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# An Interpretation on the Properties of Sisal Fiber Reinforced Concrete with Distinct Proportions of Fiber Addition

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## *ABSTRACT*

***Conventional concrete is strong in compression and weak in tension in order to overcome the weakness steel reinforcement is being provided. Researches attempted to inherit the tensile property by introducing synthetic fibres such as poly propylene, asbestos etc., and steel fibres, but they are expensive. Hence they are attempting to use the natural fibres such as straw, elephant grass, palm leaf, coconut coir etc. to incorporate tensile strength in conventional concrete. So that the traditional steel reinforcement on concrete can be reduced. In this research, sisal is being used in concrete.***

***The present research was designed to check the workability and strength properties of sisal fiber reinforced concrete with different mix proportions and different percentage of fiber addition. The materials were chosen to improve the various strength properties of the structure to obtain sustainability and better quality structure. Short discrete vegetable fiber (sisal) was examined for its suitability for incorporation in cement concrete. The physical property of this fiber has shown no deterioration in a concrete medium. Fibers were brushed, lined up and cut to obtain 4cm length.***

***Degree of workability of concrete mix with 0.2% super plasticizer and water cement ratio 0.45 had good workability with slump value 53mm and compaction factor 0.88, which is effective, was obtained. Materials were hand mixed with 0.5%, 1% and 1.5% addition of fiber in M20 and M25 mix design and casted in cubes and cylinders. The obtained specimens were subjected to tests aimed to check the compressive, tensile and flexural strength. An increase in compressive strength by 50.53% and tensile strength by 3.416% was observed for 1.5% addition of fiber in M20 mix design respectively. An increase in compressive strength by 52.51% and tensile strength by 3.904% was observed for 1.5% addition of fiber in M25 mix design respectively.***

## INTRODUCTION

Fiber reinforcement in concrete, mortar and cement paste can enhance many of the engineering properties of the basic materials, such as fracture toughness, flexural strength and resistance to fatigue, impact, thermal shock and spalling. Fibers have always been considered promising as reinforcement of cement based matrices because of their availability and low consumption of energy. Short discrete vegetable fibres namely sisal, coir and jute have been examined for their suitability for incorporation in cement concrete. The physical properties of this fibre have shown no deterioration in a concrete medium.

Sisal is a natural fiber obtained from a plant which look like gaint pineapples, and during harvest the leaves are cut as close to the ground as possible. The soft tissues are scrapped from the fibers by hand or machine. The fibers are dried and brushes remove the remaining dirt, resulting in a clean fiber. Sisal produces strudy and strong fibers. Sisal is one of the prospective reinforcing materials that its use has been more experiential. Sisal represents the first natural

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fiber in commercial application, in which it is estimated in more than half of the total of all natural fibers used. The sisal plant is a monocotyledonous, whose roots are fibrous, emerging from the base of pseudo stem.

The fibers of sisal are made of elementary fibers of 4 to 12µ diameter that are aggregated by natural bound forming small cells of 1 to 2µm. arrays are placed along the length of the plant on a regular shape with length of 45 to 160 cm. The composition of sisal fiber is basically of cellulose, lignin and hemicelluloses.

The failure strength and modulus of elasticity, besides the lengthening of rupture depend on the amount of cellulose and the orientation of the micro-fibers. The use of sisal fiber with a compatible matrix provided a new perspective for the use of natural fiber reinforced composites in the construction industry.

## SPECIFICATIONS OF FIBER

- Fiber length - 4cm
- Density - 1370 g/cm$^3$
- Absorption of water -110 %
- Tensile strength - 347- 378 MPa
- Modulus of elasticity -15GPa
- Diameter -0.5 to 0.8 mm
- Strain at failure - 3 to 5%

## OBJECTIVES OF THE STUDY

- To study the strength and workability characteristics of sisal fiber reinforced concrete.
- To study the effect of percentage of fiber added in concrete on concrete.
- To study the effect of sisal fiber reinforced concrete on different mix design.
- To study the mechanical characteristics of sisal fiber reinforced concrete.

## SCOPE OF PROJECT

- To enhance the properties of concrete using sisal fiber by replacing cement of 0.5%, 1%, 1.5% and finding the strength variation on concrete.
- To compare the physical properties of conventional concrete and sisal fiber reinforced concrete.
- The study on differed mechanical properties of sisal fiber reinforced concrete such as compressive strength and tensile strength.
- To compare the mechanical properties of different mix after using sisal fiber.

## MATERIALS AND METHODOLOGY

The experiment involves casting and testing of concrete specimens using different ratios of sisal fiber that is 0.5%, 1%, and 1.5%. Length of the fiber is 4cm. As the workability is low, after considering trial and error method of slump test and consistency test, super plasticizers is added.

