Journal of Advances in Science and Technology

Vol. 11, Issue No. 23, August-2016, ISSN 2230-9659

EXPERIMENTAL INVESTIGATION ON PARTIAL REPLACEMENT OF CEMENT WITH COCONUT SHELL ASH AND SILICA FUME IN CONCRETE

AN INTERNATIONALLY INDEXED PEER REVIEWED & REFEREED JOURNAL

Experimental Investigation on Partial Replacement of Cement with Coconut Shell Ash and Silica Fume in Concrete

Chandu Gummadi[1] G. Srikanth[2]

[1]PG Student Structural Engineering, Sindhura College of Engineering & Tech, Ramagundam Karimnagar, 123gummandichandu@gmail.com

[2]Assistant Professor, Dept. of Civil Engineering, Sindhura College of Engineering & Tech, Ramagundam Karimnagar, srikanthgajiganci24@gmail.com

Abstract – 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. So, there is a need to find alternative binding materials that can be used solely or in partial replacement of cement. Agricultural waste and industrial waste material like coconut shells and silica fume which is an environmental pollutant, are collected and used as pozzolana in partial replacement of cement in concrete production. The concrete even releases huge amount of CO_2 into atmosphere and to reduce that we have partially replaced cement with coconut shell ash and silica fume. From previous researches it was found that 10-15% replacement of OPC with CSA was recommended for heavy weight and light weight concrete production. So we have investigated on it by adding extra 5-10% of silica fume to find the compressive strength of the concrete for M_{20} Grade. The Concrete cubes were produced using various replacement levels of 0, 10,15,20,25 and 30 percent of OPC with CSA and SF. A total of 27 cubes and 27 Cylinder were produced and cured by immersing them in water for 7, 14 and 28 days respectively. Properties such as compressive strength, Tensile Strength and density were determined. The optimal 28 days strength for OPC-CSA-SF mix is recorded at 10% replacement (25.44N/mm^2). And 3.531 N/mm^2 Therefore it can be used for concrete production.

Keywords: Compressive Strength, Tensile Strength, Concrete, Coconut Shell Ash, Cement, Silica Fume

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1. INTRODUCTION:

The infrastructure development is going on increasing in our day to day life. The concrete is the premier civil construction material. Concrete manufacturing process involves consumption of ingredients like cement, aggregate, water and admixture. Cement is a high cost material in concrete which leads to increase in 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. Research addressing environmental and sustainability issues in construction has generated lot of interest in the world.

While wastes generated by industrial and agricultural process have created and management problems which pose serious challenges to efforts towards environmental conservation, their use contributes to resource conservation environmental protection and the reduction of costs . The industrial materials like silica, fly ash, GGBS, metakoline etc. Agricultural by-products like rice husk, ground nut shell, sugar cane, coconut shell. Hence, we need to convert them into useful material to minimize their negative effect on environment.

This waste material (ash) contains amorphous silica, which reacts lime more readily than those of crystalline form. The use of such pozzlonic material in concrete which leads to increase in compressive and flexural strength . According to previous researches, it was found that 10-15% replacement of OPC with CSA was recommended for heavy weight and light weight concrete production. So, we are investigating on it by adding extra 5 and 10 % of silica fume. The properties like compressive strength, Tensile strength and density were determined.

1.1 PRODUCTION OF CEMENT, COCONUT SHELL AND SILICA FUME IN INDIA

Cement

The composition of World Cement Consumption in the year 2012 is 3,313 Million Metric Tons. Amongthat 7.0% in India,57.7% in China,9.4% in Developed Countries,25.9%inOtherEmerging.

Coconut shell

India is the third largest producer of coconut products in the world. Coconut trees are widely cultivated in the southern states of India, especially Kerala. Kerala got its name itself derived from a word,'kera' meaning coconut tree. Traditional areas of coconut cultivation in India are the states of Kerala, Tamil Nadu, Karnataka, Pondicherry, Andhra Pradesh, Goa, Maharashtra, Odisha, West Bengal and the islands of Lakshadweep and Andaman and Nicobar

The composition of Coconut Production in India in the year 2009 is 10,894,000 tonnes.Traditional areas of coconut cultivation are the states of Kerala (45.22%),Tamil Nadu (26.56%),Karnataka (10.85%) and Andhra Pradesh (8.93%).

