cement. Concrete cubes are tested at the age of 7 and 28 days of curing. Finally, the strength performance of Sisal and Hybrid fiber reinforced concrete is compared with the performance of conventional concrete. From the experimental investigation, it has been found that, the optimum replacement of Sisal and Hybrid fiber to cement were 1.5% and 1.9% for M40 grade.
Keywords: Sisal fiber, Hybrid fiber, Compressive and Flexure strength.

I. INTRODUCTION

Natural fiber are now considered as a suitable reinforcing material in concrete, due to their benefits, which include low cost, high strength to weight ratio, and recyclability. The use of natural fiber in concrete is recommended since several types of fibres are available locally. Sisal is hard and tough fibre. The addition of fibers and pozzolanic materials improve the mechanical properties of concrete such as flexural, compressive, tensile strength besides creep behavior, impact resistance and toughness. Experimental studies have shown that fibers and pozzolanic materials improve the mechanical properties of concrete such as flexural and compressive strength. Moreover, the addition of fiber and pozzolanic materials makes the concrete more homogeneous and isotropic. The effect of the fibers in this composite leads to an increase in the Flexure and Compressive strength of the material. . Recently, however, the development of polypropylene fiber-reinforced concrete (PFRC) has provided a technical basis for improving these deficiencies. This paper presents an overview of the effect of Sisal and polypropylene (PP) fibers on various properties of concrete in fresh and hardened state such as workability, compressive and flexural strength.

Athiappan. K et al [1]., assed the mechanical properties like compressive and split tensile strength. Super plasticizer was used to increase the workability of concrete. M40 grade of concrete was prepared. Various results are found to increase the dosage of fiber. The Flexure strength of concrete increases with the optimum percentage of sisal fiber as compared to the strength of conventional concrete. Apoorva Chandak et al. [2], carried out a comparison between the conventional concrete and self-compacting fiber reinforced concrete in which sisal fiber and hybrid fiber of banana are used. SFRC gives lower slump which means lower workability. So, in order to increase workability plasticizer was used. The addition of fiber in concrete to increase compressive and flexure strength. Abdul Rahuman et al [3]., tried to assess workability and strength properties of sisal fiber reinforced composite using OPC cement. Compressive strength increases by 50.53% after addition of 1.5% fiber for M20 mix design, where as the increase was up to 52.51% for the same percentage addition of fiber in M25. It was found that 1.5% addition of fiber will give better strength test results.

P. Sathish et al. [4], carried out research on partial replacement of OPC cement with different percentage of slag and studying different mechanical properties. The rate of increase of compressive strength of GGBS concrete was found to be slow in the initial stage. As the curing period increased strength also increased. With the increase in GGBS, the compressive, tensile and flexure strength increased but decreased at the dose of 30% replacement of cement by GGBS. Optimum dosage for partial replacement of cement by 20% ground granulated blast furnace slag and 1% of sisal fiber gave best results in enhancing mechanical properties of concrete. A. M. Alhozaimy et al. [5], the effect of collated fibrillated polypropylene fibers on compressive and flexural strength. The impact resistance of Polypropylene fiber was also assessed. . In this study, Polypropylene fiber has no significant effect on the compressive strength and toughness of conventional concrete. However, increase in the compressive strength by 17% & 23% of plain and fibrous concrete. Milind V. Mohod. [6], studied the effect of the addition of various properties of Polypropylene fibers on the properties of high strength concrete M30 and M40 mixes. Effect on properties such as compressive, tensile, and flexural strength under different curing condition was investigated. The addition of Polypropylene fiber in a concrete increased the compressive, tensile

and flexural strength, but a decrease in workability was observed when fiber content was increased. Better results were obtained at 0.5% of Polypropylene fiber.

II. EXPERIMENTAL PROGRAMME

A. Constituent Materials

The constituent materials that would be utilized in this research work are Portland Pozzolana Cement, coarse aggregates, river sand, sisal fiber, Polypropylene fiber and water. Fine aggregate belonging to Zone III having specific gravity 2.63 and Fineness modulus 2.50 have been used. Sisal and Hybrid fiber were added to the concrete mix at replacement level of 0.5%, 1%, 1.5% & 2 % and 1.9%, 2.3% & 2.7% by weight of PPC cement. The length of Sisal and Polypropylene fiber used in concrete was 30 and 12 mm which gave good results. Physical properties of Sisal and Polypropylene fiber is given below in Table - 1.

