A Review on Fiber Reinforced Concrete using sisal fiber

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Abstract. Fiber Reinforced Concrete FRC can be used for a variety of applications. Fibers are utilized in concrete crack requiring reduction of physical property protection, drying reduction and improved strength and toughness, increased service life and decrease bleeding from water, concrete permeability, and construction value. The utilization of sisal, a natural fiber with increased mechanical efficiency, as reinforcement in an exceeding matrix based on supported cement. The proportion of sisal fiber used in concrete ranged from 0.1% to 2% of concrete and length of fiber 50mm to 60mm fiber length in concrete with aspect ratio. By adding short fibers, tensile strength is improved, thaw resistance is frozen, impact resistance, and concrete brittleness are reduced. In general, fiber does not enhance the concrete strength, as the replacement moment is reduced in the reinforcement of structural steel. This paper also represents fiber limitation content, environmental aspects, and FRC is the modern technical enhancement in the civil substructure. This review paper also describes the compressive strength test, flexural strength test, tensile strength test, impact strength test of FRC sisal fiber effect strength test.

Keywords: Sisal fiber, flexural strength, compressive strength, split tensile strength, Impact strength test.

1. Introduction
Cement is that the world’s most generally used artifact with an estimated annual use of about 2.86 billion a lot of cement. However, cement production is harmful to the environment thanks to the emissions of dioxide. Approximately 0.8 a lot of CO2 per ton produced is estimated to be released into the atmosphere [1]. It found that different structural applications like Fiber ferroconcrete within 20th century. Fiber ferroconcrete (FRC) might be a class of composite materials [2]. Reinforced Natural Fiber cement and cementitious composites commonly used primarily for low-cost housing activities and there have also been growing interest in natural fiber composites and lots of research goes round the world. The foremost important technical features like excellent lightweight tensile properties, more strength, high impact resistance, and better post cracking behavior so on [3].
The main objective is to feature natural fiber to concrete post-fracture. Because of high alkaline formation in cement-based concrete composite, the fibers are degraded [4]. It also features high resistance to freezing and thawing tolerance [5]. A wide form of natural fibers have been used in the cement concrete composition. A wide range of natural fiber like coir, jute, sisal, kenaf, banana fibers, etc., were utilized in nominal concrete. Fibers are with high strength, flexibility, extensibility, and elasticity. The fiber utilized in concrete which prevents the formulation of cracking reckoning on the changes in temperature. The fiber-enhanced composite strength applications began to be introduced in 1997 [6]. The sisal fiber percentage added 0.5% to twenty-eight total concrete weight volume. By increase fine content, the shrinkage and creep are randomly increased because it causes the rise in the volume of paste in concrete compaction.

By adding fiber to the honeycomb of fresh concrete [7]. Locally available sisal fiber in Kenya, Tanzania, and Brazil. To boost its mechanical strength and lead to concrete, Sisal fiber-reinforced concrete (SFRC) has been incorporated. It inhibits the crack propagation behavior after yield [8]. Fiber composites will be reduced in strength and sturdiness because of the degradation of fibers by combining alkaline attack and mineralization of hydrogen migration [9].

No study has yet been recorded for either cement composite, especially for flexible fibers has yet been reported, particularly for durable fibers like natural fibers. This work aims to look at cement/ cementitious composite mortar in two aspects of its fresh behavior, consistency, and low quality, affecting the steadiness and suppleness of the fresh mix [10]. Increases ductility, compressive, flexural, and strength. If we were able to increase the lifetime of concrete from 50 to 500 years, its environmental impact will decrease 10 times. Promoting the utilization of cemented building materials strengthened with vegetable fibers could therefore be the simplest way to achieving more sustainable construction. This paper examines the topic of fiber cemented materials by examining previously published work [11].

Many of the natural fiber coir, sisal, jute, banana, palmrya, pineapple, talipot, hemp, etc., are used as a resource for industrial materials. [12]. Sisal (Agave sisalana) became a pestilence monocotyledon plant in Central America that provides papermaking potential for fiber. Additionally, sisal which has historically been utilized in the assembly of natural ropes, cordage sacking, has some assets for the assembly of a variety of special paper varieties like those utilized in filters [13].

