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An Experimental Study on Strength and Durability properties of Coir Fibre and Sisal Fibre Reinforced Concrete

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ABSTRACT
The research has been carried on waste materials used in concrete to get high strength and more durability of reinforced concrete by partial replacement of Coir fibre and Sisal fibre in Concrete. Because of that we shall provide reinforcement to the concrete and generally the steel is used in concrete for increasing of ductile property as well as counteracting of both compression and tension properties. Here the cost steel is more as compared to the natural fibres and many investigations were proposed on artificial fibres substitution of steel reinforcement. In this project we would like to take the naturally available fibre named Coir fibre (coconut fibre) and Sisal fibres a substitutional material as reinforcement and study of their strength properties. The results show that the composites of reinforced with coir fibre and Sisal fibres equal proportions are reliable materials to be used in practice to produce structural elements to be used in rural and civil engineering construction. The Coir and Sisal fibre were used as reinforcement which production is a serious hazardous to human and health and it is prohibited in industrialized countries.
In this research work, an experimental investigation has been done to evaluate the strength properties of fibre reinforced concrete with partial replacement of Coir fibre and Sisal fibre equally. The preferable partial replacements of Coir fibre and Sisal fibre of **0.5%, 1%, 1.5% and 2%** by the weight of concrete as previous journals studies. The results obtained the various strength aspects analysed are compressive strength, split tensile strength and flexural strength of Coir and Sisal fibres reinforced concrete at varying percentages are mentioned above.

Key Points-Coir Fibre, Sisal Fibre, Fibre's concrete, Compressive strength, Tensile strength, and Flexural strength.

1. INTRODUCTION

Liveable is a wide crucial role in modern construction in civil engineering scenario in the world. The construction industry is transfigured in a significant manner in terms of both materials and equipment used, the cost of construction has huge along with the deteriorative impact on environment and globalisation in the world.

Coir Fibre is a natural fibre, and it is extracted from outer husk of coconut and used in products such as floor mats, doormats, brushes, and mattresses. Coir is the fibrous material found between the hard, internal shell and the outer coat of a coconut.

Sisal fibre is a promising reinforcement for use in composites on account of its low cost, easy availability, low density, no health hazards, renewability and high specific strength and modulus. The structure and properties of sisal fibre have been investigated by several researchers previously.

Fig 1: Sisal plant

Coir fibre is natural fibre is obtained and processed from the protective husk of the coconut. This brown fibre is spun in a breath which taking range of textured yarn and oven into a spectrum of colourful floor covering the husks separated from the nuts are retted in lagoons up to ten months. The retted husks are then beaten with wooden allots manually to produce the golden fibre.

Fig 2: coconut plant and its constituents

1.1 Extraction of Coir fibre process

The coir fibres are obtaining from coconut and it is extracted by the process of the green coconuts were harvested about 6 to 12 months on the palm, it contains pliable white fibres. The brownish-green fibre is obtained by harvesting fully mature coconuts when nutrition layer surrounding the seed is ready to be processed into copra and desiccated coconut and exposed to sun about 2 to 4 hours to get brown colour fibre. The fibrous layer of fruited is then separated from hard shell by driving the fruit down onto a spike to split it.

Fig 3: Coir fibre

1.2. Extraction of Sisal fibre process

Sisal Fibres are obtained from the leaves of the Sisalana plant. In India four number of sisal plants are available that are Sisalana, Vergross, Istle and Natale. The different plants having different yield of fibres and varies its strength also. Sisal fibre is vegetable fibre having specific strength and stiffness that was compared well with glass fibres, the glass fibres are most artificial resins as compared with Sisal fibres and these makes composite less attractive for low technology applications. And therefore, the Sisal fibres naturally occurring resins, mostly cashew nut-shell liquid is an attractive than other fibres.

Fig 4: Sisal fibre

1.3. Fibre Reinforced concrete

Fibre reinforcement is mainly used in shotcrete. Fibre reinforced concrete is mostly used for on-ground floors and pavements. But also used in wide range of construction parts (Beams, Columns, Foundations etc.). Addition of fibres to concrete influences its mechanical properties which significantly depend on the type, percentage and structural of fibre. Fibres with end anchorage and high aspect ratio were found to have improved tensile strength and effectiveness. It was shown that for the same length and diameter, crimped end fibres can achieve the same properties as straight fibres using 35 percent less fibres.

