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Experimental Studies of Silica Fume and Sisalfibre on Performance of Concrete

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Abstract*: The main objective of this project is to investigate effect of silica fume & fiberorientation of sisal fiber on performance of concrete, which ultimately solve the problems of waste disposal & reduces global warming and increase the strength of concrete .India is a developing country, therefore Infrastructure development is necessary for ourcountry and concrete plays a vital role in it. Concrete is the world's largest consumingmaterial in the construction field. The emission of carbon-dioxide (CO2) in the atmospherefrom the operation and maintenance of structures as well as production of buildingmaterials can be reduced by using renewable resources and construction materials.Conventional concrete is relatively strong in compression but weak in tension, in order toovercome the weakness the use of a sufficient volume of certain fibers such as sisal fiber isused in this experiment, which is easily available, renewable and economicaland enhancemany of the mechanical characteristics of the basic materials such as fracturetoughness, flexural strength and resistance to fatigue, impact, thermal shock andspalling.The study focuses on the compressive strength, split tensile strength, in 7, 14, and 28 days of curing containing different percentage of sisal fiber and silica as a partial replacement of OPC. The cement in concrete is replaced accordingly with the percentage of 0%, 10 %, and 20% by volume and 0%,1% , 1.5%and 2% of sisal fiber is added by weight of cement. Finally, the strength performance of silica blended fiber reinforced concrete is compared with the performance of conventional concrete.

Keywords: Sisal Fiber, Silica fume, Sustainable, Renewable, Global Warming, Economic.compressive strength, split tensile strength.

I. INTRODUCTION

Concrete is the most versatile building material. Concrete has a relatively low tensile strength (compared to other building materials) and low ductility. And also it is susceptible to cracking .The production of concrete leads to lot of environmental issues associated with the significant release of CO_2 and other greenhouse gases. Therefore, it is necessary to look for sustainable solutions for future concrete construction. The fusion of concrete with micro silica & natural fibres is a conventional technique. Natural fibers have the potential to be used as reinforcement to overcome the inherent deficiencies in concrete material composites. These fibers have always been considered promising as reinforcement of cement based matrices because of their availability and low consumption of energy. 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. Micro silica also known as silica fume is one of the waste materials that is being produced from alloy industries in tones of industrial waste per year in our country. It is a byproduct of producing silicon metal or ferrosilicon alloys. It consists of spherical particles with mean size of about 100 nm which is about 100 times finer than Portland cement. One of the most beneficial uses of micro silica is in concrete. Concrete containing micro silica has very high strength and is very durable.Natural fibers such as sisal fibers are preferred due to their greater advantages, which includelow cost, high strength-to-weight ratio, better durability, environmental compatibility, biodegradability and recyclability. By adding this sisal fiber it has been found that there is anincrease in properties of both fresh and hardened concrete.

II. MATERIALS USED AND PROPERTIES

A. Silica Fume

Silica fume, also referred to as microsilica or condensed silica fume, is a byproductmaterial that is used as a pozzolan. This byproduct is a result of the reduction of high-purityquartz with coal in an electric arc furnace in the manufacture of silicon or ferrosilicon alloy.Silica fume rises as an oxidized vapor from the 2000°C (3630°F) furnaces. The escapinggaseous SiO oxidizes and condenses in the form of extremely fine spherical form ofamorphous silica (SiO2); hence, it called as silica fume.

Fig .1 Silica Fume

Table 1: Properties of Silica Fume

SI NO	Properties	Result
1	color	White
2	Particle size	300 micrometer
3	Bulk Density	670 kg/m3
4	Specific gravity	2.2
5	Shape	Spherical

B. Sisal Fiber

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 decortications. During decortications, 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.

Fig .2 Sisal fiber

is fully biodegradable, green composites were fabricated with soy protein resin modified with gelatin. Sisal fiber, modified soy protein resins, and composites were characterized for their mechanical and thermal properties. It is highly renewable resource of energy. Sisal fiber is exceptionally durable and a low maintenance with minimal wear and tear. Its fiber is too tough for textiles and fabrics. It is not suitable for a smooth wall finish and also not recommended for wet areas. The fine texture of Sisal takes dyes easily and offers the largest range of dyed colours of all natural fibers. Zero pesticides or chemical fertilizers used in sisal agriculture. It is a stiff fiber traditionally used in making twine, rope and also dartboards Sisal fiber is manufactured from the vascular tissue from the sisal plant (Agavesisalana). It is used in automotive friction parts (brakes, clutches), where it imparts green strength to performs, and for enhancing texture in coatings application.

