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Addition of sisal fiber to improve tensile strength of concrete.

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ABSTRACT - *Concrete is the most widely used construction material globally, owing to its versality, durability, and relatively low cost. However, despite its numerous advantages, concrete exhibits certain limitations, such as low tensile strength and brittleness. Fiber reinforced concrete has emerged as a promising solution to improve the performance of conventional concrete. This present paper deals with the addition of 1% of sisal fiber by the weight of cement to improve tensile strength of the concrete. Sisal fibers are the natural plant-based fiber which are produced from the Agave Sisalana plant. Research methodology involves the preparation, curing and testing of cylindrical specimens at 7, 14 and 28 days.*

***Key Words*: Conventional concrete, Sisal fiber, Sisal fiber reinforced concrete, tensile strength.**

1.INTRODUCTION

Concrete is a composite mixture which includes cement, sand, coarse aggregate, and water. It acts good in compression than tension. Due to its high compressive strength and durability, many structures are constructed by concrete such as roads, buildings, tunnels, bridges, dams etc. Concrete structures can resist heavy load for long period of time without getting failure early. Fresh concrete can be casted into any shape and size.

The main drawback of using concrete is its comparatively low tensile strength, to overcome this problem reinforcement is provided in the plain cement concrete. Mainly steel bars are provided as a reinforcement material to take loads in the tension zone. Plain cement concrete with steel reinforcement is provided is known as reinforced cement concrete (RCC).

Even before loading some internal microcracks are already present in the concrete these are mainly due the change in volume and drying shrinkage. The presence and development of these microcracks are responsible for inherent weakness of concrete. For the purpose of minimizing microcracks fibers are introduced in the concrete.

1.1 FIBER REINFORCED CONCRETE (FRC)

Fiber-reinforced concrete is a composite material that consists of conventional concrete which is reinforced by fibers. Fibers are the small reinforcing material that acts as a crack arrester for concrete. They can be uniformly or randomly distributed into the cement concrete matrix. There are different types of fibers available in the market based on their origin, shapes, sizes, etc. After the addition of fibers in concrete mix these fibers interlock and entangle around the aggregate's particles. Addition of fibers provides good interlocking bond between ingredients of concrete or mortar so that chances of segregation of aggregates are reduced while placing and workability is reduced. They are widely used in providing strength to the civil structures such as beams, columns, slabs, walls etc.

1.2 FACTORS AFFECTING FRC

There are some factors that may affects the properties of fiber-reinforced concrete (FRC)

1. Types of fibers used.
2. Fiber Geometry
3. Amount of fibers used.
4. Aspect ratio of fibers
5. Distribution of fibers
6. Mixing and compaction of concrete

Aspect Ratio is the important term when we talk about FRC. This is the ratio of length of fibers to its diameter.

1.3 ADVANTAGES OF FRC

1. Provides stiffness to the structure.
2. Maintenance and repair cost is low.
3. It gives high strength to concrete.
4. Good durability.
5. Resistance to corrosion and fire.
6. Resistance to wear and tear.
7. Increases Toughness.
8. Provides long service life to the structure.

1.4 SISAL FIBER REINFORCED CONCRETE (SFRC)

Sisal fiber reinforced concrete consists of plain cement concrete or mortar with the addition of sisal fibers in it. Sisal fibers are plant-based natural fibers that are extracted from the leaves of the Agave Sisalana plant. These fibers are considered as hard fibers which is creamy white in color. Agave Sisalana plants can be easily cultivated and grows rapidly in a short duration of time. These plants can be easily seen in the hedges of field and railway tracks. Cellulose is the major constituent of plant fibers. It may find that there can be some variations in the properties of fibers due to variations in climatic conditions, age of the plant, methods used for fiber extraction.

Addition of these fibers can improve cracking performance and toughness of the concrete mix. These fibers are the commonly used fiber because of its low cost and availability. Sisal fiber plant can grow in very hard type soil where normal plants may not be grown. Sisal fiber is used in construction industries as well as also used in making ropes and other home essentials such as bag, napkin, and carpet etc.

2. LITERATURE REVIEW

2.1. STRENGTH OF SISAL FIBER CONCRETE WITH FINE CONSTRUCTION WASTE AGGREGATE By Raghu Yadav Golla (2015)

The paper discusses the development of sustainable and environmentally friendly concrete using fine aggregate from demolition waste with sisal fiber, which improves concrete properties without affecting workability. Concrete mixes with demolition waste and sisal fiber improved concrete properties, with strength enhancement up to 50% replacement of natural sand. - Sisal fiber and demolition waste had no impact on workability, and nearly equal strength as normal concrete was achieved up to 80% replacement. The methodology involved replacing natural sand with construction waste, adding sisal fiber, conducting compressive and split tensile strength tests, and assessing stress-strain behavior. Mixing, testing, and analysis were done following specific standards.