Fig 5: Fibre Reinforced concrete cubes.

1.4. Structural Behaviour of FRC

Fibre's materials are combined with concrete in structural members will be largely used in the future generations. The structural behaviour of fibre reinforced concrete as follows.

a) Flexural behaviour: The incorporation of fibres in concrete as a reinforced concrete and the flexure members are increases their ductility nature, tensile strength, moment capacity, and stiffness in concrete members. The fibres must use to improve crack controlling and instantaneous post cracking structural integrity of members.

b) Torsion behaviour: The use of fibres in concrete to eliminates the sudden failure effect of plain concrete members. It increases stiffness, torsional strength, ductility, bending capacity and it leads to obtain number of cracks with desirable crack width.

c) Shear effect: adding of natural fibre in concrete increases shear capacity of reinforced concrete. And addition of randomly distributed fibres increases shear-friction strength, the first crack strength and ultimate strength occurs by adding of fibre to concrete.

d) Column behaviour: The increase of fibre content in concrete column, slightly increases the ductility of axially loaded members. The use of fibres helps in reducing the sudden or regular failures for columns.

e) Cracking and Deflections: The fibre reinforcement concrete is effectively controlling the cracking and deflection, and strength improvement is also obtained.

1.5. Need of Study.

Coir Fibre and Sisal Fibre are having high tensile strength and t s toughest natural fibres among all mostly commonly used waste materials (natural fibres) and they have capable of taking strains 5 times higher than other fibres (referred from previously published journal). Although, these are very cheapest fibres with higher efficiency of water absorption. And these fibres having more advantages that are low cost, specific strength.

Objectives and Scope

II. Methodology

2.1 Materials collected.

The materials are collected from their respective sources like cement, fine aggregated, coarse aggregated and the raw materials are natural fibre were collected from their respective sources like coir fibre after processing completed at coconut factory, after that the processed Sisal fibre was collected the from source place (online shopping)

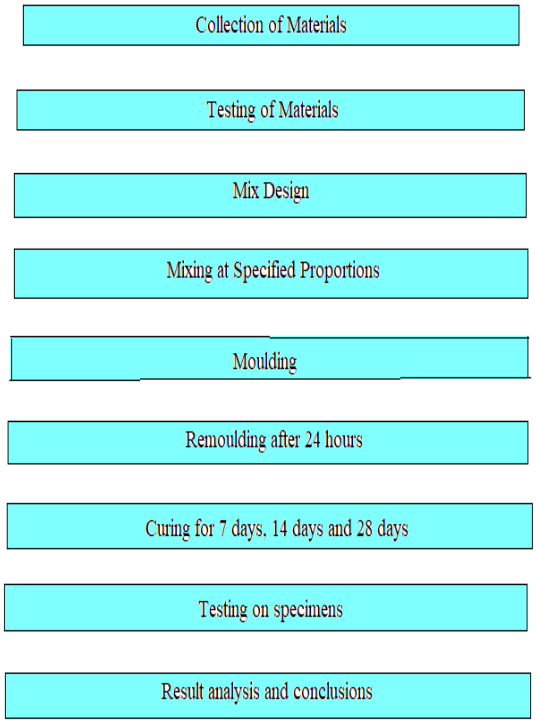

Fig 6: Schematic representation of Methodology

a) Tests on cement

The various tests done on cement are:

1. Standard Consistency
2. Initial Setting Time
3. Final Setting Time
4. Fineness of Cement
5. Density of Cement
6. Soundness of Cement

1. Tests for concrete

a) Workability test on plain concrete

Workability is defined as that it is the property of concrete mixture and that means the ease of placement and workable concrete and that can be compacted easily without any segregation. The workability is play very important role in making concrete which leads to gain the strength to the concrete. We have been conducted tests to determine the workability of conventional concrete and fibre reinforced concrete.

Slump Cone test

A slump cone test or concrete Slump test is to determine the workability or consistency of the concrete mixture prepared in the laboratory or at the construction site during work. The slump cone tests performed according to procedures mentioned as per IS 119-1959.

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The result of the slump test is a measure of the behaviour of compacted inverted concrete cone under action of gravity.

