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An Experimental Study On Strength And Fresh Properties Of Fiber Reinforced Concrete With The Addition Of Sisal Fibers

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ABSTRACT:

Concrete is a widely used building material, it is prone to quasi-brittle failure due to its high compressive strength but low tensile strength and it has limited capacity to restrict the energy absorption after yielding. It takes a huge amount of natural resources such as cement, coarse and fine aggregate. An alternative material that can be used in limited quantities to replace these natural resources may improve the performance of concrete. Natural fibers have recently generated a lot of interest in the world of building materials. Keeping in view, this study is conducted on the feasibility of adding naturally available fiber named sisal fiber in the concrete to get durability properties as they are efficient in tensile strength and preventing crack growth. The leaves of sisal plants are used to produce sisal fiber, it is mostly employed in applications such as rope manufacturing in the construction and marine industries. This research will be carried out on M30 Grade concrete and sisal fibers are added at a percentage of 0, 0.5, 1, 1.5 and 2% to the weight of cement and the lengths of sisal fiber used are 1, 2 and 3cm. Concrete characteristics in fresh state are determined by conducting the slump cone test to figure out the water-cement ratio. Strength properties are determined by Compressive, Split tensile and flexural strengths after 28 days curing of concrete.

Key Words: Natural fibers, Sisal fibers, Strength properties.

1.0 INTRODUCTION:

The demand on the building sector is expanding more than ever as a result of the growing world population. Since concrete has the most often used construction material, it strongly depends on the natural resources such as cement, coarse and fine aggregate that are readily available. It possesses distinct intrinsic qualities such as strong in compression, good at durability, fire resistance, and less permeability. This technology allows for the early processing of cement-based materials, i.e. before the curing process, into the specific forms and structural configurations that are needed. The fundamental shortcoming of these materials is their brittleness, which is related to their stiff characteristics and is responsible for fracture development and spread when subjected to loads. Such weakness causes loss of mechanical qualities, requiring expensive repair or even replacement of such materials during a relatively limited life period. As a result, concrete is fragile, has low impact resistance, and is prone to fracture. It has a poor tension strength as well.

In order to overcome these flaws, concrete's qualities have to be improved. Standard reinforcing steel bars (rebars) can be used to address some of these problems, such as poor tensile strength. Rebars resist tensile and shear stresses, whereas concrete predominantly resists compressive stresses. In a beam, longitudinal rebar resists shear forces, whereas stirrups wrapping around the transverse bar resist flexural (tensile) stress. Vertical bars and ties in a column withstand shear and compression loads, respectively. Reinforced concrete results an excellent composite material with numerous uses. But fissures in reinforced concrete members to close up until they come into contact with a rebar. To overcome the fissures, we must therefore use fiber-reinforced concrete.

Fiber reinforced concrete (FRC) is obtained by the addition of fibers to concrete. Types of fibers are Steel fibers, glass fibers, synthetic fibers and natural fibers[1]. By using an appropriate volume percentage of certain fibers, the weakness in tension can be overcome. In order to enhance the mechanical properties of concrete, it is wise to combine cement with fibers that have a high tensile strength. Concrete's toughness is significantly increased by the addition of fibers. The fibers also alter the behavior of the fiber matrix composite after it has fractured, making it more durable. FRC, which was first primarily utilized for pavements and industrial floors, is currently being used for a broad variety of applications, such as bridges, tunnel and canal linings, and hydraulic structures. Current study on the use of FRC in structural components such columns, beams, slabs and pre-stressed structures made of concrete is being conducted in India and abroad by a number of researchers.

Fibers used for the hybridization of concrete are natural fibers and synthetic fibers. The most extensively used natural fiber is sisal, which is also one of the easiest to grow. The plant known scientifically as Agave sisalana belongs to the Agavaceae (Agave) family and produces a stiff fiber that has been traditionally utilized to make twine and rope. Sisal is a very renewable energy source that is completely biodegradable. Sisal fiber has very little wear and tear and is quite resilient. The sisal fiber is obtained through a procedure called decortication, in which the leaves are pounded and battered by a wheel that spins equipped with sharp blades until only fiber are left.

2.0 LITERATURE REVIEW:

Ghule Sudarshan Uttam et.al (2022) did experimental study on Strength of Concrete by Agave Sisalana [1]. The use of sisal fiber as reinforcement in concrete and the inclusion of sisal fibers at 0.5, 1 and 1.5% to the weight of cement were both examined. For compressive and split tensile strengths, it was shown that sisal fiber should make up no more than 1% of the material.