Kerala is densely populated state and most of its population uses coconut or it's byproducts in their daily activities. Coconut shells thus get accumulated in the mainland without being degraded for around 100 to 120 years. Disposal of these coconut shells is therefore a serious environmental issue. The coconut industry in India accounts for over a quarter of the world's total coconut oil output and is set to grow further with the global increase in demand. However, it is also the main contributor to the nation's pollution problem as a solid waste in the form of shells, which involves an annual production of approximately 3.18 million tones. Coconut shell represents more than 60% of the domestic waste volume. Coconut Shell, which presents serious disposal problems for local environment, is an abundantly available agricultural waste from local coconut industries. In developing countries where abundant agricultural and industrial wastes are discharged, these wastes can be used as potential material or replacement material in the construction industry. This will have the double advantage of reduction in the cost of construction material and also as a means of disposal of wastes.

Fig.1.1 .Coconut shells

Silica fume

Silica fume is a by-product in the carbothermic reduction of high-purity quartz with carbonaceous materials like coal, coke, wood-chips, in electric arc furnaces in the production of silicon and ferrosilicon alloys. The main source of silica fume is obtained as a byproduct during iron ore extraction.

2. MATERIALS USED

2.1 Cement

The most important use of cement is the production of mortar and concrete, which is a combination of cement and an aggregate to form a strong building material that is durable in the face of normal environmental effects. In the present investigation OPC 53 grade cement is used

S. no	Properties	Values obtained
1	Specific gravity	3.15
2	Standard consistency	35%
3	Initial setting time	65 min
4	Final setting time	300 min

Table 2.1: Results of Tests on Cement

2.2 Aggregate

Sand is naturally occurring granular material composed of finely divided rock and mineral particles. The most common constituent of sand is silicon dioxide, usually in the form of Quartz. Normally fine aggregate is used as fine aggregate for preparing concrete. The aggregate which passed through 4.75mm is called fine aggregate. The aggregate which retained above 4.75mmseive is called coarse aggregate .20mm size aggregate is used

S. no	Properties	Values
1	Specific gravity	2.6
2	Water absorption	0.82%
3	Zone	II

Table 2.2: Results of Tests on Fine Aggregate

S. no	Properties	Values
1	Specific gravity	2.65
2	Fineness modulus	2.2
3	Water absorption	0.19%

Table 2.3: Results of Tests on Coarse Aggregate

2.3 Coconut shell ash (CSA)

Coconuts are referred to as "man's most useful trees", "king of the tropical flora" and "tree of life". Coconuts or its scientific name cocosnucifera are the most important of cultivated palms and the most widely distributed of all palms. Coconut shells are cheap and readily available in high quantity. The coconuts were broken manually to drain out the water. The 40 coconut half shells were sun-dried for three days. The cleaned coconut shells obtained from were cut into pieces of dimensions of 1 sq.cm using hammer and were put in stainless steels containers. The containers were then kept into muffle furnace for carbonization (carbonization is the production of charred carbon from a source material. It contains about 65 – 75% volatile matter during carbonation process the moisture is removed. The carbonization process involves converting the coconut shells to charcoal and temperature range between 400 C and 850 C sometimes reaches. During this process is Methane, CO_2 and wide range of organic vapours are released.