FRC fiber alignment relies on many variables, such as fiber properties (shape, material, aspect ratio) and fresh properties of cementitious fresh properties yet because of the placement and casting process [14]. On the premise of the above discussion, we analyzed the mechanical aspects of sisal fiber reinforced properties soils, determined in terms of strength characteristics, the optimum percentage of fibre applied to silty clay and the modes of shear failure of the soil studied. This analysis focuses on the effects of the engineering silty clay properties of varying length of fiber and contents [15].

The aim of this study is to establish workability, fire resistance, and bonding quality with the concrete substrate and demonstrate its applicability in fiber replacement. Such another system is believed to own good special applications where the fireplace occurs [5].

In general, sisal fiber is a natural fiber [16]. One of the most versatile natural fibers is sisal fiber and is cultivated very readily [17]. And Such fibers are harvested into the sisal plant on a farm in Valente, state of Bahia, Brazil, and the mechanical and physical properties of, and morphology of, sisal fibers [18]. The fibers are extracted by a hand extraction machine, which consists of either serrated or non serrated knives. Each fiber is separated and grouped accordingly dependent on the fiber size. The initial fiber size is between 0.5 to 1 m. Fibers were cut into 20mm length in the experiments. The fiber diameter is 0.15 - 0.2 mm, the aspect ratio and as follows [16]. Also, it has been found that the total crack width of slab samples with fibers content and fiber sizes is not greatly varied. The fibers have good impact and sound-absorbing characteristics and also the leaves of fibers improve fire resistance [19]. The energy absorption is found in natural fibers and the reduction sound is absorbed due to low permeability [20].
2. Sisal Fibers Extraction
The leaves of sisal are colored dark green, straight fleshy [21]. Then the sisal leaves were crushed and separated manually with a smooth-edged stick until the fibers separated shown in Fig 1. Then the fiber is cleaned thoroughly in many glasses of water to get rid of dust and surplus wastes and at last air-dried.

![Production of sisal fiber](image)

![Extraction of sisal fiber](image)

![Drying process of fiber](image)

![Separation of the sisal fiber](image)

Figure 1. Process of sisal fiber

2.1. Treatment of sisal fiber
The chemicals employed in concrete fiber treatment like hemicelluloses, lignin, pectin, ashes are employed in variable processes [16]. The ammonium treatment of the sisal was manufactured using the strategy of extrusion. The concrete fiber specimen was used of three major roles using untreated sisal fiber by using an agent of (Na OH) treated fiber also as using Na OH agent, clay sisal fiber treatment. Natural fiber water absorption is comparatively high in sisal. Compression molding operates the sisal fiber process for creating a moist sample [22]. The color of the sisal fiber being treated is white and hence the 5% solution pH range, ranges from 6.90. During the experiments, portable water with a pH of seven was used. Fiber content is observed to reducing the flow benefit, but increasing the cohesion of the composite. Additionally, the untreated fiber showed in addition to the treated fiber composites, higher flow and lower cohesion [3]. The stiffness or rigidity and strength of sisal plants depends on the content of cellulose material [17]. The chemical treatment process of sisal fibers used for concrete-like NaOH treatment [19], Ca(OH)2 [23], Sodium hydroxide, Sodium silicate [24], CaCO3, calcium glutamate, calcium acetate [25], Na2CO3 [26], NaOH solution [27].

2.2. Properties of sisal fiber
One of the natural fibers, sisal fiber, with high modulus and unique strength, low price, easy accessibility, recyclability, and high durability with low maintenance and low wear and tear [19]. The water absorption is high, the physical property of sisal fiber seen in Table 1 and Table 2.

| Sl.no | Fiber type | Fiber length (mm) | Fiber diameter (mm) | Tensile strength N/mm² | Elongation percentage % |
|-------|------------|-------------------|---------------------|------------------------|------------------------|
| 1     | Sisal fiber | 180-600           | 0.10-0.50           | 31-221                 | 14.8                   |

Table 1. Physical properties of sisal fiber [28]

| Time  | Water absorption |
|-------|------------------|
| 5 min | 62               |
| 30 min| 83               |
| 1 h   | 90               |
| 2 h   | 101              |
| 24 h  | 139              |
| 48 h  | 144              |
| 72 h  | 149              |
| 96 h  | 152              |