V. Karunya Latha et.al (2019) carried out a project on Natural Sisal Fiber Reinforced Concrete using

Experimental Studies. The study found that natural fibers have a considerable financial advantage as well as a positive influence on the environment. A small amount of fiber addition will improve the tensile strength. The addition of fibers improves bond strength, hardness, and permeability as well as tensile strength. Finally, stated that 1% fiber content as optimum dosage.

K.T. Radha Sumithra et.al (2017) conducted experimental investigation on the strength properties of sisal fiber reinforced concrete [3]. The inclusion of sisal fibers at 0, 0.5, 1, 1.5, and 2% by weight of concrete was found to be effective. It demonstrates that by incorporating fiber content into the concrete, the strength parameters may be enhanced. The compressive strength grew until the mix percentage reached 1% before the strength began to decline.

Y. K. Sabapathy et.al (2017) conducted experimental investigation on the strength parameters of sisal fiber reinforced concrete [4]. The compressive strength of concrete was observed to improve significantly with the addition of fibers, and maximum compressive strength was discovered for a fiber volume percentage of 1% in all three tested concrete grades. The flexural strength increased with an increase of fiber volume fraction. The fact that the tested examples had few cracks shows that the sisal fibers improved the cracking.

Abdul Rahuman et.al (2015) studied properties of sisal fiber reinforced concrete with varying mix proportions and percentage of fiber addition [5]. The test results showed that sisal fibers are added at 0.5, 1 and 1.5% to the weight of cement. The increase in tensile strength was almost similar at 1 and 1.5% addition of fiber. For the M20 mix design with fiber additions of 1 and 1.5%, the enhanced tensile strength was 41.37% and 44.378%. It has been determined that 1.5% addition of fiber will result in good strength.

3.0 OBJECTIVES:

- To Study the effect on utilization of sisal fibers as reinforcement in concrete when mixed in different proportions by cutting into small pieces of length 1, 2 and 3cm.

- To determine the fresh properties of concrete and strength parameters like compressive, split tensile and flexural strengths after 28 days of curing for M30 Grade concrete.

4.0 EXPERIMENTAL INVESTIGATION:

4.1 MATERIAL USED:

The materials used in this experiment are cement, sisal fibers, fine and coarse aggregates, water and super plasticizer.

- **Cement:**

Cement is a binding agent that hardens and binds to other materials, allowing them together in the construction. It has cohesive and adhesive properties. Ordinary Portland cement of grade 53 is utilized in this job in accordance with IS 12269-1970[10]. The specific gravity was 3.15 when tested in laboratory.

- **Sisal Fibers:**

Sisal fibers are utilized as a cement reinforcing agent. The material is chosen to enhance the structure's varied strength characteristics in order to make it more durable and of higher quality. Sisal fibers are added at 0, 0.5, 1, 1.5 and 2% to the weight of cement. The physical properties of sisal fibers are presented in Table 1.

Table 1: Properties of Sisal Fibers

Fiber Property	**Result**
Fiber Length	1cm, 2cm, 3cm
Fiber Diameter	0.1-0.13 mm
Aspect Ratio	100-300
Shape	straight
Color	Creamy white
Specific Gravity	0.73

- **Fine Aggregate:**

Fine aggregate used in this experiment was locally available river sand conforming to Zone-II of IS: 383-1970[10]. Fine Aggregate passed through 4.75 mm sieve, which was available locally. The Specific Gravity was 2.60 when tested in laboratory.

- **Coarse Aggregate:**

The coarse aggregate used in this study was crushed granite of maximum size 20 mm obtained from the local crushing plant and conforms to Zone II of IS: 383- 1970[10]. The Specific Gravity was 2.76 when tested in laboratory.

- **Super Plasticizer:**

Forsoc Conplast SP-430 is the chemical admixture utilized in this study. Super plasticizer has a specific gravity of 1.145 and is added at a rate of 0.2% by the weight of cement.

