Combined Effect of Silica Fume and Saw Dust as a Partial Replacement of Cement in Concrete

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Abstract – The environmental impact of OPC is significant because its production emits large amount of CO2. Utilization of industrial soil waste or secondary materials has been encouraged in construction field for the production of cement and concrete because it contributes for reducing the consumption of natural raw materials as resources. The volume of wastes generated in the world has increased over the years due to increase in population, socioeconomic activities and social development. One of the most attractive options of managing such wastes is to look into the possibility of waste minimization and re-use. The cost of cement used in concrete works is on the increase and unaffordable, yet the need for housing and other constructions requiring this material keeps growing with increasing population, thus the need to find alternative binding materials that can be used solely or in partial replacement of cement. Waste materials, in this case, Rice Husk, Saw Dust, which is an environmental pollutant it ash can be used as pozzolana in partial replacement of cement in concrete production. Concrete cubes were casted using replacement levels of 0, 1, 2 and 3 % percent of saw dust (SDA) and 5, 10, 15% of Silica Fume with OPC for M20 Grade concrete. Thus 12% replacement of OPC with SDA (2%) and Silica Fume (10%) give compressive strength at 28 days is 24.33N/mm^2 and Tensile strength is 3.45N/mm^2 .Therefore it can be used for concrete production.

Keywords: Concrete, Silica Fume (SF), Saw Dust Ash (SDA), Compressive Strength, Split-Tensile Strength.

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INTRODUCTION

Concrete is widely used as construction material for various types of structures the cost of construction materials like cement and reinforcement bars, has led to increased cost of construction. This, coupled with the pollution associated with cement production, has necessitated a search for an alternative binder which can be used sorely or in partial replacement of cement in concrete production. More so, disposal of waste materials such as rice husk, groundnut husk, corn cob and Saw Dust have constituted an environmental challenge, hence the need to convert them into useful materials to minimize their negative effect on the environment. Research indicates that most materials that are rich in amorphous silica can be used in partial replacement of cement. It has also been established that amorphous silica found in some pozzolanic materials reacts with lime more readily than those of crystalline form. Use of such pozzolanas can lead to increased compressive and flexural strengths.

1. TYPES OF WASTES

1.1 Rice Husk Ash

Agricultural wastes Rice husk ash is a major agricultural product obtained from paddy. For every 40 kN of rice 10kN of husk is produced. The husk is disposed off either by dumping it in an open heap near the mill site or on the road side to be burnt later. Burning the rice husk generated about 15-20% of its weighing as ash.

1.2 Sugarcane Bagasse Ash

The Bagasse Ash is the fibrous waste produced after the extraction of the sugar juice from cane. This material usually poses a disposal problem in sugar factories particularly in tropical countries. In many tropical countries there are substantial quantities of Bagasse (the fibrous residue from the crushing the sugar cane) and husks from rice both are rich in amorphous silica, which react with lime.

1.3 Groundnut shell ash

Groundnut shell is an agricultural waste obtained from milling of groundnut. The ash from groundnut shell has been categorized under pozzolana, with about 8.66% Calcium Oxide (CaO), 1.93% Iron Oxide (Fe2O3), 6.12% Magnesium Oxide (MgO), 15.92% Silicon Oxide (SiO2), and 6.73% Aluminum Oxide (Al2O3). The utilization of this pozzolana as a replacement for traditional stabilizers will go a long way in actualizing the dreams of most developing countries of scouting for cheap and readily available construction materials. Groundnut shell ash has been used in concrete as a partial replacement material for cement.

1.4 Saw Dust Ash

Sawdust Ash (SDA) generated from saw mills is usually delivered to landfills for disposal. Using of sawdust ash in concrete is an interesting possibility for economy on waste disposal sites and conservation of natural resources .This paper examines the possibility of using sawdust ash as replacement in cement for a new concrete. Cement was partially replaced (1%, 2% and 3%) with SDA.

1.5 Silica Fume

Silica fume, also known as microsilica, (CAS number 69012-64-2, and EINECS number 273-761-1) is an amorphous (non-crystalline) polymorph of silicon dioxide, silica. It is an ultrafine powder collected as a by-product of the silicon and ferrosilicon alloy production and consists of spherical particles with an average particle diameter of 150 nm. The main field of application is as pozzolanic material for high performance concrete.