Table 2. Water absorption of fibers over time [29]
3. Fiber Reinforced Concrete
Concrete, the world’s most inescapable material. The concrete quality is to develop new, durable, advanced composites based on cement including specific mechanical characteristics in the upcoming years [30]. The relation of mixed natural or artificial fibers to the concrete composition is referred to as Fiber Reinforced Concrete FRC, the fibers being natural fibers, glass fibers, synthetic fibers. The current widely used FRC technique the use of a single fiber from within an active restricted range includes cracking and deflection [31]. The bulk of the fiber-reinforced concrete is in single fiber composite [32]. The aim of this research was to explore the possibility of fiber reinforced concrete by using sisal fiber residues within the field, as reinforcement of composites based on cement. The main objective is to improve compatibility with the cement matrix and to review the mechanical properties of sisal fiber residue-enhanced cement-based composites. The purpose of this research is to investigate the composition of fresh conduct mortar reinforced cement and cement fiber mortar. Besides the nominal fresh cement concrete, characterized by durability and strength [10].

3.1. Application of Sisal Fiber
The fibers in composite materials with the automotive civil industry and specific technology [19] and several other low-cost housing applications and corrugated sheets produced.

3.2. Experimental programs of FRC
To manufacture the composites, materials such as OPC, sand, fiber, and water ratios were manually mixed. Fibers with a control sample of 0% [33]. The fundamental materials to enhance the fiber reinforcement of engineering properties in a concrete, mortar, and cement paste [34]. The empirical study on the composition of materials of cement, fine aggregate and coarse aggregate and portable water is used for mixing proportions The research programs used 1:3 concrete mortar composite [6, 8, 10, 35, 36] and the water-cement ratio of 0.45 [14, 15, 27, 29, 36]. The fresh mix’s workability is closely connected to the volume fraction and fiber aspect ratio [37]. Adding sisal fibre content to 0.5, 1, 1.5, 2, 2.5 and 3% of concrete composition [38, 39]. The mixing ratios for the selection of combinations of specimens in fiber ratio of 0.5%, 1%, 1.5%, and 2% with the 1:1 cement mortar and water ratio of 0.45, the length of 40 to 50mm sisal fiber [40]. The weight of sisal fiber in a fraction of 10% increases its bond strength with a hardening activity and fracturing through a failure mode [18]. The mixed concrete proportion is shown in Table-3.

3.3 Mix Proportions
Table 3. Mix Proportion [14, 15, 27, 29]

| Sample | Cement (Kg) | Fine aggregate (Kg) | Coarse aggregate (Kg) | Sisal fiber used % | Water ratio |
|--------|-------------|---------------------|-----------------------|-------------------|-------------|
| S1     | 1           | 1.5                 | 2.8                   | 0                 | 0.45        |
| S2     | 1           | 1.5                 | 2.8                   | 0.5               | 0.45        |
| S3     | 1           | 1.5                 | 2.8                   | 1                 | 0.45        |
| S4     | 1           | 1.5                 | 2.8                   | 1.5               | 0.45        |
| S5     | 1           | 1.5                 | 2.8                   | 2                 | 0.45        |

4. Mechanical Properties of FRC
Ordinary Portland Cement grade 53 for concrete preparation, was used [39]. Significantly, the presence of short fibers in a cemented matrix can contribute to an improvement in the mechanical behavior of fiber concrete composite. The existence of sisal fibers influences the strength level deleteriously [41]. The strength and flexibility of the flexural cement composites [42]. Some of the tests performed for FRC’s mechanical properties such as Compression tests, Tensile test, Flexural test [1, 9, 35, 43-45] Impact test [46-49]. Samples such as cubes, cylinders, and beams shall be cast and cured for 7 days and 28 days.
4.1 Compressive Strength Test
A material’s to breaking is thought as compression, by which the concrete is powerful in compression and weak in tension. It was then necessary to cast the compressive strength into cement mortar at a ratio 1:3 strengthened sisal fibers at four fiber content (0.5%, 1.0%, 1.5%, and 2.0% by cement weight) for 7 and 28 days respectively and a facet ratio of 200 [3]. After curing for 28 days, the deflection test was dispensed on beams of size 100×100×500mm [39]. The cube’s diameter is about 100×100×100mm [50]. However, for 3%, compressive strength decreased after 28 days of healing thanks to the increased number of voids produced by fiber addition, which was quite the optimal limit because it resulted in a very non-uniform matrix [39]. On the 7th day, the common compressive strength is eighteen.54 N/mm² shown in Figure 2. On the 28th day the mean compressive strength by 18.4% to 32% shown in Figure.3[37].

