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# An Assessment of Flexural Improvement of Light Weight Concrete via Hybrid Fibres along with Sisal Fibres in Addition to Banana Fibres

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**Abstract:** Innate fibres, these days have become the topic of argument in the research field between different scientists to inculcate it in the formation of lightweight concrete mixture. This is due to a variety of rewards connected with natural fibres like recyclable, economical, availability in large quantity and its bio-degradability. Plenty of projects have been carried out in the production of natural fibre reinforced lightweight concrete. In this project, we would like to take the naturally existing fibre named sisal fibre and banana fibre as partial replacement material. The adding of natural fibre to the lightweight concrete will enhance the diverse strength parameters like flexural strength, compressive strength, and increase the ductile behaviour. In the current work, it is intended to explore the mechanical properties of lightweight concrete with substitution of sisal fibre and banana fibre for cement in different percentages. The compressive strength, flexural strength, deflection of the beam is calculated with the reflection of M30 concrete specimens. Totally 45 number of 500 x 100 x 100mm flexural member, 45 numbers of cubes and 45 numbers of cylinders are cast and tested. It is suggested that up to 1.5% substitution of sisal fibres and banana fibre with cement provide at M30 grade of concrete giveing the most beneficial increases of strength values. The assessment outcome indicated that the sisal fibres and banana fibre were efficient in improving the performance of lightweight concrete

## Introduction

A random try have been made in the earlier period to reduce the self weight of concrete to increase the effectiveness of concrete as a structural material [2]. Lightweight concrete (LWC) is a fascinating field of explore and has been extensively used in buildings since many decades. It has much reward such as better thermal insulation, sound assimilation, fire and frost control and increased seismic performance. The light-weight concrete is a concrete which has a density of 300 to 1850 kg/m$^3$ [4] .There are many benefits of having low density. It helps in reduction of deceased load, increases the augmentation of building. The self weight of a building on the foundation is a significant aspect, in case of loose soil and it can be rectified by using the light weight concrete as one of the way [5]. Air-conditioning is required in the structure where it is obtained by the using

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light weight concrete with low thermal conductivity will be appropriate [6]. The light weight concrete can be obtained by using industrial wastes such as clinker, fly ash, steel slag and bamboo etc. and by the addition of air in concrete.

Natural fibre has extraordinary application in the ground of civil Engineering [8]. Natural fibres are a good reinforcing substance. Sisal fibre shows prospective strengthening effect in light weight concrete on relation of its with low cost, ease of use, low density, non hazardous one, sustainable and high specific strength and modulus [9]. The configuration and properties of sisal fibre have been scrutinized by several researchers. Sisal fibre in reinforced concrete along with light weight concrete effect over other conventional material seems largely from their higher specific strength, stiffness and fatigue uniqueness which enable structural performance to be more adaptable.

## Materials Used

*Cement*

Cement, a well accepted obligatory material, it is forever advantageous to use the finest cement in constructions. Consequently, the selection of cement may be varying on the type of construction. Ordinary Portland cement is available in three different grades of 33, 43, and 53. In this assignment, 53 grade ordinary Portland cement is used for the scrutinizing.

*Table 1 Properties of cement*

| Properties | Value |
|---|---|
| Fineness Modulus | 3.5 |
| Specific gravity | 2.9 |
| Consistency | 30.2% |
| Initial Setting Time | 30 Minutes |
| Final Setting Time | 1 Hour |

*Manufacturing Sand (M Sand)*

M Sand is worn like a fine aggregate in this project. The sand used in this project where nearby procured. M sand is acknowledged as manufactured sand. It is a crushed aggregate product from hard granite stone which has irregular edges, washed and graded with consistency to be used as a replacement of river sand. The practice of M Sand can overcome the defects taking place in concrete such as honeycombing, segregation, voids, capillarity etc. Usage of M-Sand can radically decrease the cost, it does not hold impurities and wastage.

*Table 2 Properties of fine aggregates*

| Properties | Value |
|---|---|
| Specific Gravity | 2.55 |
| Fineness Modulus | 2.65% |
| Water Absorption | 1.50% |
| Size | Passing through 4.75mm sieve |

*Coarse Aggregate*

The coarse aggregate obtained from the crushing plant is used in the present study. The physical parameters of coarse aggregate like specific gravity, water absorption and fineness modulus are tested in accordance with IS: 2386. The coarse aggregate used in this examination is of the dimension 20mm. It gives sufficient strength to the concrete. The aggregate takes up 70-80 per cent of the volume of the concrete. The meticulous selection of aggregate in any mix of concrete is chosen for their durability, strength, workability, and capability to obtain good results.