1.8 Scope of study

In the present study we are partially replacing the cement by Saw Dust Ash (SDA) and silica fume for M20 Grade concrete in different percentages 0%, 1%, 2%, 3% of Saw Dust Ash and 5%, 10%, 15% of silica fume casted 30 no of cubes of 150mm x 150mm x 150mm and done comparative study on normal concrete and Saw Dust Ash + Silica Fume concrete.

2. MATERIALS USED

The basic materials for mixing concrete are required such as

6. Cement
7. Fine aggregate
8. Coarse aggregate
9. Saw Dust
10. Silica fume
11. Water

Cement

The cement used was OPC 53 grade cement. The different tests were conducted as per Indian Standards to determine the properties of this cement. For initial & final setting time IS: 8112-1989 is used and for standard consistency of cement IS: 4031(part-4) 1988. For specific gravity of cement (IS: 2720- part 3) is used. The Table 2.1 shows the results

S. no	Properties	Values obtained
1	Specific gravity	3.15
2	Standard consistency	35%
3	Initial setting time	60 min
4	Final setting time	300 min

Table 2.1: Results of Tests on Cement

Fine aggregate

The sand is used as fine aggregate is used in the concrete. Various tests were conducted to determine the properties of fine aggregate which are shown in the Table 2.2. Grading is the particle- size distribution of an aggregate as determined by a sieve analysis. The tests were done according to IS: 2386 (Part-1) – 1963.

S. no	Properties	Values
1	Specific gravity	2.61
2	Water absorption	0.82%
3	Zone	II

Table 2.2: Results of Tests on Fine Aggregate

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Coarse aggregate

Aggregate is commonly considered inert filler, which accounts for 60 to 80 percent of the volume and 70 to 85 percent of the weight of concrete. Maximum size of aggregate affects the workability and strength of concrete. In this study the natural coarse aggregates are used, which was bought from the nearby quarry. Aggregates of 20 mm passed and 12.5 mm retained size were chosen for the experiment which is clean and free from deleterious materials. The following Table 2.3 shows the tests conducted in order to determine the properties of this aggregate.

S. no	Properties	Values
1	Specific gravity	2.65
2	Water absorption	0.18%

Table 2.3: Results of Tests on Coarse Aggregate

Saw Dust Ash (SDA)

Sawdust is a by-product from timber, it is a waste product obtained during sawing of timber into standard sizes. The sawdust was obtained from timber milling market (ogbosisi) Owerri. This material was first dried to remove the natural moisture. The waste was burnt in an enclosure (i.e. open drum) at temperature of about 400-500°C to obtain sawdust ash. The ash was allowed to cool; thereafter the ash was sieved with 150μm sieve aperture to obtain the finest particle of material which approximates to the fineness of that of cement used.

Fig 2.1 Burning process of saw dust

Fig 2.2 Saw Dust ash Chemical Properties of Saw Dust ash and Silica

3. EXPERIMENTAL INVESTIGATION

In the present study we are partially replacing the cement by saw dust ash and silica fume for M20 Grade concrete in different percentages 0%, 1%,2%, 3%, SDA and 5%,10%,15% casted 30 no of cubes of 150mm x 150mm x150mm.To achieve the objectives of the investigation the experimental program was planned to cast around 30 No of cubes. The compression testing machine and the tensile strength of specimens are determined.

Mix proportion

OPC	SILICE FUME	SDA
100%	0%	0%
94%	5%	1%
93%	5%	2%
92%	5%	3%
89%	10%	1%
88%	10%	2%
87%	10%	3%
84%	15%	1%
83%	15%	2%
82%	15%	3%

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Oxide	% percentage	
	SDA	SILICA
SiO_2	65.3	94.3
Al_2O_3	4.0	0.09
Fe_2O_3	2.23	0.10
CaO	9.6	0.30
MgO	5.8	0.43
MnO	0.01	-
Na_2O	0.07	0.27
K_2O	0.11	0.83
P_2O_5	0.43	-
SO_2	0.45	-

Table No 3.1 Mix proportion

4. TEST AND RESULTS

4.1 Compressive Strength

Compressive strength test on cubes were carried out using the Universal Testing Machine (UTM). Compressive test were carried out on cubes of dimensions 150 × 150 × 150 mm after 7 days 14 and 28 days. For each test and for each mix three specimens were tested. The compressive strength was computed using the expression F_c= P/A for cubes, Where, F_c is the compressive stress in MPa. P is the maximum load applied in Newton and A is the cross sectional area in mm^2. Standard cast iron moulds of size 150x150x150mm for cubes are used in the preparation of specimens. The experimental setup is shown in below figures.

