EXPERIMENTAL STUDY ON FIBRE REINFORCED HIGH STRENGTH CONCRETE

Mr. K.Ramakrishna[1], Sk.Najiya[2], P.V.V.A.Nagaraju[3], V.Bhargav[4], S.Balakiran[5]
[1]Assistant Professor, [2,3,4,5] B.tech IV year Student
C.E Dept
Usharama College of Engineering& Technology
Telaprolu, Krishna District, Andhra Pradesh, India

Abstract: High Strength Concrete is required in civil engineering projects that have concrete components that must resist high compressive loads. It has been used in components such as columns, shear walls and foundations. High strength concrete use is considered to be a structure over story buildings. It is occasionally used in the construction of highway bridges. The use of high strength concrete is (HSC) is increased now a days. It is observed that HSC is relatively brittle material. Fibres are added to improve its ductility. Experimental study is carried out to assess the mechanical properties of Fibre Reinforced High Strength concrete (FRHSC) of grade M50. The FRHSC gives the result of strength by adding different percentage of fibres in M50 grade concrete mix. This paper investigates the study the behaviour of fibres in fibre reinforced high strength concrete. The aim of the research to evaluate the effect of addition of nylon and silica on the compression strength and density of concrete. The high strength concrete mix by adding ceramic powder 10% to attain good strength. In this study material properties of an FRHSC containing sisal, nylon fibres are determined which include compressive strength and split tensile strength. In this experimental work there is replacement of cement and sand materials. Cement is replaced by sisal and nylon is replaced by sand. In this study, influence of 1%, 1.5%, and 2% fibres in different volume fractions in M50 grade HSC is investigated. Experimental study results showed that the high strength concrete by using of fibres up to 2% sisal and nylon fibres together with admixtures is to make as effective and improved the compression strength and split tensile strength of the cubes are tested for 7, 14 and 28 days.

KEYWORDS: Nylon, sisal fibres, ceramic powder, compressive strength, split tensile strength, high strength concrete.

1. INTRODUCTION

Fibre Reinforced Concrete is gaining an increasing interest among the concrete community for the reduced construction time and labour costs. Fibre Reinforced Concrete is concrete containing fibrous material which increases its structural integrity. Fibres include steel fibres, glass fibres, synthetic fibres and natural fibres. Within these different materials fibres that character of fibre reinforced concrete changes with varying concretes, fibre materials, geometrics, distribution, orientation and densities.

Nylon fibre added in the concrete improves the tensile strength but decreases the workability. For this ceramic powder is added which improves the workability. The amount and type of waste materials have been increased accordingly. The concept of using fibres to improve the characteristics of construction materials is very old. Early applications include addition of straw to mud bricks, use of continuous reinforcement in concrete increases strength and ductility, but requires careful placement and labour skill.

A large variety of fibres, include mineral fibres (glass, carbon, steel etc.), organic manmade fibres (polypropylene, polyvinylene, etc.) and organic natural fibres (coconut, sisal fibres etc.) have been used as reinforcement of composites such as cement paste, mortar, and concrete to improve the tensile strength, shear strength, toughness, resistance to cracking, durability, and to impart additional energy absorbing capability so as to transform a brittle material into a ductile material.

Investigations have been carried out in many countries on various mechanical properties, physical performance and durability of concrete materials reinforced with natural fibres from coconut husk, tree sisal, sugarcane bagasse, jute, bamboo, wood and other vegetable fibres. These investigations have shown commercial prospects of this new distinct group of materials for application in low cost housing construction. The aim of the experimental work is to study the effect of adding randomly distributed two types of fibres Sisal Fibre, Nylon fibre on the properties of plain concrete.

NYLON FIBRE
It is the first synthetic fibre made by man without using any natural raw material. Nylon is a polymer which has a molecular structure built up from a large number of similar units bonded together based on aliphatic or semi -aromatic polyamides. The first nylon was produced by DuPont in 1935. Nylon is a thermoplastic material that can be used for a wide range of applications in the construction industry, when heated it can be moulded into a range of shapes or films, or it can be drawn into fibres. It is white in colour and its length is 12mm-18mm. It absorbs water about 3.5%.
Uses:
1. It can be used It is used in sheets, rods, tubes, pipes, screws, washers, bolts, spacers, safety nets, plumbing fittings, and so on.