Table – 1: Physical properties of Sisal and Polypropylene Fiber

PHYSICAL PROPERTIES	SISAL FIBER	POLYPROPYLENE FIBER
Tensile Strength (MPa)	610-720	550-700
Young's modulus (GPa)	9-24	3.5-6.8
Elongation at Break (%)	2-3	21
Density (g/cm^3)	1.34	0.91g/cm^3

B. Mixture Proportion

Saturated surface dry coarse aggregate, natural fine aggregate, cement, water and super plasticizer amount for each cluster concrete having different proportion of Sisal (0.5, 1, 1.5 & 2%) and Polypropylene fiber (0.4, 0.8 & 1.2%) were used. The optimum percentage of Sisal fiber 1.5% by weight of cement was used. This optimum percentage of Sisal fiber used was fixed. adding different percentage of Polypropylene fiber i.e 0.4, 0.8 and 1.2 was used to make hybrid Sisal/Polypropylene fiber reinforced concrete.

C. Mix Proportioning For Hybrid Fibre Reinforced Concrete

For developing Hybrid reinforced concrete mix the sisal fiber content was kept constant at 1.5% in all the mix proportions of HFRC and Polypropylene fiber percentage was varied at 0.4%, 0.8%, and 1.2%. The mix proportioning of hybrid fiber reinforced concrete is shown in Table – 2.

Table – 2: Mix Proportioning For Hybrid Fibre Reinforced Concrete

Mix. Group	Cement Content Kg/m^3	w/c	Water Content Kg/m^3	Hybrid fibre Replacement (%)		Fine Aggregate Kg/m^3	Coarse Aggregate Kg/m^3		Super Plasticizer @ 1.2% by weight of cement Kg/m^3
				Sisal fibre	Polypropylene fibre	River Sand	20 mm	10 mm	
N	450	0.38	170.50	0	0	595.60	885.42	354.17	5.46
$HN_{0.4}$	441.45	0.38	170.50	6.75	1.8	595.60	885.42	354.17	5.46
$HN_{0.8}$	439.65	0.38	170.50	6.75	3.6	595.60	885.42	354.17	5.46
$HN_{1.2}$	437.85	0.38	170.50	6.75	5.4	595.60	885.42	354.17	5.46

D. Testing

Various tests were conducted to evaluate the effect of Sisal fiber and Hybrid fiber (Sisal + Polypropylene) on compressive and flexural strength test. Sisal 0.5%, 1%, 1.5% and 2% and Polypropylene fiber 0.4%, 0.8% and 1.2% was used as partial replacement by weight of cement. In this paper, the result analyses of compressive and flexural strength were discussed. Comparisons between conventional concrete, Sisal and Hybrid fiber (Sisal + Polypropylene) reinforced concrete has been done on the basis of experimental tests conducted.

III. RESULTS AND DISCUSSION

A. Effect on Workability

The consistency of Sisal fiber and Hybrid fiber reinforced concrete for each mixed group has been determined using the slump test in accordance with IS: 1199-1959. The test results for the workability of Sisal and Hybrid fiber reinforced concrete mix at varying replacement percentages are shown in **Table 3.**

Table – 3: Slump Values for Hybrid fiber reinforced Concrete Mix

Mix Group	**Hybrid fiber percentage (%)**		**Slump (mm)**
	Sisal fibre	**Polypropylene fiber**	
C	0	0	75
$HN_{1.9}$	1.5	0.4	60
$HN_{2.3}$	1.5	0.8	51
$HN_{2.7.}$	1.5	1.2	40

For concrete mix having hybrid fiber, the slump was also decreasing with the addition of Hybrid fiber as shown in Table – 3. Observation during mixing and casting showed that despite decrease in the slump, the workable mix was achieved at 1.9% replacement but above this percentage, concrete mix became little harsh at2.3% and 2.7% replacement level. However, some difficulty in finishing was experienced in case of casting of Hybrid fiber reinforced concrete mix **$HN_{2.3}$** and $HN_{2.7}$ as concrete mix became harsh.