Table 1: slump values for conventional concrete

S. No	W/C Ratio	Slump Value (mm)	Status
1	0.4	35	Target slump not achieved
2	0.45	58	Target slump not achieved
3	0.50	115	Desired slump is obtained. (True Slump > 100mm)

Fig 7: slump cone test apparatus

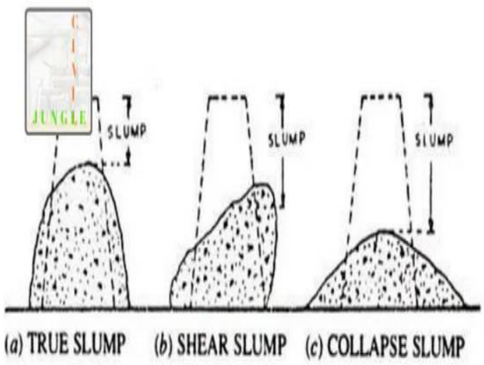

Fig 8: Characteristics of slump cone test

b) Workability test on fibre reinforced concrete

Slump cone test:

Slump test is the most used method of measuring consistency of concrete. The slump test does not measure the workability of concrete; it is useful to attain the difference in the steady of fresh concrete and detecting variations in the uniformity of concrete mix from batch to batch. The water content in concrete is the most familiar reason, as other factors such as particle shape and grading of aggregate may varies the slump for fibre reinforced concrete. The following table shows the slump values for reinforced concrete.

Table 2: slump values for fibre reinforced concrete

S. No	Percentage of natural fibres	W/C Ratio	Slump Value (mm)	Status
1	0 % fibres	0.50	115	Desired slump is obtained. (True Slump > 100mm)
2	M1 (SF+CF of 0.5%)	0.50	80	Target slump not achieved
3	M2 (SF+CF of 1%)	0.50	95	Target slump not achieved
4	M3 (SF+CF of 1.5%)	0.50	112	Desired slump is obtained. (True Slump > 100mm)
5	M4 (SF+CF of 2%)	0.50	120	Desired slump is obtained. (True Slump > 100mm)

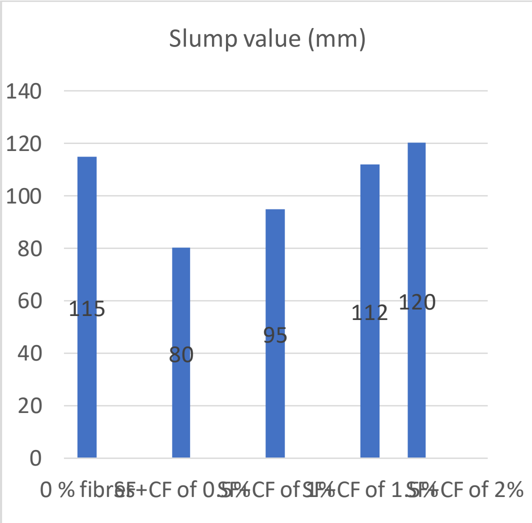

Fig 9: Variation of slump values for different mixes of reinforced concrete

2.2 Casting of concrete Cubes, Cylinders and Beams

The size of moulds having the sizes are cube size with 150mm x 150mm, cylinder size with 150mm x 300mm and the beam size with 700mm x 150mm x 150mm. The specimens could allow to remain in the steel moulds for the 24 hours at certain feasible condition. After that these were demoulded with care so as no edges were broken and were placed in the water tank at the feasible condition for curing and after that the demoulding the specimen by losing the screws of the steel mould, the cubes, cylinders, and beams were placed in the water for 7 days, 14days and 28days.

i) Casting of raw and processed coir and Sisal fibres reinforced concrete

The calculated amount of cement, sand and coarse aggregate mixed along with natural fibres of Coir and Sisal fibres of CF+SF (Coir fibre + Sisal fibre) of 0.5%, 1%, 1.5% and 2% of total weight of concrete, respectively. And then added the water stage wise and mixed thoroughly until get uniform colour. And make a fibre reinforced concrete with cubes, cylinder, and beams moulds.

Figure 10: Casting of cubes

Figure 11: Casting of cylinders

Figure 12: casting of Beams

ii) Testing of moulds

The remoulded specimens after being cured at 7days, 14days and 28days are taken out and dried in sunlight and tested under compression testing machine and universal testing machine with testing apparatus.

iii) Specimen details

The specimens are prepared as we required of average of three specimens for cubes, cylinders, and beams.