Table 2: Properties of Sisal Fiber

SI NO	Properties	Result
1	Fiber length (mm)	50
2	Diameter (µm)	200
3	Density (g/cm3)	1.45
4	Specific modulus (Gpa)	7
5	Modulus of elasticity (Gpa)	9.4
6	Tensile Strength (MPa)	568
7	Moisture absorption	11%
8	Elongation at failure	2
9	Young's modulus (Gpa)	9
10	Porosity (%)	17
11	Cellulose content (%)	67

C. Cement

Cement may be defined as a material which possess very good adhesive and cohesiveproperties which make it possible to bond with other material to form compact mass.Ordinary Portland Cement 53 grade was used in this experimental work. The cement properties were evaluated as per the IS: 4031-1996 and IS: 12269-1987

Table 3: Properties of Cement

SI NO	Properties	Result
1	Specific gravity	3.1
2	Fineness Modulus	2.99
3	Standard Consistency	31.25%
4	Initial Setting time	36 minutes
5	Final Setting time	390 minutes

D. Fine aggregate

The crushed sand used for experimental program was locally procured andconforming to Zone I. The fine aggregates were tested as per Indian Standard SpecificationIS: 383-1970.

Table 4: Properties of Fine aggregate

SI NO	Properties	Result
1	Specific gravity	2.47
2	Fineness Modulus	2.99
3	Bulk density(kg/m3) (loose state)	1542
4	Bulk density(kg/m3) (compacted state)	1701
5	Water absorption(%)	1

E. Coarse aggregate

Aggregates passing through 20mm sieve and retained on 4.75mm sieve were sievedand tested as per Indian Standard Specifications IS: 383-1970.

Table 5: Properties of Coarse aggregate

SI NO	Properties	Result
1	Specific gravity	2.74
2	Fineness Modulus	7.34
3	Bulk density(kg/m3) (loose state)	1426
4	Bulk density(kg/m3) (compacted state)	1706
5	Water absorption(%)	.5

F. Water

In this study, normal tap water was used. Fresh potable water, which is free fromconcentration of acid and organic substance is use for mixing the concrete.

III. PREPARATION AND TESTING OF SPECIMEN

The specimen of standard cube of 150 mm x 150 mm x 150mm and standard cylinders of 300mm x 100 mm are used to determine the compressive strength , spilt tensilestrength of concrete. Three specimens were tested for 7,14& 28 days with each proportion of sisal fiber and silica fume replacement. The constituents are weighed and the materials were mixed by hand mixing .The water binder ratio (W/B) (Binder = cement + partial replacement of silicafume) adopted was 0.45 and sisal fiber was added based on cement content and weight of super plasticizer was estimated as 0.8% of weight of binder. Theconcrete was filled in various layers and each layer was compacted .The specimen was demoulded after 24 hrs,cured in water 7, 14, 28days, and then tested for compressive and split tensile strength as per Indian Standards.

IV. TEST RESUTS AND DISCUSSIONS

Resultsof fresh andhardened concrete with sisal fiber and partial replacement of silica fume are discussed in comparison with normalconcrete

Table:6 Results of Compressive strength and Tensile strength

Mix ID	%of silica fume	% of sisal fiber	Compressive strength (N/mm2)			Split tensile strength (N/mm2)	
			7 days	14 days	28 days	7 days	28 days
Conventional concrete			21.71	27.71	31.20	2.51	3.50
M1	10%	0.5%	21.90	29.90	31.50	2.60	3.62
M2		1%	22.20	28.40	31.70	2.77	3.71
M3		1.5%	22.90	29.00	32.30	2.91	4.10
M4		2%	22.30	28.50	31.80	2.80	3.80
M5	20%	0.5%	21.80	27.80	31.40	2.59	3.58
M6		1. 1%	22.10	28.20	31.60	2.62	3.60
M7		1.5%	22.80	28.90	32.20	2.70	3.90
M8		2%	22.20	28.30	31.70	2.67	3.70