![Figure 2. Compressive force test at 7 days](8, 36) [Figure 3. Compressive force test at 28 days](8, 36)

4.2 Flexural Strength Test
Flexural strength usually referred to as rupture unit, or bending strength, or transverse rupture strength could be a material-specific property, the strain that a cloth yields in an exceedingly flexural test [32]. It’s the strain with which the materials yields in an experiment with flexure. The transverse bending test is most ordinarily used to the above, where a specimen with either a circular or rectangular cross-section is bent to fracture or yielding employing a flexural test of three points. The residual sisal fiber’s ultimate strength values ranged from 129 MPa to 378 MPa before accelerated aging reckoning on the calculation, probably because these fibers are waste produced during the processing of useful fibers used in the industry [31].

4.3 Impact Test
The impact strength of cement mortar slab characteristics composites were found with 300 × 300 × 20 mm slab specimens cast in cement mortar at a ratio of 1:3, sisal-reinforced reinforcement fibers at four fiber composition (0.5%, 1.0%, 1.5%, and 2.0% by weight of cement) and a side ratio of 200 [51]. The cracking initiation was supported by visual observation and the cumulative collapse made up our minds therefore supported the amount of blows required to open the crack within the sample enough to spread the crack throughout the whole thickness of a specimen [52]. The energy of impact stored by the mortar slab specimens was calculated supported the volume of blows required to initiate the primary crack, the amount required to avoid causing the ultimate failure, and therefore the impact energy of blow [53].

4.4 Tensile Strength Test
Friction length shows the strength of things like fiber density, fiber length, and bonding [54]. The orientation of the fibers is incredibly random, which weakens the composite’s tensile properties [55]. During this analysis, the low fiber loading us with another possible reason used only 20% of fiber loading...
weight. Several researchers have found that the burden of 20% of sisal fiber composites has lower tensile properties [56]. The bending tests were conducted in an exceedingly deflection mode with a load rate of 0.3 mm/min and therefore the maximum load values were measured and analyzed. The concrete's flexural strength and fracture energy decrease as temperature increases. Such reduction exists for experiments on preloaded samples with and without higher preloading. The split strength is around 2.03 at 7 days shown in Figure 4. The split strength is around 2.69 at 28 days shown in Figure 5[57].

![Figure 4. Tensile strength at 7 days [58, 59]](image1)
![Figure 5. Tensile strength test at 28 days [58, 59]](image2)

5. **Conclusion**

It is clear that from the above review that the concrete at the fiber content of over 2% and a discount in fiber content is typically over 30 to 50mm in fiber length. The fiber ratio is compared with the diameter size. Water absorption is powerful in natural fibers because it increases the strength of the physical and mechanical properties of high tensile and compressive strength. The paper is thus concluded with improvement within the number of fibers being measured by a decrease in mechanical properties of over 1.5%. The strength is going to be increased by adding the fibers in small amounts.

- Introduction of natural sisal fibers to an increase in the flexural strength and fracture strength of the concrete in addition to compositions without natural fibers.
- The mechanical characteristics of the sisal fiber based mostly on the manufacture, condition as well as size of the sisal fiber, which will determine the characteristic properties, and also on the natural parameters, such as the size of the fiber, the length of the gauge, the strain rate and the environment of the study.
- On the opposite hand, there was higher ductility within the fracturing of the samples using natural fibers, in other words, adding natural fibers to the concrete could better control the cracking of the concrete.
- After the whole value of flexural strength had been reached at the tip of the research studies for giant deflections, the fibers still allowed the 2 sections of the samples to remains together. Under both tensile conditions, numerous cracking activity was observed and loads of cracking.

6. **Future prospects**

It is clear from this review that chemically processed or treated substances became future altered sisal fiber reinforced composites as a consequence of its strong mechanical structural materials, economic and ecological characteristics.

In recent literary studies, crack durability and rupture processes of sisal fiber composites doesn’t seem to have become analyzed in any detail. If new enhanced material are to be produced for safe crack growth, this is vital.

The material strength of sisal-fiber composites tested by tests are most often inconsistent with the mixture law. Only if the interface strength and the failure mechanisms are understood can a complete description be obtained. In particular, more work is required to understand the 'hybrid' effects of sisal/glass composites.
Due to the relatively lesser costs of sisal fibers, inexpensive methods of processing can be formed for the composites. It is essential to analyze the interaction amongst mechanical properties and methods of manufacturing.

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