Fig. 4.1 Compressive Test machine

OPC	SILICA FUME	SDA	COMPRESSIVE STRENGTH N/mm2		
			7DAYS	14DAYS	28DAYS
100 %	0%	0%	11.15	16.48	20.14
94%	5%	1%	11.83	17.64	21.24
93%	5%	2%	12.92	18.01	21.55
92%	5%	3%	12.61	17.8	22.22
89%	10%	1%	13.32	19.12	22.89
88%	10%	2%	14.02	19.86	24.33
87%	10%	3%	13.2	19.04	21.55
84%	15%	1%	14.98	19.47	21.33
83%	15%	2%	11.68	17.93	20.1
82%	15%	3%	13.87	16.67	19.11

Table 4.1 Compressive strength

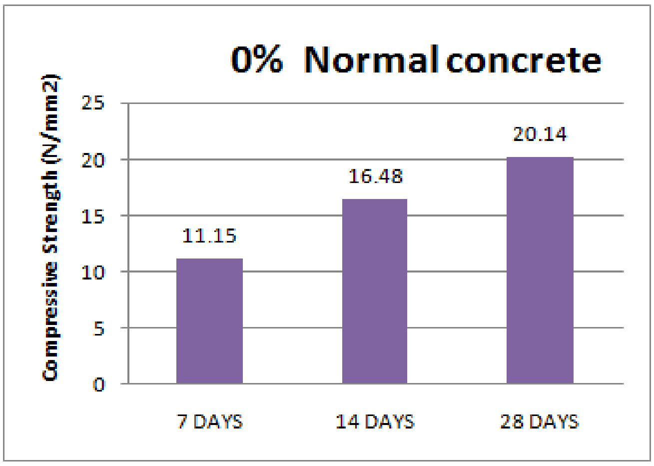
Tensile strength

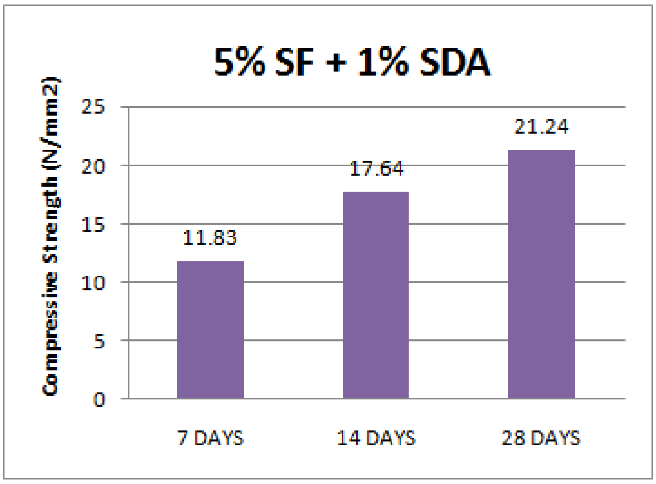
Tensile strength is an important property of concrete because concrete structure are highly vulnerable to tensile cracking due to various kinds of effect and applied load itself, however tensile strength of concrete is very low compared to compressive strength of concrete.