Fig.2.1 .coconut Shell Ash

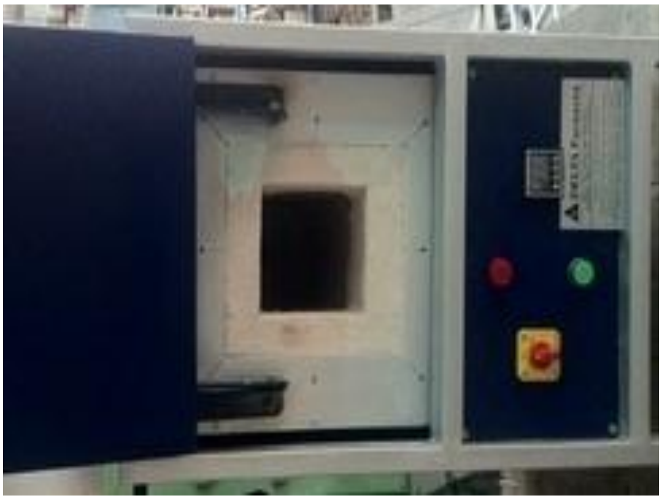


Fig.2.2 .Muffle Furnace

2.4 Silica fume

Silica fume, also known as micro 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. It is sometimes confused with fumed silica (also known as pyrogenic silica, CAS number 112945-52-5). However, the production process, particle characteristics and fields of application of fumed silica are all different from those of silica fume. One of the most beneficial uses for silica fume is in concrete. Because of its chemical and physical properties, it is a very reactive pozzolan. Concrete containing silica fume can have very high strength and can be very durable.

The raw materials are quartz, coal, and woodchips. The smoke that results from furnace operation is collected and sold as silica fume, rather than being land filled. Perhaps the most important use of this material is as a mineral admixture in concrete. Silica fume consists primarily of amorphous (non-crystalline) silicon dioxide (SiO_2). TM C 1240 and AASHTO M 307. The individual particles are extremely small, approximately 1/100th the size of an average cement particle. Because of its fine particles, large surface area, and the high SiO_2 content, silica fume is a very reactive pozzolan when used in concrete.

Oxide composition in Ordinary Portland Cement, CSA& Silica Fume

Oxide	Percentage concentration (%)		
	OPC	CSA	SF
SiO_2	20.7	37.97	95.92
Al_2O_3	5.75	24.12	-
Fe_2O_3	2.5	15.48	1.33
CaO	64	4.98	0.36
MgO	1	1.89	0.38
MnO	0.2	0.81	-
Na_2O	0.6	0.95	0.12
K_2O	0.15	0.83	0.30
P_2O_5	0.05	0.32	-
SO_3	2.75	0.71	-
LOI	2.3	11.94	1.58

Table.2.4 .composition of Cement, CSA & SF

Coconut shell

The physical properties of coconut shell Ash are shown below table.

S.no.	Parameter	Test results
1	Specific gravity	1.33
2	Water absorption (%)	25
3	Bulk density(Kg/M^3)	
	Loose	592.59
	Compacted	800

Table 2.5.Physical Properties of CSA

Silica fume

The physical properties of silica fume are shown below table

Properties of silica fume

S.no.	Parameter	Test results
1	Specific Gravity	2.2
2	Bulk Density	576, (Kg/m^3)
3	Size , (Micron)	0.1
4	Surface Area , (m^2/kg)	20,000
5	Si02	(90-96)%
6	Al_2O_3	(0.5 -0.8)%

Table 2.6.Physical Properties of silica fume

3. EXPERIMENTAL INVISTIGATION

3.1 General

In the present study we are partially replacing the cement by coconut shell ash (CSA) and Silica fume (SF) for M20 Grade concrete in different percentages 0%, 10%+5%, 10%+10%, 15%+5%, 15%+10%,20%+5%,20%+10%,25%+5%,25%+10% and casted 27 no of cubes of 150mm x 150mm x150mm. To achieve the objectives of the investigation the experimental program was planned to cast around 27 No of cubes. And the cubes were tested under 200 ton compression testing machine to study the compressive strength of the cubes, the details of the experimental program for cubes are mentioned in the table below.

3.2 Mix Proportion

The concrete mixture proportions for M20 Grade concrete are 1:1.5:3 and water cement ratio 0.5,the cubes were casted using varying OPC-CSA-SF Ratio. The Cement is replaced by CSA and SF in different ratio

%	OPC	CSA	SF
0	100	0	0
10%+5%	85	10	5
10%+10%	80	10	10
15%+5%	80	15	5
15%+10%	75	15	10
20%+5%	75	20	5
20%+10%	70	20	10
25%+5%	70	25	5
25%+10%	65	25	10

Table 3.1.Mix Proportion

4. TEST & RESULTS

4.1 Workability test

Slump test

Ingredients of mixes are properly mixed so as to produce homogeneous and uniform fresh concrete in macro-scale in order to know its workability using slump test. The results of same test for the conventional concrete and various CSA concrete are shown in table 4.1