Materials Research Proceedings **19** (2021) 77-85 https://doi.org/10.21741/9781644901618-10

*Table 3 Properties of coarse aggregates*

| Properties | Value |
|---|---|
| Fineness Modulus | 8.12 |
| Specific gravity | 2.9 |
| Water absorption | 2.8 |
| Size | 20 mm |

*Coarse aggregate bamboo*

The bamboo is less in weight, elastic, hard, high durable with great tensile characteristic, and economical material than the other building materials. Bamboo can be used in a variety of building mechanism. Bamboo structures are good in flexibility, earthquake resistant nature with high torsion resistance, light weight and economical. Practice of bamboo may be lead for green buildings and sustainable growth, Bamboo can be used as bamboo flooring, decking, decorative paneling, and siding and as coarse aggregate for light weight concrete. Due to its natural characteristics of bamboo houses hold the both earthquake and cyclone resistant effects. In this project the bamboo are wrecked into a parts of required sizes associated to coarse aggregate and sieved through 4.75mm sieve to eliminate the smaller particles.

*Table 4 Properties of coarse aggregate bamboo*

| Properties | Value |
|---|---|
| Fineness Modulus | 8.95 |
| Specific gravity | 0.6 |
| Water absorption | 21% |
| Size | 20mm |

*Figure 1 Bamboo*

*Sisal Fibre*

Sisal fibre is one of the most important accepted natural fibres and is enormously easily cultivated with a lesser amount of water requirement. It has a small crop growing period and grows in nature in the cultivable and non-cultivable lands, the material is selected based on the improvement of different strength properties of the structure to gain sustainability and higher performance. Short distinct vegetable fibre (sisal) is examined for its appropriateness for merging in cement concrete. Sisal fibre requires only a little amount of process In the current investigation, sisal fibre is constantly used in all mix with different ratios.

Materials Research Proceedings **19** (2021) 77-85 https://doi.org/10.21741/9781644901618-10

*Table 5 Physical Properties of Sisal Fibre*

| Properties | Value |
|---|---|
| Average length(mm) | 300 |
| Average Diameter(mm) | 0.12 |
| Average Tensile Strength($N/mm^2$) | 1090 |
| Elongation | 18.2 |
| Water Absorption (%) | 76.7% |

*Figure 2 Sisal Fibres*

*Banana Fibre*

The banana is a fibrous fraction casing the stem. It constitutes 25–45% of the total size of the fruit. Banana husk fibres are primarily constituted of hemicelluloses and not of cellulose. Banana fibres hold 13 to 24.6% of lignin, 35 to 64.8% of hemicelluloses, 4.4% of ash content and leftover 8 to 25% of water content. The fibres bordering the internal layer are unevenly lignified group of cells with banana fibres and the portions of the core coating surround soft fibres. Banana fibre is extremely hemi cellulosic and superior to that of any other fibres. The Properties of Banana fiber are given in table 2.6. Banana fibres are durable, tough, resistant, resilient and long-lasting. Banana fibre is a replacement in the mix with a percentage to the weight of cement

*Figure 3 Banana Fibres*

*Table 6 Physical Properties of Banana Fibre*

| Properties | Value |
|---|---|
| Width(micron meter) | 250 |
| Density(Kg/m$^3$) | 1150 |
| Initial Modulus(Gpa) | 5 |
| Tensile strength(Mpa) | 115 |
| Elonagtion(%) | 35 |

*Water*

Amalgamation and curing is done by clean water, which was gratis from any other impurities like oils, acids, alkalis, sugar, salts, and organic ingredients that may be injurious to concrete or steel. The pH for clean water is supposed to not be less than 6 for concreting.

**Preparation and testing of specimen:**

*General*

The investigational work was planned to examine the mechanical properties like flexural behavior of concrete with 15% of replacement of coarse aggregate by bamboo and 1%, 1.5%, 2% and 2.5% of sisal fibres and banana fibre as hybrid fibre reinforced concrete with the weight of cement and for M30 grade of concrete all along with 0.1% of replacement of water with super plasticizer due to adding up of sisal fibres and banana fibre in concrete. The compressive strength of the cube, split tensile strength of cylinder and flexural behavior of the beam is analysis for 7, 14, 28 days.

