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Experimental Study on Composite Concrete RC Frame Structure using Sisal Fibre

P. Vanmathi[1], A. Dharani[2]

[1]PG Student (Structural Engineering), [2]Assistant Professor,
[1,2]Civil Department, Paavai Engineering College, Pachal, Tamil Nadu, India

ABSTRACT

This project aims to compare the mechanical properties of Sisal fiber in the improvement of load carrying capacity of concrete structure in different layers. Beams and columns may be strengthened in flexure through the use of sisal fiber bonded to their tension zone using epoxy as a common adhesive. Due to several advantages of sisal fibre wrapping over conventional techniques used for structural repair and strengthening. In our project is study about load carrying capacity of an RCC frame wrapped with sisal fiber. An experimental study is to predict the maximum load carrying capacity, deflection of the composite RCC structure. Finally the results are compared with conventional framed structure, which is suitable for strength and rehabilitate the concrete structure.

KEYWORDS: Sisal fibre, Fibre, RC Frame, Composite Structure and Sisal Fibre Composite

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I. INTRODUCTION

CONCRETE

Concrete is a composite material that consists of a cement paste within which various sizes of fine and course aggregates are embedded. It contains some amount of entrapped air and may contain purposely-entrained air by the use of air-entraining admixtures. Various types of chemical admixtures and/or finely divided mineral admixtures are frequently used in the production of concrete to improve or alter its properties or to obtain a more economical concrete.

SISAL FIBRES

Fibres are usually used in concrete to control cracking due to both plastic shrinkage and drying shrinkage. They also reduce the permeability of concrete and thus reduce bleeding of water. Some types of fibres produce greater impact, abrasion and shatter resistance in concrete. Generally fibres do not increase the flexural strength of concrete, and so cannot replace moment resisting or structural reinforcement. Indeed, some fibres actually reduce the strength of concrete. The amount of fibres added to a concrete mix is expressed as a percentage of the total volume of the composite (concrete and fibres), termed volume fraction (Vf). Vf typically ranges from 0.1 to 3%. Aspect ratio (l/d) is calculated by dividing fibre length (l) by its diameter (d). Fibres with a non-circular cross section use an equivalent diameter for the calculation of aspect ratio. Sisal is a bio degradable organic fibre material containing 46% lignin, 54% cellulose. Because its high content of lignin, sisal is much more advantageous than other natural fibres.

II. OBJECTIVES OF THE STUDY

The main objectives of this study are,

1. To study the mechanical properties of conventional concrete structure and compare with sisal fibre wrapped concrete structure. To determine the bond strength between sisal fibre concrete.
2. To determine the flexural strength of sisal fibre reinforced concrete beam with sisal fibre.
3. To compare the flexural behaviour of sisal fibre reinforced concrete beams with conventional concrete structure.

III. SCOPE FOR STUDY

1. Natural fibres as reinforcement in composites have been studied by many researchers only for non-structural members.
2. Natural fibres are good alternative at lower cost and promote sustainable development. Earthquakes have caused mass destruction of buildings because of non-engineered constructions.
3. A sisal fibre is exceptionally durable and require low maintenance with minimum wear and tear. Sisal is one of the promising natural fibre.

4. Hence sisal fibre reinforced concrete (SFRC) and sisal fibre rope is investigated for their potential in low-cost housing in under- developed and developing countries.