Specimen	% coconut	% silica fume	Slump (mm)
A1	0	0	62
A2	10	5	66
A3	10	10	70
A4	15	5	69
A5	15	10	75
A6	20	5	75
A7	20	10	78
A8	25	5	82
A9	25	10	88

Table 4.1 Slump Test

4.2 Density &Compressive & Tensile strength of concrete

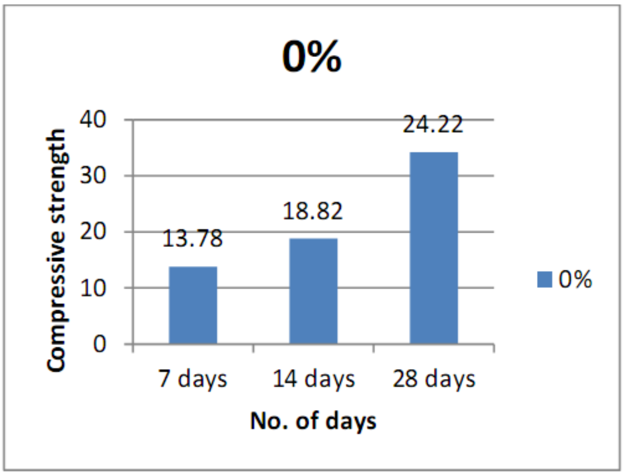
% Replacement (CSA+SF)	Curing age (days)	Density (kg/m^3)	Compressive strength (N/mm2)	Tensile Strength (N/mm2)
	7	2525.5	13.78	2.598
0	14	2522.0	18.82	3.037
	28	2514.0	24.22	3.445
	7	2487.11	7.81	1.956
10+05	14	2472..12	18.12	2.98
	28	2462.22	22.18	3.297
	7	2449.78	6.91	1.84
10+10	14	2405.92	15.94	2.795
	28	2402.96	25.44	3.531
	7	2555.85	6.22	1.746
15+05	14	2515.10	13.80	2.6
	28	2503.12	19.89	3.122
	7	2477.63	5.94	1.706
15+10	14	2423.32	11.61	2.385
	28	2406.12	20.14	3.141
	7	2395.01	5.69	1.67
20+05	14	2392.89	11.11	2.333
	28	2382.25	17.10	2.895
	7	2482.87	5.67	1.667
20+10	14	2461.11	12.12	2.437
	28	2374.52	18.41	3.003
	7	2432.77	5.44	1.633
25+5	14	2367.41	11.99	2.424
	28	2362.22	18.10	2.978
	7	2359.12	4.89	1.548
25+10	14	2347.72	10.04	2.218
	28	2346.17	16.17	2.815

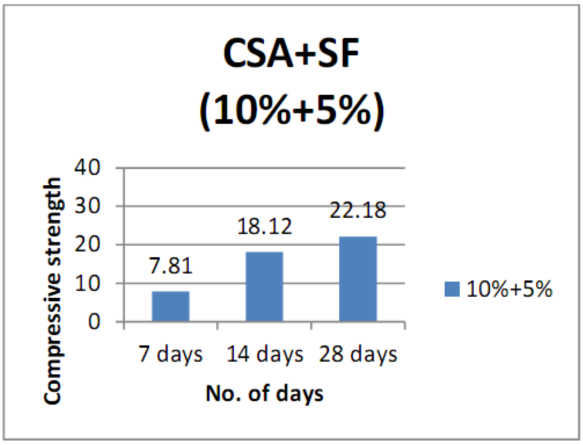
Table 4.2 Density &Compressive & Tensile strength of concrete

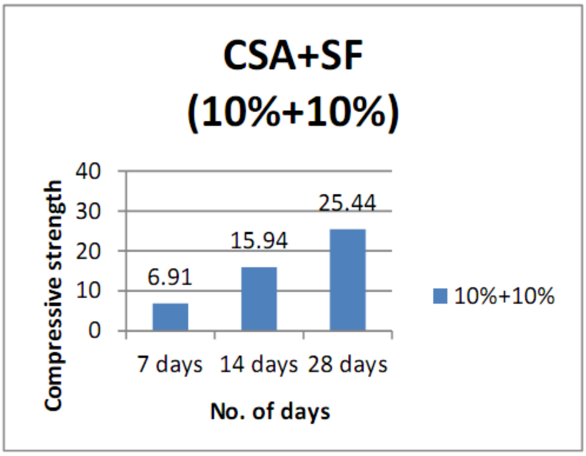
Fig .4.1 Compressive & Tensile strength of concrete