- **Mix Proportions:**

A water-cement ratio (water/cement) of 0.46 is adopted. The amount of cement used is 380 kg/m³. As a result, the water content should be 175 kg/m³. The amount of fine aggregate used is 610 kg/m³, whereas the amount of coarse aggregate is 1170 kg/m³. The fiber added to the concrete for the aim of studying the properties of the fiber reinforced concrete; the addition is around 0, 0.5, 1, 1.5, and 2 % by weight of cement for the relevant mix, respectively. The final mix proportion of M30 concrete is 1:1.60:3.07.

4.2 METHODOLOGY:

Controlling and validating the quality of cement concrete processes depend on concrete testing. Systematic testing of the raw ingredients, freshly poured concrete, and cured concrete must be a part of any concrete quality control program. This will boost the material's effectiveness and give people more reason to be confident in how well concrete will perform in terms of strength. The test procedures should be simple, direct, and easy to follow. Testing Hardened Concrete has several goals, one of which is to make sure that the concrete used on the project site has developed the required strength. Fresh concrete may be molded into any shape and is also referred to as plastic concrete. The strength of the cement plays a major role in determining the concrete strength. To establish whether fresh concrete is workable, a slump test will be conducted. The hardened concrete will undergo tests to determine its compressive, split tensile and flexural strengths after 28 days of cure.

5.0 RESULTS AND DISCUSSIONS:

5.1 SLUMP TEST:

The slump cone test was done to assess the workability of natural sisal fiber concrete. The results reveal that increasing the fiber cement content reduced the slump due to fiber water absorption. The addition of sisal fiber to plane concrete can increase the mixture's stability and cohesion while decreasing its workability (see Table.2)

Table 2: Slump values

Slump Values in mm				
S.no.	% of Sisal fibers added	Length of Sisal fibers		
		1cm	2cm	3cm
1	0%	60	60	60
2	0.50%	52	50	48
3	1%	45	43	40
4	1.50%	38	35	33
5	2%	30	28	25

The variation of slump with the addition of sisal fibers of different lengths and quantity are presented in Figure 1.

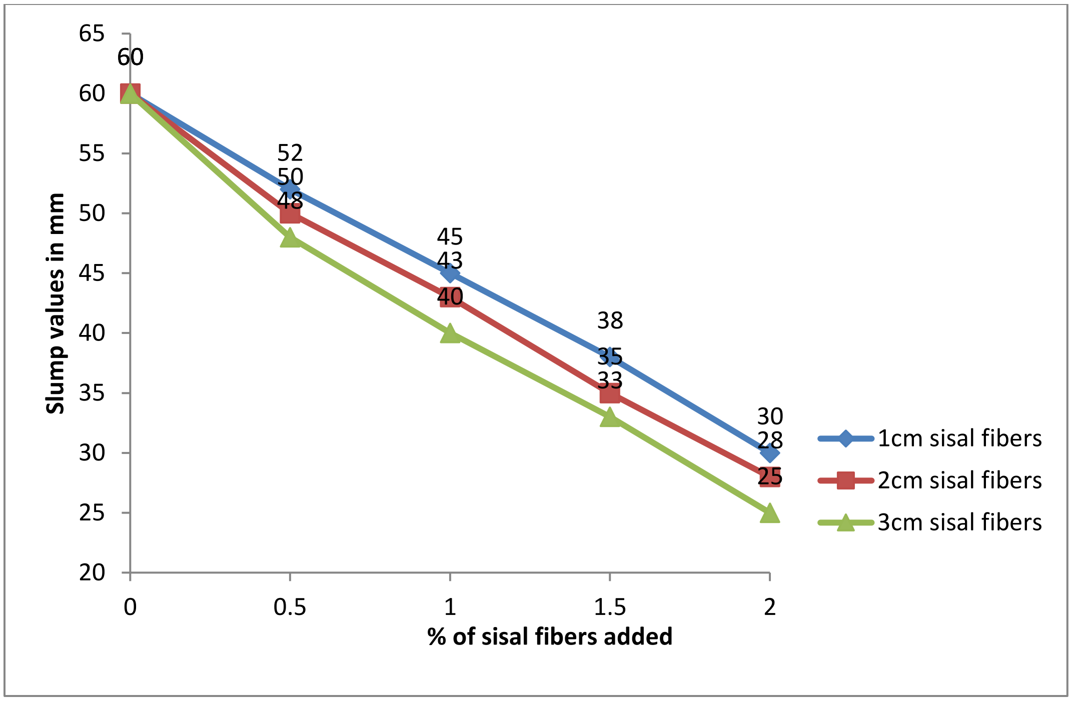

Figure 1: Variation of slump

5.2 COMPRESSIVE STRENGTH:

The compressive strength of concrete depends upon several factors, including the water cement ratio, the strength of the cement used, and quality control during production. For the compression test, cube specimens with dimensions of 150x150x150mm were used, in accordance with IS: 516-1959[10]. The typical Compressive Testing Machine (CTM) with a capacity of 2000kN was used to measure the compressive strength. 45 cube specimens were tested with different volume fraction of fiber at 0, 0.5, 1, 1.5 and 2%by weight of cement for 28 days (see Table 3)