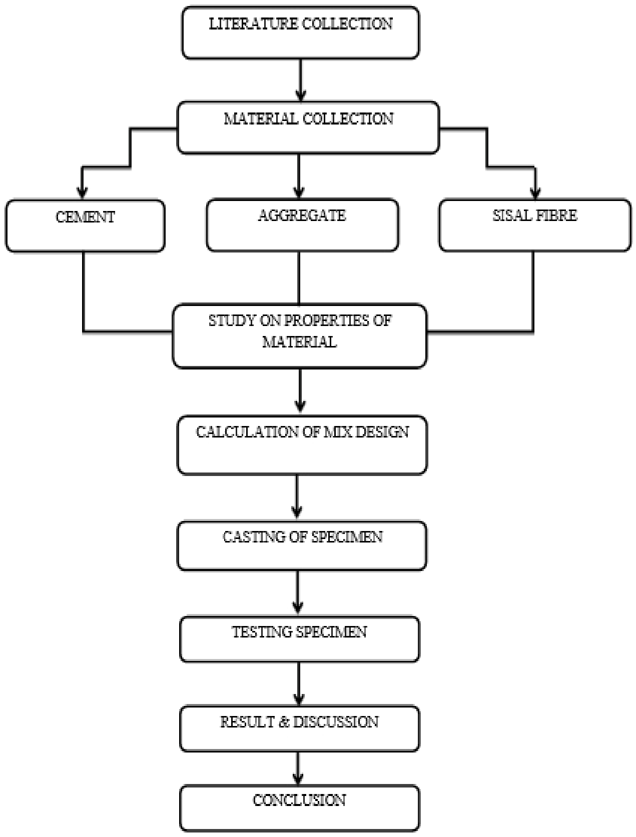
IV. LITERATURE REVIEW

Abass Abayomi Okeola et. al (2018) Concrete is a very popular material in the construction industry—it is, however, susceptible to quasi-brittle failure and restricted energy absorption after yielding. The incorporation of short discrete fibres has shown great promise in addressing these shortfalls. A natural fibre such as sisal is renewable, cheap, and easily available. It has also exhibited good tensile strength and can significantly improve the performance of concrete. In this study, the physical and mechanical properties of sisal fibre-reinforced concrete were reported. Sisal fibres were added in the mix at percentages of 0.5%, 1.0%, 1.5%, and 2.0% by weight of cement. Physical properties measured are workability, water absorption, and density while mechanical properties reported are compression strength, split tensile strength, and static modulus of elasticity. The computed modulus of elasticity of sisal fibre-reinforced concrete was compared with predicted values in some common design codes. From the study, it was concluded that sisal fibre can enhance the split tensile strength and Young's modulus of concrete but cannot improve its workability, water absorption, and compressive strength.

Reneesha.V et. al (2018) The main objective of this project is to investigate effect of silica fume & fibre orientation of sisal fibre on performance of concrete, which ultimately solve the problems of waste disposal & reduces global warming and increase the strength of concrete .India is a developing country, therefore Infrastructure development is necessary for our country and concrete plays a vital role in it. Concrete is the world's largest consuming material in the construction field. The emission of carbon-dioxide (CO_2) in the atmosphere from the operation and maintenance of structures as well as production of building materials can be reduced by using renewable resources and construction materials .Conventional concrete is relatively strong in compression but weak in tension, in order to overcome the weakness the use of a sufficient volume of certain fibres such as sisal fibre is used in this experiment, which is easily available, renewable and economical and enhance many of the mechanical characteristics of the basic materials such as fracture toughness, flexural strength and resistance to fatigue, impact, thermal shock and spalling .The study focuses on the compressive strength, split tensile strength, in 7, 14, and 28 days of curing containing different percentage of sisal fibre and silica as a partial replacement of OPC. The cement in concrete is replaced accordingly with the percentage of 0%, 10 %, and 20% by volume and 0%,1% , 1.5% and 2% of sisal fibre is added by weight of cement. Finally, the strength performance of silica blended fibre reinforced concrete is compared with the performance of conventional concrete.

Kanchidurai S et. al (2017) Fibre reinforcement usually increases the performance of the concrete in many aspects, this paper deal addition of Sisal Fibre Reinforcement (SFR) in concrete to improve the performance at the same time reducing cement consumption by replacing with Groundnut Shell Ash (GSA). These materials not just lessen the emanation of carbon dioxide gas in the climate additionally utilized as a substitute for the bond to take care without bounds demand. In the present work, GSA replacement for cement is 0, 5, 10, 15 and 20%; SFR is added for each set percentage of GSA as 1, 2 and 3% by its weight. Na_2CO_3 treatment was carried out to reduce the potential deterioration of SF. The compressive strength, flexural bending strength, deflection of the beam and economic consideration for M25 concrete specimen was done. Totally 120 numbers concrete 150 x150 mm cube and 9 number of 100 x 150 x 800mm flexural member cast and tested. It is recommended up to 10% of replacement of cement by GSA and 2 % addition of SF provide optimum values from investigation and economic consideration.

V. METHODOLOGY



VI. MATERIAL AND PROPERTIES

1. CEMENT

The cement used was ordinary Portland cement 53 (OPC 53).All properties of cement were determined by referring IS 12269 - 1987. Cement is the important building material in today's construction world. 53 grade Ordinary Portland Cement (OPC) conforming to IS: 8112-1989. Table 1 gives the properties of cement used.