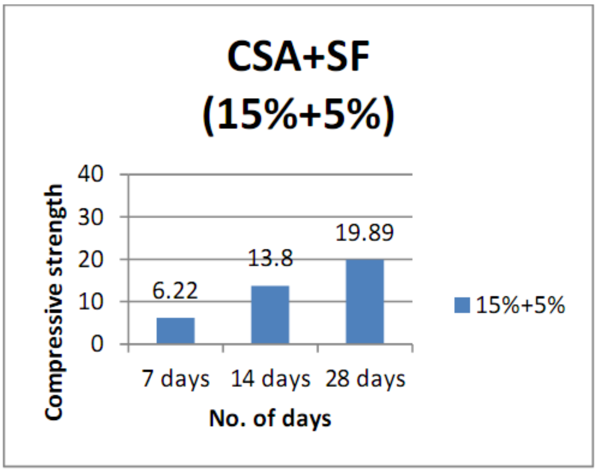
5. GRAPHS

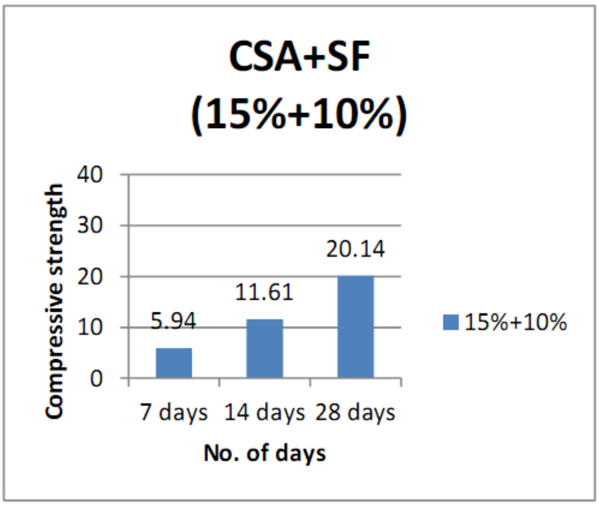
Compressive strength at 7, 14, 28 Days

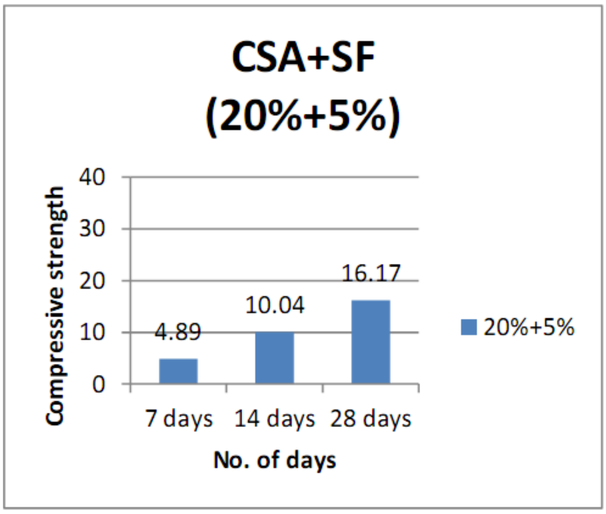


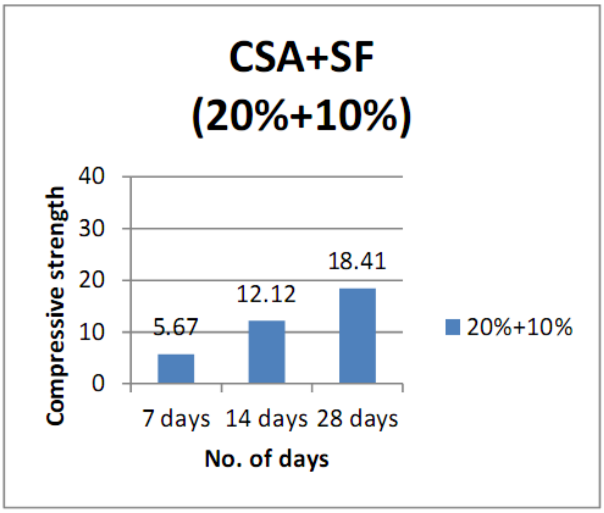

CSA+SF
(10%+5%)
Compressive strength
40
30
20
10
0
7.81
18.12
22.18
7 days
14 days
28 days
No. of days
10%+5%