For the test models, 53 grades Ordinary Portland Cement, M sand, coarse aggregate, bamboo, super plasticizer, sisal fibres and banana fibre are being analyses.

The greatest size of the coarse aggregate was restricted to 20mm. the concrete mix proportions of M30 grade with the water-cement ratio of 0.50 were utilized. The concrete mix was proposed to attain the flexural strength of 30MPa after 28 days curing period. The concrete beams (500mm × 100mm × 100mm) for regular as well as other mixes were cast. Each layer was compacted with 25 blows using a 16mm diameter rod.

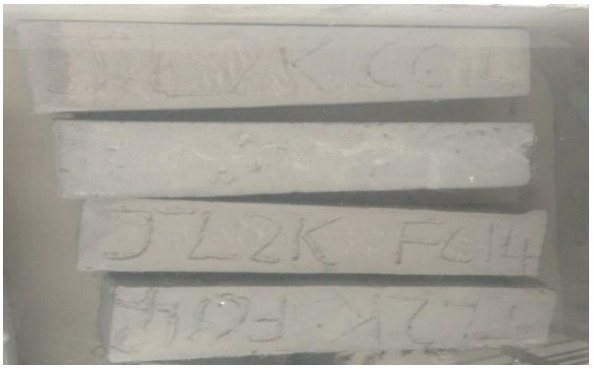

*Figure 4 Test samples*

*Table 7. Sample Specimen Details*

| S.No | Specimens | Details |
|---|---|---|
| 1 | Sample 1 | 1% sisal and banana fibre for weight of cement and 15% bamboo for weight coarse aggregate |
| 2 | Sample 2 | 1.5% sisal and banana fibre for weight of cement and 15% bamboo for weight coarse aggregate |
| 3 | Sample 3 | 2% sisal and banana fibre for weight of cement and 15% bamboo for weight coarse aggregate |
| 4 | Conventional concrete | $M_{30}$ grade of light weight concrete |

*Compressive strength test*

The sample cubes of size 150mm x 150mm x 150mm is cured for respective days as 7,14 and 28 days, the specimen is tested in compression testing machine with sample set as per date.

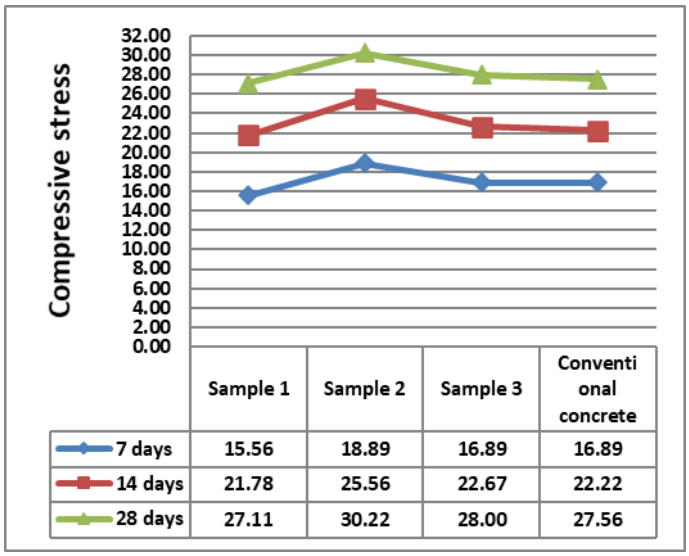


*Figure 5 Graph Showing the Results of Compressive Strength of HFRC.*

*Tensile Strength test*

The sample cylinder specimens shall be 150 mm in diameter and 300 mm long is cured for respective days as 7, 14 and 28 days, the specimen is tested in compression testing machine with a sample set as per date.