2. Its fibres can be woven together to produce a silky and lightweight fabric that in carpeting, canopies, sheets, and so on.
Advantages:
1. The advantages of nylon include its strength, durability, high pressure- bearing capacity and corrosion resistance.
2. It also has a low coefficient of friction meaning it can be used in applications that involve rotation or sliding with little or no lubrication.
3. Nylon is also water proof and fast drying.
4. However, it can dissolve when exposed to chemicals such as phenols, alkalis and acids.

Characteristics:
1) Nylon is strong and lightweight.
2) The fibres that makeup nylon are non-absorbent and smooth,causing items that are constructed of this fibre to dry quick.
SISAL FIBRE:
Sisal fibre is extracted from the leaves of the plant Agave sisalana. In India four varieties of sisal plants are found - Sisalana, Vergross, Istle, and Natale. Different varieties of plants have different yields of fibres. Leaves from the first two varieties yield more fibres than those from the other two. The fibre content also varies with age and source of the plant. The chemical composition of the leaf is moisture (87.25%), fibre (4%), cuticle (0.75%), and other dry matter (8%).The strands are usually creamy white, average from80 -120cm in length and 0.2 - 0.4mm in diameter. The ends of the fibre are broad and blunt. The sisal fibre contains mechanical, ribbon, and xylem fibres. It is valued for cordage because of its strength, durability, ability to stretch, affinity for certain dyestuffs, and like coir, it is resistant to deterioration in saltwater. The highergrade fibre is converted into yarns for the carpet industry. Sisal is now also used as reinforcement in polymer-matrix composites.
Physical Properties:
1. Length-2.88mm
2. Width-22.6m
3. Elongation- 3.02%
4. Moisture regain- 13%
Chemical composition:
The components of sisal fibre % by weight:
1) Cellulose (55-65)
2) Hemi- cellulose (10-15)
3) Pectin (2-4)
4) Lignin (10-20)
5) Water soluble materials (1-4) 6) Fat and wax (0.15-0.3)
7) Ash (0.7-1.5)

Applications of sisal:

- The short sisal fibre, with its features of softness, high flexibility, high friction resisting, acid resisting and alkali resisting, it is an excellent material of high quality sofa, wadding mat pulp constructing materials.
- The plants can also be used as an effective hedge to protect crops and land form predators, and the extensive root system helps to reduce soil erosion in arid areas.
- Other sisal materials include rope sisal core for steel wire rope, yarn and twine, sisal cloth polishing, buff carpet pulp, constructing materials and doormats.

2. MATERIALS AND METHODS

The concrete mix design as recommended by IS:10262-2009 was used to prepare test samples. The concrete mix was design to study on fibre reinforced high strength concrete. Portland cement, sand, coarse aggregate and water are mixed with sisal, nylon fibres and ceramic waste powder with different percentages of mix proportion.

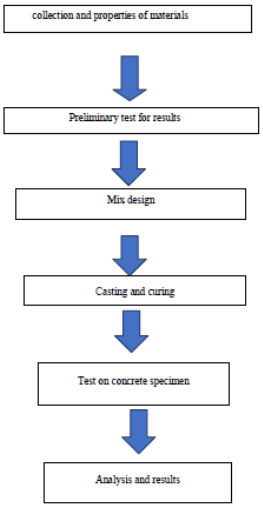

Fig.1. Methodology

General:
The experimental investigation consists of casting and testing along with concrete mix. Each set comprises of 9 cubes for determining compression test by taking 1%, 1.5%, 2%, of sisal and nylon fibres, 10% of ceramic waste powder is added in concrete mix. Some percentage of sisal with different cement percentages are taken and in the place of nylon with different sand percentages are taken. Each set comprises of 9 cubes for determining compression strength at optimum value.
Cube specimen dimensions is of 15cm x15cm, the moulds are applied with a lubricant before placing the concrete. After 24 hours of casting, the moulds are removed and the removed cubes are placed in a curing tank carefully.
Cylindrical specimen dimensionsof height is 300mm and diameter is 150mm, as the same process repeats in this section.