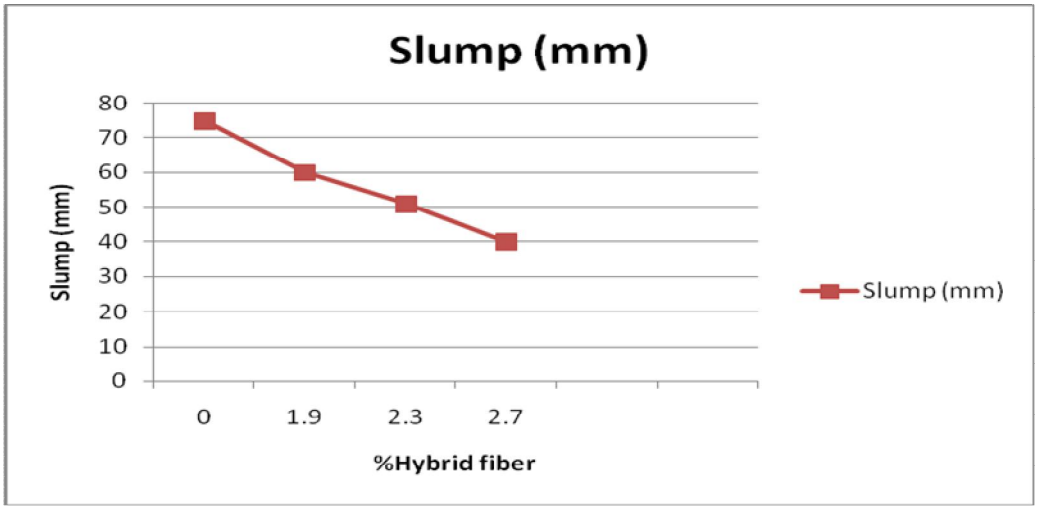

Fig 1: Variation of Slump value of Hybrid fiber reinforced concrete

B. Effect on Compressive Strength

The compressive strength of Sisal and Hybrid (Sisal + Polypropylene) fiber reinforced concrete were taken and compared with conventional concrete. The specimens of size 150x 150 x150 mm were cast and tested for its compressive strength at 3 different curing periods which is 7 and 28 days as given in Table 4.4. The results obtained from the tests are represented as under in tabular and graphical form

Table – 4: M40 grade Compressive Strength of Hybrid fiber reinforced concrete

Mix Group	Hybrid fiber percentage (%)	Compressive strength (N/mm^2)	
		7 days	28 days
N	0	32.88	49.33
$HN_{0.4}$	1.9	40.44	54.22
$HN_{0.8}$	2.3	37.33	51.11
$HN_{1.2}$	2.7	33.44	49.66

Table - 4, shows the variation in the compressive strength of Hybrid fiber reinforced concrete with the increase in Polypropylene fiber percentage and constant percentage of sisal fiber in all hybrid mix at 7 days and 28 days. It can be inferred that compressive strength of Hybrid fiber reinforced concrete increased at 1.9%. However, the increase in compressive strength at replacement percentage of 2.3% and 2.7% which is less than as compared to replacement percentage of 1.9%.