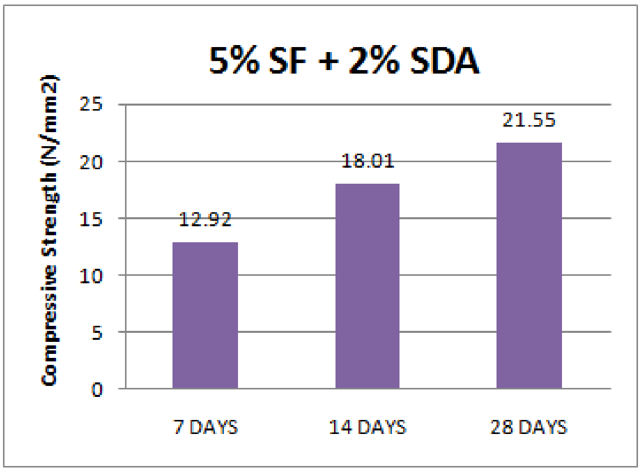
OPC	SILICA FUME	SDA	TENSILE STRENGTH N/mm2		
			7DAYS	14DAYS	28DAYS
100%	0%	0%	2.34	2.84	3.14
94%	5%	1%	2.41	2.94	3.23
93%	5%	2%	2.52	2.97	3.25
92%	5%	3%	2.49	2.95	3.30
89%	10%	1%	2.55	3.06	3.35
88%	10%	2%	2.62	3.12	3.45
87%	10%	3%	2.54	3.05	3.25
84%	15%	1%	2.71	3.09	3.23
83%	15%	2%	2.39	2.96	3.14
82%	15%	3%	2.61	2.86	3.06