2.2. CONCRETE REINFORCED WITH SISAL FIBERS (SSF): OVERVIEW OF MECHANICAL AND PHYSICAL PROPERTIES By Ahmed et al (2022)

The paper provides an overview of the mechanical and physical properties of concrete reinforced with sisal fibers, highlighting their potential in enhancing strength and durability while affecting flowability, and suggests areas for further research. The main findings include the variation in physical characteristics of SSF based on plant age, decreased flowability with SSF addition, and the increase in strength properties of concrete up to a limit with SSF. The methodology involves examining the mechanical and physical properties of concrete reinforced with sisal fibers (SSF), including analyzing the qualities of SSF, the interface between SSF and the matrix, and the properties of SSF-reinforced concrete such as fresh properties, mechanical strength, and durability. The study evaluates how SSF enhances strength and durability while impacting flowability and provides recommendations for future research.

2.3. STUDY ON PROPERTIES OF SISAL FIBER REINFORCED CONCRETE BY ADDING OF DIFFERENT PERCENTAGES AND DIFFERENT SIZES OF SISAL FIBER by Dilip Kumar et al (2018)

The paper discusses the use of sisal fiber reinforced concrete to enhance workability and strength properties, highlighting its reliability for structural elements in construction, along with improvements in compressive strength, tensile strength, and water absorption. It also mentions the significance of compressive strength in concrete and the potential use of Metakaolin as a concrete constituent with pozzolanic properties. Sisal fiber reinforced concrete is a reliable material for structural elements, with 2.5% fiber addition showing better strength. The methodology involved hand mixing materials with different percentages of sisal fiber in the M25 mix design, casting specimens in cubes and cylinders for testing, conducting slump cone tests for workability assessment, and evaluating strength and durability by adding various percentages of sisal fiber with cement.

2.4. A COMPARATIVE PERFORMANCE OF SISAL AND POLYPROPYLENE FIBERS IN ENHANCING TENSILE STRENGTH OF CONCRETE by Srinivasa Rao Naraganti et al (2017)

The paper compares the performance of polypropylene (PP) fibers and sisal fibers in enhancing the tensile strength properties of concrete, confirming a good correlation between PFRC and SFRC, and suggesting sisal fibers as a potential alternative to PP fibers. Further research is being conducted to assess the durability properties of the fiber-reinforced concretes. Polypropylene (PP) fibers have been effective in improving various engineering properties of concrete, while sisal fibers showed potential as an alternative but did not achieve the same strength levels as PP fibers. The methodology involved using manually extracted 12 mm long sisal fibers at different dosages to evaluate their influence on the tensile strength properties of M30 grade concrete. Split tensile and flexural strength of PFRC and SFRC were assessed at various ages, with a focus on establishing a correlation between the tensile strength properties of the two types of concrete.

3. SCOPE AND OBJECTIVES

3.1. Evaluate the impact of incorporating sisal fibers on the tensile strength of concrete.

3.2. Investigate the optimal proportion of sisal fibers to achieve maximum enhancement in tensile strength.

3.3. Compare the tensile properties of sisal fiber-reinforced concrete (SFRC) with conventional concrete.

3.4. Examine the durability and long-term performance of SFRC in terms of tensile strength under various environmental conditions.

It provides insights into the potential applications and benefits of utilizing sisal fibers as a sustainable reinforcement option for concrete construction. It explores the feasibility of incorporating sisal fibers into concrete mixes to enhance tensile strength while maintaining economic viability. It also offers recommendations for optimizing the production process and practical implementation of sisal fiber-reinforced concrete in construction projects. It contributes to the body of knowledge on sustainable materials and techniques for improving the mechanical properties of concrete, particularly focusing on enhancing tensile strength through the addition of natural fibers like sisal.