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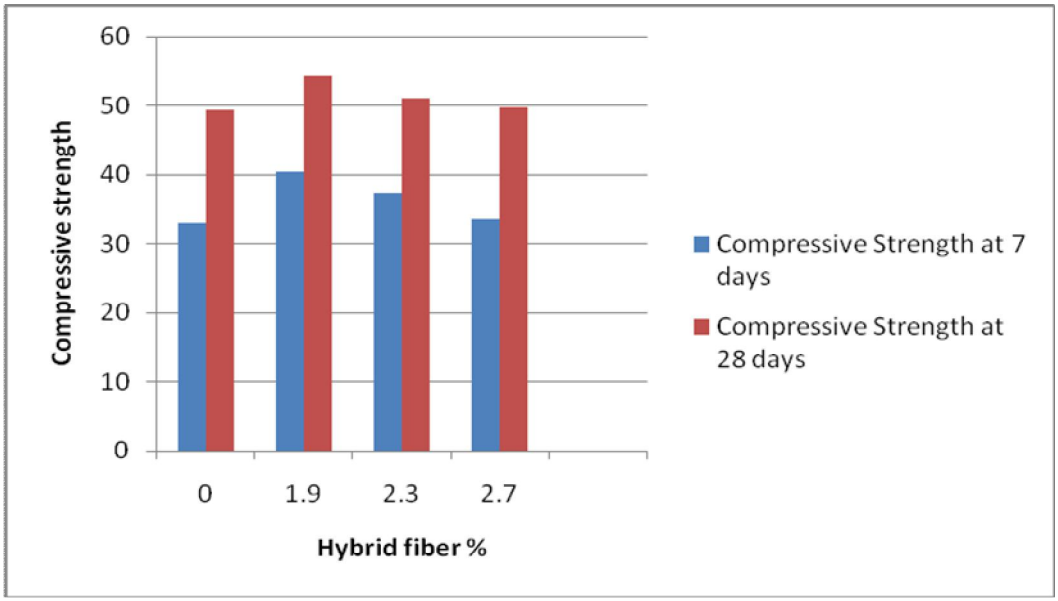

Fig 2: Variation of Compressive strength of Hybrid fiber reinforced concrete 7 and 28 days

From Fig 2, it could be seen that with an increase in the percentage of hybrid fiber (sisal + Polypropylene) compressive strength increases at both 7 and 28 days. The maximum compressive strength 40.44 N/mm^2 and 54.22 N/mm^2 at 7 and 28 days was obtained at 1.9% fiber content. The increase of compressive strength up to 1.9% and then a decrease in compressive strength could be seen at 2.7 % addition of Hybrid fiber.

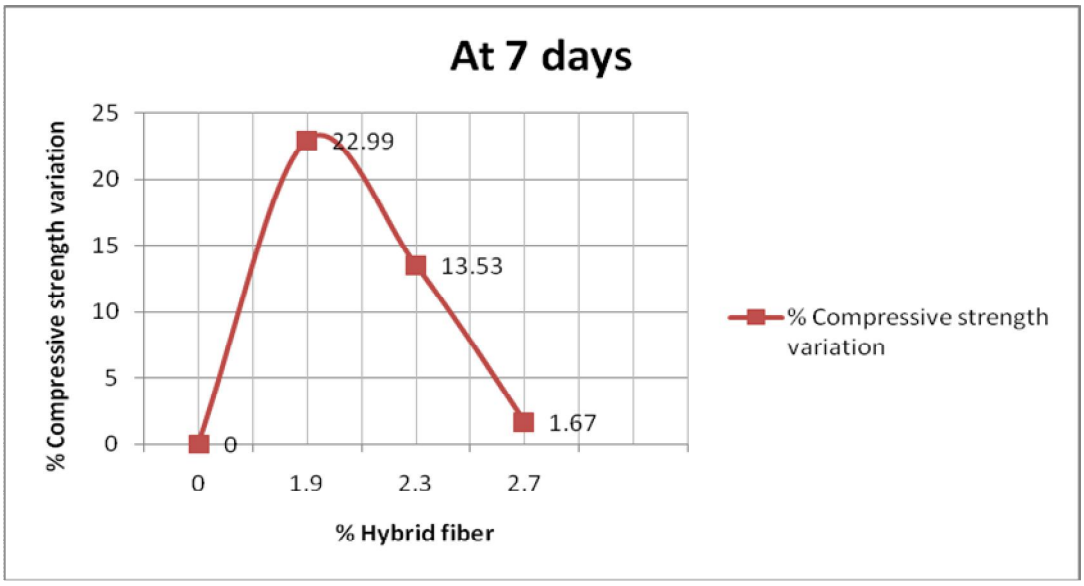

Fig 3: Percentage of Compressive strength variation in Hybrid fiber reinforced concrete at 7 days

From Fig 3, it could be seen that with an increase in the percentage of Hybrid fiber compressive strength increase at 7 days. The maximum compressive strength of 22.99% was obtained at 1.9% fiber content. However, the increase in compressive strength for replacement percentage of 2.3% and 2.7% were 13.53% and 1.67%, which is less than as compared to compressive strength at replacement percentage of 1.9%.

