

# Durability and Mechanical Study on Concrete Using Natural Fibers (sisal fiber)

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**Abstract:** Natural fibers have long been used for this purpose as subject of Investigation for their use as reinforcement in concrete in order to reduce the cost of the construction and increase the strength of the concrete. It also be used to attain a high strength and stiffness with low component weight. Natural fibers are not only strong and lightweight but also relatively very cheap. Natural fibers are effective and economically produce good quality fiber. Natural fibers are straw, elephant grass, palm leaf, coconut coir etc. Sisal fiber is then most widely used natural fiber and is easily cultivated in India. The processing techniques are physical and mechanical properties. Sisal fiber is an agricultural product. It is used as reinforcement in concrete. Sisal fiber is used to increase the strength of the building. Conventional concrete is strong in compression and weak in tension. Mechanical properties such as compressive strength and tensile strength are determined. The various percentage of sisal fibers such as 0.5%, 1.0%, 1.5% and 2% will be added in M30 grade of cement. Water absorption and acid attack test will also be done in this project.

## INTRODUCTION

Durability of material, is defined as the service life of a material under given environmental conditions. The above definition holds good for all concrete and cementitious composites. However, in case of natural fiber composite, not only the environment, but also the internal environment in the matrix, play a combined role in determining its durability. Sisal fiber is obtained from the leaves of the Agaves is lana produced in tropical region. Sisal fiber has high cellulose content (70%) and density(1.450g/cm<sup>3</sup>). The material is chosen to improve the various strength properties of a structure to obtain sustainability and better quality structure. The advantages of natural fiber materials are strength, durability, reduce cost of environmental compatibility and bio degradability. It is a hard and tough fiber. In components such as slabs and pavements, fiber is added to control cracking induced by temperature variation. Most of the studies on sisal fiber concrete involve the use of ordinary Portland cement. However high alumina cement with additives such as fly ash, slag, silica fume, have been used to improve the durability of the composites.

### I. MATERIAL AND METHODS, EXPERIMENTAL INVESTIGATION AND RESULTS

#### Cement test

The Cement is a binding material. Anhydrous cement does not bind fine and coarse aggregate. It acquires adhesive property only when mixed with water. The chemical reactions that take place between cement and water is referred as hydration of cement. During the course of reaction C<sub>3</sub>S and C<sub>2</sub>S with water, calcium silicate hydrate (C-S-H) and calcium hydroxide, Ca(OH)<sub>2</sub> are formed. C-S- H are the most important that determines the good properties of concrete. In our project Ordinary Portland Cement of 53 Grade from a single batch was used for the entire work and care has been taken to store it in airtight containers to prevent it from being affected by the atmospheric, monsoon and humidity. The various tests were conducted for cement. The cement used for this project is OPC – 53grade.

Table: Physical Properties of Cement

S.No	Name of the tests	Tested value	Value As per IS:12269-1987
1.	Standard consistency test	36%	-
2.	Strength test	54.08N/mm <sup>2</sup>	53 N/mm <sup>2</sup>
3.	Specific gravity	3.1	3.15



**Fig: Cement (OPC-53Grade)**

**(a) Initial setting time test**

The setting time refers to the time it takes for cement to harden and become stable after it has been mixed with water. This process involves a series of chemical reactions that lead to the formation of a hardened mass. To measure the setting time of cement, two tests are commonly used – the initial and final setting time tests. The initial setting time of cement is the time taken by the cement paste to set and harden to a point where it can no longer be disturbed by any external force. This is typically measured using the Vicat apparatus, and the standard requirement is that the initial setting time should not be less than 30 minutes for ordinary Portland cement

**Table: Initial Setting Time of Cement**

IS sieve designation	Percentage passing	Remarks
4.75mm	99.8	As per IS 383- 1970 it is conformed to zone III
2.36mm	99.4	
1.18mm	89.6	
600µm	64.7	
300µm	9.2	
150µm	1.1	
75 µm	0.6	

**Fine aggregate test**

It should be free from clay, silt and other impurities. It should not contain harmful chemicals in any form. Medium and fine sand shall be used for the mortars. Coarse sand shall be sieved through 2.36mm sieve and used to make the concrete. The various tests were conducted for fine aggregate. The test results of Sieve analysis and specific gravity were in table.