S.NO	PROPERTIES OF CEMENT	VALUE
1	Fineness of cement	7.5%
2	Grade of cement	53 Grade(OPC)
3	Specific gravity of cement	3.15
4	Initial setting time	30min
5	Final setting time	600min
6	Normal consistency	35%

Table 1 Physical Properties of Cement

2. PROPERTIES OF FINE AGGREGATE

The sand which was locally available and passing through 4.75mm IS sieve is used. Locally available river sand conforming to Grading zone I of IS: 383 –1970.Clean and dry river sand available locally will be used. Sand passing through IS 4.75mm.

S.NO	PROPERTIES	VALUE
1	Specific Gravity	2.65
2	Fineness Modulus	2.25
3	Water absorption	1.5%

3. PROPERTIES OF COARSE AGGREGATE

Crushed granite aggregate with specific gravity of 2.77 and passing through 4.75 mm sieve and will be used for casting all specimens. Several investigations concluded that maximum size of coarse aggregate should be restricted in strength of the composite. In addition to cement paste – aggregate ratio, aggregate type has a great influence on concrete dimensional stability.

S.NO	PROPERTIES	VALUES
1	Specific Gravity	2.68
2	Size of Aggregates	20mm
3	Fineness Modulus	5.96
4	Water absorption	2.0%
5	Impact Test	15.2%

Table 2 Properties of Coarse Aggregate

4. PROPERTIES OF SISAL FIBRE

Sisal fibre (Agave sisal fibreana) is an agave that yields a stiff fibre traditionally used in making twine rope and also dartboards. The term may refer either to the plant or the fibre, depending on context. It is sometimes incorrectly referred to as sisal fibre hemp because hemp was for centuries a major source for fibre, so other fibres were sometimes named after it.

Fig 1 Sisal Fibre

Properties	Value
Density	1.33 g/cm3
Tensile Strength	600-700x10^6N/m^2
Modulus of elasticity	38 Gpa
Elongation at failure	2-3%
Moisture absorption	11%

Table 3 Mechanical Properties of Sisal fibre

Chemicals	Percentage
Cellulose	65%
Hemicelluloses	12%
Lignin	9.9%
Waxes	2%
Total	100%

Table 4 Chemical Composition of Sisal Fibre

VII. MIX DESIGN

MIX DESIGN OF CONCRETE

The control mix was designed to make M30 grade of concrete as per IS 10262-2009.

Mix Proportion of Ratio

Cement : 330 kg/ m^3
Water : 150 kg/ m^3
Fine aggregate : 789.7 kg/ m^3
Coarse aggregate : 1206.9 kg/ m^3

The details of mix proportions are given in Table.

	Cement	Fine Aggregate	Coarse Aggregate	Water
By weight (kg/m^3)	330	789.7	1206.9	150
By ratio	1	2.4	3.65	0.45

Table 5 Mix Proportion of Material

VIII. EXPERIMENTAL SET UP:

TESTS

1. COMPRESSIVE STRENGTH

Compression test is conducted at the end of the 7th and 28th day of casting the specimens. The load was applied without any shock and continuously until the failure of the specimens. The maximum load is applied to the specimens until the failure is recorded.

fc= load/ Cross sectional area

Fig 2 Compressive strength testing of Cube Specimens

2. FLEXURAL STRENGTH

Before applying the FRCM system, the specimens were flipped upside down to make the application process easier. To apply the FRCM, the surface of the beam was roughened then dampened with water, but without having any standing water at the surface. An initial layer of mortar was applied, approximately 3 mm thick. The applied strengthening was then wet-cured for 3 days.

Fig 3 Flexural Strength Testing of Beam

3. T-SECTION – CYCLIC LOAD TEST (WITH SFRP)

Test Setup: The specimens were fixed on universal testing machine such that the both ends of column were fixed by UTM. The projections of beam length 300 mm on either side of the column were fixed by proving ring attached with hydraulic jacks. Only one end beam was loaded by means of hydraulic jack and readings are taken from proving ring. Other end of the beam also have same arrangement but only for supporting purpose.

Packing plates were placed on either side of the column. The hydraulic jack and proving ring was seated vertically. A dial gauge was placed on top of the application of load on the beam for measuring deflections. The least count of dial gauge is 0.01mm.