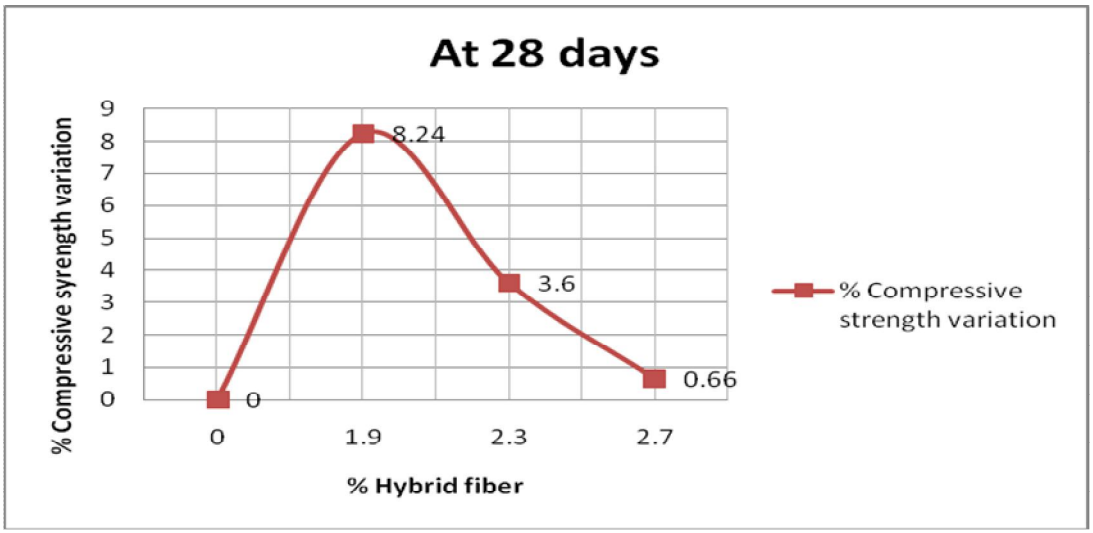

Fig 4: Percentage of Compressive strength variation of Hybrid fiber reinforced concrete at 28 days

From Fig 4 similarly, it could be seen that with an increase in the percentage of Hybrid fiber compressive strength increases at 28 days. The maximum compressive strength of 8.24% was obtained at 1.9% fiber content. However, the increase in compressive strength at replacement percentage of 2.3% and 2.7% were 3.6% and 0.66%, which is less than as compared to compressive strength at replacement percentage of 1.9%

C. Effect on Flexure Strength

Flexural strength is a measure of the tensile strength of concrete. It is a measure of an un-reinforced concrete beam or slab to resist failure in bending. Test results of Flexural strength test at the age of 7 and 28 days are given in Table 5.

Table – 5: M40 grade Flexure Strength of Hybrid fiber reinforced concrete (Beam 500×100×100mm)

Mix Group	Hybrid fiber Percentage (%)	Flexure Strength (N/mm^2)	
		7 days	28 days
N	0	5.56	6.84
$HN_{0.4}$	1.9	6.52	7.64
$HN_{0.8}$	2.3	6.04	6.92
$HN_{1.2}$	2.7	5.68	6.88

Table – 5, given that Flexure strength of Hybrid fiber reinforced concrete increase with increase in the percentage of Polypropylene and constant sisal fiber up to 2.7% at 7 and 28 days. It can be inferred that flexure strength of Hybrid fiber reinforced concrete increased at 1.9%. However, the increase in flexure strength at replacement percentage of 2.3% and 2.7% which is less than as compared to replacement percentage of 1.9%.