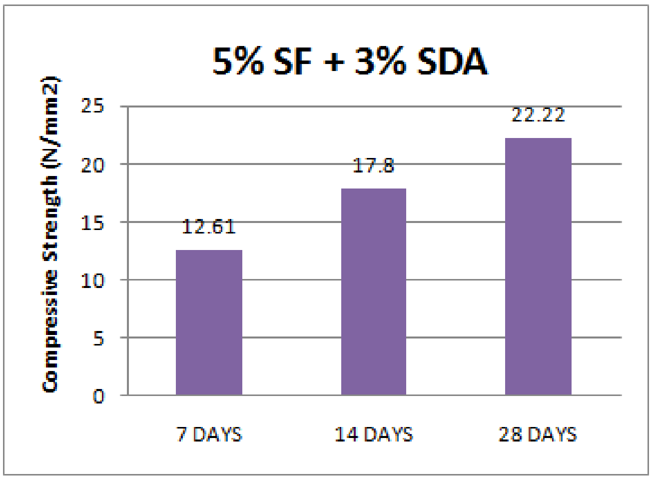
Table 4.2 Tensile strength of concrete

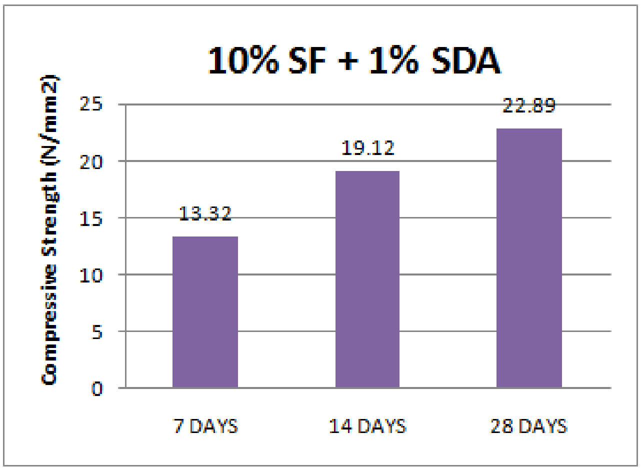
Graphs Compressive strength

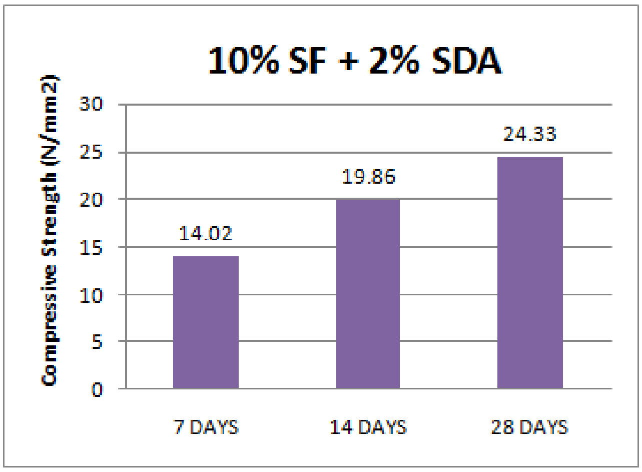


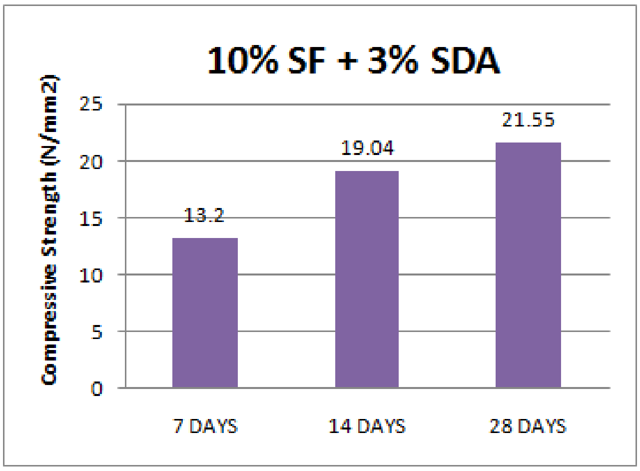


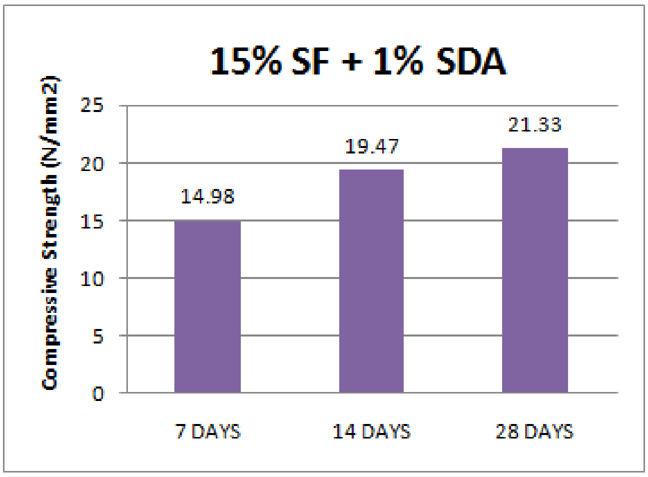