2.2 Test on concrete specimens prepared.

i) Compressive strength of concrete
ii) Tensile strength of concrete
iii) Flexural strength of concrete

III. Results and discussions

A) Compressive strength of concrete

The compressive strength of specimens was done on the compression testing machine and taken the average value of three specimens recorded of plain concrete (conventional concrete) and fibre reinforced concrete. The cube specimens are tested on compression testing machine.

i) Compressive strength of conventional concrete

The compressive strength of conventional concrete is employed from the compression testing machine by keeping the 150mm cube specimens on it and apply the axial load gradually until to get ultimate load obtain to break the specimen. For each trial mix combination, three cubes were tested at the age of 7 days, 14 days, and 28 days of curing period. The testes were carried out at a uniform stress after the specimen has been centred in the testing machine. The dial reading at the instant was recorded, which is the maximum load applied. The maximum load divided by the cross area of specimen is equal to the maximum cube compressive strength.

Table 3: Strength of conventional concrete

S.NO	No. of days	Compressive strength of concrete (N/mm2)	Tensile strength of concrete (N/mm2)	Flexural strength of concrete (N/mm2)
1	7	30.12	1.52	3.3
2	14	32.2	1.99	3.52
3	28	39.25	2.52	4.58

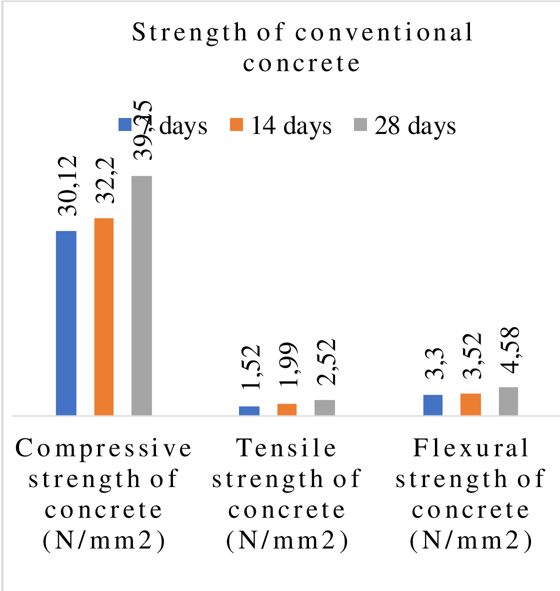

Fig 13: Variation compressive strength of conventional concrete

From the above table 5.1 show s that the variation of compressive strength, tensile strength, and flexural strength at 7days, 14 days and 28 days curing period respectively, obviously the strengths increase with increasing the number of days of curing period for both conventional concrete and fibre reinforced concrete.

ii) Compressive strength of fibre reinforced concrete

The compressive strength of fibre reinforced concrete is employed from the compression testing machine by keeping the 150mm cube specimens on it and apply the axial load gradually until to get ultimate load obtain to break the specimen. For each trial mix combination, three cubes were tested at the age of 7 days, 14 days, and 28 days of curing period. The testes were carried out at a uniform stress after the specimen has been centred in the testing machine. The dial reading at the instant was recorded, which is the maximum load applied. The maximum load divided by the cross area of specimen is equal to the maximum cube compressive strength.

B) Comparative study of test results

i) Comparison of compressive strength of conventional concrete and fibre reinforced concrete

Table 4: Comparison of compressive strength of conventional concrete and fibre reinforced concrete

S. No	Compressive strength (N/mm2)			
	Percentage of natural fibres	7 days	14 days	28 days
1	0 % fibres	30.12	32.2	39.25
2	0.5% of S+C (Sisal +Coir)	30.85	33.12	39.89
3	1% of S+C	31.20	34.20	40.52
4	1.5% of S+C	32.15	34.82	41.08
5	2% of S+C	28.20	30.12	33.33

