

## Evaluation of strength characteristics of fibre reinforced concrete: A case study of glass and sisal fibres

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### Abstract

The strong performance of fibre reinforced concrete with the stepped introduction of glass and sisal fibre was evaluated. In this study, fibres as light reinforcements with varying percentages of 0, 0.25, 0.50, 0.75, 1.00, 1.25 and 1.5 by weight of concrete were added to M15 grade concrete. The water/cement mix proportions ratio was 0.6. Control specimens, such as cubes were cast and tested at 7, 14, 21 and 28 days respectively to determine the mechanical properties. Glass fibre resulted in the most workable mix as compared to the sisal fibre with the highest slump and compaction factor of 19.50 mm and 0.93 respectively on the addition of 0.25% fibre. The addition of glass and sisal fibres in plain concrete (control) up to 1% increases the strength of concrete while the addition of fibres content greater than 1% resulted in a reduction in the strength of concrete. The optimum glass and sisal fibre content was 1% with maximum compressive strength of 36.50 N/mm<sup>2</sup> and 34.67 N/mm<sup>2</sup> at 28 days respectively. The experimental study revealed that glass fibre was stronger than sisal fibre. Hence, the fibre content of 1% is recommended for use as light reinforcement in concrete.

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### 1. Introduction

Conventional plain concrete is known to be strong in compression but weak in tension, thus the provision of reinforcement is essential to improve its tensile strength. The application of composite materials in concrete with a view to improving its strength and satisfying design requirements has been in practice over the years. Natural fibres are continuous filaments which are sourced from animals or plants. The following are forms of natural fibre but not limited to sisal, coir, elephant grass, bamboo, water reed and palm fibres. They can be twisted or woven into sheets sequel to their application as light reinforcement due to their flexibility and renewability. Glass fibre is a recently introduced material in fibre reinforced concrete. Tensile strength of this is very high varying from 1020 to 4080 MPa. This is generally used in exterior facade panels. Glass are less dense compared to steel [1]. The distinctive properties of natural fibre reinforced concretes are improved tensile and bending strength, greater ductility, and greater resistance to cracking and hence improved impact strength and toughness [2]. Many researchers have investigated the engineering and durability characterization of

composite fibres. Badrinath et al. [3] investigated the mechanical properties of banana and sisal fibre composite. These fibres were used as main reinforcing material coated with the epoxy resin to increase the effectiveness. It was noted that sisal unidirectional oriented fibres showed hike in compressive strength compared to bi-directional, whereas banana bi-directional showed higher tensile strength compared to unidirectional. Flexural strength of sisal unidirectional exhibits higher strength than banana fibre. It was also observed that percentage of sisal fibre absorb more water compared to banana epoxy resin composite. The percentage of absorption of ordinary water is more compared to sea and distilled water. Chandramouli et al [4] conducted an experimental study to investigate the effect of the use of alkali resistant glass fiber on the tensile and flexural strength of concrete of grades M20, M30, M40 and M50. The author claimed that the modulus of rupture is about 20 MPa of polymer concrete that contained 20% polyester resin and about 79% fine silica aggregate. Furthermore, modulus of rupture was increased about 20% and the fracture toughness about 55% by adding about 1.5% chopped glass fiber. Muthuswamy and Thirugnanam [5] described experimental work on high-performance hybrid fiber-reinforced concrete using three fibers even steel, glass and polyester fiber of prestigious brand. Super plasticizer and silica fume was added as a mineral additive to partially replace the cement in concrete. The results showed a significant improvement in the strength of the hybrid fiber reinforced concrete. This study examined and evaluated the strength properties of glass fiber reinforced concrete and sisal.

## 2. Materials and methods

### 2.1. Materials

Materials used in the study were ordinary Portland cement, water, aggregates (fine and coarse) and fibres (glass and sisal).

**Cement:** Dangote Ordinary Portland cement of grade 42.5R was used throughout the study in preparing the concrete mixes. A constant water cement ratio of 0.65 was used throughout the research.

**Water:** Potable water obtained from the laboratory tap with pH of 7.8 was used for mixing and curing purposes.

**Aggregate:** River sand deposit was used as fine aggregate and well graded coarse aggregate was obtained from Elega quarry, Abeokuta.

**Fibres:** The glass fibre was obtained from Manweb Nigeria Limited located in the Industrial Area in Ikeja, Lagos Fig. 1. The glass fibre came as a mat and had to be plucked down to the required fibres. Sisal rope was obtained from a local store Fig. 2. The sisal fibres had to be untwined to obtain the individual fibres required for the experiment.



Figure 1. Glass Fibre



Figure 2. Sisal Fibre

### 2.2. Methods

Conventional concrete of M15 grade was used in this study using glass and sisal fibres as reinforcements with varying percentages of 0, 0.25, 0.50, 0.75, 1.00, 1.25 and 1.5 by weight of concrete with relative mixes of P1, P2, P3, P4, P5, P6 and P7 respectively (Table 1). Mix proportioning was based on the water cement ratio of 0.6

(water/cement). The basic materials were tested to analyse their properties. The effect of workability on the mixes was studied. Control specimen such as cubes was cast and tested at 7, 14, 21 and 28 days respectively to determine the mechanical properties.