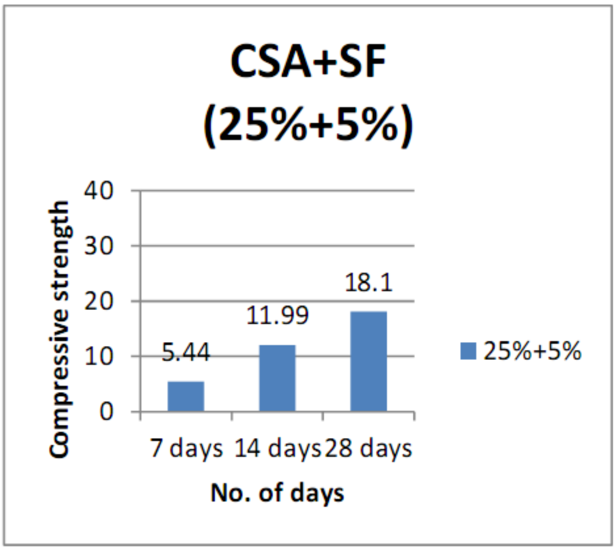

CSA+SF
(10%+10%)
Compressive strength
40
30
20
10
0
6.91
15.94
25.44
7 days
14 days
28 days
No. of days
10%+10%

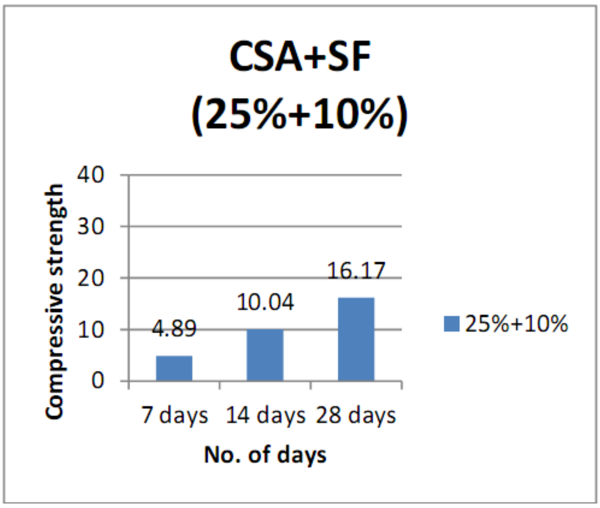

CSA+SF
(15%+5%)
Compressive strength
40
30
20
10
0
6.22
13.8
19.89
7 days
14 days
28 days
No. of days
15%+5%


CSA+SF
(15%+10%)
Compressive strength
40
30
20
10
0
5.94
11.61
20.14
7 days
14 days
28 days
No. of days
15%+10%

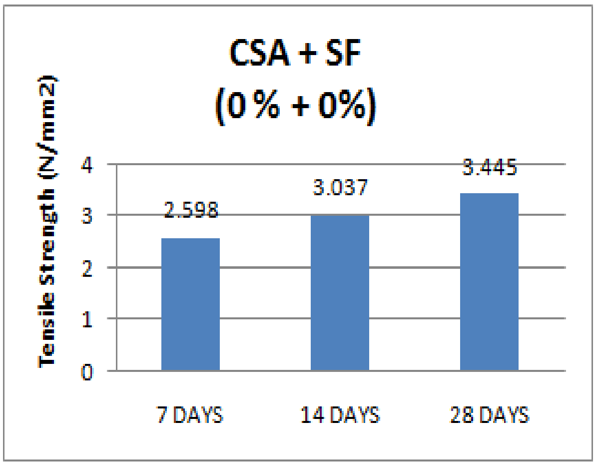

CSA+SF
(20%+5%)
Compressive strength
40
30
20
10
0
4.89
10.04
16.17
7 days
14 days
28 days
No. of days
20%+5%