4. MIX DESIGN

Stipulations for proportioning

Grade of concrete = M30

Grade of cement = OPC 53

Maximum size of aggregate = 20 mm

Exposure condition = severe

Fine aggregate = zone II

Slump = 75 mm

Test data recorded

Specific gravity of cement = 3.15

Specific gravity of coarse aggregate =2.73

Specific gravity of fine aggregate = 2.6

Water absorption for coarse aggregate = 1.0

Water absorption for fine aggregate = 1.16

1) Target mean strength

$f'ck = fck + 1.65 \times S$

OR

$f'ck = fck + X$

a) $f'ck = 30 + 1.65 \times 5 = 38.25$ N/mm^2

where, S = standard deviation (table 2, clause no 4.2.1.3 IS code 10262 -2019)

b) $f'ck = 30 + 6.5 = 36.5$ N/mm^2

where, X = factor based on grade of concrete (Table 1, clause 4.2, IS Code 10262- 2019)

The higher value of the above two will be adopted for the target mean strength that is 38.25 N/mm^2.

2) approximate air content

The approximate amount of entrapped air to be expected in normal concrete is 1 % for 20 mm nominal maximum size of aggregate. (As per table no 3, clause 5.2, IS code 10262 – 2019)

3) Selection of water cement ratio

According to table no 5 of IS code 456 – 2000, for RCC works maximum water cement ratio for extreme exposure condition is 0.45, but as per chart given in page no 4 of IS code 10262 – 2019 estimated water cement ratio for target mean strength 38.25 N / mm^2 is 0.48.
Hence, adopted water cement ratio will be 0.45.

4) Water content

From table 4, clause 5.3, IS code 10262 – 2019

Water content = 186 kg, for 50 mm slump for 20 mm aggregate. according to code increase 3 % water content for every additional increase of 25 mm slump value.

5) Calculation of cement content

Water cement ratio = 0.45

Water content = 191.58 kg

Cement content = 191.58 / 0.45 = 425.73 kg / m^3

425.73 kg / m^3 > 320 kg / m^3 (ok)

6) Adding 1 % sisal fiber by the weight of cement

Cement content = 425.73 kg / m^3

1% of sisal fiber by the weight of cement content =

1/ 100 × 425.73 = 4.2573 kg / m^3

Actual cement content = 425.73 – 4.2573 = 421.478 kg / m^3

421.47kg /m^3 > 320 kg / m^3 (ok)

7) proportion of volume of coarse and fine aggregate

As per table no 5, clause 5.5, IS Code 10262 – 2019
The proportionate volume of coarse aggregate corresponding to 20 mm size of aggregate and fine aggregate (zone II) for water cement ratio of 0.50 = 0.62

In the present case water cement ratio is 0.45, then according to the code recommendation the volume of coarse aggregate is required to be increased to decrease the fine aggregate content.

Water cement ratio is decreased by 0.50 – 0.45 = 0.05

The proportion of volume of coarse aggregate is increased by (0.02/ 0.05) × 0.05 = 0.01

So, the corrected proportion of volume of coarse aggregate for the water

Cement ratio of 0.45 = 0.01 + 0.62 = 0.63

Volume of fine aggregate content = 1 – 0.63 = 0.37

(8) Mix calculations

a) Total volume = 1 m^3

b) Volume of entrapped air = 0.01 m^3

c) Volume of cement $= \dfrac{\text{mass of cement}}{\text{Sp. gravity of cement}} \times 1000$

$= 421.478 / 3.15 \times 1000$

$= 0.133\ m^3$

d) Volume of sisal fiber $= \dfrac{\text{mass of sisal fiber}}{\text{Sp. gravity}} \times 1000$

$= 4.2573 / 0.7 \times 1000 = 0.0061\ m^3$

e) volume of water $= \dfrac{\text{mass of water}}{\text{sp. gravity}} \times 1000$

$= 191.58 / 1 \times 1000$

$= 0.1915\ m^3$

i) volume of all in aggregate = [(a-b) – (c+ d+ e)] = [(1- 0.01) – (0.133 + 0.0061 + 0.1915)] = 0.66 m^3

j) Mass of coarse aggregate = vol. of all aggregate × vol. of CA × sp. gravity of CA × 1000= 0.66 × 0.63 × 2.73 × 1000 = 1135.134 kg

k) Mass of fine aggregate = vol. of all aggregate × vol. of FA× sp. gravity of FA × 1000 = 0.66 × 0.37 × 2.6 × 1000 = 634.92 kg

(9) Site corrections

l) Absorption of fine aggregate = 1.16%
= 1.16 / 100 × 634.92 = 7.36 liter

m) Absorption of coarse aggregate = 1 %
= 1 /100 × 1135.134 = 11.35 liter

n) Total absorption = 18.71 liters

o) Actual amount of water to be used = 191.58 + 18.71 = 210.29 liters

p) Actual weight of fine aggregate to be used = 634.92– 7.36 = 627.56 kg

q) Actual amount of coarse aggregate = 1135.134 - 11.35 = 1123. 784 kg

5. RESULT AND CONCLUSION

From the below test results it is clearly seen that there is an increase in split tensile strength after adding sisal fiber in the concrete mix .