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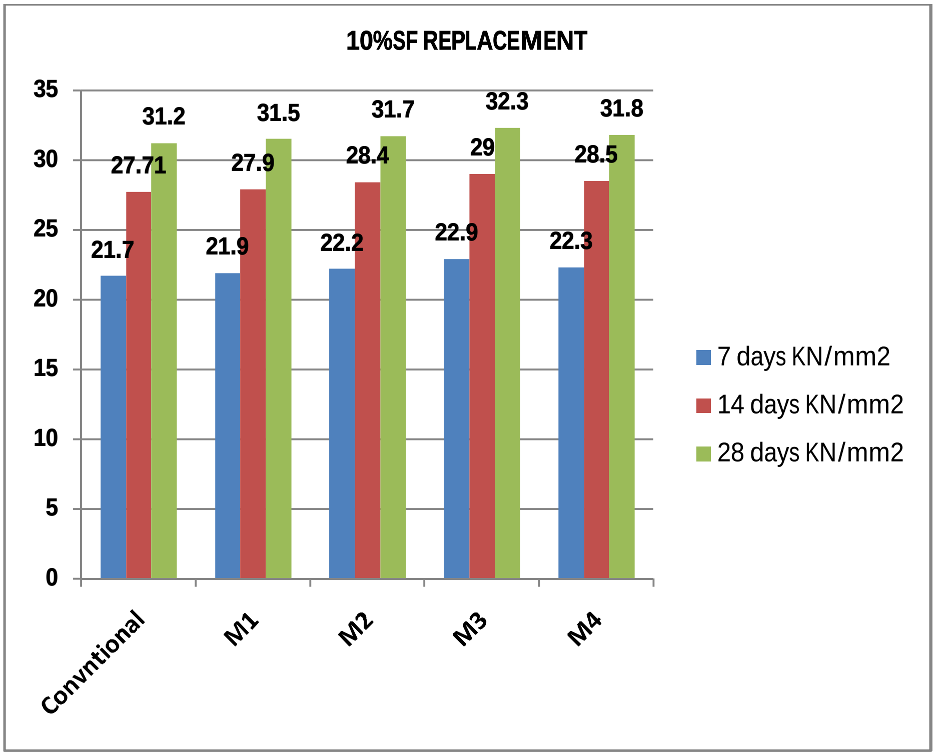
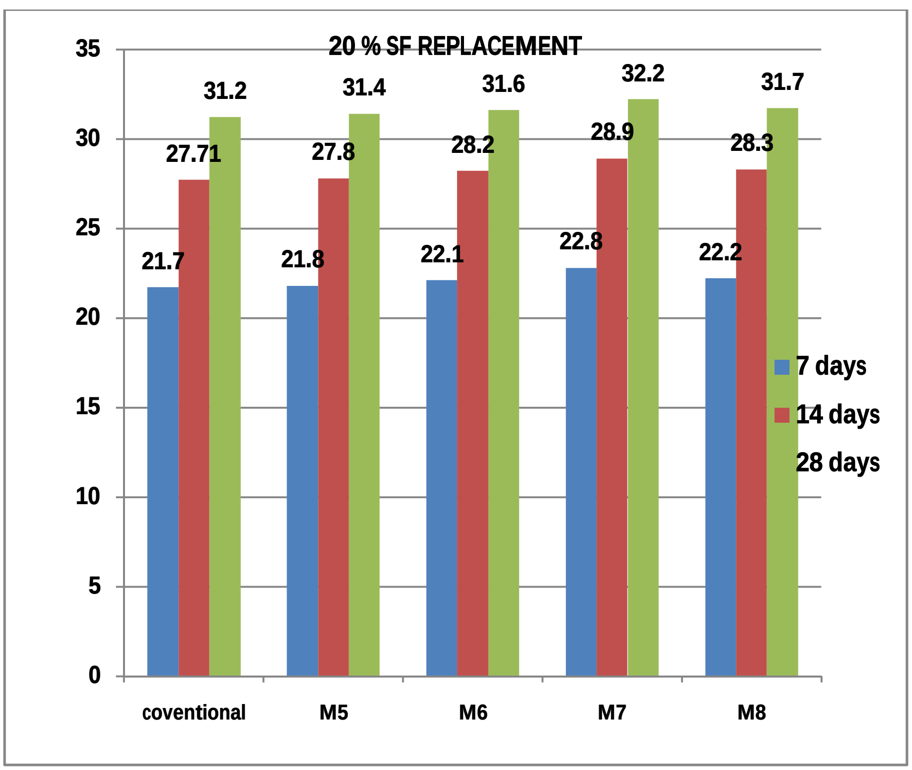
A. Compressive Strength

results of compressive strength were presented in table .The cubes were tested using Universal Testing Machine (UTM) and Compression Testing Machine (CTM) .and compressive strength of 7,14 and 28 days were obtained.From Fig ,The maximum compressive strength is obtained in 10% of silica fume and 1.5 % of sisal fiber ..