Table 3: Average Compressive Strength

Average Compressive strength (N/mm²) for 28days				
S.no.	% of Sisal fibers added	Length of Sisal fibers		
		1cm	2cm	3cm
1	0%	37.12	38.01	36.14
2	0.5%	38.25	39.19	37.44
3	1%	39.05	40.02	38.55
4	1.5%	37.99	39.01	37.64
5	2%	36.99	37.89	36.54

The variation in compressive strength with various proportions of sisal fibers and its lengths is depicted in Figure 2.

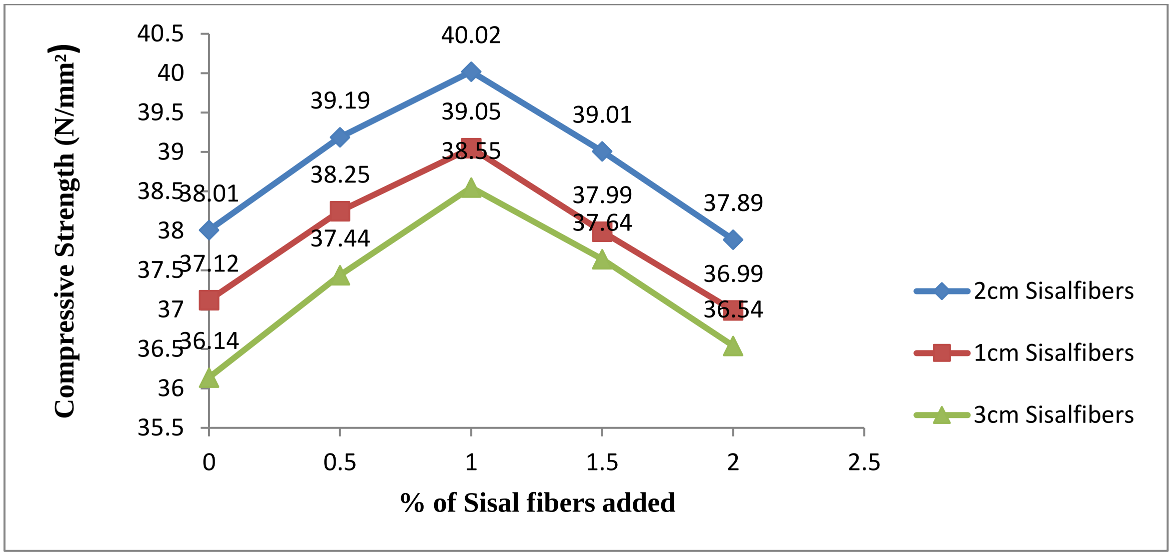

Figure 2: Variation of Compressive Strength

The findings show that the compressive strength of concrete has been increased from 0 to 1% and after that it is subsequently decreased from 1 to 2% for all three lengths of sisal fibers. It is noted that 2cm length gave optimum compressive strength of 40.02 N/mm^2. The examination of the examined specimens revealed that these fibers were efficient in bonding with the concrete matrix, preventing the formation of cracks.

5.3 SPLIT TENSILE STRENGTH:

Reinforcement is used in concrete since it is incapable of withstanding tensile loads. This test indicates that resistance to cracks by the fibers when subjected to tensile loads. With a 600 kN capacity, the standard Universal Testing Machine (UTM) used to conduct the tensile strength test. 45 cylindrical specimens of each size 300 mm long with 150mm diameter were tested with different fiber volume fraction from 0 to 2% by weight of cement for 28 days as per IS: 5816-1999[10] (see Table 4)

Table 4: Average Split Tensile strength

Average Split Tensile strength (N/mm²) for 28days				
S.no.	% of Sisal fibers added	Length of Sisal fibers		
		1cm	2cm	3cm
1	0%	2.95	3.02	2.89
2	0.5%	3.06	3.15	3.00
3	1%	3.25	3.39	3.14
4	1.5%	3.12	3.25	3.05
5	2%	3.01	3.13	2.94

The variation of tensile strength with different proportions of sisal fibers and its lengths is depicted in Figure 3.