Table 1. Sample mix constituent and proportions

Mix	Fibre Variation (%)	Cement (Kg)	Fine Aggregate (Kg)	Coarse Aggregate (Kg)	Fibre Content	Water (Kg)
P1	0	17.35	34.71	69.2	0	10.41
P2	0.25	17.35	34.71	69.2	0.043	10.41
P3	0.50	17.35	34.71	69.2	0.087	10.41
P4	0.75	17.35	34.71	69.2	0.130	10.41
P5	1.00	17.35	34.71	69.2	0.174	10.41
P6	1.25	17.35	34.71	69.2	0.217	10.41
P7	1.50	17.35	34.71	69.2	0.260	10.41

### 3. Results and discussion

#### 3.1. Effects of workability

The results of workability are presented in Table 2. The workability of the concrete mixes was affected with the stepped introduction of glass and sisal fibres. The slump value of glass fibre ranged from 19.70 to 16.90 mm while sisal fibre ranged from 19.70 to 16.40 mm. Compaction factor value of glass fibre ranged from 0.94 to 0.83 while sisal fibre ranged from 0.94 to 0.76. The slump and compaction factor values decreases with stepped introduction of sisal and glass fibres. Glass Fibre resulted in the most workable mix as compared to the sisal fibre with the highest slump and compaction factor of 19.50 mm and 0.93 respectively on the addition of 0.25% fibre. Furthermore, glass fibre exhibits a more flexible structure as compare to the stiffer more irregularly shaped structure of the sisal fibres. The relationship between the compaction factor test and the slump test shows that the greater the slump the more compact the material (Table 2).

Table 2. Workability of the fibre variation

Mix	Fibre Variation (%)	Slump		Compaction Factor	
		Glass Fibre (mm)	Sisal Fibre (mm)	Glass Fibre	Sisal Fibre
P1	0	19.70	19.70	0.94	0.94
P2	0.25	19.50	18.90	0.93	0.89
P3	0.50	19.30	18.50	0.91	0.87
P4	0.75	19.00	18.00	0.89	0.85
P5	1.00	18.50	17.70	0.87	0.80
P6	1.25	17.20	16.90	0.85	0.78
P7	1.50	16.90	16.40	0.83	0.76

#### 3.2. Compressive strength

The results of the compressive strength for glass and sisal fibres are presented in Tables 3 and 4 respectively. The addition of glass and sisal fibres in plain concrete (control) up to 1% fibres content increases the strength of concrete. However further increase in fibre content (1.25% and 1.50%) reduces the strength of concrete (Table 3 and 4). Fig. 3 shows the variation of compressive strength with increase in glass fibre content with respect to aging. Curing period is known to affect the strength of concrete. From Fig. 3, the mix with 1% glass fibre is the optimum glass fibre content with maximum compressive strength of 36.50 N/mm<sup>2</sup> at 28 days. The variation of compressive strength with increase in sisal fibre content with respect to aging is illustrated in Fig. 4. The mix with 1% sisal fibre is the optimum sisal fibre content with maximum compressive strength of 34.67 N/mm<sup>2</sup> at 28 days Fig. 4. The reduction in the strength of concrete mixes with glass fibre content greater than

1% could be due to the effect of balling causing binding deficiency between fibres. The experimental study revealed that glass fibre was the stronger when compared to sisal fibre.

Table 3. Compressive strength for glass fibre

Mix	Fibre Variation (%)	Compressive strength for Glass Fibre (N/mm <sup>2</sup> )			
		7 days	14 days	21 days	28 days
P1(Control)	0	13.37	15.22	17.57	30.25
P2	0.25	13.95	15.85	18.34	31.87
P3	0.50	14.88	16.03	19.51	33.45
P4	0.75	16.20	16.83	23.97	35.21
P5	1.00	16.88	17.50	28.76	36.50
P6	1.25	15.79	16.18	24.10	31.62
P7	1.50	14.25	15.45	20.86	27.53

Table 4. Compressive strength for sisal fibre

Mix	Fibre Variation (%)	Compressive strength for Glass Fibre (N/mm <sup>2</sup> )			
		7 days	14 days	21 days	28 days
P1(Control)	0	13.37	15.22	17.57	30.25
P2	0.25	13.56	15.64	21.76	31.76
P3	0.50	14.68	15.98	22.28	32.28
P4	0.75	16.03	16.42	22.85	32.85
P5	1.00	16.75	17.34	24.67	34.67
P6	1.25	15.64	16.00	20.68	30.68
P7	1.50	14.15	15.33	21.75	26.75