## MATERIALS USED

- Cement used-ordinary Portland cement
- Cement of specific gravity - 3.15
- Coarse of aggregate specific gravity - 2.66
- Fine of aggregate specific gravity - 2.60
- Super plasticizer- 2% to the weight of cement
- Sisal fiber length- 4cm
- Sisal fiber percentage addition - 0.5%, 1%, 1.5% to the weight of cement
- Water cement ratio – 0.45

Sisal fibre for RCC

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## METHODOLOGY

The methodology explains about the step by step procedure that is going to be done in the project. The methodology is explained in the following figure.

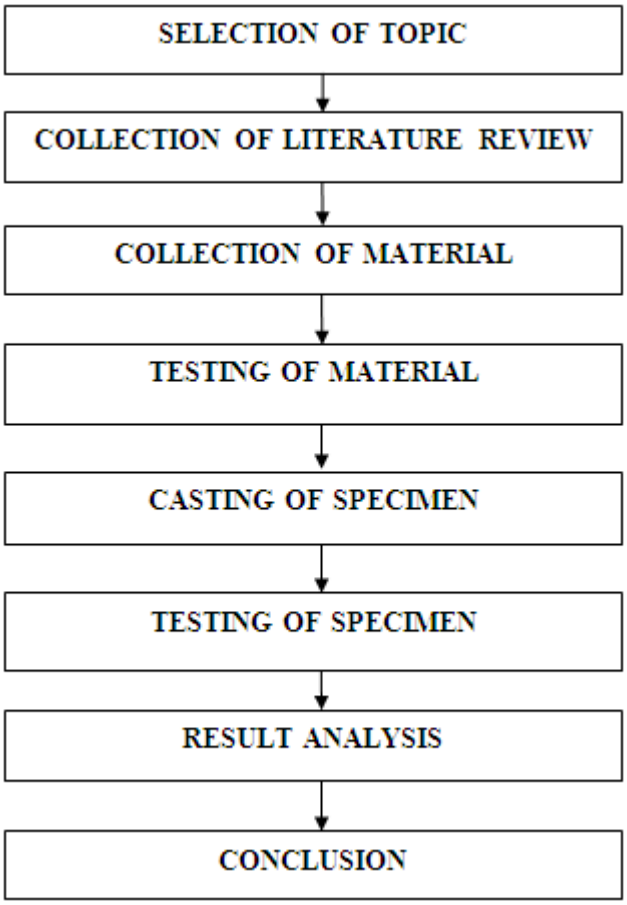


Figure 3.1Methodology flow chart

## EXPERIMENTAL STUDY

### SLUMP TEST

The concrete slump test is an empirical test that measures workability of fresh concrete. The test measures consistency of concrete in that specific batch. It is performed to check consistency of freshly made concrete. Consistency refers to the ease with which concrete flows. It is used to indicate degree of wetness.

The dry cement and aggregate will be mixed for a minute and after addition of fiber, mixing will be continued for another minute. Materials are mixed after adding water and are placed in slump cone in four layers and tamped continuously. After two minutes the cone is removed slowly in vertical direction and the difference between the original cone and subsided concrete is taken.

Slump = H2 – H1

H1 = Height of the cone

H2 = Height of the subsided concrete

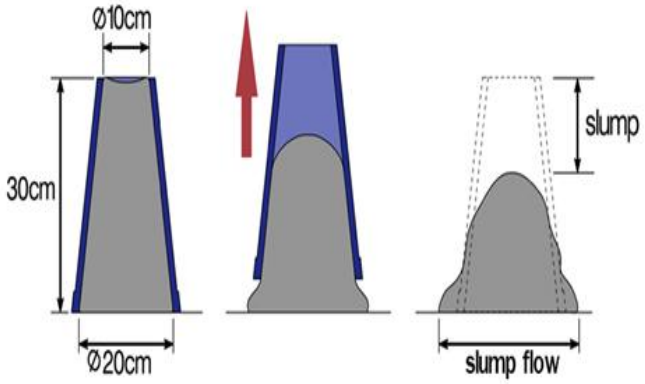


Figure 4.1 Slump cone test

### COMPACTION FACTOR TEST

The dry cement and aggregate will be mixed for a minute and after addition of fiber, mixing will be continued for another minute. Materials are mixed after adding water. Take the weight of the empty cylinder. Place the material in the top hopper and allow it to settle for two minutes. Open the trap door and allow the concrete to fall into the lower hopper and from the lower hopper into the cylinder. Clear the excess concrete and level the top of cylinder and weight it. Remove all the concrete from the cylinder and place concrete in four layers and compact it using tamping rod and weight the weight of the cylinder.