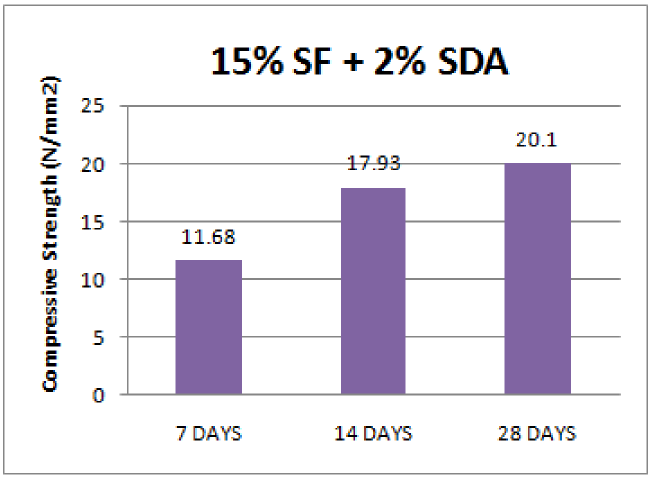


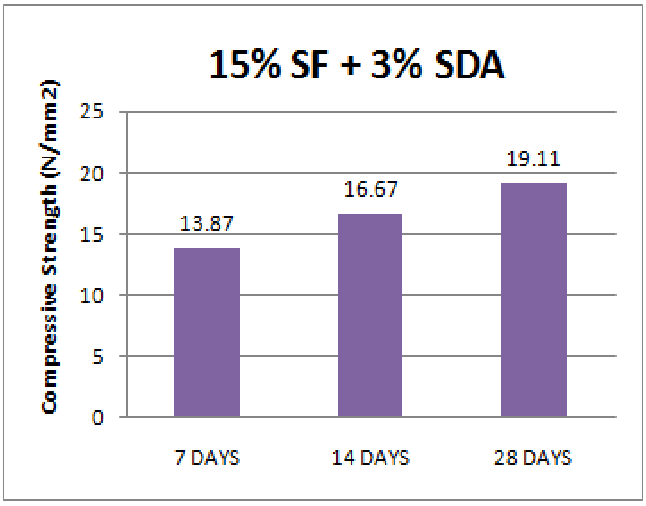




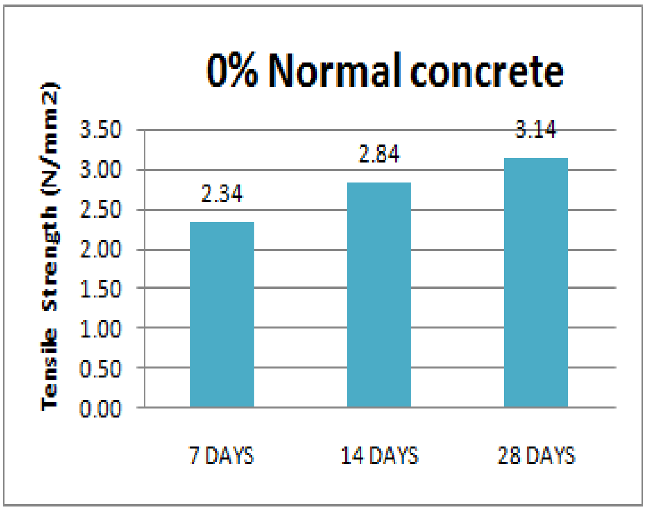


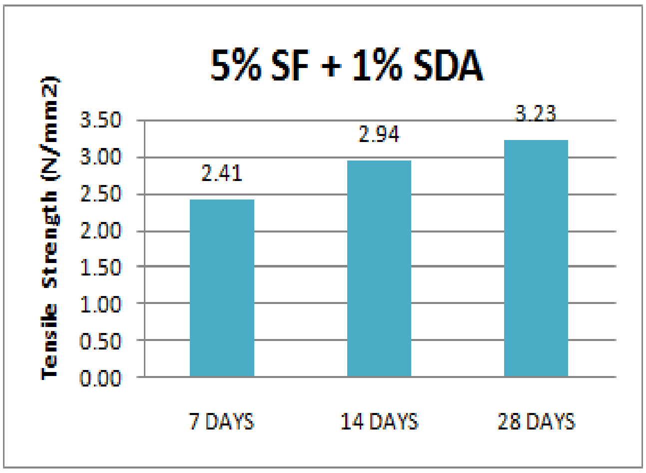


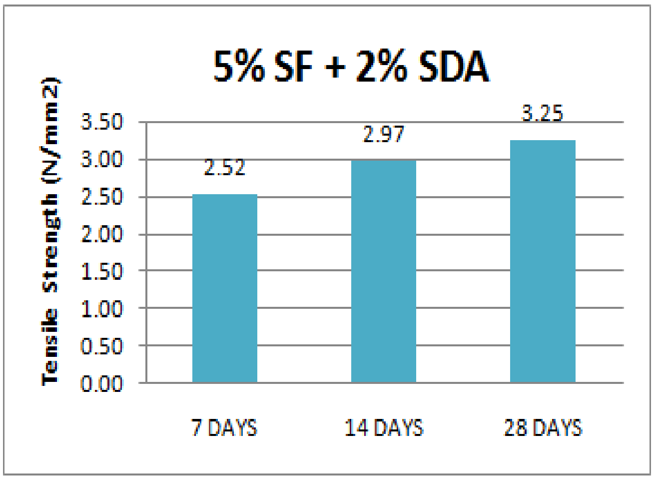


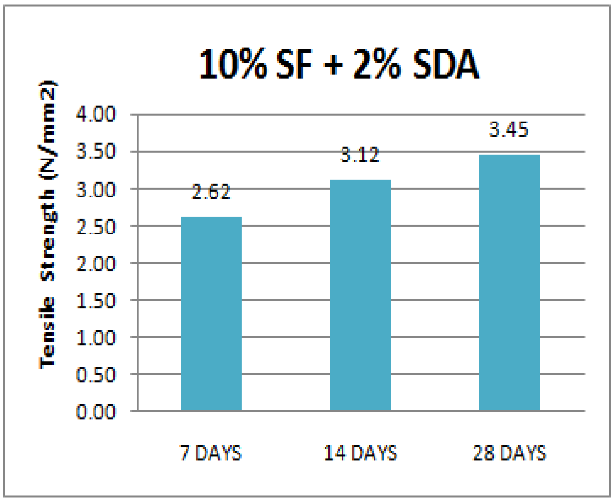


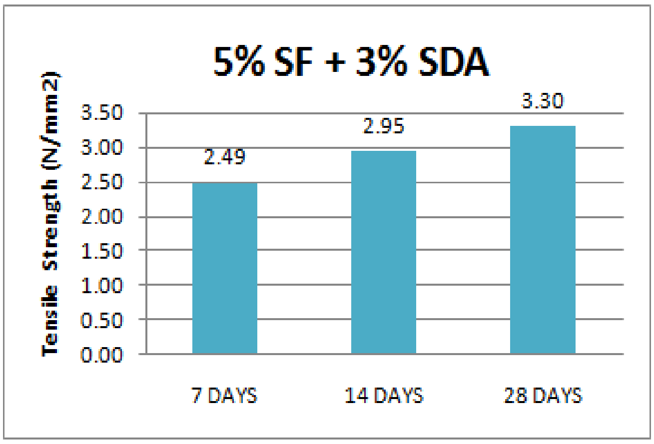