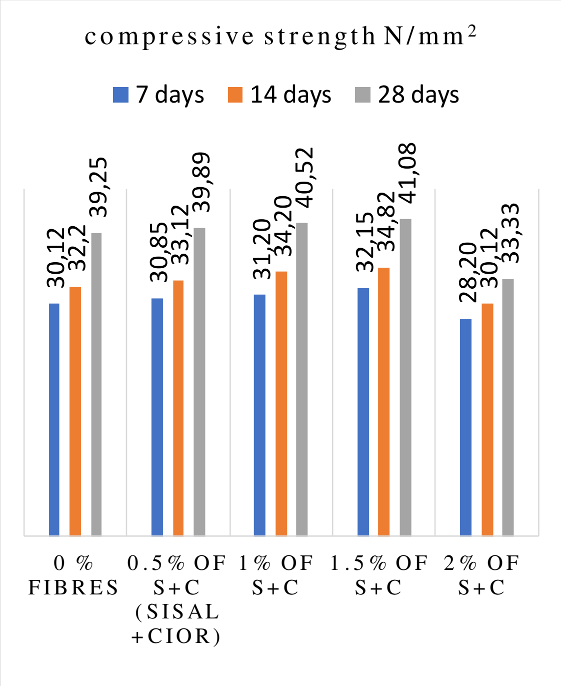

Figure 14: Variation compressive strength of fibre reinforced concrete

From the above fig 5.2 shows that the variation of compressive strength at 7days, 14 days and 28 days curing period respectively, here we observed that the maximum compressive was reaches at 1.5% of (Sisal +Coir) Fibres in concrete as compared with the conventional concrete. Obviously increasing the number of days of curing period while concrete gets more strength. The variation of compressive strength shows in graph.

ii) Comparison of split tensile strength of conventional concrete and fibre reinforced concrete

Table 5: Comparison of split tensile strength of conventional concrete and fibre reinforced concrete

S. No	Tensile strength (N/mm2)			
	Percentage of natural fibres	7 days	14 days	28 days
1	0 % fibres	1.52	1.99	2.52
2	0.5% of S+C (Sisal +Coir)	2.15	2.30	2.65
3	1% of S+C	2.32	2.50	2.67
4	1.5% of S+C	2.45	2.52	2.78
5	2% of S+C	1.88	1.99	2.02

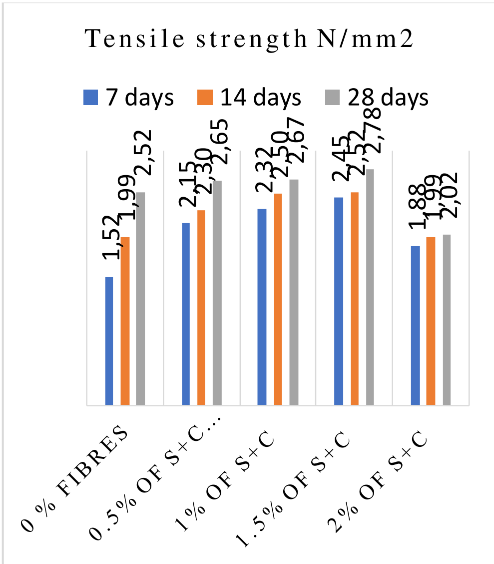

Figure 15: Variation split tensile strength of fibre reinforced concrete.

From the above table 5.3 shows that the variation of split tensile strength at 7days, 14 days and 28 days curing period respectively, here we observed that the maximum split tensile strength was reaches at 1.5% of (Sisal +Coir) Fibres in concrete as compared with the conventional concrete. Obviously increasing the number of days of curing period while concrete gets more strength. The variation of split tensile strength shows in graph.

iii) Comparison of flexural strength of conventional concrete and fibre reinforced concrete

Table 5: Comparison of flexural strength of conventional concrete and fibre reinforced concrete

S. No	Flexural strength (N/mm2)			
	Percentage of natural fibres	**7 days**	**14 days**	**28 days**
1	0 % fibres	3.3	3.52	4.58
2	0.5% of S+C (Sisal +Coir)	8.20	8.50	9.10
3	1% of S+C	8.52	8.58	9.23
4	1.5% of S+C	8.90	9.13	9.55
5	2% of S+C	9.10	9.52	9.99