Compaction factor = A/B

A = W2 - W1

B = W3 – W1

A = partially compacted concrete

B = Fully compacted concrete

W1 = Weight of empty cylinder

W2 = Weight of cylinder + concrete falling from height

W3 = Weight of cylinder + fully compacted concrete

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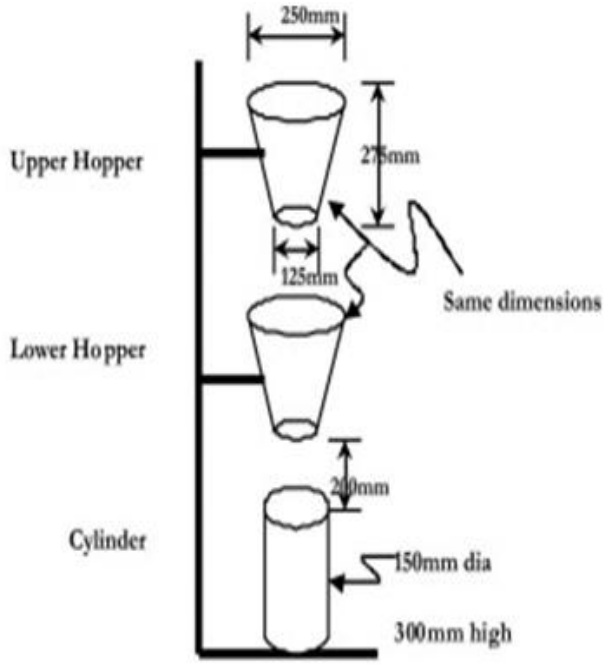


Figure 4.2 Compaction factor test apparatus

## MIXING, PLACING AND CURING

The dry cement and aggregate will be mixed for one minute by hand mixing and will be continued for further one minute while about 80 percentage of water will be added. The mixing will be continued for another one minute and finally the remaining water will be added and then mixing was continued for additional two minutes

Place the concrete in the mould and compaction will be done by using a suitable tamping rod and care will be taken to see that no segregation of concrete takes through the moulds.

The degree of control can be estimated statistically by the variations in test results. The variation in strength results from the variations in the properties of the mix ingredients and lack of control of accuracy in batching, mixing, placing, curing and testing. The lower the difference between the mean and minimum strengths of the mix lower will be the cement-content required. The factor controlling this difference is termed as quality control

Fig 4.3Casting of concrete

After 24 hours, the specimen will be demoulded and curing under water until testing.

Fig 4.4 Casted concrete cubes and cylinder

Fig 4.5 Curing of Specimen

In this study, a total of 8 types of concrete cubes are casted based on the different compositions of materials.

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## COMPRESSIVE STRENGTH OF CUBE

It is one of the most important properties of concrete and influences many other describable properties of the hardened concrete. The mean compressive strength required at a specific age, usually 28 days, determines the nominal water-cement ratio of the mix.

The other factor affecting the strength of concrete at a given age and cured at a prescribed temperature is the degree of compaction. According to Abraham's law the strength of fully compacted concrete is inversely proportional to the water-cement ratio

However, the compressive strength tends to increase with the decrease in size of aggregate.


Fig 4.6 Compression testing of Specimen

## SPLIT TENSILE STRENGTH OF CONCRETE

The tensile strength of concrete is one of the basic and important properties.Splitting tensile strength test on concrete cylinder is a method to determine thetensile strength of concrete. The concrete is very weak in tension due to its brittle nature and is not expected to resist the direct tension

The concrete is very weak in tension due to its brittle nature and is not expected to resist the direct tension. The concrete develops cracks when subjected to tensile forces. Thus, it is necessary to determine the tensile strength of concrete to determine the load at which the concrete members may crack

To determine the splitting tensile of concrete.
Equipment for Splitting Tensile Test of Concrete:
Compression testing machine, two packing strips of plywood 30 cm long and 12mm wide.

The cylinder mould shall is of metal ,3mm thick. Each mould is capable of being opened longitudinally to facilitate the removal of the specimen and is provided with a means of keeping it closed while in use. The mean internal diameter of the mould is 15 cm ± 0.2 mm and the height is 30 +/- 0.1 cm. Each mould is provided with a metal base plate mould and base plate should be coated with a thin film of mould oil before use, in order to prevent adhesion of concrete.

### Compacting of Concrete

The test specimen should be made as soon as practicable after the concrete is filled into the mould in layers approximately 5 cm deep. Each layer is compacted either by hand or by vibration

Fig 4.7 Testing of cylinder

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## RESULTS AND DISCUSSION

### SLUMP TEST

**Table 5.1 Test without super plasticizers and 1.5% fiber.**

| Water cement ratio | Slump value in mm |
|---|---|
| 0.35 | 1 |
| 0.40 | 3 |
| 0.45 | 4 |

**Table 5.2 Test with super plasticizerand 1.5% fiber**

| Water cement ratio | Slump value in mm |
|---|---|
| 0.35 | 14 |
| 0.40 | 26 |
| 0.45 | 53 |

Degree of workability for concrete mixture with 2% super plasticizer and water cement ratio 0.45 is having slump 53mm. It has good workability.