Tensile strength

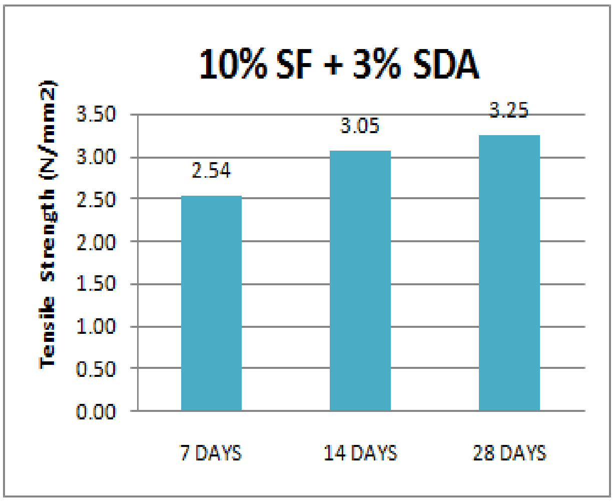


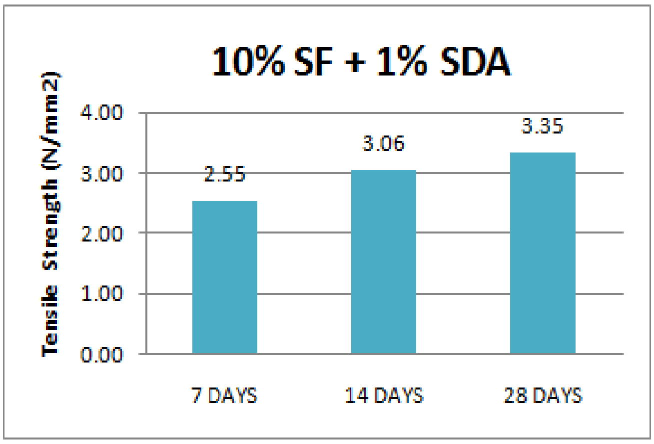


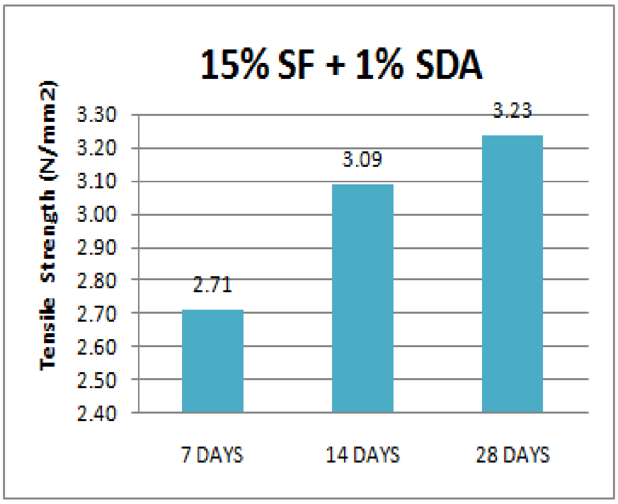

5% SF + 2% SDA
Tensile Strength (N/mm2)
3.50
3.00
2.50
2.00
1.50
1.00
0.50
0.00
2.52
2.97
3.25
7 DAYS
14 DAYS
28 DAYS