The material characteristics that are used in this study given in brief are as follows:
Ordinary portland cement 53grade with specific gravity of 3.15, locally available river sand with bulk density of 1705 kg/m^3 and specific gravity of 2.56 and confirming to zone 2 of IS:18-383. Coarse aggregate with bulk density of 1675 kg/m^3 and specific gravity of 2.74, water confirming to the requirements of concreting and curing as per IS:456-2000.
Material properties:
Concrete is a composition of three raw materials, cement, fine aggregate and coarse aggregate these three raw materials play an important in manufacturing of concrete will changes.
Cement:
Cement is mainly used as a binder in concrete,Cement is the

 ISSN (Online): 2347 - 4718

main constituent in manufacturing of concrete. The characteristics like strength and bonding of concrete will be greatly affected by changing the cement content. Cement used in this project is Ordinary Portland Cement (OPC) of 53 grade confirming to IS :12269-1987.

Fine aggregate:

The aggregate size is lesser than 4.75mm is considered as fine aggregate. The sand particles should be free from any clay or inorganic materials and found to be hard and durable. Aggregates of size ranges between 0.075mm-4.75mm are generally considered as fine aggregates.The fine aggregates are selected as per IS-383 specifications.

Coarse aggregate:

The aggregate size is bigger than 4.75mm is considered as coarse aggregate. It can be found from original bed rocks. Coarse aggregates are available in different shape like rounded irregular or partly rounded, angular flaky. In this experimental work we have used the maximum size of coarse aggregate is 12.5 mm.

Nylon fibre:

Nylon polymers can be mixed with a wide variety of additives to achieve many different property variations. Nylon is white in colour and its length is 12mm and 0.6mm diameter. Nylon fibres are exceptionally strong and elastic than other fibres. The fibres have excellent toughness abrasion resistance. Density of nylon is 1.15g/cm. Nylon is replaced with sand in the addition of 1%, 1.5%,2%, of sisal is used in concrete mix.

Figure 2:NYLON FIBRE

Sisal fibre:

Sisal fibre strands are usually creamy white average from 80-120cm in length and 0.2- 0.4mm in diameter and are lustrous in appearance. Density of sisal fibre is 1.16g/meter cube,elongation is 2-3%, Sisal fibre is replaced with cement and addition of 1%, 1.5%, 2% of sisal is used in the replacement of cement.

Figure 3:SISAL FIBRE

Ceramic powder:

Ceramic powder consists of ceramic particles and additives that improve a powders ease of use during component fabrication. Additives include a binding agent to hold the powder together after compaction and a release agent to enable a compacted component to be easily removed from the compaction die. It is additionally added to the concrete mix about 10% of it is used to get strength.

Figure 4 CERAMIC WASTE POWDER

Superplasticizer:

Super plasticizers are also known as high-range water reducers that are additive used in making high strength concrete. Plasticizers are chemical compounds that enable the production of concrete with approximately 15% less water content. Superplasticizers allow a 30% or more reduction in water content.

It is chemical admixtures that are added to the concrete to improve their flowing ability, they help to reduce the amount of water in the concrete and to improve the strength and durability of concretes. They achieve a reduction in water content without loss of workability.

Figure 5 SUPERPLASTICIZER

3. RESULTS & DISCUSSION

EXPERIMENTAL RESULTS

The standard dimensions of cubes 150mm x 150mm x150mm is casted and tested to find out the compression strength for 28 days. The standard dimensions of cylinder 300mm x 150mm x 150mm casted and tested to find out the split tensile strength for 28 days. The removed specimens are placed in the water for 28 days for curing purpose. After water cured specimens are taken out and allowed to dry under shade, these specimens are tested for compressive strength and split tensile strength for 28 days

COMPRESSION STRENGTH TEST:

After 7 days, 14 days, and 28 days of curing. The cubes were taken out from curing tank, dried and tested using a compression testing machine. These cubes were loaded on their sides during compression testing such that the load was exerted perpendicularly to the direction of casting. The cubes were placed in the compression testing machine and the loads are applied gradually at rate. The average value of compression strength of three cubes was taken as the compression strength. The compression strength of conventional concrete was found.