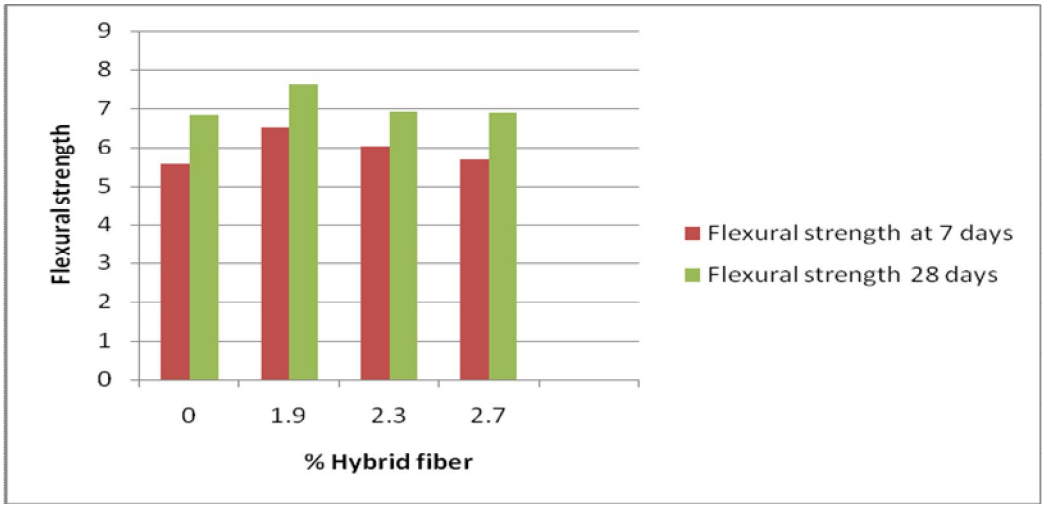

Fig 5: Variation of Flexure strength of Hybrid fiber reinforced concrete

From Fig 5, it could be seen that with an increase in the percentage of Hybrid fiber (sisal + Polypropylene). Flexure strength increases at both 7 and 28 days. The maximum Flexure strength 6.52N/mm^2 and 7.64N/mm^2 at 7 and 28 days was obtained at 1.9% fiber content. The increase in Flexure strength up to 1.9% and then a decrease in strength could be seen at 2.7 % addition of Hybrid fiber.

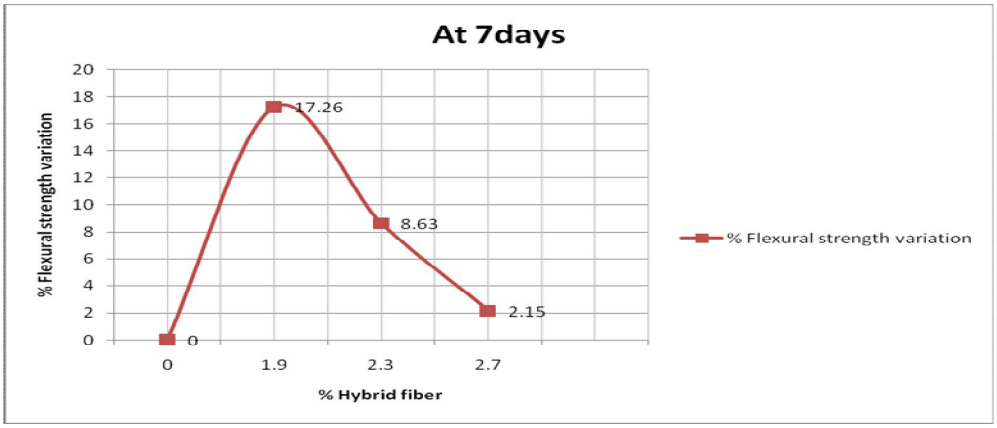

Fig 6: Percentage of Flexure strength variation of Hybrid fiber reinforced concrete at 7 days

From Fig 6, it could be seen that with an increase in the percentage of Hybrid fiber flexure strength increases at 7 days. The maximum flexure strength of 17.26% was obtained at 1.9% fiber content. However, the increase in flexure strength for replacement percentage of 2.3% and 2.7% were 8.63% and 2.15%, which is less than as compared to compressive strength at replacement percentage of 1.9%.