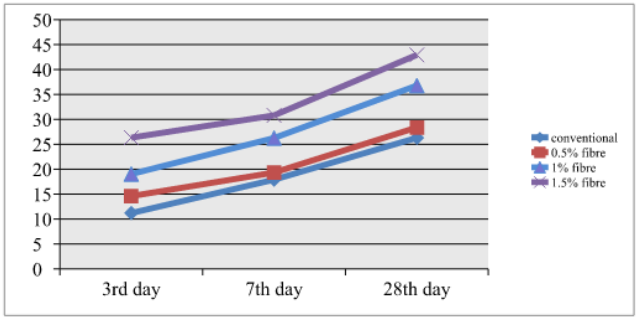
### COMPRESSIVE STRENGTH

In the study of strength of materials, the compressive strength is the capacity of a material or structure to withstand loads tending to reduce size. It can be measured by plotting applied force against deformation in a testing machine.

Compressive strength is one of the important properties of concrete cube size 150mmx150mmx150mm were cast with varying proportion of manufactured sand and oven dried for 24hours at 60°c and compressive strength for 7, 14, 28 days were tested. Compressive strength of concrete is shown in table

**Table 5.5 Compressive strength for M20**

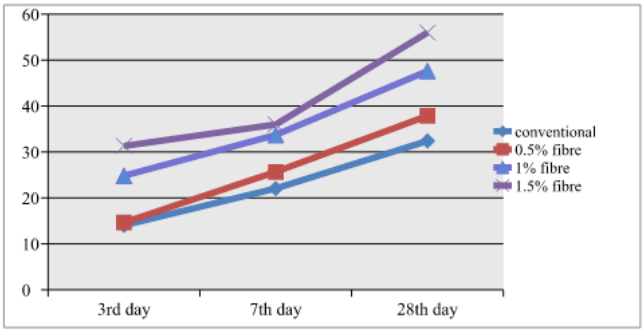
| | 3rd day (N/mm²) | 7th day (N/mm²) | 28th day (N/mm²) |
|---|---|---|---|
| **Conventional** | 11.2 | 19.9 | 26.3 |
| **0.5% fiber** | 14.6 | 19.33 | 28.38 |
| **1% fiber** | 19.03 | 26.26 | 36.78 |
| **1.5% fiber** | 26.33 | 30.80 | 42.93 |



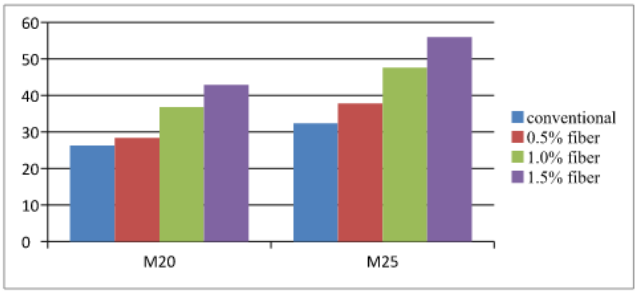

Graph 5.1 Compressive strength for M20

**Table 5.6 Compressive strength for M25**

| | 3rd day (N/mm²) | 7th day (N/mm²) | 28th day (N/mm²) |
|---|---|---|---|
| **Conventional** | 17.6 | 22.05 | 32.4 |
| **0.5% fiber** | 18.63 | 25.67 | 37.86 |
| **1% fiber** | 24.82 | 33.70 | 47.62 |
| **1.5% fiber** | 31.3 | 35.98 | 55.99 |




Graph 5.2Compressive strength for M25




Graph 5.3 Comparision of Compressive strength for M25 and M20 with different fiber addition

### CONCLUSION

- The study has concluded that there was an increase in slump value from 4mm to 53mm after addition of super plasticizer. Degree of workability for 1.5% sisal fiber added concrete mixture with 0.2% super plasticizer

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and water cement ratio 0.45 provided good workability.

- Compaction factor increases by 0.02 to 0.03 after addition of super plasticizer in 1.5% fiber addition in concrete.
- According to the study, 1.5% addition of fiber was more effective on compression strength for both the mix design M20 and M25.
- The percentage increase in the tensile strength was comparatively more in M20 than M25. The increase in the tensile strength is almost same for 1% and 1.5% addition of fiber.
- There is a decrease in the flexural strength for 1.5% addition of fiber by 7.692% when compared to 1% addition of fiber.
- Hence, the addition of 1% sisal fiber in concrete is found to be effective and economical as it gives good compression, tensile, and flexural strength.

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