**Fig: Fine aggregate**

**Table: Sieve analysis of fine aggregate**

Trial	Initial setting time (minutes)	Initial reading
1.	15 min	5.5mm
2.	17 min	4.3mm
3.	21 min	3.3mm
4.	27 min	2 mm
5.	30 min	Below1.5mm



Empty Pycnometer

Pycnometer

Pycnometer Pycnometer + fine aggregate + F.A + water+ water

**Fig: Specific Gravity Test on Fine Aggregate Table: Specific gravity of fine aggregate**

Description	Weight of sample
Weight of empty pycnometer (w1)	625gm
Weight of pycnometer + fine aggregate (w2)	825gm
Weight of pycnometer + F.A + water(w3)	1620gm
Weight of pycnometer + water (w4)	1492gm

$$\text{Specific gravity of fine aggregate (G)} = \frac{\text{Dry weight of fine aggregate}}{\text{Weight of equal volume of water}}$$

### Seaggregate test

Aggregate shall be of inert materials and should be clean, dense, hard, durable, non- absorbent and capable of developing good bond with mortar. The aggregate shall be of hard broken stone of granite or similar tone and it should be free from dust, dirt and other foreign matter. The stone ballast shall be of 20mm size and it should retain in a 12.5mm square mesh and well graded such that voids do not exceed 42%. The various tests were conducted for Coarse aggregate. The test results of Sieve analysis and specific gravity were in table.



**Fig: Coarse aggregate**

### RESULT

$$\text{Weight of equal volume of water} = \frac{W_2 - W_1}{(W_4 - W_1) - (W_3 - W_2)} = \frac{200}{72} \quad G = 2.7$$

- The given sample of Fine aggregate conforms to IS specifications.
- The given sample of fine aggregate falls under Zone – II

### Inference

- Fineness modulus for fine aggregate value range from 2 to 4. If Value is greater than 4 will be unsuitable for concrete works.

**Table:** Sieve analysis of coarse aggregate

IS sieve designation	Percentage passing	Cumulative percentage retained	Remarks
80mm	100	0	As per IS 383-1970 It is conformed to 20mm Size
40mm	100	0	
20mm	53.4	46.6	
10mm	0	100	
4.75mm	0	100	

**Table:** Specific gravity of coarse aggregate

Description	Weight of sample
Weight of empty pycnometer (w1)	625gm
Weight of pycnometer + coarse aggregate (w2)	825gm
Weight of pycnometer + C.A + Water(w3)	1620gm
Weight of pycnometer + water (w4)	1492gm

Specific gravity of Coarse aggregate =  $\frac{\text{Dry weight of Coarse aggregate}}{\text{Weight of equal volume of water}}$

$$\text{Weight of equal volume of water} = \frac{W_2 - W_1}{G}$$

Sisal Fiber is one of the most widely used natural fiber and is very easily cultivated. It is obtain from sisal plant. The plant, known formally as Agave sisalana. These plants produce rosettes of sword-shaped leaves which start out toothed, and gradually lose their teeth with maturity. Each leaf contains a number of long, straight fibers which can be removed in a process known as decortication. During decortication, the leaves are beaten to remove the pulp and plant material, leaving the tough fibers behind. The fibers can be spun into thread for twine and textile production, or pulped to make paper products.

#### Chemical Treatment

Alkali treatment using sodium hydroxide (NaOH) is the most commonly used treatment for bleaching and cleaning the surface of sisal fiber to produce high quality fibers. 5% NaOH solution was prepared using sodium hydroxide pellets and distilled water. Sisal fibers were then dipped in the solution for 2 hours separately, then it is washed with running water. It was then kept in hot air oven for 3 hours at 80°C.

#### Specification of Sisal Fiber

##### Result

$$\text{Water } (W_4 - W_1) - (W_3 - W_2) = (200/72) \text{ G} = 2.7$$

- The given sample of coarse aggregate conforms to IS specifications.

##### Inference

- Fineness modulus for coarse aggregate value range from 7 to 8. If value is greater than 8 will be unsuitable for concrete works.

Water used for mixing and curing of concrete shall be clean and free from oils, acids, alkalis, salts and organic materials or the other substances the may be deleterious to concrete or steel. Portable water shall be used for mixing of concrete. Suspended solid matter in the water shall not exceed more than 200mg/l. the pH value of the water shall not less than 6.

**Table:** Properties of sisal fiber

Properties of Fiber	Sisal Fiber
Length	40mm-50mm
Specific Gravity	1.02-1.04
Diameter	0.1-0.2mm
Aspect Ratio	38.46

#### Sisal Fiber



**Fig:** sisal fiber

#### Properties of Sisal Fiber

- It is recyclable
- It exhibits good sound and impact absorbing properties
- Its leaves can be treated with natural borax of resistance properties.