Materials Research Proceedings **19** (2021) 77-85 https://doi.org/10.21741/9781644901618-10

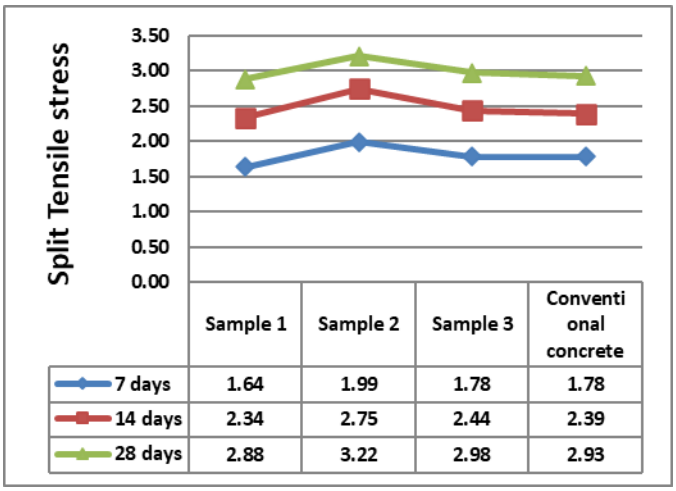


*Figure 6 Graph Showing the Results of tensile strength test of HFRC.*

*Flexural strength Test*

The concrete beam is placed in the testing machine in such a method the load shall be applied on the surface of the beam. The load shall be applied from the initial stage and then rises at a steady rate until the first crack of the specimen to the increasing load maximum up to the breakdown of the specimen. The highest load applied to the sample shall be noted and the exterior surface cracks are recorded at a different level. The samples are analyzed to find out the mechanical properties.

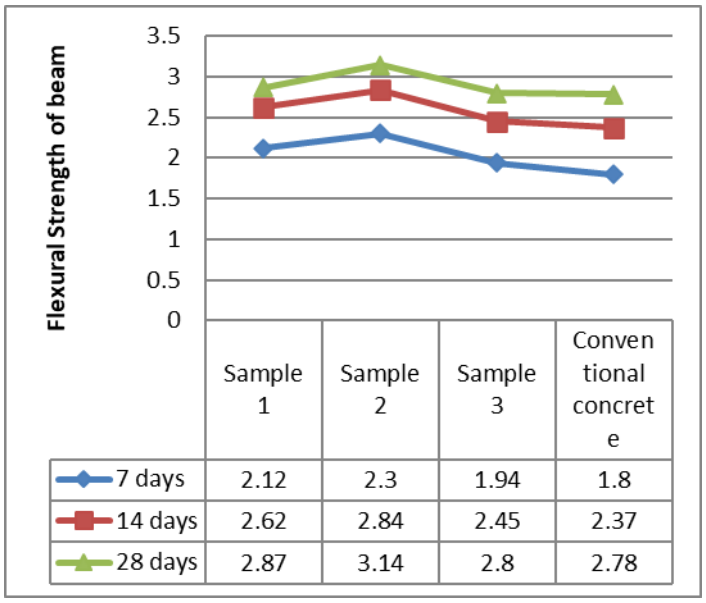


*Figure 7 Graph Showing the Results of Flexural strength of HFRC.*

**Result and Discussion**

The experimental results of adding Sisal fibre, banana fibre and Bamboo as a replacement of cement and coarse aggregates in concrete are represented in the work. The comparison of mechanical properties of the hybrid fibre reinforced concrete and conventional concrete is discussed. The hardened concrete properties are analyzed and compared for all the sample sets.

We found that the use of Sisal fibre and banana fibre increases the flexural strength of the concrete. Thus, the building work with Bamboo concrete is environmentally safe and also economical. Sisal fibre and banana fibre can be used as a partial alternate for cement which will reduce the cost of cement in concrete and also diminish the expenditure of construction. Therefore, it is safe to swap the cement in practically with 1.5% Sisal fibre and banana fibre to obtain good strength parameters. It also enhances the workability of fresh concrete. It is proved that the flexural strength is enlarged up to the optimal level of replacement of Sisal fibre, banana fibre and Bamboo. The optimum percentage of replacement Sisal fibre and banana fibre by cement is 1.5% and Bamboo by coarse aggregate at 15%. Adjustment of water level in mix design is balanced by adding a super plasticizer by 0.1% of water, thus results in good workability of concrete. Reduction in cement content did not cause any violent result in strength parameters. 7 days, 14days & 28 days compressive strength, split tensile strength and flexural strength is extra than the conventional light concrete. The hybrid fibre reinforced concrete with Sisal fibre, banana fibre and bamboo is shows good result in strength characteristics.

*Figure 8 Experimental setup*

## Conclusion

It is proved that the flexural strength is enlarged up to the optimal level of replacement of Sisal fibre, banana fibre and Bamboo as 27%. The optimum percentage of replacement Sisal fibre and banana fibre by cement is 1.5% and Bamboo by coarse aggregate at 15%.

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