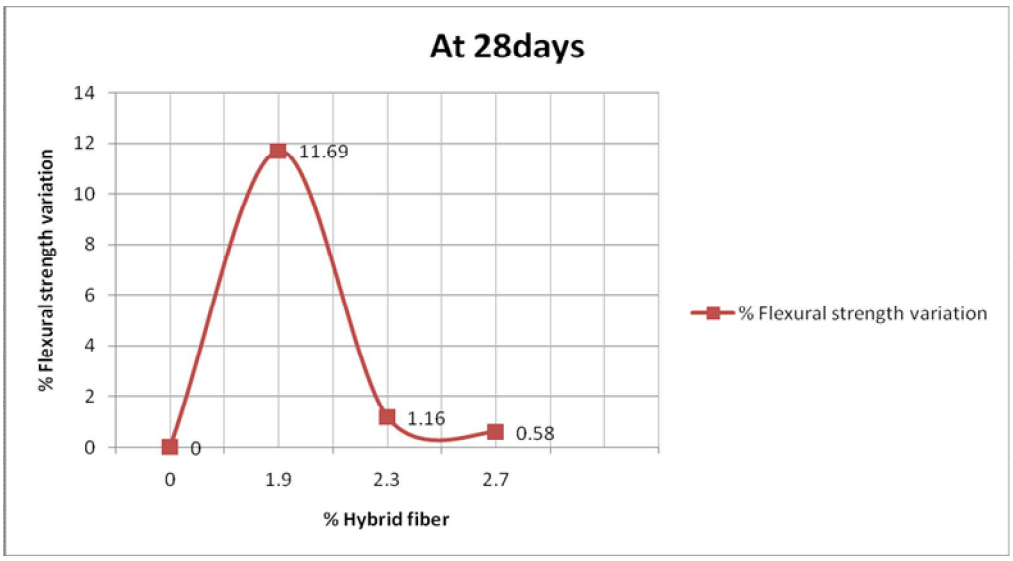

Fig 7: Percentage of Flexure strength variation of Hybrid fiber reinforced concrete at 28 days

From Fig 7, it could be seen that with an increase in the percentage of Hybrid fiber flexure strength increases at 28 days. The maximum flexure strength of 11.69% was obtained at 1.9% fiber content. However, the increase in flexure strength for replacement percentage of 2.3% and 2.7% were 1.16% and 0.58%, which is less than as compared to compressive strength at replacement percentage of 1.9%.

IV. CONCLUSIONS

From the results and analysis of this experimental work, carried out, the following conclusions were arrived:

A. The study suggests that there has been decrease in the workability on the addition of Sisal and Hybrid fiber. With the increase in percentage of fiber content, continuous decrease in workability was observed.

B. The harshness in the concrete mix was observed on addition of Sisal and Polypropylene fibers.

C. In the present experiment, the length of Sisal and Polypropylene fiber used in concrete was 30 and 12 mm which gave good results.

D. The optimized percentage of Sisal and Hybrid fiber were 1.5% and 1.9% (1.5+0.4) at which maximum value for compressive and flexure was obtained as compared to other percentages of Sisal and Hybrid fiber.

E. Compressive and Flexure strength were increased for Sisal fiber reinforced concrete at 1.5% of fiber content by weight of cement and decreased at 2%.

F. The increase of compressive strength of Sisal fiber reinforced concrete at 7 and 28 days was 17.57% & 7.19% at 1.5% and similarly, the increase in Compressive strength for Hybrid fiber reinforced concrete was 22.99 & 8.24% at 1.9% as compared to conventional concrete at 7 and 28 days respectively.

G. The increment of Flexure strength of Sisal fiber reinforced concrete at 7 and 28 days was 14.38 & 8.18% at 1.5% and similarly, the increment in Flexure strength for Hybrid fiber reinforced concrete was 17.26% & 11.69% at 1.9% as compared to conventional concrete at 7 and 28 days respectively.

H. The optimized percentage of Sisal and Hybrid fiber were 1.5% and 1.9% at which maximum value for compressive and flexure was obtained as compared to other percentages of Sisal and Hybrid fiber.