At 7 days of testing the increase in tensile strength is about 20.77%, at 14 days increased strength is about 12% and after 28 days of testing 11.84% increase in split tensile strength.

The split tensile strength of concrete can be calculated by formula = 2P/3.14LD

Where, P = Applied load, L = Length of the specimen,
D = diameter of specimen

Split tensile strength for M30 grade conventional concrete are as follows –

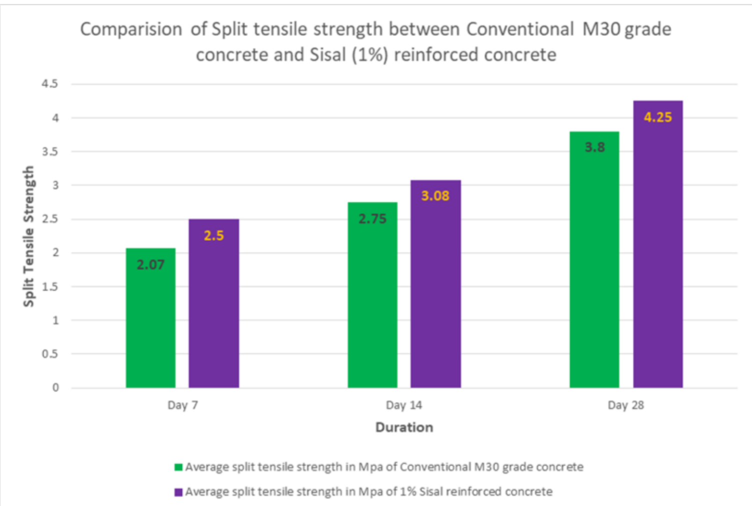
Serial no	Age of specimen	Ultimate load in KN	Split tensile strength in MPa	Average split tensile strength in MPa
1.	7 days	161.26 132.07 145.81	2.28 1.87 2.06	2.07
2.	14 days	195.81 180.07 207.83	2.77 2.55 2.94	2.75
3.	28 days	288.02 253.03 279.34	4.07 3.58 3.95	3.80

Table 5.1- Split tensile strength for M30 grade conventional concrete

Split tensile strength for M30 grade concrete when 1 % sisal fiber is added is tabulated below –

Serial no	Age of specimen	Ultimate load in KN	Split tensile strength in MPa	Average split tensile strength in MPa
1.	7 days	181.40 172.32 177.08	2.56 2.44 2.51	2.50
2.	14 days	198.99 243.33 212.54	2.82 3.44 3.00	3.08
3.	28 days	328.72 303.22 267.46	4.66 4.29 3.79	4.25

Table 5.2- Split tensile strength for M30 grade concrete when 1 % sisal fiber is added



Comparison of Split tensile strength between Conventional M30 grade concrete and Sisal (1%) reinforced concrete

6.REFERENCE

1. Raghu Yadav Golla. “Strength of Sisal Fiber Concrete with Fine Construction Waste Aggregate.” International Journal of Research in Engineering and Technology 04, no. 14 (April 25, 2015): 5–8. https://doi.org/10.15623/ijret.2015.0414002.

2. Ahmad, Jawad, Ali Majdi, Ahmed Farouk Deifalla, Nabil Ben Kahla, and Mohammed A. El-Shorbagy. “Concrete Reinforced with Sisal Fibers (SSF): Overview of Mechanical and Physical Properties.” Crystals 12, no. 7 (July 7, 2022): 952. https://doi.org/10.3390/cryst12070952.

3. Kumar, Dilip, and N. Victor Babu. “Study on Properties of Sisal Fiber Reinforced Concrete by Adding of Different Percentages and Different Sizes of Sisal Fiber.” International Journal of Management Technology and Engineering 8, no. 8 (December 2018): 11.

4. Naraganti, Srinivasa Rao, Rama Mohan Rao Pannem, and Jagadeesh Putta. “A Comparative Performance of Sisal and Polypropylene Fibers in Enhancing Tensile Strength of Concrete.” International Journal of Engineering and Technology 9, no. 2 (April 30, 2017): 1475–83. https://doi.org/10.21817/ijet/2017/v9i2/170902055.