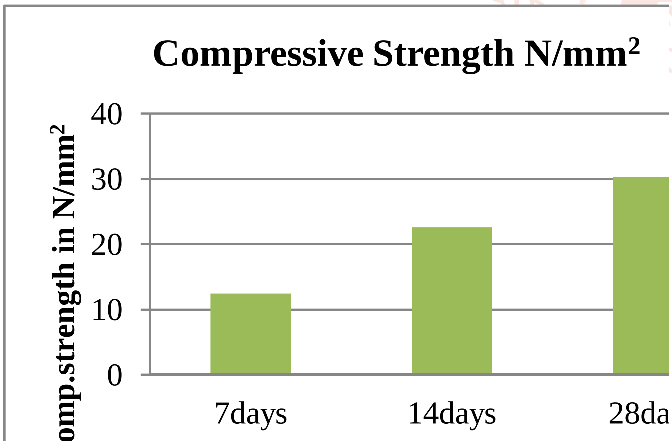
Fig 4 Test on T Beam

IX. RESULTS & DISCUSSION

1. COMPRESSIVE STRENGTH OF CONCRETE CUBE

Grade	Curing Days	Opt.mix			
		M1	M2	M3	Avg
M30	**7**	12.6	12.4	12.4	12.46
	14	22.6	22.4	22.8	22.6
	28	30.4	30.2	30.4	30.3

Table 6 Compressive Strength of Concrete Cube



Graph for Compressive Strength on Cube

2. SPLIT TENSILE STRENGTH ON CYLINDER

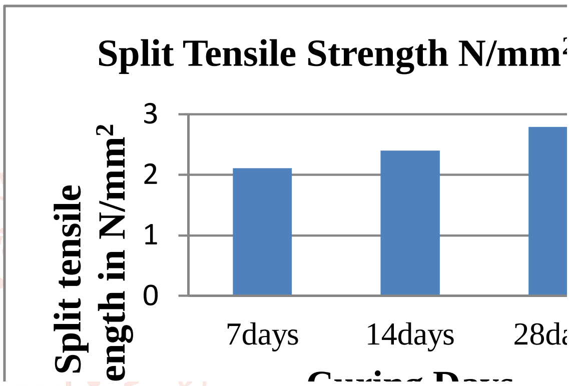
To find out the tensile strength of the cylinder, the tests are carried out at the age of 7 days, 14 days and 28 days. The size of the concrete cylinder specimens is about 150 mm diameter and 300 mm height as per IS: 5816-1970 code book for tensile test with the grade of M40. The strength of cylinder attain maximum tensile load is 2.79 N/mm² strength at 28 days.

Grade	Curing Days	Opt.mix			
		M1	M2	M3	Avg
M30	**7**	2.06	2.12	2.17	2.11
	14	2.32	2.42	2.48	2.40
	28	2.74	2.80	2.83	2.79

Table 7 Split Tensile Strength of Concrete Prism

Control mix	Days	CC	Flexural strength in /mm2		
			SFRP thickness		
			2mm	3mm	4mm
M30	7	6.8	8.1	8.6	9.1
	14	7.6	8.8	9.8	10.3
	28	10.6	11.2	11.8	12.1