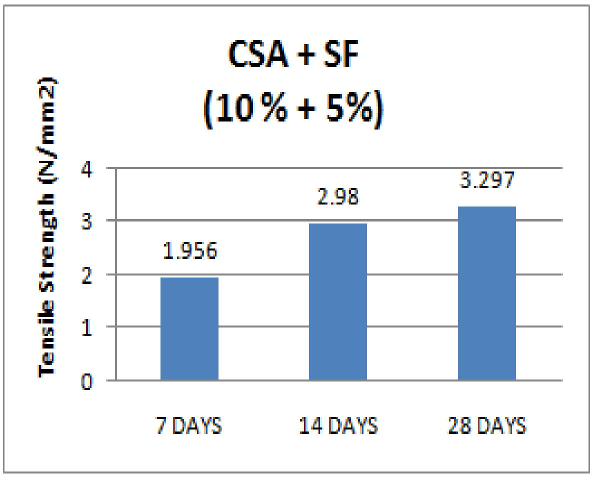

CSA+SF
(20%+10%)
Compressive strength
40
30
20
10
0
5.67
12.12
18.41
7 days
14 days
28 days
No. of days
20%+10%

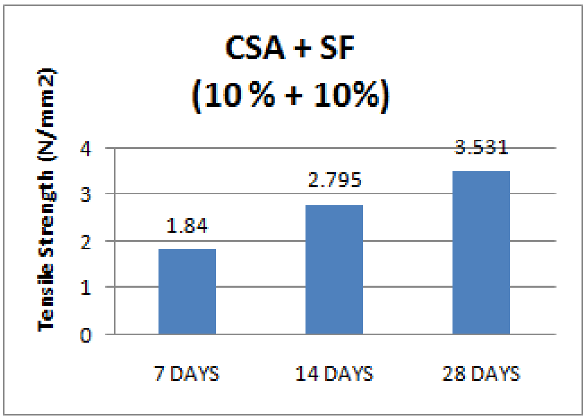


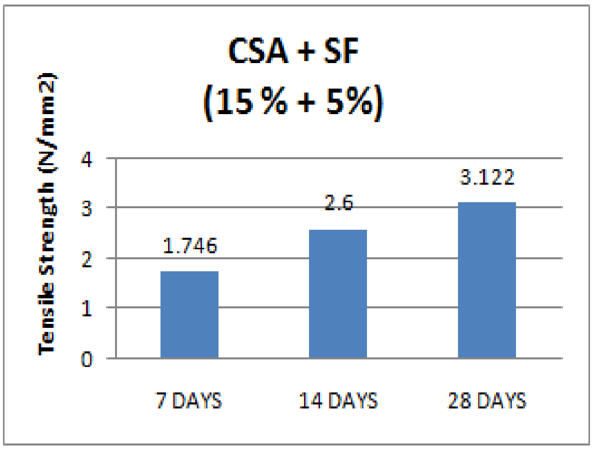


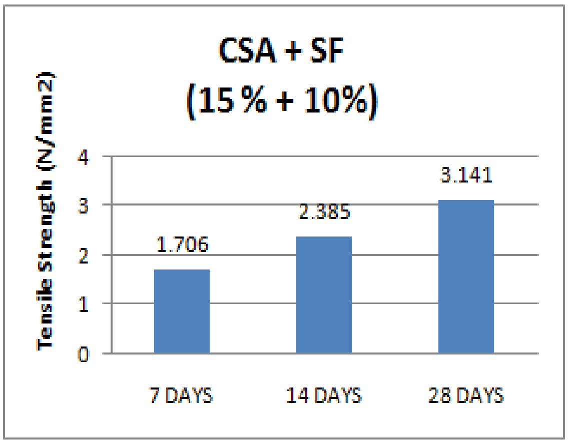
Tensile strength at 7, 14, 28 Days

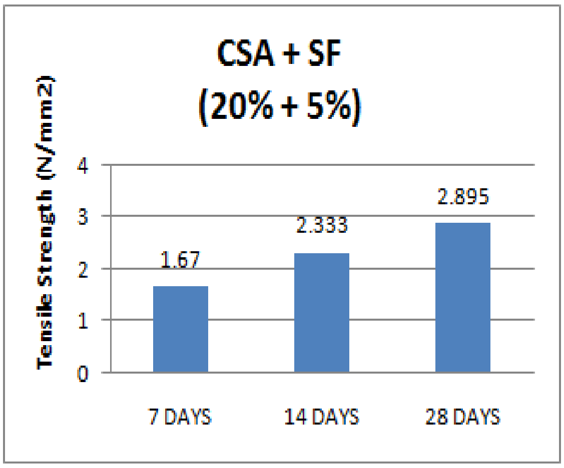


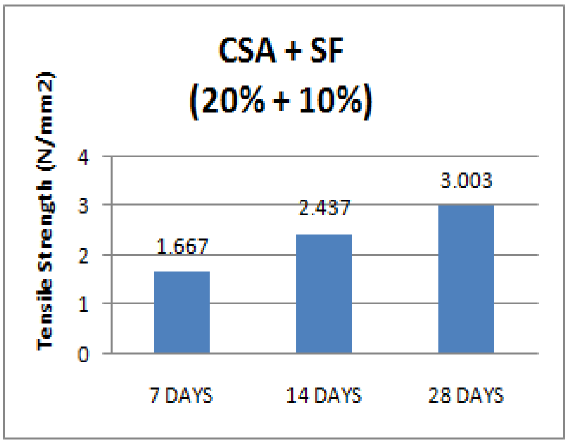


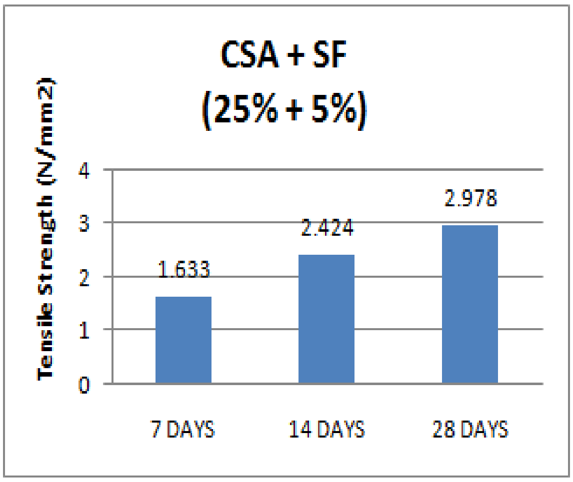


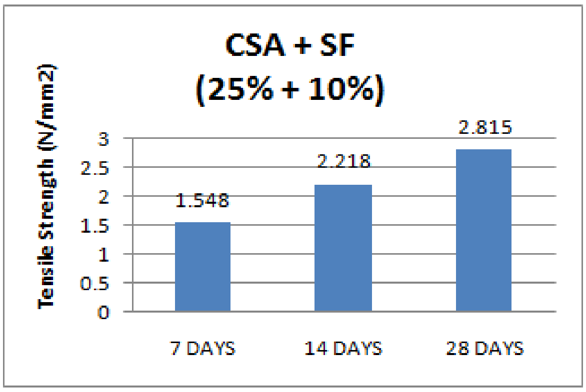












CONCLUSION:

- The results obtained from CSA,SF and OPC mix shows that the average density decrease with percentage replacement for 0% is 2525.5Kg/m^3 for (25%+10%) at 35% replacement is 2359.12Kg/ m^3
- The compressive strength and Tensile Strength decreases with increase in percentage replacement of OPC with CSA and SF.
- The 7 days strength decreases from 13.78N/mm^2 for OPC to 4.89N/mm^2 for 35% replacement with CSA and SF. The strength after 28 days curing decreases from 24.22N/mm^2 for OPC to 16.17N/mm^2 and Tensile strength 3.445 n/mm2 for 0% to 2.815 N/mm2 for 35% replacement with CSA.
- The optimal 28 days strength for OPC-CSA-SF mix is recorded at 10%+10% (20%) replacement (25.44N/mm^2). And Tensile strength is 3.531 N/mm2.
- The utilization of this product in concrete work would reduce the effect of this agricultural and industrial waste acting as the agent of environmental pollution.

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