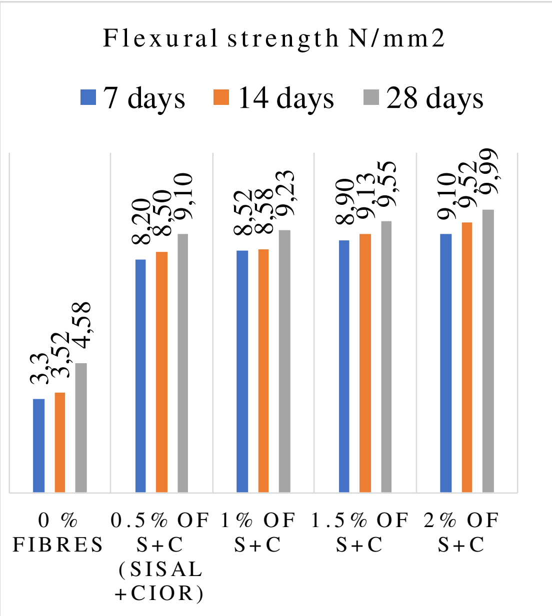

Figure 16: Variation Flexural strength of fibre reinforced concrete

From the above table 5.4 shows that the variation of flexural strength at 7days, 14 days and 28 days curing period respectively, here we observed that the maximum flexural strength was reaches at 2% of (Sisal +Coir) Fibres in concrete as compared with the conventional concrete. Obviously increasing the number of days of curing period while concrete gets more strength. The variation of flexural strength shows in graph.

C) Comparative study of strength at 7days, 14days and 28days curing period.

i) Comparison of Strength for 7days curing period.

ii)

Table 6: Strength at 7 days curing period.

Strength at 7 days curing period for different mixes				
S.NO	**Mix proportions**	**Compressive strength of concrete (N/mm2)**	**Tensile strength of concrete (N/mm2)**	**Flexural strength of concrete (N/mm2)**
1	0 % fibres	30.12	1.52	3.3
2	0.5% of S+C (Sisal +Coir)	30.85	2.15	8.20
3	1% of S+C	31.20	2.32	8.52
4	1.5% of S+C	32.15	2.45	8.90
5	2% of S+C	28.20	1.88	9.10

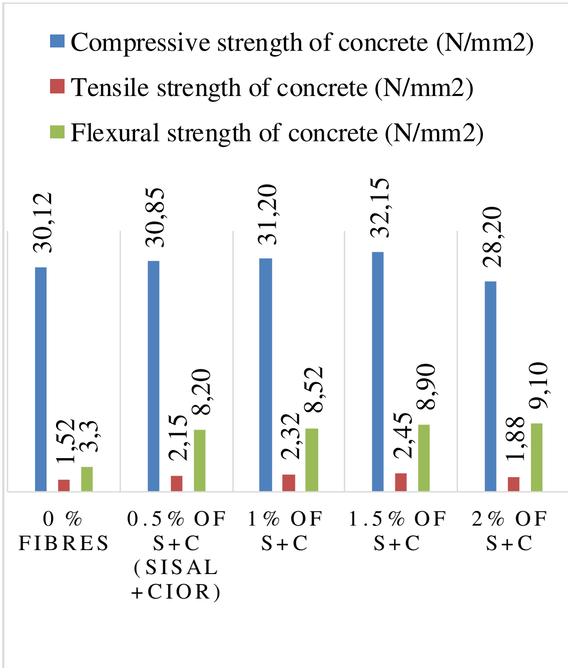

Fig 17: Variation of testing results at 7 days curing period.

Here, from above fig 5.5, the variation of testing results was studied at 7days of curing period for compressive strength, split tensile strength and flexural strengths were observed that the maximum compressive and spit tensile strengths were obtained at 1.5% of fibres content, but the maximum flexural strength has been obtained at 2% of fibre content in fibres reinforced concrete.

i) Comparison of Strength for 14 days curing period.

Table 8: Strength at 14 days curing period.

Strengths at 14 days curing period for different mixes				
S.NO	**Mix proportions**	**Compressive strength of concrete (N/mm2)**	**Tensile strength of concrete (N/mm2)**	**Flexural strength of concrete (N/mm2)**
1	0 % fibres	32.2	1.99	3.52
2	0.5% of S+C (Sisal +Coir)	33.12	2.30	8.50
3	1% of S+C	34.20	2.50	8.58
4	1.5% of S+C	34.82	2.52	9.13
5	2% of S+C	30.12	1.99	9.52