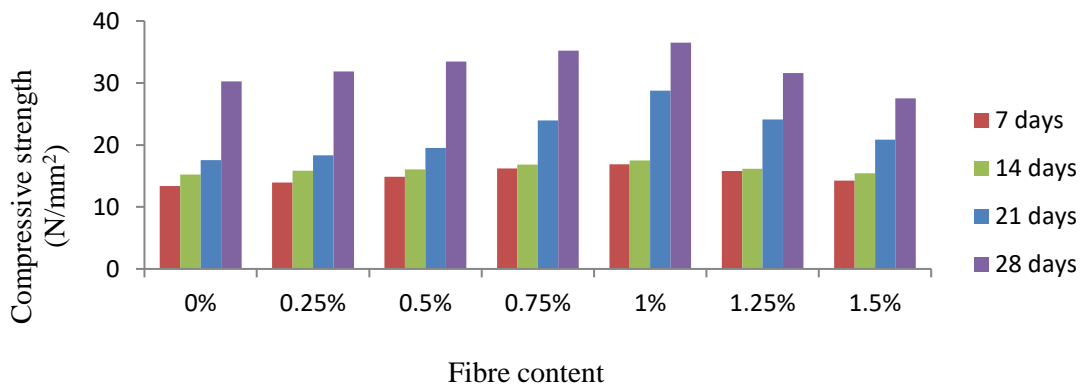


Figure 3. Variation of glass fibre content with respect to compressive strength and aging

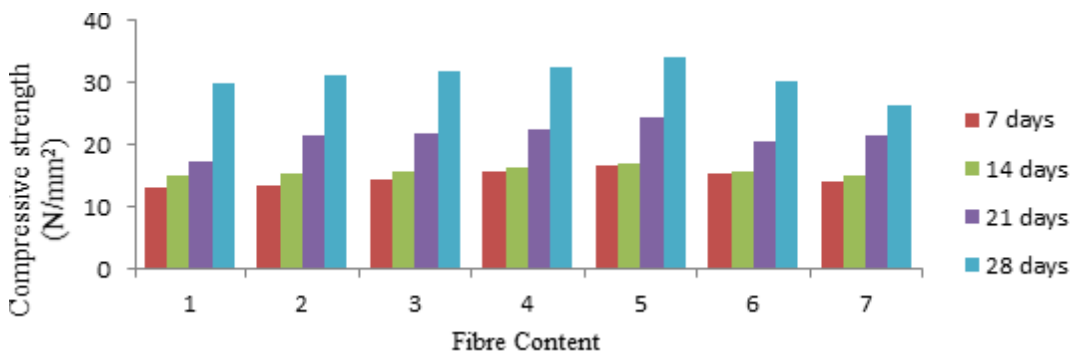


Figure 4. Variation of sisal fibre content with respect to compressive strength and aging

#### 4. Conclusion

Experimental study was conducted on the strength characteristics of fibre reinforced concrete using glass and sisal fibres at varying proportions. The following conclusions are drawn from the investigation.

- a) The slump and compaction factor values decreases with stepped introduction of sisal and glass fibres.
- b) The addition of glass and sisal fibres in plain concrete (control) up to 1% increases the strength of concrete.
- c) The addition of fibres content greater than 1% resulted to reduction in strength of concrete.
- d) The optimum glass and sisal fibre content was 1% with maximum compressive strength of 36.50 N/mm<sup>2</sup> and 34.67 N/mm<sup>2</sup> at 28 days respectively.
- e) The experimental study revealed that glass fibre was stronger than sisal fibre as light reinforcement.

#### Declaration of competing interest

The authors declare that they have no any known financial or non-financial competing interests in any material discussed in this paper.

#### References

- [1] A. Hoda and K. P Patil, "Performance Evaluation of Concrete by using Sisal Fibre and Bamboo Fibre," *International Journal of Engineering and Management Research*, vol. 8, no. 3, pp. 177-180, 2018.
- [2] K. T. R. Sumithra and A. B. S Dadapheer, "Experimental Investigation on the Properties of Sisal Fiber Reinforced Concrete," *International Research Journal of Engineering and Technology*, vol. 4, no. 4, pp. 2774-2777, 2017.
- [3] R. Badrinath and T. Senthilvelan, "Comparative investigation on mechanical properties of banana and sisal reinforced polymer based composites," *International Conference on Advances in Manufacturing and Materials Engineering*, vol. 5, pp. 2263-2272, 2014.
- [4] K. Chandramouli, R. P. Srinivasa, N. Pannirselvam, S. T. Seshadri, and P. T. P Sravana, "Strength and durability characteristic of glass fibre concrete," *International Journal of Mechanics of Solids*, vol. 5, no. 1, pp. 15-26, 2010.
- [5] K. R. Muthuawamy and G. S. Thirugnanam, "Mechanical properties of hybrid fibre reinforced high performance concrete," *Indian Concrete Journal*, vol. 87, no. 4, pp. 50-55, 2013.