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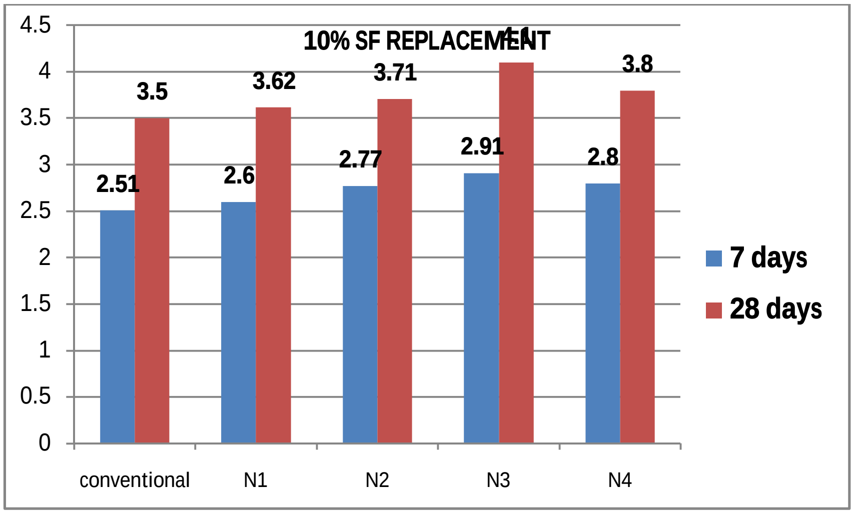
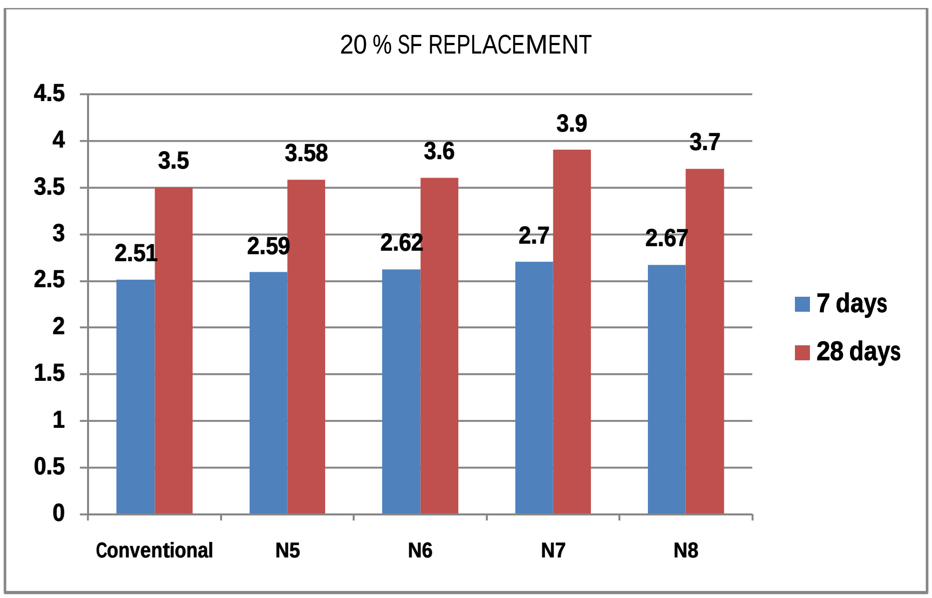
B. Split Tensile strength

The results of split tensilestrength were presented in Table .The cylinders were tested using Universal Testing Machine (UTM) and Compression Testing Machine (CTM) . and split tensile strength of 7,and 28 days were obtained. From Fig ,The maximum tensile strength is obtained in 10% of silica fume and 1.5 % of sisal fiber .





V. CONCLUSION

A. With the increasing of Silica Fume and Sisal Fiber the compressive strength and split tensile strength are also increased

B. It was observed that 28 days Compressive strength of M30 grade concrete increased in 31.20 to 32.30 N/mm2 and Tensile strength increased in 3.50 to 4.10 N/mm2.

C. It is concluded that the maximum Compressive strength and Tensile strength was obtained in 10 %Silica Fume replacement and 1.5 % Sisal Fibre addition.