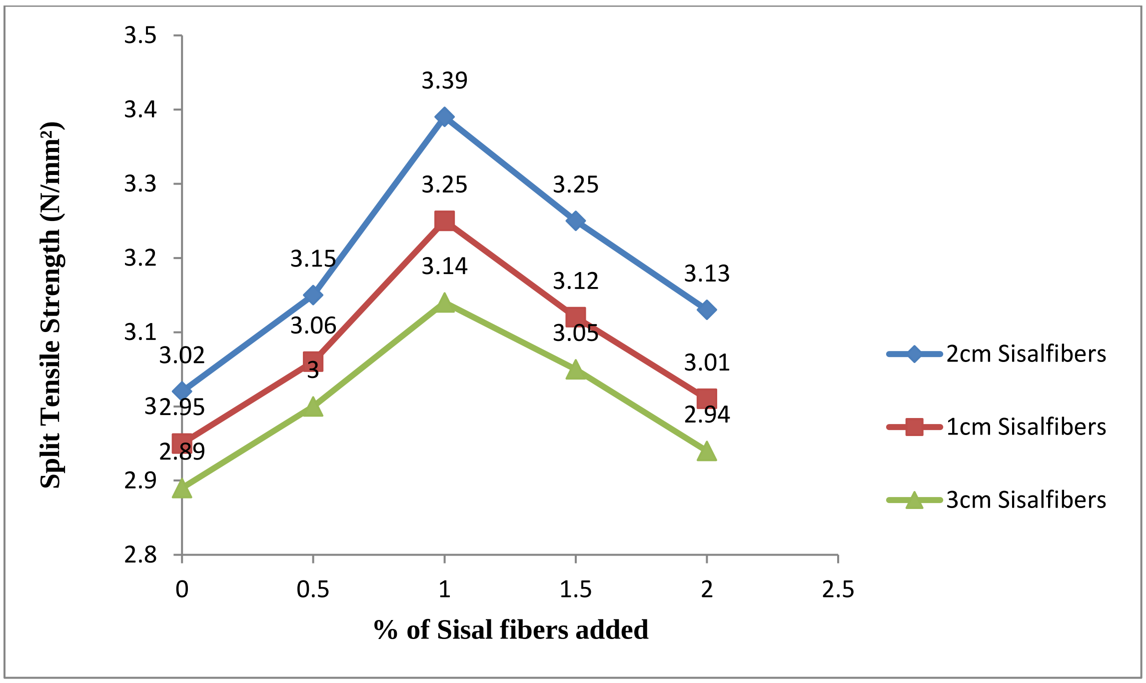

Figure 3: Variation of Split Tensile strength

The findings show that the split tensile strength of concrete with an increase from 0 to 1% and after that it is subsequently decreased from 1 to 2% for all three lengths of sisal fibers. It is noted that 2cm length gave optimum tensile strength of 3.39 N/mm^2.

5.4 FLEXURAL STRENGTH:

The flexural strength test determines the intensity of a beam or slab resist against tensile forces due to flexure. This experiment investigates the bonding strength of sisal strands in concrete. The flexural strength test was performed on 15 beam specimens with dimensions of 500 x 100 x 100mm and fiber volume fractions ranging from 0, 0.5, 1, 1.5 and 2% by weight of cement for 28 days as per IS: 516-1956[10] (see Table 5)

Table 5: Flexural strength

Flexural strength (N/mm²) for 28days				
S.no.	% of Sisal fibers added	Length of Sisal fibers		
		1cm	2cm	3cm
1	0%	8.02	8.14	7.88
2	0.5%	8.44	8.59	8.23
3	1%	8.78	8.99	8.54
4	1.5%	8.46	8.67	8.31
5	2%	8.12	8.33	8.01

The variation of flexural strength with different proportions of sisal fibers and its lengths is depicted in Figure 4.