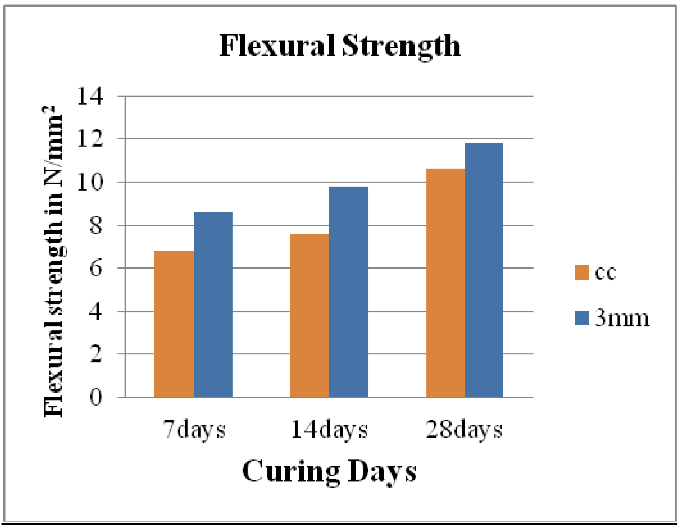
Table 8 Flexural Strength of Beam



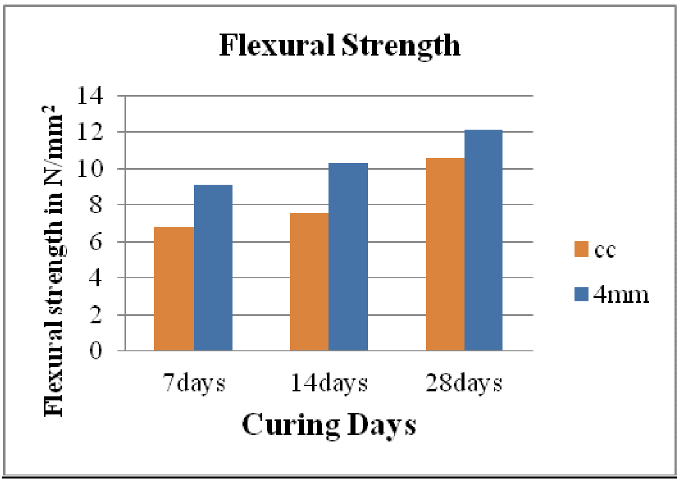
Graph for Split Tensile Strength on Prism

3. FLEXURAL STRENGTH ON BEAM

Flexural test of beam is carried out at the age of 7 days, 14 days and 28days with the size of 150 mm x 150 mm x 700 mm specimen by using universal testing machine. The flexural strength is find out by applying two point load condition. Maximum strength of beam attains 9.1 N/mm², 10.3 N/mm², and 12.1 N/mm² for 7, 14 and 28 days respectively. The results are tabulated in table 8.3 and the graph for flexural strength on beam as shown in figure 8.3 (a), Figure 8.3 (b) and Figure 8.3 (c)



Graph for CC Vs 3mm thickness OC (OPTIMIZED CONCRETE)

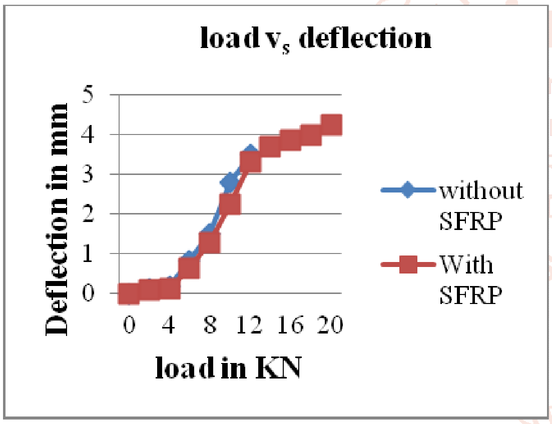


Graph for CC V_S 4mm thicknesses OC (OPTIMIZED CONCRETE)

4. CYCLIC LOAD TEST

The specimen was tested in a loading frame. A hydraulic jack was used to apply the axial load for column. To record the load precisely a proving ring was used. The load is applied forward cyclic and deflection measured from every 2 KN.

The deflection was measured at the beam free end tip. Loading is applied gradually such as 2, 4, 6, 8, 10, 12, KN respectively for forward direction.



Cyclic load graphs for T Beam

S.NO	Load in 'KN'	Deflection in mm	
		Without SFRP	With SFRP
1	0	0	0
2	2	0.12	0.08
3	4	0.20	0.14
4	6	0.85	0.65
5	8	1.50	1.28
6	10	2.80	2.25
7	12	3.50	3.32
8	14	-	3.68
9	16	-	3.85
10	18	-	3.98
11	20	-	4.25

Table 9 Cyclic Load Value of the Specimen

The SFRP specimen, the first crack formed in the beam portion at a load of 6 kN. Bond failure of the wrap was noticed on the tension side of the beam at a load of 8 kN and on the tension side of the compression side of the beam at a load of 14 kN. The application of the load was stopped when the deflection at the free end of the beam reached 3.50 mm. The load corresponding to this deflection was 12 kN.

X. CONCLUSION

Based on the experimental investigations carried out on the control and Sisal fibre wrapped beam-column joint specimens, the following conclusions are drawn

1. The load deformation characteristics were high for SFRP retrofitted specimens over the control specimens. This resulted in a substantial increase in the energy absorption characteristics of the specimens that were retrofitted with SFRP.
2. The energy absorption capacity of the SFRP wrapped specimens was in the range 15% over the control beam-column joint specimens.
3. The case of the wrapped specimens, the failure was noticed in the beam portion only and the column was intact.
4. Generally SFRP as a strengthening material led to increased ultimate capacity and decreased ductility compared to those of control joints specimen.

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