D. At 20 % replacement ,the strength of concrete decreases due to excess fines and lesser cement content.

E. The strength of sisal fibre addition to silica concrete is higher when compared to conventional concrete.

F. Workability decreases with increase in percentage of sisal fiber as well as silica fume.

G. It is concluded that 10% replacement of micro silica induces higher strength properties and good workability properties. This may be due to the filling effect of micro silica

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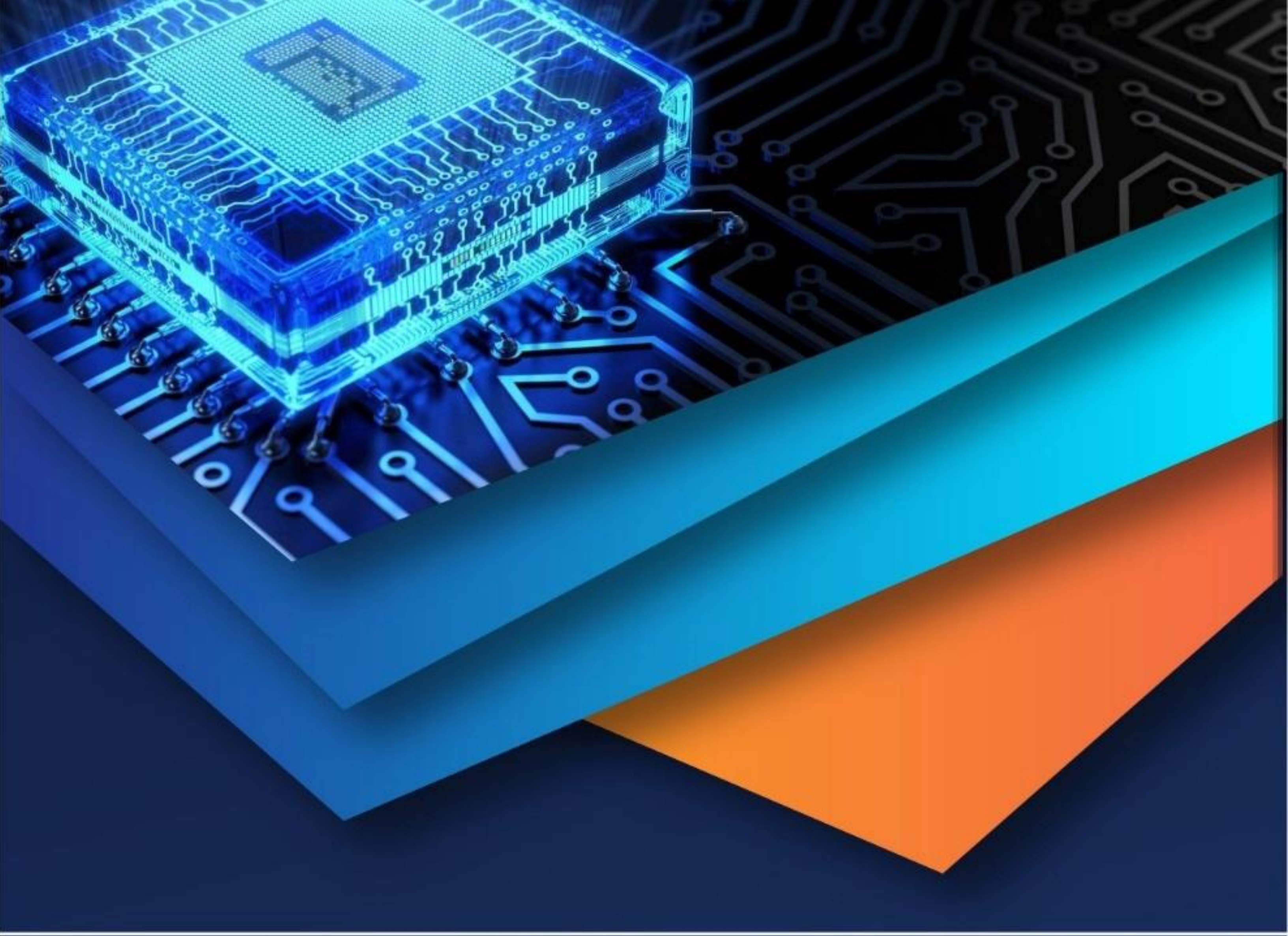

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