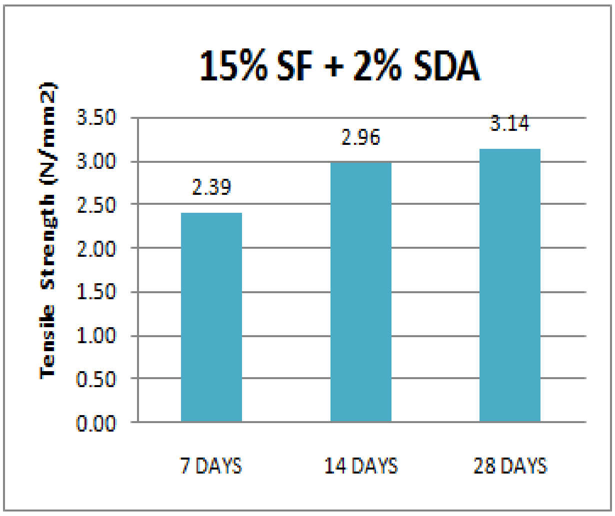

10% SF + 2% SDA
Tensile Strength (N/mm2)
4.00
3.50
3.00
2.50
2.00
1.50
1.00
0.50
0.00
2.62
3.12
3.45
7 DAYS
14 DAYS
28 DAYS

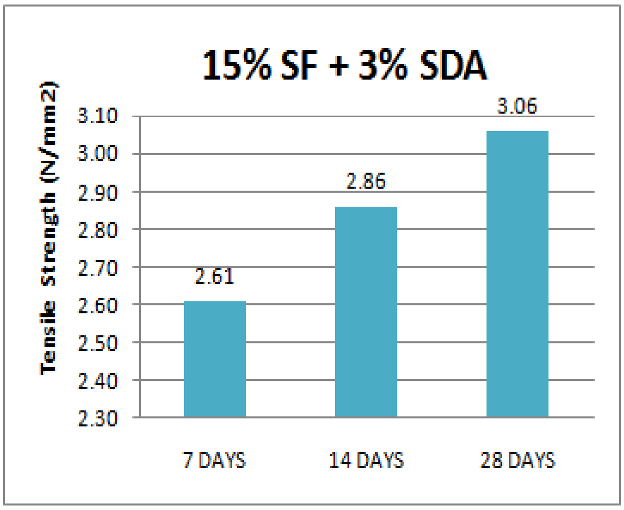

5% SF + 3% SDA
Tensile Strength (N/mm2)
3.50
3.00
2.50
2.00
1.50
1.00
0.50
0.00
2.49
2.95
3.30
7 DAYS
14 DAYS
28 DAYS


10% SF + 3% SDA
Tensile Strength (N/mm2)
3.50
3.00
2.50
2.00
1.50
1.00
0.50
0.00
2.54
3.05
3.25
7 DAYS
14 DAYS
28 DAYS


10% SF + 1% SDA
Tensile Strength (N/mm2)
4.00
3.00
2.00
1.00
0.00
2.55
3.06
3.35
7 DAYS
14 DAYS
28 DAYS


15% SF + 1% SDA
Tensile Strength (N/mm2)
3.30
3.20
3.10
3.00
2.90
2.80
2.70
2.60
2.50
2.40
2.71
3.09
3.23
7 DAYS
14 DAYS
28 DAYS





CONCLUSION

From the tests conducted on SDA and silica fume replaced in cement for concrete as presented in various sections, the following conclusions are made.

- It is observed that for a given mix, the water requirement increases as the SDA content increases.
- The compressive strength of cubes of the concrete for all mix increases with age of curing SDA and silica fume is available in significant quantities as a waste and can be utilized for making concrete. This will go a long way to reduce the quantity of waste in our environment.
- The optimum replacement level in cement with SDA is 2% and Silica fume 10%. It gives maximum Strength of 14.02 N/mm^2,19.86 N/mm^2,24.33 N/mm^2, for 7, 14, 28 days Respectively
- The tensile strength with replacement of cement with SDA is 2% and Silica fume 10% the strength is 2.62 N/mm^2, 3.12 N/mm^2,3.45 N/mm^2,The maximum SDA is 2% and SF 10% can be replaced with cement in concrete

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