- It is available as plaid, herring bone and twill.
- A sisal fiber is anti-static, does not attract o dust particles and does not absorb moistu water easily.

#### Application of Sisal Fiber

- Floor, slab, beam, piles, retaining walls, lintel, road, bridges, airport runways etc.
- Plain concrete & Wall plastering
- Footings, foundations, pavements walls, wall paneling's and tanks
- Manhole covers & slope stabilization etc.

Water cement ratio	% of sisal fiber	Slump in mm
0.45	0%	91
0.45	0.5%	65
0.45	1%	68
0.45	1.5%	56
0.45	2%	53

#### Advantages of Sisal Fiber

- Sisal fiber is 100% bio-degradable and recyclable and thus environmentally friendly.
- It is a natural fiber with golden and silky shine and hence called The Golden Fiber.
- It is the cheapest vegetable fiber procured from the baste or skin of the plant's stem.
- It is the second most important vegetable fiber after cotton, in terms of usage, global consumption, production, and availability.
- It has high tensile strength, low extensibility, and ensures better breathability of fabrics. Therefore, sisal is very suitable in agricultural commodity bulk packaging.

#### Disadvantages of Sisal Fiber

- The crease resistance of sisal is very low.
- Drape property is not good enough.
- Create Shade effect and becomes yellowish if sunlight is used.
- If sisal is wetted it loses its strength

### FRESH CONCRETE TESTS SLUMP CONE TEST

Table: Slump results



Fig: Slump test

The slump value decreased with increase in percentage of sisal fibre.

### COMPACTION FACTOR TEST

Table: Compaction factor results

Water cement ratio	% of sisal fibre	C.F
0.45	0%	0.745
0.45	0.5%	0.680
0.45	1%	0.692
0.45	1.5%	0.662
0.45	2%	0.652



Fig: Compaction factor test

There was no much variation in compaction factor was very minute after addition of sisal fibre.

### HARDENED CONCRETE TESTS COMPRESSION STRENGTH



Fig: Compression testing

Table: Compression strength results

% of sisal fibre	7days (N/mm <sup>2</sup> )	28days (N/mm <sup>2</sup> )
0%	18.34	33.67
0.5%	21.11	38.22
1%	23.67	42.56
1.5%	24.34	45.12
2%	22.83	45.78

Weight of acid attack results

% of sisal fibre	Weight of concrete (W1) kg	Weight of acid attack concrete (W2) kg	% of loss of weight of concrete = ((W1- W2)/W1) x 100
0%	8.89	8.76	1.46
0.5%	8.88	8.79	1.01
1%	8.87	8.60	3.04
1.5%	8.84	8.77	0.79
2%	8.74	8.53	2.40

### DISCUSSION

- The work ability of concrete was affected to a large extend on addition of sisal fiber.
- There was no much difference in value of compaction factor after the addition of fiber in concrete.
- According to the study, 1.5% addition of fiber was more effective on compressive strength and the fiber content increases when there is increase in tensile strength which was comparatively more than conventional concrete.
- Due to acid attack in concrete to there was reduction in weight and strength in concrete.

From the above results 1% and 1.5% of addition of fiber was more effective on compressive strength when compared to convention after acid attack.

## II. CONCLUSION

- In concrete the compressive strength achieved higher than conventional when 1.5% sisal fiber added to the concrete and the tensile strength was higher in 2% but there was little variation between 1.5% & 2%.
- The compressive strength and split tensile strength of sisal fiber reinforced concrete test results has shown that the strength of sisal fiber reinforced concrete is increased gradually when we increase the percentage of fiber.
- So finally, it is recommended that sisal fiber reinforced concrete gives better result when compared to conventional concrete.
- It was observed from results that the maximum percentage loss in weight and percentage reduction in compressive strength due to acids at M30 grade concrete.
- It's identified that reduction in compressive strength due to sulphates at M30 grade concrete is maximum in 0% replacement of sisal fiber and minimum in 1.5% replacement of sisal fiber.
- Maximum reduction in weight due to sulphates is 1% replacement of sisal fiber and minimum reduction is 1.5% replacement of fiber.
- It has been clearly noted that adding of sisal fiber gives good strength with W/C ratio 0.45 for M30 grade concrete.

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