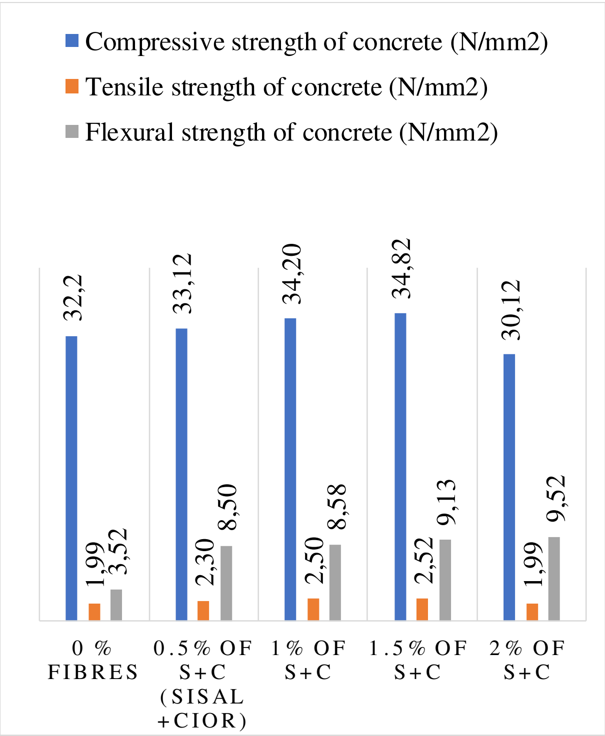

Fig 18: Variation of testing results at 14 days curing period.

Here, from above fig 5.6, the variation of testing results was studied at 14days of curing period for compressive strength, split tensile strength and flexural strengths were observed that the maximum compressive and spit tensile strengths were obtained at 1.5% of fibres content, but the maximum flexural strength has been obtained at 2% of fibre content in fibres reinforced concrete.

i) Comparison of Strengths for 28 days curing period.

Table 9: Strength at 28 days curing period.

Strength at 28 days curing period for different mixes				
S.NO	**Mix proportions**	**Compressive strength of concrete (N/mm2)**	**Tensile strength of concrete (N/mm2)**	**Flexural strength of concrete (N/mm2)**
1	0 % fibres	39.25	2.52	4.58
2	0.5% of S+C (Sisal +Coir)	39.89	2.65	9.10
3	1% of S+C	40.52	2.67	9.23
4	1.5% of S+C	41.08	2.78	9.55
5	2% of S+C	33.33	2.02	9.99

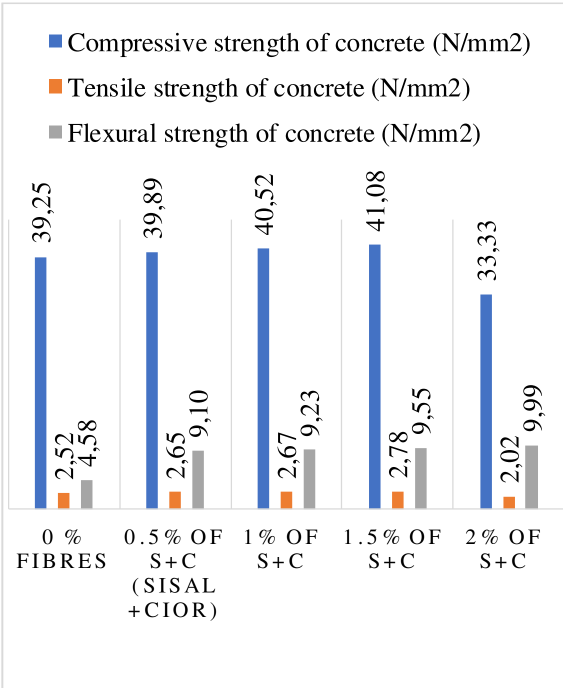

Fig 19: Variation of testing results at 28 days curing period.

Here, from above fig 5.7, the variation of testing results was studied at 28days of curing period for compressive strength, split tensile strength and flexural strengths were observed that the maximum compressive and spit tensile strengths were obtained at 1.5% of fibres content, but the maximum flexural strength has been obtained at 2% of fibre content in fibres reinforced concrete.

CONCLUSIONS

7.1 Conclusions

From above experimental study, the following conclusion were obtained. Using the Sisal fibre and Coir fibre concrete gets increases the strength of concrete.

- All the mixes are showing better results when both sisal fibre and Coir fibre are used in one concrete specimen.
- The optimum percentage of sisal fibre plus coir fibre for maximum strength was 1.5% for compressive strength, 1.5% for split tensile strength and 2% for Flexural strength.
- Workability decreases with increase in percentage of sisal fibre replaced with 0.5%, 1%, 1.5 %, and 2 % of volume of cement.
- The flexural strength of the Sisal fibre and Coir fibres replaced beam the strength attained is higher than normal strength concrete at 28days of curing period.
- The reduction of compressive strength, split tensile strength is observed at 2% of Sisal fibre and Coir fibres reinforced concrete.
- Toughness of concrete also increases by addition of fibres content in concrete for making as reinforced concrete.

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