OUT-TURN OF SISAL FIBER & SILICA FUME AS A PARTIAL SUBSTITUTION OF CEMENT ON THE PERFORMANCE OF CONCRETE

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Abstract:
In the field of construction, with the release of carbon-dioxide, the production of concrete leads to a negative impact on the environment. Therefore, there is a need to limit cement usage. One of the ways to reduce the cement content in concrete is using sisal fiber & micro silica as a partial alternative. Sisal fibers are one of the most popular alternatives for concrete reinforcement and are proven to show significant features including great tensile strength and sustainability. This paper aims to investigate the outcome of subsuming silica fume and sisal fiber in concrete which eventually solves the problems related to waste disposal and global warming and produces high performance concrete. The use of natural fibers & supplementary cementitious materials in concrete has gained a lot of attention from the past few years to their potential of increasing the durability and mechanical properties of concrete. In this study several cement mixtures were made with distinct proportions of sisal fiber & micro silica. The mechanical properties of the resulting concrete were then evaluated and compared with the normal concrete. Additions of silica fume into the concrete were 5% and10% by the weight of cement and volume of fractions of sisal fiber were 0.5% to 2%. Incorporation of silica fume improves the bond strength betweeen the particles of concrete where as sisal fiber bridges the cracks developed in the concrete by increasing the ductility and decreaing the brittleness and offers resistance to impact loading.

Keywords: *Silica fume, Bond strength, Mechanical properties, Subsuming ,Waste disposal, Concrete.*
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I. INTRODUCTION

One of the most versatile, man-made construction and building material all over the world is concrete. It is a composite material made from a mix of cement, water and aggregates (coarse & fine). It is considered to be a cheap material comparatively and has long life with little care and maintenance. Concrete is strong in compression but it has relatively low tensile strength, low ductility and is always at a risk of cracking. However these properties can be magnified by adding different types of additives to the concrete. This research focuses on the addition of natural fiber and supplementary material to the concrete which in return ameliorates the concrete properties. The fusion of cement with silica fume not only reduces the cement usage but also provides an important advantage in economically sustainable ways, as the use of waste materials in concrete contributes to less natural resource consumption and small amount of carbon-dioxide emissions. Silica fume (SF) is a ultrafine pozzolanic substance collected as a by-product of smelting process in the production of silicon metal and ferro-silicon alloy in concrete and

has the most beneficial uses. Silica fume is made of amorphous spherical particles with a mean size of 0.1-0.2 µm which is roughly about 100 times finer than cement. Addition of silica fume can thus improve the rheological properties of concrete. It can also reduce the permeability, porosity and bleeding of concrete and adds to the strength and durability of the concrete. On the other hand sisal fiber has greater advantages such as improved durability, recyclability and high strength-to-weight ratio.

II. AIM

To study the effect of incorporating sisal fiber and silica fume on the mechanical properties of concrete by partially replacing the cement.

III. MATERIALS

SILICA FUME: Silica fume, also known as micro silica and condensed silica fume consists of very fine particles of SiO_2,due to its large specific area and amorphous nature it becomes highly reactive pozzolanic material. It is composed of pure silica in a noncrystalline form. Iron,alkali oxides and magnesium are also found in smaller amounts in its composition.

Fig.1 Silica Fume

Table1 Properties of Silica Fume

S. NO.	Properties	Result Observed
1	Color & Shape	Dark Grey, Spherical
2	Specific Gravity	2.2
3	Particle Size	0.3µm
4	Bulk Density	650kg/m^3

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Sisal Fiber: It is a type of natural fiber reinforcement that can be used both as a primary and secondary reinforcement which distributes load, increases strength and toughness of the concrete. In case of secondary reinforcement (slabs and pavements) fibers are added to prevent cracking by temperature variations and humidity. The major role played by sisal fiber in concrete is the post cracking performance and improved toughness. A sisal plant can be grown in a shorter span of time and can produce around 200-250 leaves during its life span. Each leaf of a healthy sisal plant may approximately produce 1000-1200 bundles of fibers. Slow down of hydration process takes place by adding sisal fibers to the concrete.

Fig.2 Sisal Fiber

Table 2 Properties of Sisal Fiber

S. NO.	Properties	Result Observed
1	Diameter	200 µm
2	Length of fiber	40 mm
3	Density	1.4 g/m^3
4	Tensile Strength	560 Mpa
5	Modulus of Elasticity	10 Gpa
6	Moisture Absorption	11%
7	Porosity	17%
8	Specific Modulus	8 Gpa
9	Elongation at Failure	3%
10	Cellulose Content	70%
11	Young’s Modulus	10 Gpa

Cement: Cement is a blend of composites made by burning limestone and clay having adhesive and cohesive properties. In this study the cement used is ordinary portland cement (OPC) supplied by ACC limited company. The specific gravity of the ordinary portland cement is nearly 3.15 g/cm^3.The properties of cement were evaluated as per IS: 12269- 1987

Table 3 Proprties of cement

S.NO.	Properties	Result Observed
1	Fineness Modulus	97% passes through 90 micron sieve
2	Initial Setting Time	135
3	Final Setting Time	290
4	Standard Consistency	31%

Water: In this study of experimentation, the water used was normal tape water with a pH of 6.5, free from acidic concentration and organic matter.