Compression strength = P/A

Where, P =compression load (KN)

A = area of the cube (150 x150 x150mm)

Compressive strength for design mix

The following are the various results obtained for concrete and the value are tabulated as below. A graph is plotted between curing time (days) on X- axis and compressive strength on Y-axis. On observing the graph, strength is increasing for 7, 14, 28 days.

Table 1 compression strength values for 1% sisal and nylon mix at 7, 14 and 28 days

S.No	Time (days)	Compression load (KN)	Compressive strength (MPa)	Average strength (MPa)
1	7	825	36.55	36.23
		816	36.26	
		808	36.90	
2	14	1147	50.9	50.6
		1142	50.75	
		1136	50.4	
3	28	1247	55.4	55.07
		1240	55.11	
		1232	54.7	

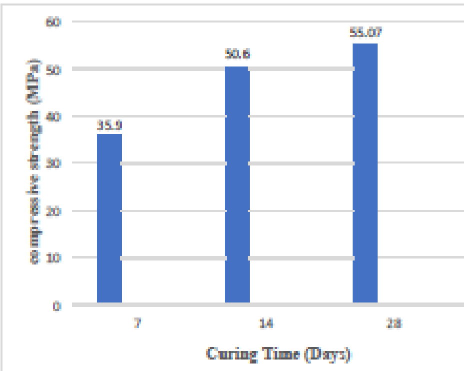

Figure 6 : graph representing compressive strength values for 1%nylon and sisal mix

Compressive strength for 1.5% sisal and nylon mix

The following are various results obtained for concrete and the values are tabulated as below. A bar graph is plotted between curing time (days) on X-axis and compressive strength on Y-axis. On observing the graph, strength is increasing for 7, 14 and 28 days.

Table 2 : compression strength values for 1.5% sisal and nylon mix at 7, 14, 28 days

S.No	Time (days)	Compressive load (KN)	Compressive strength(MPa)	Average strength (MPa)
1	7	837	37.2	36.9
		831	36.9	
		827	36.7	
2	14	1156	51.37	51
		1148	51.02	
		1135	50.44	
3	28	1270	56.4	56.08
		1262	56.08	
		1255	55.74	

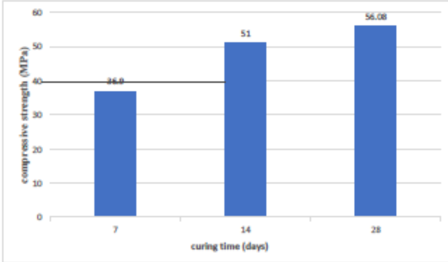

Figure 7 : Graph representing compressive strength values for 1.5% nylon and sisal mix

Compressive strength for 2% sisal and nylon mix

below. A bar graph is plotted between curing time (days) on X-axis and compressive strength on Y-axis. On observing the graph, strength is increasing for 7, 14 and 28 days

Table 3: compressive strength values for 2% sisal and nylon mix at 7,14 and 28 days

S.No	Time (days)	Compressive load (KN)	Compressionstrength (MPa)	Average strength (MPa)
1	7	850	37.7	37.4
		843	37.3	
		837	37.2	
2	14	1203	53.46	52.8
		1190	52.88	
		1186	52.17	
3	28	1356	60.2	60.00
		1349	59.95	
		1341	59.60	

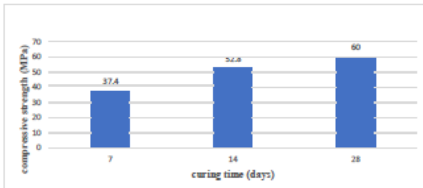

Figure 8 Graph representing compressive strength values for 2% nylon and sisal mix

Compression strength values for 7 days from 1% to 2%

The following are various results obtained for concrete and the values are calculated

as below. Graph is plotted using replacement of nylon and nylon on X-axis and compression

strength on Y-axis.