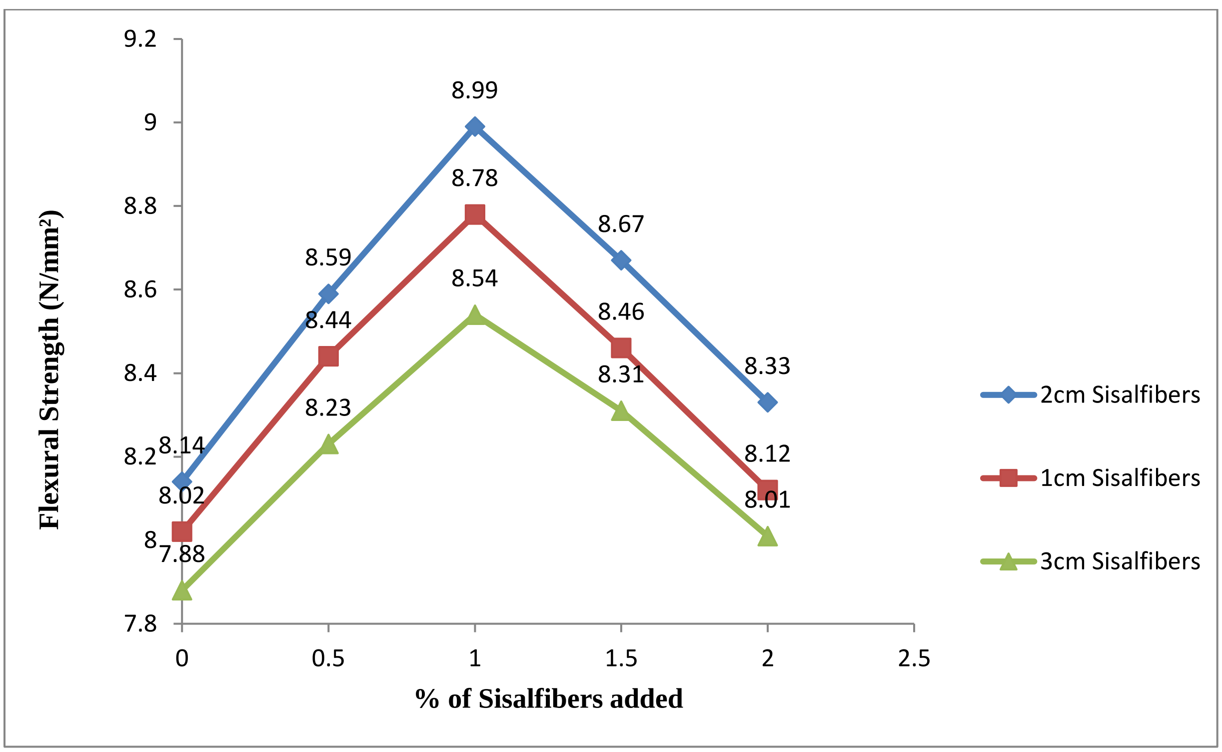

Figure 4: Variation of Flexural Strength

It can be observed from the graph that the flexural strength of concrete has been increased from 0 to 1% and after that it is subsequently decreased from 1 to 2% for all three lengths of sisal fibers. It is noted that 2cm length gave optimum flexural strength of 8.99 N/mm^2. The examination of the examined specimens revealed that these fibers were efficient in bonding with the concrete matrix, preventing the formation of cracks.

6.0 CONCLUSIONS:

1. From the experimental study, it is noted that slump decreases with an increase in percentage of sisal fibers for all lengths.
2. It is observed that the addition of sisal fibers to concrete boosted its compressive, split tensile and flexural strengths i.e.,the optimum compressive strength of 40.02 N/mm^2 is obtained with a maximum gain of 10.70%, for split tensile strength 3.39 N/mm^2 is obtained with a gain of 17.30% and flexural strength was 8.99 N/mm^2 with a gain of 14.08%.
3. The maximum compressive, tensile and flexural strengths of concrete were found to be for a sisal fiber volume fraction of 1% by weight of cement for all lengths.
4. Out of the three lengths of sisal fibers investigated, it is noted that 2cm length gave optimum slump and hardened properties.
5. The presence of fewer cracks in the examined specimens indicates that the sisal fibers were efficient in enhancing concrete cracking resistance.
6. Hence it is concluded that Natural Sisal fibers can be used effectively in the production of M30 grade concrete.

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- Flexural strength: IS: 516-1956.