Fine Aggregates (Sand): The sand used for this experimentation was locally obtained, graded into Zone I and contains much coarser material.The testing of fine aggregates was as per IS 383: 1970.

Fig.3 Fine Aggregates

Table 4 Properties of Fine Aggregates

S.NO.	Properties	Remarks
1	Fineness Modulus	2.98
2	Bulk Density	1700kg/m^3

3	Water Absorption	1.5%
4	Specific Gravity	2.37

Coarse Aggregates: As per Indian Standard Specifications (IS : 383-1970) the coarse aggregates were tested.
Well graded aggregates were used, passing through 20mm sieve and retaining on 4.75mm sieve.

Fig. 4 Coarse Aggregates

Table 5 Properties of Coarse Aggregates

S.NO.	Properties	Remarks
1	Fineness Modulus	7.23
2	Bulk Density	1704kg/m^3
3	Water Absoption	0.6%
4	Specific Gravity	2.65

IV. EXPERIMENTAL PROCEDURE

For determining the compressive strength, the specimen of standard cube (150mm×150mm×150mm) was used. For determining the flexural strength a standard beam specimen of (150mm×150mm×700mm) was used and for determining the split tensile strength, standard cylindrical specimen of 300mm height and 150mm diameter was used. These specimens were tested for 7 and 28 days with different proportions of silica fume and sisal fiber replacement. A total of 9 cubes, 9 beams and 9 cylinders were casted for the strength parameters to be evaluated. Hand mixing was adopted for mixing of the materials.The water binder ratio adopted was 0.35 and sisal fiber was added as per the cement content used. The concrete was filled in three layers and each layer of the concrete was compacted by a tampering rod of 16mm diameter. The specimen was demoulded after 24 hours and curing tank was used for curing of the concrete samples for a period of 7 and 28 days. All the tests were conducted as per IS 516:1959

V. RESULTS

Table 6 Result of Compressive strength

Concrete Mix	Silica Fume (%)	Sisal Fiber (%)	7 days	28 days
M0	0	0	21.57	29.21
M1	5	0.5	22.10	31.70
M2	5	1	22.40	31.90
M3	5	1.5	23.19	32.50
M4	5	2	22.50	32.01
M5	10	0.5	22.01	31.60
M6	10	1	22.30	31.80
M7	10	1.5	23.09	32.40
M8	10	2	22.40	31.90

The results of the compressive strength are presented in Table 6 above. The cubes where tested using compression testing machine (CTM) and compressive strength of 7 and 28 days was obtained. Maximum compressive strength was obtained in 5% of silica fume and 1.5% of sisal fiber. There is a notable improvement in the compressive strength of concrete by incorporating sisal fiber and silica fume.

Table 7 Result of Flexural strength

Concrete Mix	Silica Fume (%)	Sisal Fiber (%)	7 days	28 days
M0	0	0	6.47	8.76
M1	5	0.5	6.63	9.51
M2	5	1	6.72	9.57
M3	5	1.5	6.93	9.75
M4	5	2	6.75	9.60
M5	10	0.5	6.60	9.48
M6	10	1	6.69	9.54
M7	10	1.5	6.93	9.72
M8	10	2	6.72	9.57

The results of the flexural strength of concrete replaced with silica fume and sisal fiber are presented in Table 7. The test was carried out as per IS 516:1959 to obtain the flexural strength of the concrete with different mix proportions at 7 and 28 days. The maximum increase in flexural strength was obtained when silica fume was replaced by 5% and sisal fiber by 1.5%.

Table 8 Result of Split tensile strength

Concrete Mix	Silica Fume (%)	Sisal Fber (%)	7days	28 days
M0	0	0	2.61	3.60
M1	5	0.5	2.70	3.72
M2	5	1	2.88	3.81
M3	5	1.5	3.11	4.20
M4	5	2	2.90	3.90
M5	10	0.5	2.69	3.68
M6	10	1	2.72	3.70
M7	10	1.5	2.80	3.99
M8	10	2	2.77	3.80

The split tensile strength results are presented in Table 8. The maximum split tensile strength was obtained in 5% of silica fume and 1.5% of sisal fiber.

VI. CONCLUSION

- With increase in Silica Fume and Sisal Fiber the mechanical properties of the concrete were also increased.
- The maximum Compressive strength, Flexural strength and Tensile strength of concrete was obtained at 5% Silica Fume replacement and addition of Sisal fiber by 1.5%.
- At 10% replacement of Silica fume the strength of the concrete decreases.
- The strength of concrete incorporated with sisal fiber and silica fume is higher as compared to normal concrete.
- The workability of the concrete decreases with the increase in sisal fiber and silica fume.
- The compressive strength after 28 days of M30 grade concrete increased to 32.ghN/mm^2, flexural strength increased to 9.75 N/mm^2 and the Tensile strength increased to 4.20N/mm^2.

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