Table 4:compressive strength values at 7 days

Days	Compressive strength (MPa)		
	1%	1.5%	2%
7	35.9	36.9	37.4

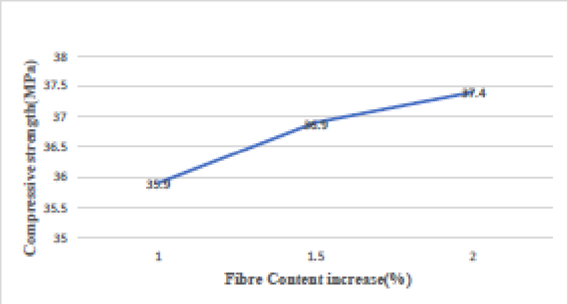

Figure 9 Graph representing fibre content increase in 1% to 2% for 7 days

Compressive strength values for 14 days from 1% to 2%

The following are various results obtained for concrete and the values are calculated as below. Graph is plotted using replacement of nylon and sisal on X-axis and compressive strength on Y-axis.

Table 5 Compressive strength values at 14 days

Days	Compressive strength (MPa)		
	1%	1.5%	2%
14	50.6	50.9	52.8

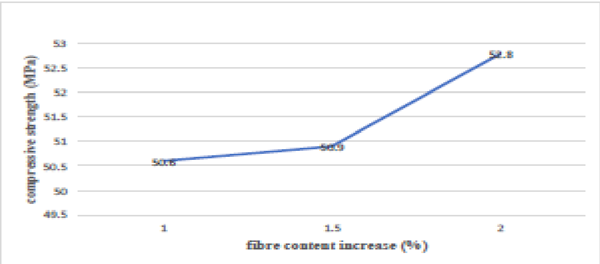

Figure 10 Graph representing fibre content increase in 1% to 2% for 14 days

Compressive strength values for 28 days from 1% to 2%

The following are various results obtained for concrete and the values are calculated as below. Graph is plotted using replacement of sisal and nylon on X-axis and compressive strength on Y-axis.

Table 6 compressive strength values at 28 days

Days	Compressive strength (MPa)		
	1%	1.5%	2%
28	55.07	56.08	60.00

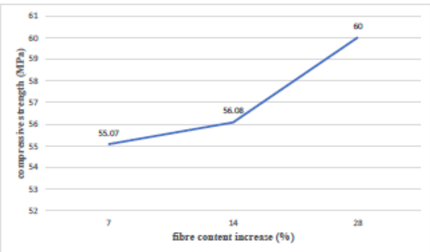

Figure 11 Graph representing fibre content increase in 1% to 2% for 28 days

Comparing the compressive strength values for 7, 14 and 28 days

The following are various results obtained for concrete and the values are tabulated as below for 1% to 2% of sisal and nylon mix. And on observing the graph, optimum strength has occurred at and there after strength has been

Table 7. compressive strength values occurred at 7, 14 and 28 days

Days	Compressive strength (MPa)		
	1%	1.5%	2%
7	36.23	36.9	37.4
14	50.6	51	52.8
28	55.07	56.08	60.00

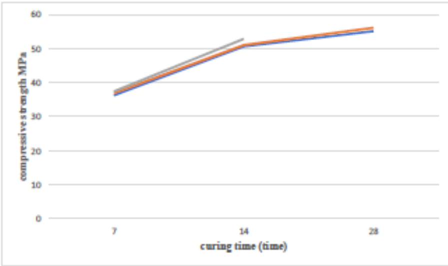

Figure 12 comparing the compressive strength values for 7, 14, 28 days

EFFECT OF VARIATION OF SISAL AND NYLON ON SPLIT TENSILE STRENGTH

The test was carried out to obtain split tensile strength of M50 concrete. The split tensile strength of concrete is tested for 28 days for 2% replacement of sisal with cement and nylon with sand and the values are represented in table noand also graph were plotted below figure.