V. LIMITATIONS OF THE STUDY

There are some limitations related to present study which the researcher had not been taken in to account. These limitations were as follows:

A. In the present study, the experimental program was not carried out by varying length of hybrid fibers.

B. Pre-treatment of fibers with chemicals may behave in a different manner with concrete mix and may have same or different impact on the strength parameters.

C. Sisal fiber is not readily available in northern part of India. It was procured from Chennai

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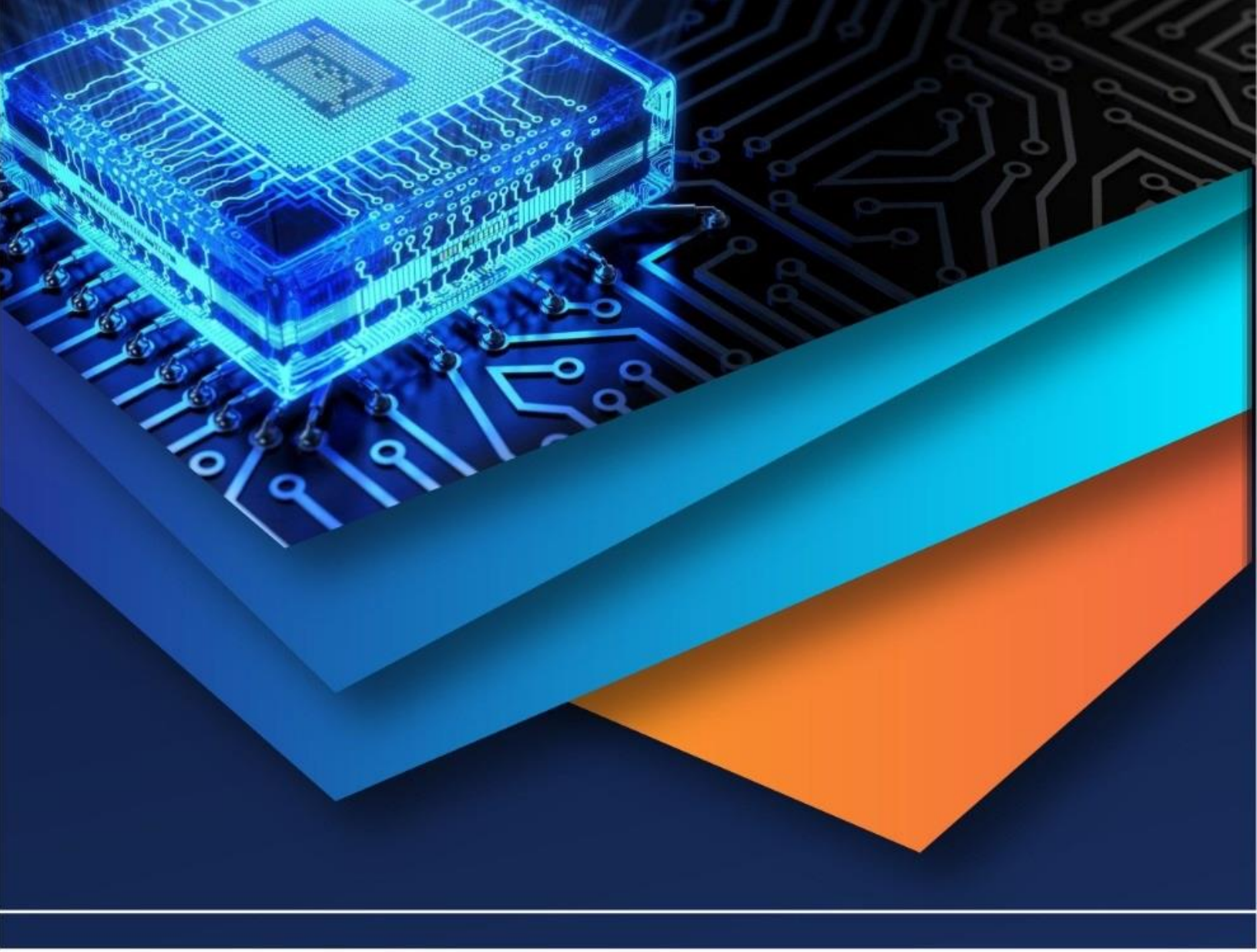

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