Table 8 Overall results of development of split tensile strength in M50 concrete with age

Percentage of sisal and nylon fibres	Split tensile strength (Mpa)
	28 days
2%	1.57
	2.29
	3.58

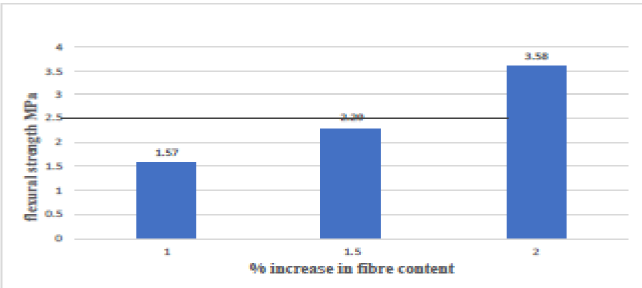

Figure 13 Graph representing split tensile strength of value of 2% fibres mix

4. CONCLUSIONS

Based on experimental observations, the following conclusions are drawn:

In this study cubes and cylinders are prepared using M50 grade and concrete cubes are prepared by mixing of fibres from 1%, 1.5% and 2% in concrete mix.

The compression strength those cubes and cylinders are tested for 7, 14 and 28 days respectively.

By observing the graph which are created using compression strength and split tensile strength at a different percentage we can say that up to 2% of fibres are added with cement, aggregates.

When compared compression strength of cubes which are added with fibres to the compression strength of mix design the strength values are in acceptable range.

When compared split tensile strength of cylinders which are added with fibres to the mix design the strength increases with percentage for 28 days.

REFERENCES

1) Samantha Acosta-Calderon, Pablo Gordillo Silva, Navtividad Garcia- Troncoso, Dan V. Bompa and Jorge Flores-Rada. Comparative evaluation of sisal and polypropylene fibre reinforced concrete properties. Fibres 2022,10,31. https://doi.org/10.3390/fib 10040031.
2) Flavio de Andrade Silva, Nikhilesh Chawla, Romildo Dias de Toledo Filho.An experimentalinvestigation of the fatigue behaviour of sisal fibres. F.D.A. Silva et al./ materials science and engineering A 516 (2009) 90-95.
3) NaraindasBheel, T. Tafsirojjaman, Yue Liu, Paul Awoyera, AneelKumar and Manthar Ali Keerio. Experimental study on engineering properties of cement concrete reinforced with nylon and jute fibres. Buildings 2021, 11, 454. https://doi.org/10.3390/buildings 11100454.
4) Venkateshwaran. S, Kalaiyarrasi. A. R .R PG student 2018 JETIR June 2018, volume 5, Issue 6 (ISSN-2349-5162).
5) Md. Akhtar Hossain, Md. MahbuburRahman, Abu Zakir Morshed and SK. Maruful Haque. Investigation of the effect of nylon fibre in concrete rehabilitation. 1st international Conference on Civil Engineering for Sustainable Development (ICCESDD-2012).
6) Sarmed Fadhil and Mohanad Yaseen. The Effect of Adding Different Types of Natural Fibres on Mechanical Properties and Impact Resistance of Concrete. Research Journal of Applied Sciences, Engineering and Technology 9(12): 1091-1096, 2015. ISSN:2040-7459; e-ISSN:2040- 7467.
7) Rahesh Hari, K.M. Mini. Mechanical and durability properties of sisal nylon 6hybrid fibre reinforced high strength SSC. Construction and building materials 204 (2019) 479-491.
8) Abdullah Tahir, Kiran Kumar Poloju. Use of ceramic powder in concrete – strength & durability properties. Journal of Student Research (2017).
9) Pramod V Badyankal, Manjunatha T S,Gurushanth B Veggar. Wear and water absorption behaviour of banana and sisal hybrid fibre polymer composites. International Journal of Engineering & Technology, 7 (3.34) (2018) 424-427.
10) IS 383: 1970, specifications for coarse and fine aggregate from natural sources for concrete, Bureau of Indian standards, New Delhi, India.
11) IS 10262-2009, recommended guidelines for concrete mix deign, Bureau Standards, Delhi, India.
12) IS: 516-1959, Indian Standard methods of tests for strength of concrete, Bureau of Indian standards, New Delhi, India.

